Advisory Committee on Fisheries Management ICES CM 1999/ACFM:11

REPORT OF THE

STUDY GROUP ON MULTIANNUAL ASSESSMENT PROCEDURES

Vigo, Spain
22-26 February 1999

International Council for the Exploration of the Sea

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1 INTRODUCTION

1.1 Terms of reference (TOR)

The Study Group on Multi-annual Assessment Procedures (SGMAP) met in Vigo, 22 to 26 February 1999 to address the following terms of reference:

a) investigate and propose appropriate simplified methodology and procedures which may be used to provide management advice (such as TACs) in years when a full assessment is not performed;
b) provide software for the assessment tools proposed which are not currently available at ICES Headquarters;
c) in order to test the proposed methodology, identify the stocks currently assessed by the WGSSDS and the WGHMSA which may be the subject of less frequent assessments while still providing adequate information for annual management advice;
d) advice on multi-annual assessment schedule for each stock and identify the methodology to be used here;

At its 1997 Annual Science Conference in Baltimore USA, ICES adopted and implemented a new structure for its scientific Committees. The intent was to similarly revise the structure of the Advisory Committees in order to increase the efficiency of the advisory process and to be able to better meet future needs for integrated and ecosystem advice. The revision of the structure of the Advisory Committees is not yet completed and a Co-ordinating Group on ICES Advice (CGADV) has been created to further the process.

The workload of ACFM and associated Working Groups has grown considerably over the years and continues to do so, to the extent that the work to be done is now considered to put excessive strain on the Secretariat, on Working Groups, and on ACFM to the extent that the quality of advice suffers, and that mistakes are being made. It is expected that a solution to the workload problem will alleviate the quality control problem, but not resolve it. There is also a perception, especially outside of the WG and ACFM member community, that improved methodologies and working procedures could lead to more reliable, more robust, and more useful advice. The main objective for SGMAP is to investigate what methods, if any, could be used to provide better quality advice at a lesser cost, whether all assessments need to be done every year, and if not, how to choose those that could be done at a lower frequency. If and where possible multiyear advice could be envisaged. This would not only enhance the credibility of the advice, it could also lead to an improved planning environment for the industry.

Assuming that additional resources will not be made available and that the number and scope of requests will not decrease, or perhaps increase, it is obvious that the only solution is to improve the process and methods used to provide advice. Given the perceived magnitude of the discrepancy between the workload and the resources available to do it, radical changes, rather than minor adjustments, are believed to be necessary.

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1.2 Comments on TOR by SG

Referring to the terms of reference 1 and 3 requesting '.. simplified methodology and procedures which may be used to provide management advice (such as TACs) in years when full assessment is not performed 'and '.. identify stocks.. which may be subject to less frequent assessments while still providing adequate information for annual management advice.', the interpretation by the Study Group is that one should consider both advice in terms of proposed TACs valid for several years ahead, as well as other forms of multiyear advice.

Multiyear advice has long been seen as desirable by the fishing industry and by fishery management agencies. Under current assessment and fishery management practices, providing multiyear TAC advice, where TAC in each year is expected to track changes in stock size while keeping or bringing the stock within safe biological limits would require knowledge of actual catches in the coming years, relatively precise knowledge of incoming recruitment and future biological parameters. The candidate stocks, for which the accuracy in predictions perceived to be needed by the fishery management agencies can be achieved, will at best be very few.

Apart from this, the interpretation by the Study Group is that advice for a given year without doing assessment every year implies that advice based on the most recent assessment must be given for several years ahead, with or without yearly adjustments based on other procedures to evaluate the current state of the stock. Such advice cannot always be in terms of recommended TACs. Rather, the Study Group would point to situations where other kinds of advice may be more appropriate. A detailed outlining of such kinds of advice would be beyond the scope of this Study Group, but several occasions where this should be considered are pointed out in the report.

2 MULTI-ANNUAL ASSESSMENT PROCEDURES (MAP)

2.1 General

Essentially, what we are seeking is a mechanism whereby more robust advice is provided, in the sense that advice would be less sensitive to the availability and/or quality of particular data. At the same time this would respond to concerns of stability, consistency, credibility, and workload across the advisory system. Moving to a multi-annual scheme has implications in terms of frequency of assessment, time horizon of advice, methodological and logistical considerations, but all these are closely linked to the character or content of the advice that we intend to provide. One may ask whether tracking the ups and downs of stocks just at the boundaries of so-called safe biological limits is the best service science can provide to customers of advice and other interested parties.

So far, ICES advice in any year Y has mainly taken the form of (tables of) TAC recommendations for year Y+1 based on analyses of data up to year Y-1. Weaknesses in this process have become increasingly apparent. The intention is to track stock development closely, but the data and tools available cannot deliver this properly. VPA is adequate to estimate past states, but the current state on which TAC forecasts are based is the least precisely estimated, and subject to the largest revisions as assessments incorporate subsequent data; incoming year classes may make up a large share of the predicted catches (if not of SSB) but, for many stocks, their strength has to be assumed in the absence of supporting data; assumptions have also to be made about catches or fishing mortality in the interim year Y, and about the reference fishing mortality and exploitation pattern for the prediction years. In other words, there is an inescapable inability to estimate many of the prediction parameters accurately in real time and it should not come as a surprise that the values adopted for several of them are proved wrong in retrospect. Advice based on short-term forecasts is also recognised to be much too myopic, as the consequences of present decisions on future states and the price to pay in future catches are not shown explicitly; there has been some improvement in this regard with the introduction of medium-term projections but, with most methods in use, these remain dependent on the accuracy of initial stock size estimates.

ICES continues to confine itself in VPA-based approaches and proves unable to say anything useful about stocks which, for any reason, do not fit in that straightjacket. Also, ICES is unprepared to deal with direct effort management, and has provided little if any response to managers' needs in the process leading to capacity reductions.

In addition to adopting this character of advice, ICES has been willing to provide it annually partly because clients requested it, but also because it convinced them that it could. Although this has been doable for many years as ICES member countries were committing sufficient forces to support the system, we are now reaching a point where, due to staff and budget reductions imposed on most laboratories, the amount and quality of assessment work is getting harder to maintain. This is reflected in reduced expertise available in working groups, and in difficulties to maintain the basic data collection programmes (sampling, surveys, etc.) required to provide reliable foundations for advice. Currently, several institutes are entirely dependent on EC funds for the continued collection of essential data. Moreover, ACFM itself is getting overwhelmed by the number of stocks and fisheries it has to advise on each year. At present, both the quality control function and the provision of relevant advice are being compromised, and things may get worse as additional requests are expected for advice on ecosystems issues or integrated management. Recourse to more efficient, automated processes might expedite the review process, but improving the relevance of advice is not simply a matter of technology.

The adoption (even superficial) of the precautionary approach provides the opportunity to reconsider the character of advice. It calls for longer term views and clarifies the remit of scientists, which is to define limit reference points and to identify management options such that these limits have a small probability of being exceeded. Managers are left free to seek for specific objectives within the constraint of resource sustainability. Indeed, ACFM has anticipated such a move by stating, in the introductory section of its reports, that its overall objective is "to provide the advice necessary to maintain viable fisheries within sustainable ecosystems", and this cannot be simply equated with TAC advice and point estimates. It is thus consistent with the PA to deliver a type of advice which is less dependent on the occasional ups and downs in the fishery or vagaries in the latest VPA, and is more focused on medium-term risks. Managers may well be ready to accept such advice and work it into their decision-making scheme; the fact is that ACFM did not give them the chance to try a different product. In any case, it would be preferable to introduce such a change in a constructed way, rather than under the pressure of circumstances if and when means suddenly prove inadequate to provide the current type of advice.

Reducing the frequency of assessment updates seems to be one of the few possibilities available in the face of limited (or even shrinking) scientific resources. This does not imply ceasing to provide annual advice, however, unless management bodies explicitly ask for a different time frame. With a type of advice which is less sensitive to year-to-year changes, it means that the same bases would stand over the period between assessment updates, unless some significant change in the fishery requires otherwise. (In)consistency and (un)stability might become much less of a problem, and credibility might suffer less.

A possible scheme is to ask working groups to provide catch options for 2–3 year ahead if considered feasible, and to update assessments and forecasts when considered necessary. If released from the pressure of re-assessing anew all stocks each year, working groups might have a chance to deal with some of the major deficiencies in data which the current overload prevents addressing. More time and attention would be available for in-depth quality control on those stocks, for integrating more ecological or mixed fisheries considerations, and for exploring more fully the management implications notably in the face of uncertainties. Hopefully, integrating the typical uncertainties and variability associated with each stock/fishery in a risk analysis framework, and expressing the outcome of assessments in probabilistic terms may open the way for advice which is less likely to vary in substance from year to year. Operational methods to conduct risk analyses are being evaluated and will become part of the working groups' toolkit; however, interpreting the results will require careful consideration by the working groups.

Of course, some flexibility should be preserved such that the bases of advice for the "other" stocks in the rotation can be updated in case some influential parameter deviates significantly from the predicted or assumed course. For that purpose, reasonably standardised and validated methods should be made available to working groups, to avoid anarchy. Likewise, ACFM will need agreed procedures for updating its advice, and more so for incorporating new information (e.g., survey data) produced off line.

A potential risk associated with reduced frequency of assessments is that less pressure would be put on the institutes to work out the data and maintain the databases for the 'unassessed' stocks. Working group members should still be requested to assemble and validate the data each year, and include them in the report whether there is a full assessment or not.

2.2 Simplified Methodology and Procedures

This section addresses Term of Reference (a) ' investigate and propose simplified methodology and procedures which may be used to provide management advice (such as TACs) in years when a full assessment is not performed.' It is presupposed that such simplified methodology would be used in situations where:

1. There is a requirement to provide management advice, including a catch option table with options corresponding to $\mathbf{F}_{sq}$ and some defined F such as $\mathbf{F}_{pa}$ (among other options)

2. Some assessment, considered reliable, is available up to some time in the past.

3. Due to lack of some recent information (possibly catches, abundance indices or recruitment survey data) or other reasons, the assessment is not updated.

Although assessment methods exist which allow fitting population models with missing observations in the catch, catch at age or survey observations, there is concern that these may be unstable and may be overly sensitive to variability in the data. Therefore we briefly mention some simple methods which may be used in such situations and have been proposed in ICES CM 1984/Assess:19 and ICES CM 1986/Assess:10. A comprehensive review has not been attempted, but is proposed either for intersessional work or for referral to a methodological working group.

We note that simplicity is rarely achieved without cost. Missing information introduces uncertainty, which propagates forwards in time very rapidly in assessment models (e.g., forecasts). Applying simple, deterministic models in such situations can introduce a large risk of substantial error. The simplest way to reduce uncertainty in such cases will usually be to use all available information.

Two general approaches exist, based on either age-structured or biomass - based approximations for use where age-structured data are not available. A third alternative is to attempt to estimate catches which would maintain exploitation rates at historic values, using survey information but without using catch data.

Overall, there is a requirement to identify forecasting methods which can be used to provide advice which is robust and consistent with the most recent assessment, and which can also be used to identify probability statements. The performance of such methods will be expected to deteriorate as more years with missing information intervene in the analysis.

It may be considered undesirable to use different assessment models in different years, if provision of advice with consistent statistical properties is a consideration.

2.2.1 Biomass-dynamic based Procedures

Cases where no recent information on catches nor survey information is available

In cases where only a biomass-dynamic assessment model (e.g., 'ASPIC','CEDA', MRAG, 1992; 'BIODYN', Punt and Hilborn, 1996) has been fitted to some time period in the past and no recent data on either catch or surveys are available, it is inappropriate to attempt to calculate catch options. In some cases it may be appropriate to provide advice in the form of general statements such as:

*Catches greater than ***** t have historically resulted in fishing mortalities exceeding* $\boldsymbol{F_{pa}}$

*The last assessment of this stock, made in 19**, indicated a biomass below* $\boldsymbol{B_{pa}}$

*Effort has declined considerably since the last assessment of this stock, made in 19**...*

Cases where catch data are available but recent survey data are not

If recent data on catches are available and a historic biomass-based assessment is available, an updated estimate of stock size can be calculated by deterministic or stochastic forecasting from the most recent assessment. No explicit recruitment assumptions are necessary. This can provide a starting point for a catch option table, based on yield/biomass ratios rather than F. This method has been applied to Western Mackerel and has been found to provide estimates of stock size and catch forecasts closely similar to those obtained by VPA methods. Further testing of this approach, as applied to Western Mackerel, will be carried out using a management simulation procedure (WD Kolody and Patterson) intersessionally and reported on at the 1999 meeting of the WGMHSA.

In some cases a historic age-based assessment could be considered as a starting point for a biomass-dynamic model, although it would be preferable to formulate a model that uses age-structure directly where it is available.

Cases where survey data are available but catch data are not

In principle, deterministic forecasts of stock size using survey data are simple to calculate. Most often however, survey observations are sufficiently variable (CV > 0.6) that using such stock size estimates as inputs into catch option tables will not result in forecasts that are sufficiently robust to be used for management purposes. Hence, projections from some historic assessment cannot be used in such cases, unless some strong constraining assumptions (e.g., shrinkage or inverse-variance reweighting) can be made to stabilise catch forecasts. Where age-structures from surveys can be used these may contribute additional information which can be used to help stabilise the estimates.

Alternatively, it may be possible to make probabilistic statements about future catches in such cases, based on stochastic projection methods that explicitly recognise variability in survey data.

Cases where a recruitment survey is available

Partially age-structured models which use information both on biomass dynamics and on age-structure, where it is available have been developed in a number of areas. Delay-difference models (Schnute, 1985; Hilborn and Walters, 1992; Conser, 1998) use this approach.

2.2.2 Cases where a historic Age-structured Assessment exists

Cases where no recent information on catches nor survey information is available

Comments made in Section 2.2.1 apply here also.

Cases where catch data are available but survey data are not

If recent data on catches are available and a historic assessment is available, an updated estimate of stock size can be calculated by deterministic or stochastic forecasting from the most recent assessment.

An explicit recruitment assumption will be necessary. If no age-structure information is available about catches in the intervening years, an assumption about selection pattern will have to be made based on a stable period in the most recent assessment. Where age-structure information is available, then various alternative treatments are:

1. Treat the observations in the intermediate years as exact, and calculate population abundances and fishing mortalities according to the catch equation
2. 2. Use the observations to calculate population abundances deterministically, and then estimate a 'rescaled' fishing mortality on the assumption that fishing mortalities were generated with error around a historic exploitation pattern (ICES CM 1999/ACFM:6).

Cases where survey data are available but catch data are not

Attempting deterministic forecasts based on the assumption that survey data are observed without error is likely to result in highly variable forecasts and is not recommended. Models that treat survey data as observed with noise in such situations (e.g., constrained separable models, time series, etc.) have been used but do not fall in the category of simple methods.

Several age-structured models exist which allow population parameters to be estimated in cases where some years of catch information are unreliable or missing (refs. to COMFIE 1997) but these models rely on attempting to make trade-offs between structural constraints made to stabilise the estimates, and using new but unreliable information. They are not simple models and fall outside the scope of this text.

Cases where a recruitment survey is available

Conceptually, age-structured assessments can be updated using standard software (XSA, ICA) which allow for assessments to be calculated in cases where age-structured survey information in recent years may not be available at all ages. However, the stability of population estimates in such cases is not thoroughly understood. Alternatively, an 'RCT3' approach could be used to make robust yet conservative recruitment forecasts.

2.2.3 *'Status Quo'* methods

Some methods purport to provide catch forecasts which correspond to a recent level of exploitation without any explicit calculation of biomass or exploitation rate. Three such methods were proposed historically by the ICES Methods Working Group in 1984 and 1985. Although newer methods have been developed since (e.g., Horbowy, 1992), a description of these approaches may remain relevant.

These approximations were designed for use in situations where fishing mortality has been stationary, and a catch forecast is required based on information about historic catches and information on recent recruitment. The general approach is to reduce the population dynamics model to three components: increase in biomass due to growth, decreases in biomass due to mortality, and increase in biomass due to recruitment.

Delay-Difference Approach

ICES C.M. 1984/Assess:19 reviewed two methods (named 'DROP' and 'DOPE' therein) which are variants of a modelling approach which combines simple parameterisation of growth and recruitments, due to Deriso (1980). The approach was developed further by Schnute (1985) and became generally known as delay-difference models (q.v. Hilborn and Walters, 1992).

The 'DROP' formulation begins from Deriso's (1980) form, which relies on modelling change in exploitable biomass B from year y to year y+1 as a function of total mortality Z, incoming recruitment R, and a growth coefficient g:

$$B(y+1) = B(y)\,(1+g)\exp(-Z) - B(y-1)\,g\exp(-2Z) + R(y+1) \qquad (1)$$

This was reparameterised in terms of yield Y and yield/biomass ratio F (approx. equal to fishing mortality) by substituting $B(y) = Y(y)/F(y)$ (etc.)

$$Y(y+1) = Y(y)\,(1+g)\exp(-Z)\,F(y+1)/F(y)$$

$$- Y(y-1)\,g\exp(-2Z)\,F(y+1)/F(y-1) + R(y+1)\,F(y+1) \qquad (2)$$

If a catch forecast for year t+1 is required that corresponds to fishing mortality $F(y+1) = pF(y)$ then this simplifies to

$$Y(t+1) = p\,Y(t)\,(1+g)\exp(-Z) - p\,Y(t-1)\,F(t)/F(t-1)\,g\exp(-2Z) +$$

$$p\,R(t+1)\,F(t) \qquad (3)$$

One should expect that the growth parameter g can be estimated conventionally from catch-at-weight data. Short-term forecasts may be relatively insensitive to assumptions made about Z, but the method requires an estimate of F(y). ICES C.M. 1984/Assess:19 suggest that estimates of F could be derived from a reparameterisation of the above in the form of a linear regression with observed recruitment index as an independent variable,

$$R\text{ hat }(y) = Y(y) - Y(y-1)\,(1+g)\exp(-Z) + Y(y-2)\,g\exp(-2Z) + e \qquad (4)$$

but such an approach appears unlikely to be productive except in cases where a very precise recruitment index is available.

A further simplification is to assume F is stationary over the time-series. Under this assumption one approach suggested was to estimate F(t), g.exp(-2Z) and (1+g) exp(-Z) as coefficients in a multiple linear regression of: Y(t+1) on Y(t), Y(t-1), R(t+1). Clearly the error-structure of this time-series model violates the assumptions of independence in a multiple regression. Use of modern spreadsheets would allow a nonlinear minimisation of such a model (possibly formulated using eqn. 2 as the structural model, defining F, g and Z as parameters and minimising an observation error on recruitment surveys) to be performed relatively simply. However, an attempt to apply the model during the Study Group meeting in this way to Southern Horse Mackerel resulted in markedly poorer prediction of catches than the use of a simple average catch.

The 'DOPE' method is similar in principle to the above, but includes in addition information on the catch in number by year, C(y), and also the von Bertalanffy asymptotic weight Wi:

$$Y(y+1) = PY(y)\,g\exp(-Z) + PC(y)\,(1-g)\,Wi\exp(-Z) + P\,F(y)\,R(y+1)$$

The estimation procedure tested by ICES (C.M.1984/Assess:19) was a multiple linear regression based on Y(t+1) as the dependent variable and Y(t), C(t), R(t+1) as independent variables. As above, modern software would allow this to be reformulated as a nonlinear time-series model relatively simply.

The 'SHOT' method may be considered a simplification of the above methods in which the F-*Status-quo* catch in the forthcoming year is predicted only from the catch in the previous year and a recruitment index.

Some investigation of the performance of this model family was examined by NRC (1998). Using a few case-studies designed to test robustness of assessment models to mis-specification, these models were found to be superior in their performance to models that used biomass alone, but less reliable than age-structured assessments.

2.2.4 Depletion Models (De Lury etc.)

Cases where total catch numbers and indices of total abundance in terms of numbers are available can be used with depletion models (e.g., used on some Deep Sea stocks). The method can either be used with an assumption of constant recruitment (which may not be unreasonable for long-lived stocks with recruitment low relative to population size) or with an additional index of recruitment (e.g., either from a recruitment survey, or constructed from numbers at the youngest age in the survey, or from a first mode/several length classes in a length frequency). An assumption about M needs to be made.

These methods provide estimates of population size in numbers, which can of course be converted to biomass using a mean weight, and estimates of catchability for each index (survey, and recruitment if used). Estimates of exploitation rate can also be determined. However, using this method with missing data is essentially similar to those discussed in the two previous sections.

2.2.5 Conclusions

1. So-called 'short cut' methods are not necessarily simple. Assessment or forecasting methods that rely on estimating few parameters make correspondingly stronger structural assumptions and there is a greater risk that the assumptions shall be violated and strong biases in catch forecasts introduced thereby. Additionally, methods that rely on treating the most recent survey observation as precise may introduce unacceptable variability in catch forecasts unless some constraining assumption is applied. Choice of such a constraining assumption is not obvious. Hence, although the 'status quo' methods are attractive in concept they are not necessarily robust.

2. The costs and benefits of applying the 'short cut' methods should be evaluated, preferably inside management procedure simulation experiments (see Section 3.1).

3. The choice of appropriate methods is likely to be highly case-specific. In particular, different variability of surveys and different proportions of yield made up of recruiting year-classes will strongly affect the choice of the most appropriate model.

4. It was considered undesirable in principle to use different models in forecasts; alternating between complex age-structured stock projections and simpler forecast methods in different years was deemed unappealing.

5. Due to the hidden complexities and potential pitfalls of the simpler forecasting methods, and the requirement for extensive testing to address these issues, attempts to introduce such models are likely to increase rather than decrease the workload on assessment working groups, at least in the short term.

2.3 Model Uncertainty and the Multi-Annual Approach

Uncertainty in estimates of population parameters in stock assessments arises from several sources (see review by Francis and Shotton, 1998). Variability of observations around a chosen structural model can be quantified in a number of ways and the resulting uncertainty in population trajectories can be provided to managers as stochastic medium-term projections. However, uncertainty as to the most appropriate model to use (model formulation, structural constraints, parameter constraints etc.) is also a real uncertainty, and this latter component is difficult to quantify. Arguably, most major difficulties in fisheries forecasting and advice (e.g., Peruvian anchoveta, Northern cod, Arctic cod) have resulted from model uncertainty and not from stochastic observation error.

In the current ICES advisory framework, model uncertainty is not recognised. Advice is given on an annual basis based on a single assessment structural model, even though other models which may be almost equally credible could lead to very different catch forecasts (e.g., Hiis Hauge, 1998). Inevitably in such a framework, revisions of choice of appropriate model structure can cause large revisions in perceptions of stock size, which result in damage to the credibility of the advisory process.

There are three principal approaches which could be used to reduce the sensitivity of advice to model uncertainty. The first would be design and implement a formal management procedure in which management responses to new information are agreed in advance by all the interested parties, and the rules for interpreting the new information are also agreed. Such procedures can be designed to be robust to a range of alternative models, and so increase the robustness of advice to model uncertainty. This approach requires the prior agreement of the interested parties, which may take some time to achieve where there are many users of a resource with competing objectives. Alternatively, one may seek to ensure a more rigorous examination of alternative models by more extensive peer-review of assessments, and in the case that a change in model perception becomes required, a formal mechanism for a smooth transition in the form of advice should be sought. A third and less obvious alternative is that ICES advice could be recast in a form which is less model-sensitive (e.g., changes in catch forecasts reformulated as a constrained response to new survey data without an intermediate assessment). This approach is difficult to test because the management response to such advice is not pre-determined. At present, the relative benefits of the three approaches have not been evaluated, and are likely to be highly case-specific.

Estimation of current stock size and calculation of associated catch options under an explicit recognition of model uncertainty is not a trivial task (e.g., Patterson, 1998). Under other institutional frameworks than the ICES system, advisory procedures have been devised which are intended to be robust to model uncertainty (e.g., Punt 1998). Under these systems, TACs are set according to predefined harvest rules which translate new survey data into changes in TACs in a pre-agreed fashion. These systems were designed in part to reduce the workload of the annual stock management process.

Such systems, however, require the agreement of interested parties in the long term. Where such agreements could be reached, a way forward may exist for the design and implementation of multi-annual assessment procedures.

In many other cases, the approach is not feasible. However, a requirement may exist to attempt to restrict model error and model variability as far as possible. Solutions to this difficulty are not obvious without introducing major increases in working group workloads. Faced with a requirement to provide advice based on the most credible stock assessment, it is a legitimate activity of working groups to revise model structure moderately often in the light of new information. However, one should expect that under good Working Group assessment practice, assessment models shall not be changed unless a clear improvement in performance can be demonstrated, or a strong violation of the assumptions of the existing model can be shown. In practice it is not clear that such is usually the case, and large variations in advice can result from relatively minor alterations in assessment model assumptions.

If substantive changes in an assessment model is contemplated (e.g., changes in age-range for catchability constraint in XSA, shrinkage weighting, separability constraints, etc), the Study Group commends the following procedures:

1. The assessment should not be altered unless there are clear, documented and strong grounds for doing so, either in terms of improved performance or in terms of statistical acceptability.

2. If an alteration is proposed, the assessment and forecasts calculated on the previous assumptions should be provided to ACFM in the Working Group's report, together with the new assessment and corresponding forecast and detailed exposition of the basis for the change.

3. ACFM will review the technical basis for the change and may:

   - decide to accept the new assessment,- use the old assessment for advisory purposes,
   - consider both assessments in providing advice
   - appoint an external review body to investigate the problematic issue further.

This approach should afford ICES an improved stability in its advice while not compromising the quality of the science.

3 PERFORMANCE EVALUATION OF MAP

3.1 General Considerations of Performance Evaluation

The Study Group considered that where new methods or procedures associated with MAPs are introduced, tests of their behaviour should be conducted. Testing should, ideally, be done before implementation, but in some cases testing will have to be done in parallel with implementation (e.g., when missing data forces a Working Group to follow an alternative approach).

Simulation testing is important for at least three reasons. First, it helps quantify effects of different procedures. Second, it helps to identify potential problems which may not be anticipated a priori. Third, it provides an objective way of choosing between different procedures or methods, and therefore provides a framework for agreeing on an approach. For example, if a 'Status Quo' method (Section 2.2.3) were to be used instead of age-based stock projections for formulating advice in terms of TACs, then it would be important to know whether the two methods would behave in similar or very different ways. It would be important to know whether the two methods have similar or different associated probabilities of leading the stock outside safe biological limits.

Although ad hoc tests could be devised to compare procedures, a more appropriate way would be to do Monte Carlo simulation testing within the framework of management procedure evaluation (see below). These types of simulations are aimed at evaluating the performance of the combination of the stock assessment, formulation of advice (which may involve stock projections), as well as other factors that impact on the stock.

Testing can be approached in two ways: generic tests or stock-specific tests. Although generic tests are potentially useful, they should be carefully designed to incorporate relevant parameter ranges so that inferences are likely to be valid. Stock-specific tests will tend to be less extensive, with the focus on parameter-ranges for that stock only.

3.1.1 Model Framework

Many management procedure evaluation studies have been done in a wide range of contexts and, based on these, guidelines and pitfalls have been identified (see e.g., papers in Payne, In Press).

It is useful to consider the following framework when constructing simulation models for evaluating management procedures:

Operating model (describes the true stock dynamics)
Observation model (describes the data collection procedure)
Assessment model (e.g., XSA, ICA etc.)
Harvest Control (how TACs or effort levels are calculated, recommended)
Harvest Decision (the actual agreed TAC or effort level)
Implementation (the actual removals from the stock, which may not equal the agreed TAC).

It is clearly a rather daunting task to model all these components fully, and some (e.g., the process of agreeing TACs) may be very difficult or impossible to model mechanistically. Simplifications are therefore often required, though potential shortcomings of such simplifications need to be borne in mind. There is a large body of literature that can be consulted in this regard (Payne (In Press) and references therein).

It is important to incorporate the assessment procedure that will be used, and to quantify (as well as possible) the uncertainties involved (e.g., parameters describing assessment error, such as error variance, autocorrelation and bias). There is also scope for incorporating model uncertainty into the simulation process. Work on the issue of dealing with uncertainty, and formulating advice under uncertainty is currently underway at many institutes, and coordinated in an EU Concerted Action program.

3.1.2 Performance Measures

It is standard procedure to identify a suite of performance measures, or relevant indicators, which can be used to compare the performance of different management procedures or scenarios (e.g., a comparison of annual assessments versus assessments every X years). Here it is important not only to consider measures of the location of distributions (e.g., mean, median of catches over a 20-year period, say), but also indicators of spread (e.g., variance, inter-quartile range), and possibly shape. Some obvious indicators are mean and variance of catch, mean and variance of interannual difference in catch. In the context of the precautionary approach, probability statements, such as $P(SSB< \mathbf{B}_{pa})$ or $P(F> \mathbf{F}_{pa})$ are clearly also relevant.

Performance measures based on distributions of quantities such as catch or SSB does not always reflect the full picture, however, and some consideration of the time series of these quantities are also useful (e.g., for revealing cycles, trends etc.).

3.1.3 Harvest Control and Harvest Decision

The relative benefits and consequences of changing from an annual to a multiannual assessment procedure can only be properly evaluated when the harvest control and harvest decision components can be adequately specified. Adequate specification of these components and the appropriate choice of performance parameters are difficult where there are no clear management objectives. In such cases, the management response to advice (in terms of eventual changes in the exploitation of the stock) may need to be inferred either from past performance or from agreed management procedures.

3.2 Methodology and Tests

3.2.1 Simple State Space Models applied to Catches of North Sea Cod

Nicholson and O'Brien (WD 5) examined agreed total allowable catches (TACs) as a time series, using simple state space models. These models comprised a stochastically evolving mean TAC, which could be extended to incorporate a trend, or to exploit additional information about fish stocks, such as that from surveys. During the meeting the models were fitted to the landings data for the North Sea cod, Skagerrak and area 7d (WGNSSK report, ICES CM 1999/ACFM:8).

The following figures show a simple random walk fitted to the catches. The first figure spans the years 1963 to 1997, the second figure is restricted to the years 1984–1997 for which there are also data from the English Ground Fish Survey (GFS). In both cases, the random walk component is significant.

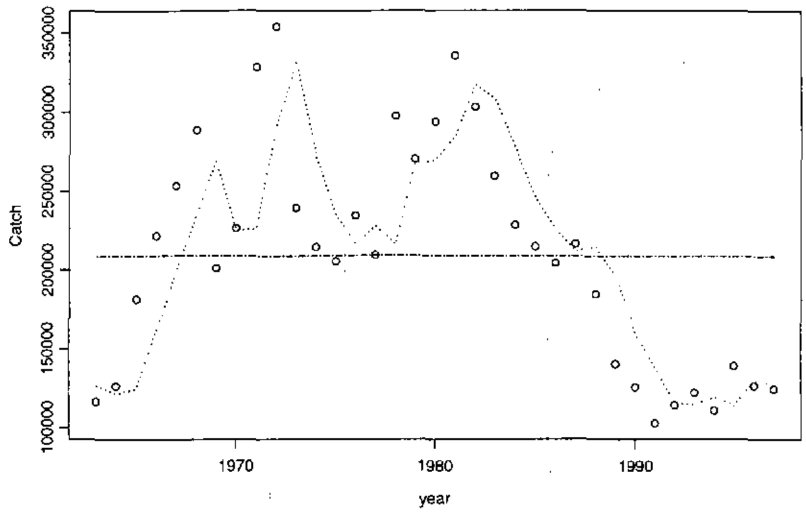


Figure 3.2.1 The time series of North sea cod catches with estimates predicted from a simple mean and a random walk model (1963 – 1997).

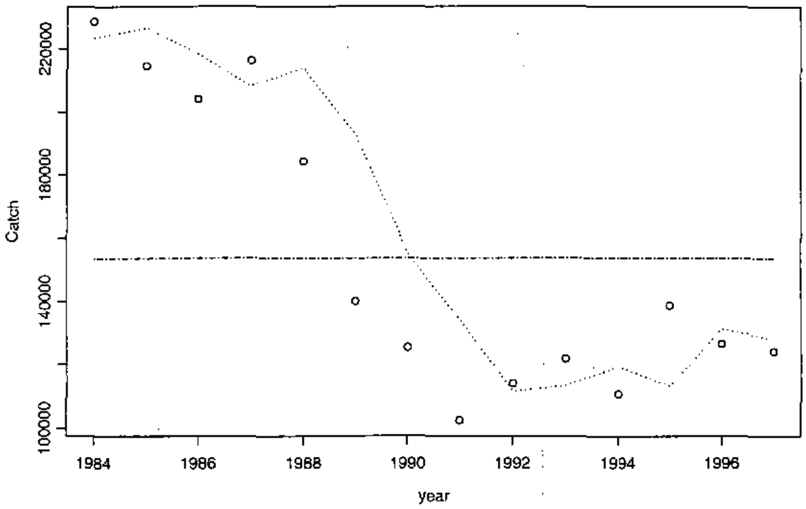


Figure 3.2.2 The time series of North sea cod catches with estimates predicted from a simple mean and a random walk model (1984 – 1997).

The following table compares the fits obtained by incorporating a linear model of the weight of *mature* and *immature* cod observed in the English GFS for the data from 1984–1997:

Model		-2logLikelihood	Number of parameters
$C_y = \mu_y + \varepsilon_y$	μ_y = constant	313	2
$C_y = \mu_y + \varepsilon_y$	$\mu_y = \mu_{y-1} + \delta_y$	294	3
$C_y = \mu_y + \beta_1 x_{mat} + \beta_2 x_{imm} + \varepsilon_y$	$\mu_y = \mu_{y-1} + \delta_y$	280	5

From the differences in the -2logLikelihoods, the *mature* and *immature* categories generate a significant improvement.

The estimated parameters for the model including x_{mat} and x_{imm} are $\hat{\sigma}_1 = 6020, \hat{\sigma}_2 = 10500$, $\hat{\mu}_0 = 137500, \hat{\beta}_1 = 9173$ and $\hat{\beta}_2 = 4443$. Figure 3.3.3 shows the fitted model.

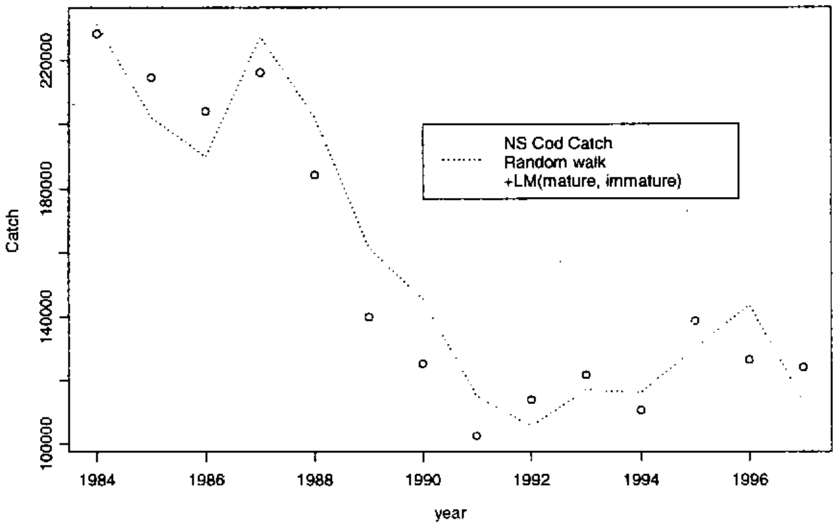


Figure 3.2.3 The time series of North sea cod catches with estimates predicted from a model including a random walk and the GFS survey data as a linear component.

The following table gives the annual catches together with the fitted values, the contributions of the random walk (μ_y) and the linear model (LM) components to these estimates.

Year	Catch (000's)	Fitted = $\hat{\mu}_y$ + LM	$\hat{\mu}_y$	LM
1984	228	231	135	94
1985	215	202	145	67
1986	204	190	156	45
1987	216	227	147	71
1988	184	202	133	55
1989	140	161	116	28
1990	125	146	100	29
1991	102	115	90	15
1992	114	106	97	16
1993	122	117	100	20
1994	111	116	96	16
1995	139	130	103	34
1996	126	144	89	41
1997	124	113	97	24

Although simple, the model does provide a crude insight into the development of catches. The table of fitted values for the model with both a linear model of GFS covariates and a random walk shows how the fitted values are generated partly by scientific information, and partly by some stochastic component, presumably outside the control of scientific information - at least that contained in the GFS data.

The model could be useful for predicting catches for intermediate years when multi-annual assessments are made, assuming that that the procedure for generating the catches would have remained the same. The simplicity of the model is reflected in the grouping of the survey data into two intuitive management-oriented categories (mature and immature). A few broad categories allow ease of interpretation, and also keeps the number of potential covariates small. This is important with data for only 14 years, as here.

3.2.2 Evaluation of likely Implications of MAP for Catch and Stock Biomass Dynamics

The aim of this working document (Basson 1999, WD 2) was to explore the likely effects of multi-annual assessment procedures (MAPs) on spawning stock biomass and catch dynamics. A relatively simple simulation model with deterministic projections, as currently used for short term projections at ICES working group meetings, but with a range of additional options relevant to MAPs was used. Examples of options were: the frequency of assessments (e.g., annual, every 2nd, 3rd year etc.) and whether a harvest control rule is implemented when SSB falls below $\mathbf{B}_{pa}$. In the context of the precautionary approach, it would be inappropriate to use deterministic projections in actual MAP's. It is, however, often informative to use simple models to explore the basic dynamics under a range of different scenarios.

As an example stock, and for illustrative purposes only, anglerfish in Div. VII & VIII was chosen.

A simulation model was constructed in which the assessment component does not perform an actual assessment, but samples directly from the numbers-at-age in the true population. This is a potential weakness, and in the ideal situation the actual assessment procedure which would be used in practice, should be built into the simulation.

Simulation tests were designed to consider the interactions between assessment frequency and (i) assessment error, (ii) TACs updated or fixed, (iii) harvest control rule implementation, (iv) non-adherence to recommended TAC and (v) stock-recruitment assumptions on catch and biomass dynamics.

The variance and autocorrelation of assessment errors used in the example was chosen arbitrarily and was low (sd = 0.14 on the first age class, ac = 0.1). It is difficult to estimate the characteristics of assessment error since we never know the true stock size. Some of the simulation results may be quite different if the assessment is highly uncertain and/or if the assessment is biased.

Two options for setting multi-annual TACs were considered: constant TACs for a period of *y* years, and TACs initially set for *y* years but updated (or recalculated) in non-assessment years. In the latter case, updating simply involved using actual catch at age in projections rather than projected catch at age.

This WD looked at two options for harvest control: (a) constant F, irrespective of whether SSB is above or below $\mathbf{B}_{pa}$, and (b) harvest control where F is reduced when SSB is, or is predicted to fall below $\mathbf{B}_{pa}$.

The simulation also contains a component which models the fact that the agreed TAC is not always equivalent to the recommended TAC. This is potentially important, particularly when there are large differences between ACFM recommended and agreed TACs, for whatever reasons. A preliminary analysis of recommended versus agreed TACs, for 20 stocks on which ICES advise, indicated that agreed TACs were generally somewhat above the recommended values, and there appeared to be limits to the percentage interannual changes managers were prepared to make. In general, larger percentage increases were tolerated than percentage decreases.

To illustrate the effects of different stock-recruit model assumptions, a Ricker and a double-linear model were used.

Results for the example stock (with chosen parameters) show that means of the distributions of, for example, SSB, catch and year-to-year changes in catch are not sensitive to different assessment frequencies, but the shape of the distributions are sensitive to assessment frequency. It is unsurprising that the distributions have longer tails when assessments are not done annually. In terms of year-to-year changes in catch, most changes are smaller when TACs are fixed for longer periods of time (even if TACs are also updated with observed catches), but a few changes (associated with years when the stock is assessed) are much larger than in the case where assessments are done annually.

3.2.3 Modelling Multiannual Management of Mackerel

A working document was presented reporting on the development of a simulation framework for evaluating the consequences of various multi-annual management procedures under different assessment scenarios and different scenarios of underlying stock population dynamics (Kolody and Patterson, 1999, WD 4). In an example of the application of this approach, Monte Carlo simulations of NE Atlantic mackerel population dynamics were initiated to compare performance of annual and triennial assessments over a 20 year period. The underlying operating model was initiated in two ways: 1) the age-specific fishing mortality and numbers at age were set equal to the recent ICA assessment (ICES CM 1999/ACFM:6), or 2) population states and age-specific fishing mortality were randomly drawn from the variance-covariance matrix from this assessment. Population trajectories were calculated with stochastic recruitment variability, while observations of catch and spawning stock biomass were generated with errors consistent with ICA assumptions. The annual TAC (corresponding to a fixed harvest control policy (F = 0.17)) for each fishery was set with either annual ICA assessments or triennial ICA assessments coupled with deterministic population projections during intermediate years. Preliminary results indicate that triennial assessments perform essentially the same as annual assessments if the initial conditions are known perfectly, P(F> $\mathbf{F}_{lim}$ = 0.26)< 0.01 (i.e., probability of limit exceeded at least once over a 20 year period). The admission of uncertainty in the initial state of the model (which is considered more appropriate) results in a much higher frequency of limit violations, with triennial assessments somewhat more risky (P(F> $\mathbf{F}_{lim}$) = 0.52) than annual assessments (P(F> $\mathbf{F}_{lim}$) = 0.35) (Figure 3.2.3.1). In all cases, the total yield was similar (< 3% difference) across scenarios, while the mean change in TAC between consecutive years was substantially lower in the triennial assessment case (Table 3.2.3.1). A range of additional scenarios for more comprehensive testing were proposed for intersessional work.

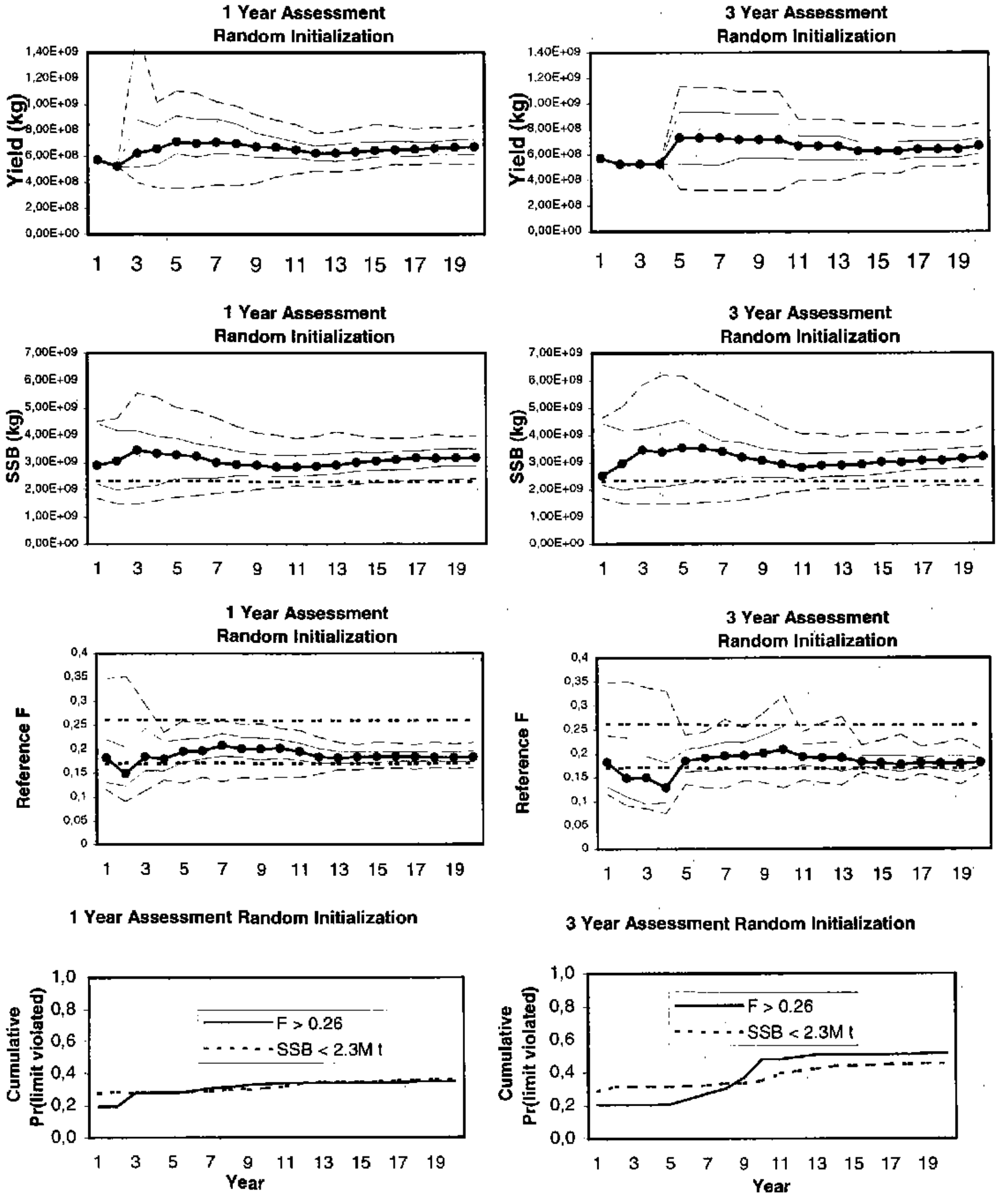
Preliminary conclusions from this work are that, despite concerns about model instability, some improvement in the performance of the assessment procedure (in terms of avoiding limit reference points) can be obtained by calculating assessments every year rather than every three years. Further explorations are needed to evaluate the robustness with which this conclusion can be drawn, and will be reported to the Mackerel, horse mackerel, sardine and anchovy Working Group at its 1999 meeting.

Table 3.2.3.1. Summary diagnostics of NE Atlantic mackerel fishery simulations comparing annual and triennial ICA assessment regimes combined with a fixed fishing mortality policy (target F = 0.17) over a 20 year period, repeated 200 times.

Assessment Scenario	**Mean *Yield* (*t*)**	**Mean *ΔYield* (*t*)**	**P($SSB < SSB_{lim}$) X 100%**	**P($F > F_{lim}$) X 100%**
Annual, Fixed Initialization	648 000	36 700	**0	**0.5
Triennial, Fixed initialization	645 000	26 200	**0	**1.0
Annual, Random Initialization	663 000	68 800	*27 **36.5	*20 **35.0
Triennial, Random initialization	649 000	43 300	*28 **45.5	*21 **51.5

* probability of limit violation in the first year only

** probability of at least one limit violation during the entire 20 year simulation



(A) (B)

Figure 3.2.3.1. NE Atlantic Mackerel fishery simulation diagnostics from (A) annual and (B) triennial ICA assessments and a fixed fishing mortality policy of F=0.17, initialized with random draws of numbers at age and F at age. 5, 25, 50, 75 and 95th percentiles of 200 simulations are indicated in the upper six panels, along with reference points.

3.2.4 Predictability of Assessments in a Separable Model

Skagen (1999, WD 7) considers the discrepancies between a stock projection with known catches (i.e., essentially a forwards VPA) and the ICA assessment with the same catches (i.e., estimating parameters in a separable model for fishing mortalities using egg survey SSB as supporting information). The example stock was NEA mackerel.

The projection will depend on the assumed stock numbers in the initial year and the subsequent recruitments. The ICA assessment with triannual SSB-estimates as the only supporting data, be sensitive to noise in the catch data as well as to deviations from the model assumptions. The assessment for the NEA mackerel in particular is known to be very sensitive to the weight given to the SSB-estimates from the egg surveys relative to the weight given to the catch data.

Comparisons were made for the years 1993–1997, with each of them taken as the last assessment year. For each of these examples, the stock was projected forwards with the actual catches, but with a fixed assumed recruitment of $4000*10^6$. The results shown in Figure 3.2.4.1 for the SSB show that both projections starting in different years and the assessments themselves may diverge quite strongly. The 1995 egg survey led to a shift in the estimated time course of the SSB. The projections initiated in from assessments including the 1995 survey tended to diverge more than those before. These results will be sensitive to the relative weighting of the egg surveys.

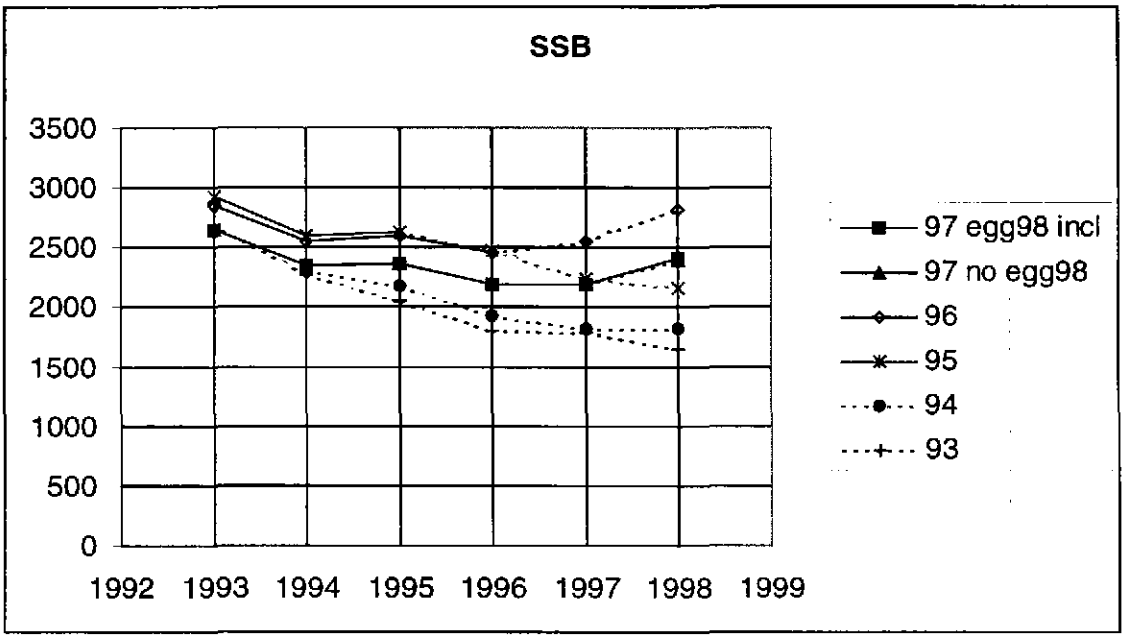


Figure 3.2.4.1 SSB estimates for NEA mackerel obtained by running ICA until the year indicated, and then projecting the stock forwards in time. Broken lines indicate the projection periods.

3.2.5 Existing Variability in Assessments

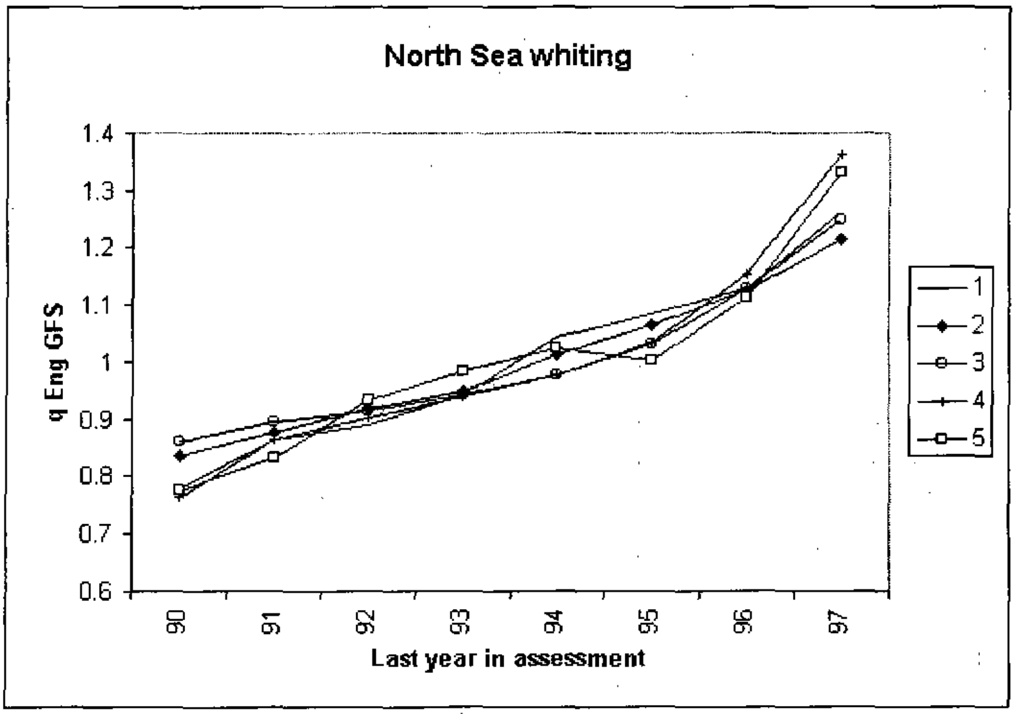
There is a perception that it has been necessary to change the settings of XSA from one assessment to the other in order to maintain consistency in the perception of the changes in stock size, and that the process of changing the parameters consumes a large portion of the Working Group meetings. The sensitivity of XSA assessments was investigated by doing retrospective analyses for North Sea cod, plaice, and whiting, and also for Faroe haddock, using the default values for XSA. Either the Total Biomass (North Sea cod, North Sea plaice, Faroe haddock) or the SSB (North Sea whiting), depending on which one correlated best with landings, were used to calculate the ratios in subsequent assessments (1991/1990 is the 1990 biomass from the 1991 assessment divided by the 1990 biomass in the previous assessment) in the following table.

Year	Faroe Haddock Total B	North Sea cod Tot B	North Sea plaice Tot B	North Sea Whiting SSB
1991/1990		0.870		
1992/1991		0.855		0.874
1993/1992		0.901		
1994/1993		1.024	0.907	0.848
1995/1994	0.899	1.044	0.878	1.074
1996/1995	1.326	0.978	0.970	0.856
1997/1996	1.481	0.933	1.067	0.890
Avg F_{93-97}	0.26	0.76	0.44	0.63

Except for Faroe haddock, these results suggest reasonably small changes in the perception of stock size from one year to the next when consistently using the same XSA settings. The larger changes observed for Faroe haddock could be related to the lower fishing mortality apparently exerted on that stock.

SG participants who are regular members in assessment working groups noted that standard procedures and XSA settings have been adopted for most of the 'mature' assessments, and that conducting the assessment and the projections is not the main time-consuming activities at the WG meetings. Responding to special ACFM requests, such as those related to defining safe biological limits and estimating limit and pa reference points, the sheer number of stocks to review in some WGs, are main time consumers. The absence of well documented, integrated, and easy to use software combined with inadequate support from the ICES Secretariat on the availability and usage of existing software also results in considerable wastage of energy.

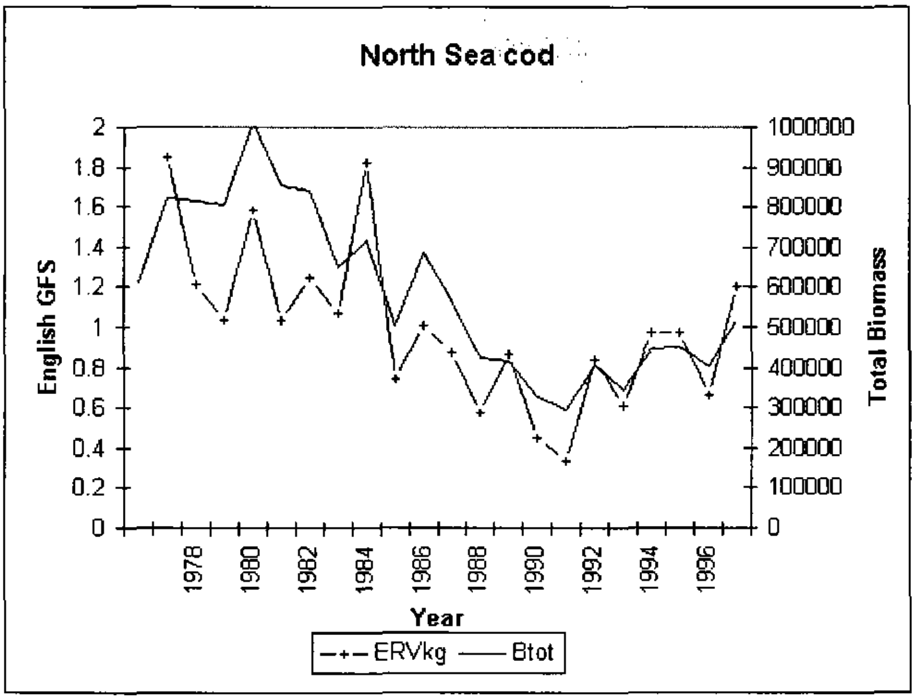
If the stability in subsequent assessments seen above is due to stability in catchability estimates, it might not be necessary to refit XSA each year. Instead the catchability estimates from a given assessment could be used to calculate stock size based only on the indices. Software does not presently exist to do that, but it should be relatively straightforward to implement a simplified procedure to provide stock forecast based on given catchability estimates and stock size indices. Catchability estimated in each of the retrospective analyses described above, have been plotted to estimate their stability. The result for North Sea whiting suggest that estimated catchability has changed for several of the stock size indices as indicated below for the English Groundfish Survey. It would therefore not appear wise to pursue this approach further.



Stock production Models

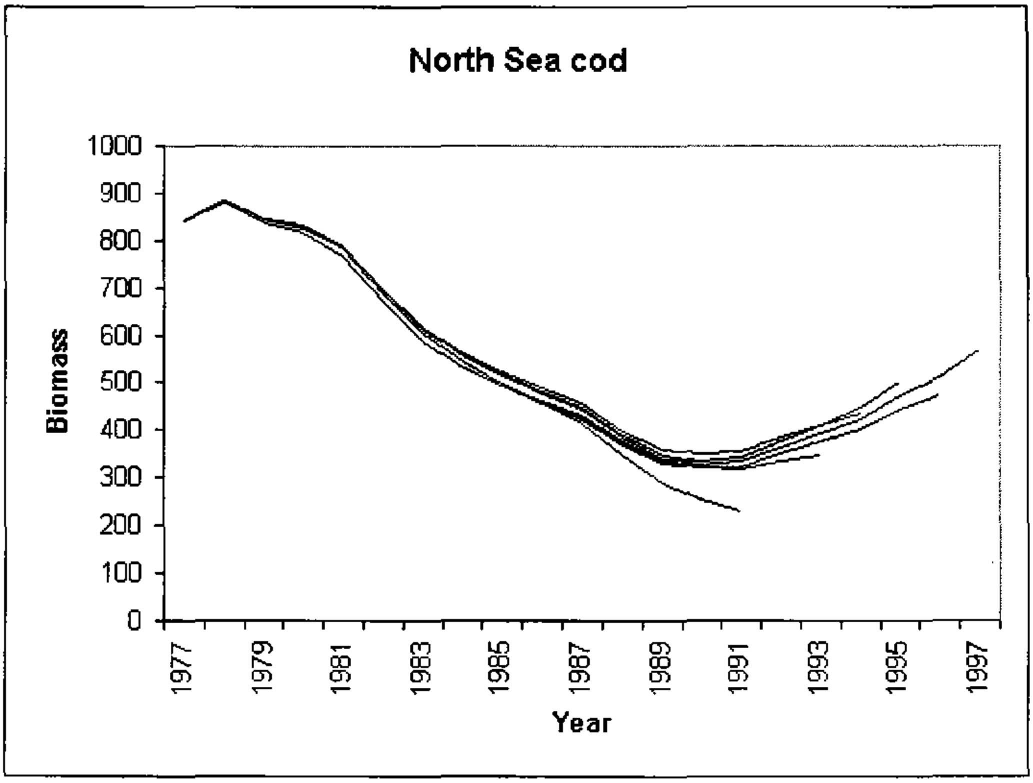
General production models (Schaefer 1954; Fox 1970; Pella and Tomlinson 1969) require only catch data and either a fishing effort index or an index of stock size. Given their relative simplicity, they are often perceived as potentially more stable than VPA as tools to provide advice. Production models can be fitted using equilibrium or dynamic methods. Punt and Hilborn (1996) strongly recommend against using equilibrium and effort-averaging methods.

A bulk biomass index of stock size for North Sea cod was derived by multiplying the English Groundfish Survey indices at age by mass at age and summing over ages. This index is reasonably well correlated with the total biomass estimate from the most recent assessment (r = 0.78). The two series are plotted versus time in the graph below.



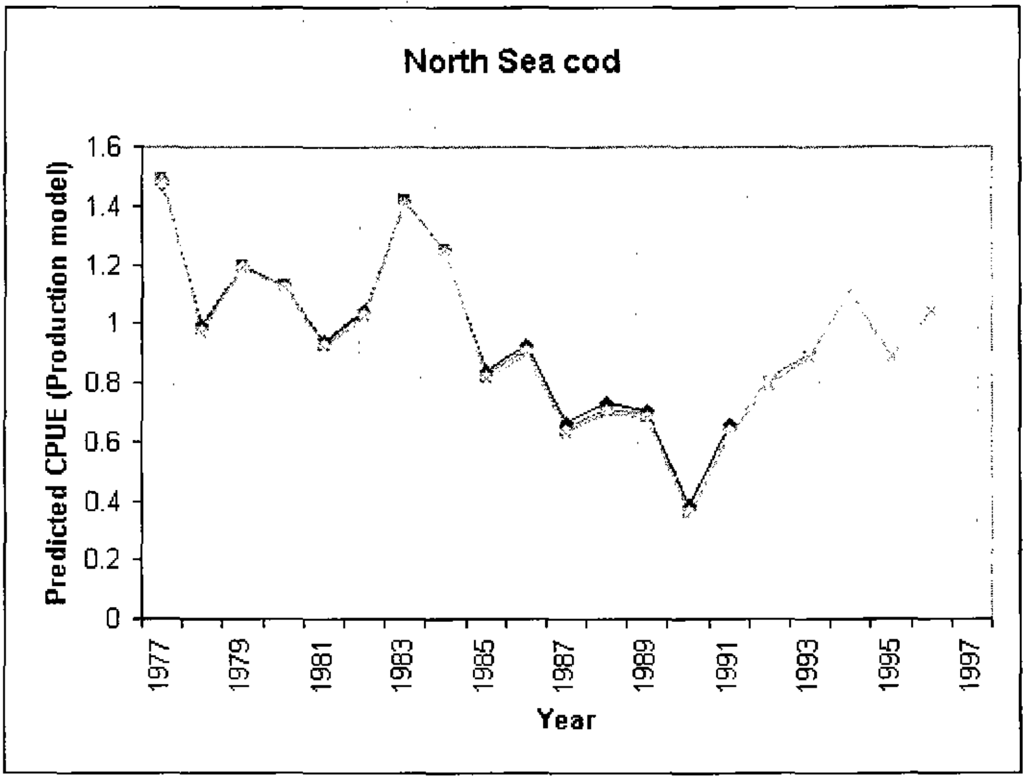
Dynamic methods can be fitted assuming either observation errors or process errors. When fitting dynamic models, Hilborn and Walters (1992) warn against attempting to estimate too many parameters from the data, and they recommend using as much extraneous information as possible.

Following their advice, we can use the 1977 total biomass estimate (840.457 tonnes) from the most recent assessment as the initial biomass when assuming observation error and q need not be estimated as it can be derived analytically by averaging and exponentiating the ratio of the (ln) CPUE/Biomass. A retrospective analysis was conducted whereby the OBSWO.XLS spreadsheet prepared by Punt and Hilborn (1996) was modified for North Sea cod and used to fit an observation error general production model using progressively fewer years. Solver is used to find the minimum Sum of Square Residuals. The resulting biomass trends are presented in the graph below:



In each case, the fitting was initialised by assuming an intrinsic growth rate (r) = 0.50 and a carrying capacity (K) = 2.3 million tonnes. Minimisation were constrained to K = 3 million tonnes. The constraint was hit in the first four trials, 1977–1991 to 1977–1994. Additional constraints were that 0.10 $\leq r \leq 0.99$ and K $\geq$ BI, the initial biomass. The estimated r was relatively stable between r = 0.42 and r = 0.47. The graph shows that observation error general production model would have provided a reasonable basis for the provision of TAC advice, based on only one stock size index. Biomass dynamic models have been used to provide advice on both species of southern anglerfish (ICES C.M. 1999/ACFM:6) where age data is unreliable. Modelling trials for North Sea sprat and Western mackerel by the relevant WG suggested that biomass dynamics may be useful for these species. However, fitting observation error general production model, even using a reasonably well-behaved index of stock size, and estimating only a few parameters is not straightforward.

Similarly, the PROCESS.XLS spreadsheet of Punt and Hilborn (1996) was modified to fit a process-error general production model to North Sea cod using progressively fewer years. Because the exploitation rate is relatively high, and because the index of stock size is for the second half of the year, the average of the predicted CPUE estimates for consecutive years were averaged to compare with the observed ones. The same initial values and constraints were used as for the observation error method, but in addition, initially q had to be constrained to be higher than 0.0001. The constraint was hit in every case, and instead of trying to estimate q, it was assumed that q was equal to 0.002, approximately equal to the average of the stock size index divided by the XSA biomass estimate. The estimated biomass trends are shown in the graph below:

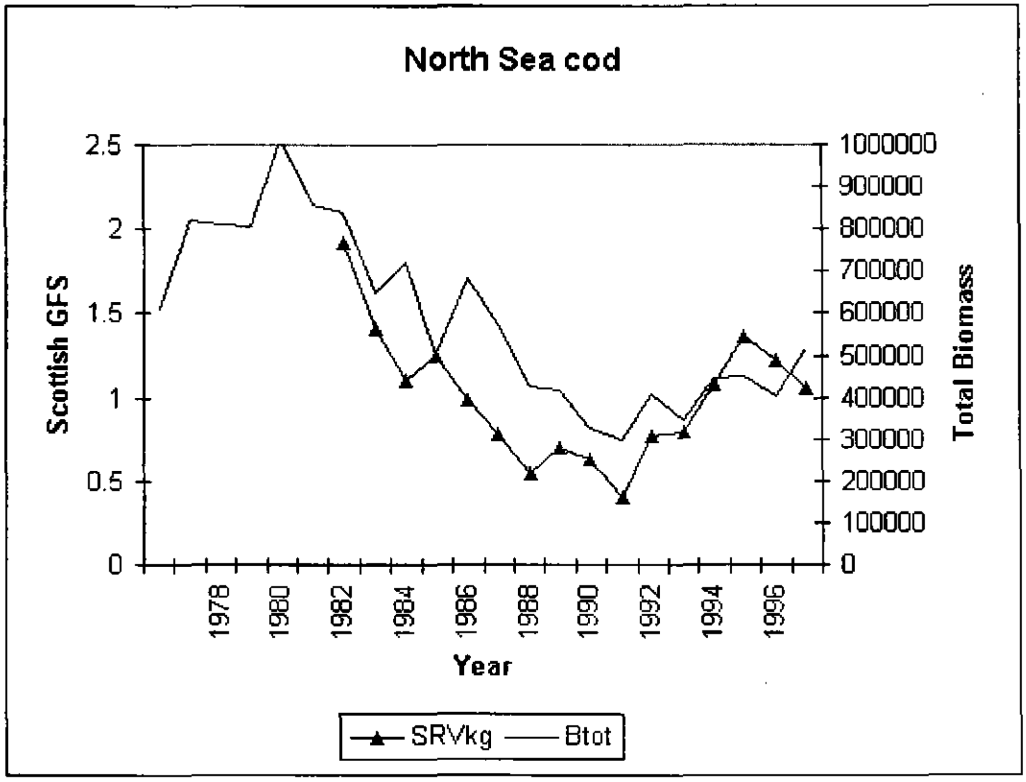


When observation error is assumed, the biomasses are estimated sequentially, and the predicted CPUE is calculated by multiplying the predicted biomass by q. When process error is assumed, the yearly biomasses are estimated by dividing yearly observed CPUE by q, and therefore the fit between observed CPUE and predicted CPUE is very good. Punt and Hilborn (page 20) state "However, Butterworth and Andrew (1987a) and Polacheck *et. al.* (1993) found that assessments based on process-error assumptions have higher variance and are much more sensitive to the selection of an error structure than assessments based on observation-error assumptions." Although no retrospective pattern are observable, great confidence in the abundance index would be required in order to use a process-error general production model. Similar to observation-error assumption, we can conclude that fitting process error general production model, even using a reasonably well-behaved index of stock size, and estimating only a few parameters is not straightforward.

Relative changes

The fitting of process-error general production models essentially results in the predicted CPUE tracking very closely the observed CPUE and the only advantage in fitting a model to such data is that parameters such as MSY and fMSY (if it can be interpreted meaningfully) can be derived. Otherwise, if an index of stock size is considered to reliably estimate future relative changes in stock size, it could be used to advise changes in catches without the mediation of model fitting.

A bulk biomass index was derived from the Scottish Groundfish Survey as was done for the English Groundfish Survey. The Scottish Groundfish biomass index in year y is well correlated with the total biomass estimate from the most recent assessment two years hence (r = 0.82) and the two series are plotted versus time in the graph below.



Although not obvious from the graph above, the variability of an index of stock sizes derived from research surveys would be expected to be more variable than the real variability in the stock. Therefore, a damper would be required in order to avoid reacting to minor changes due to the variability in the estimated changes rather than to real changes in stock size. The approach could be modified to induce changes in exploitation rates either up or down, if those were deemed warranted. This is essentially the approach used for South African anchovy (Butterworth and Bergh 1993).

If a set of meaningful indices of relative change in stock size are available, these could be used in a similar fashion, but unequal weighting of the series may be deemed necessary, with associated problems. To quote a prominent SG and WG member "sometimes it makes life easier to have only one index of stock size".

3.2.6 Error Propagation in stock Forecasts

Errors in catch predictions based on the current ICES procedure of projecting population estimates at age forward in time were investigated using "exact" population abundance and fishing mortality at age. The propagation of errors was examined by the introduction a stepwise increase in the number of assumptions used by the prediction model. Preliminary results are presented in Figure 3.2.6.1 and Table 3.2.6.1, the summary statistics are given in terms of the relative difference between the "exact" and projected catches taken in each year of the 32 year time series. The base line run would therefore have a mean of 1.0 with s.d. 0.0. and would use the exact fishing mortalities, population numbers and weights at age. The numbers and fishing mortalities are based on the North Sea cod assessment results. In each run these were replaced by the following assumptions:

1. The exact fishing mortality at age was replaced by an average of the three previous years, scaled by the ratio of the means over a range of ages, to the exact mortalities in the year of prediction (one year ahead).
2. Simulation 1 with the use of the average weight at age from the previous three years.
3. Simulation 2 with the replacement of the exact recruiting population in each year by a geometric mean of the three previous years' exact recruitment numbers.
4. Simulation 2 with the replacement of the exact population numbers at age by the exact population numbers at age "brought forward" from the previous year using the average fishing mortalities. Recruitment was taken as the exact population number for the age in the year of prediction.
5. Simulation 4 with the replacement of the exact recruitment by a geometric mean of the previous three years.

6. Simulation 5 with the populations being brought forward by two years and the population at the second age also taken as a three year geometric mean of the populations at the recruiting age brought forward by the average fishing mortality.

This preliminary study indicates that, even without the introduction of errors in the population numbers resulting from the use of a population assessment model, the catches at age can only be predicted with a c.v. of around 10% in the first year and 20% in the second year of a prediction. Although the magnitude of the errors will be stock specific, depending on the variability and trends in fishing mortality, stock weights and recruitment, the analysis raises serious concerns as to the precision of the deterministic catch option tables prepared by ICES working groups. The "exact" catch for an "exact" fishing mortality is a commonly propagated mis-perception of the accuracy of the assessment and prediction process.

The stochastic nature of the assessment and prediction process must be accounted for in any catch option tables presented to managers for the decision making process. Errors in fishery parameters derived from the retrospective assessment and propagated through prediction models should be presented in a clear format. One way in which this could be achieved is for ICES advice to be presented as the risk to the stock, in terms of the probability of F and SSB going above or below reference levels, if a specified catch is taken in the next few years. The table would provide the advice required, in terms of catches, but would reflect the uncertainty in the assessment and forecasting process.

Tables of this form have been proposed previously for stocks where the current state is considered to be uncertain, an example being the Western horse mackerel stochastic forecast table (ICES 1998 WGMHSA) the relevant table from which is reproduced in Table 3.2.6.2. A major advantage of this approach to ACFM is that it would allow decisions to be made as to whether small changes in the assessment estimates derived after the addition of a new years' data, have a significant impact on the robustness of the advice given in previous years.

Table 3.2.6.1 Summary statistics for the prediction scenarios

Scenario	1	2	3	4	5	6
mean	0.98	0.99	0.99	0.99	0.99	0.99
sd	0.08	0.09	0.11	0.09	0.11	0.18
cv	0.08	0.09	0.11	0.09	0.11	0.18
median	0.97	1.01	1.01	0.99	1.00	0.98
med/mean	0.99	1.02	1.03	1.00	1.01	0.99

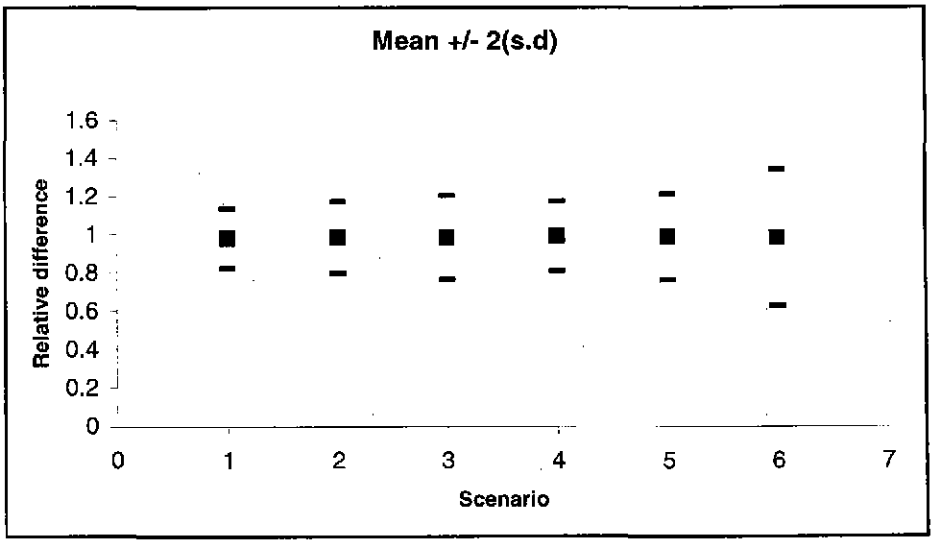


Figure 3.2.6.1 The mean relative difference with confidence intervals given by mean +/- two standard deviations between the predicted and exact catches taken within a 32 year simulation analysis of the catch prediction process.

Table 3.2.6.2. Western Horse Mackerel. Catch option table, calculated as expactation and percentiles of Bayes posterior distributions. (a) SSB, catch and F/M in 1998; (b) SSB in 1999 for F = M or catch = 50–400Kt in 1999 (c) SSB in 2000, for F = M or catch 50 to 400Kt in 1999 and 2000; (d) catch corresponding to F = M; (e) F/M in 1999; F/M in 2000. (Taken from ICES 1998).

(a)		**1998**			Estimated Risk in 1998	
	Expected		Percentiles			
		25 %	50 %	75 %	P(SSB<500,000t)	P(SSB<SSB(1983))
SSB (Thousand t)	1032	728	972	1251		
Catch (Thousand t)	400	*no uncertainty admitted*			0,06	0,46
F(4-14,w)/M	5,49	3,88	5,07	6,52		

(b)		**SSB in 1999 (Kt)**			Estimated Risk in 1999	
Catch (Thousand t)	Expected		Percentiles			
		25 %	50 %	75 %	P(SSB<500,000t)	P(SSB<SSB(1983))
Catch for F=M	940	620	877	1169	0,00	0,00
50	945	618	885	1174	0,14	0,55
100	927	601	867	1155	0,16	0,57
200	889	563	831	1118	0,19	0,60
300	849	521	791	1080	0,23	0,64
400	807	477	749	1040	0,27	0,68

(c)		**SSB in 2000 (Kt)**			Estimated Risk in 2000	
Catch (Thousand t)	Expected		Percentiles			
		25 %	50 %	75 %	P(SSB<500,000t)	P(SSB<SSB(1983))
Catch for F=M	1015	672	951	1262	0,00	0,00
50 Kt in 1999 and 2000	1032	671	967	1297	0,11	0,47
100 Kt in 1999 and 2000	972	612	905	1235	0,16	0,53
200 Kt in 1999 and 2000	849	489	781	1112	0,26	0,63
300 Kt in 1999 and 2000	727	365	660	986	0,36	0,74
400 Kt in 1999 and 2000	611	239	530	856	0,47	0,83

(d)		**Catch for F=M**		
Catch (Thousand t)	Expected		Percentiles	
		25 %	50 %	75 %
1999	66	48	61	79
2000	69	52	65	82

(e) Fishing Mortality Relative to Natural Mortality in 1999, for catch options in 1999 = 50 to 400 000t and catch in 1998=400 000t				
Catch in 1999 (Thous. t)	Expected		Percentiles	
		25 %	50 %	75 %
50	0,75	0,50	0,67	0,89
100	1,54	1,01	1,37	1,83
200	3,33	2,10	2,88	3,92
300	5,39	3,29	4,55	6,41
400	7,67	4,60	6,47	9,34

(f) Fishing Mortality Relative to Natural Mortality in 2000, for catch options in 1999 -2000 = 50 to 400 000t and catch in 1998=400 000t				
Catch in 1999 and 2000	Expected		Percentiles	
(Thousand t)		25 %	50 %	75 %
50	0,69	0,47	0,62	0,82
100	1,52	0,98	1,32	1,79
200	3,85	2,21	3,10	4,40
300	7,21	3,79	5,52	8,71
400	10,70	5,87	9,12	14,92

4 CRITERIA FOR MAP

4.1 Introduction

The motives for considering multiyear advice in general, and the background for the considerations by this Study Group in particular, are outlined in Section 1.3. These includes both the need for the industry and management for background information for planning beyond the next year, the need for ICES to rationalise its work, and concerns that single year TAC recommendations may not always be the most appropriate precautionary advice. The less information there is about the state of the stock, the greater is the risk that a change in the state will only be discovered at a very late stage. In such cases, advice other than recommending annual TAC's may be worth considering.

In most cases where MAPs could be considered, the advice should not necessarily be in the form of recommended TAC's for the next 3 years, but rather in the form of precautionary guidelines for the exploitation for some years ahead.

4.2 Factors to be considered before adopting a MAP

The introduction of MAPs must be considered on an individual stock basis, taking the characteristic dynamics of the stock and fisheries exploiting it into account. In any case, the development of the stock will have to be monitored, and one will have to be prepared to change the policy on short notice if there is strong evidence that the development of the stock is not as assumed when the advice was given. The need for frequent updating depends both on the consistency of the assessment and on the dynamics of the stock. The list below includes some important criteria that should guide the choice.

Criteria relating to stock dynamics

1. As a general point, a short-lived species would need more frequent monitoring. This is also, and even more so, the case when the short life span is induced by a high fishing mortality. The advice should either be to implement a real time management, as is done for e.g., Icelandic capelin, or by some more long term strategic type of advice.

2. Shoaling pelagic species fished with active searching methods are at high risk of declining SSB and increasing F, and will require more frequent monitoring.

3. Stocks where there are reasons to suspect a regime shift in biological parameters (natural mortality, maturation and growth) pose special problems. Some of these changes are notoriously difficult to identify, but they may have a severe impact on the production capacity of the stock and may call for rapid revisions of the advice. (ref. COMFIE 1999).

4. For stocks where very large year classes appear occasionally, the management regime may have to be different according to whether a large year class is present or not. The management may need to be more restrictive as a large year class is disappearing. Western horse mackerel may be one example where the harvesting strategy should change as the dominating 1982 year class disappears. On the other hand, if the size of a large year class is well characterised, a long term strategy may be devised for the harvesting of this year class. Such strategies are to some extent implemented for Norwegian spring spawning herring.

5. For stocks with large year to year variations in the recruitment, the time frame for the advice will to a large extent depend on the availability of indicators of year class strength. The problems encountered in one years predictions if a large proportion of the catch in the prediction period consists of year classes which have to be assumed with little or no supporting evidence, will be exaggerated by implementing a MAP.

Criteria relating to the fishery

6. If the exploitation rate is high, so that the catch is to a large extent driven by the recruitment, delays in recognising a decline in stock abundance may rapidly lead to a severe depletion of the stock.

7. More frequent adjustments will be needed if trends in the exploitation rate are suspected: a common case would be if a new fleet starts to take part in a previously stable fishery, or if there are new developments in fishing technology.

8. Shifts in the exploitation pattern, e.g., by change in regulations or in market conditions or in the behaviour of the fishery for other reasons, may call for revision of the advice.

Criteria relating to assessments

9. Stocks where the assessment recently is known to have been problematic or misleading, or where the biological data are being revised, are not good candidates for MAP's at present.

10. The best case for MAP's are the stocks where the information available is such that the assessment and predictions are robust to the applied methodology. This relates less to the abundance of data than to the value of the information in terms of signal to noise ratio, contrast and consistency between sources of information.

11. When evaluating the feasibility of MAP's, the added value of new information is important to consider. In particular, if the yearly update will mainly transfer noise into the forecast, advice on a larger time frame and in another form would be more appropriate.

Criteria relating to decisions

12. When considering MAP's, one should take into account the extent to which the assessments effectively influence the final management decisions.

4.3 Categories of stocks for which MAP may be considered

The following is an attempt to classify stock types into categories, each of which imply different points that should be considered when discussing the introduction of multiannual assessment procedures.

Tables 4.3.1 and 4.3.2 give an overview of some key numbers, representing some of the points raised in Section 4.2, that should be considered as indicators of the feasibility of MAP for the stocks covered by the Southern Shelf WG and the Mackerel, Horse mackerel, Sardine and Anchovy WG. For each stock, an attempt has been made to refer it to the category above in the cases where MAP's could be considered. However, this should be considered further by the respective Working Groups. For some stocks, MAP's are clearly not appropriate at the moment, and the reasons are indicated briefly in the tables.

1. Stocks where the information available is such that the assessment and predictions are robust to the applied methodology, the stock is relatively stable and the exploitation rate is modest, are the most likely candidates for considering a time frame beyond one year for advice in terms of TAC proposals. The consistency from year to year of assessments and the correspondence between assessment and predictions should be examined by simulations and retrospective analysis as outlined in Section 3. Depending on how strict the criteria to be applied are, the range of stocks that should belong to this category may be quite limited. The introduction of MAP's for such stocks will hardly save work for ICES, but should serve to provide the industry and managers with more useful advice. These bodies should be aware that the price to pay may be a more cautious advice, since the additional uncertainty caused by the longer time frame for projections may lead to lower advised TAC's under the precautionary approach.

2. Stocks where only a limited amount of information is added in most of the years. A typical example is the NEA mackerel, where the only data supplied every year are new catch at age data, except in every 3rd year, when there is a new SSB estimate from an egg survey. The possibility that the assessment could be substituted by an annual forward projection in which the actual catches are taken into account, should be investigated.

3. Stocks which are borderline with respect to signal/noise ratio in assessment data, or the validity of the assessment is questionable for other reasons, as discussed in Section 4.2. In some situations, the value of new stock assessment calculations may be small because the information content of new data is low with respect to the management decision-taking. In some cases, stocks may be candidates for MAPs if they have stable underlying dynamics (e.g., demersal stocks fished at low fishing mortalities with stable effort) such that new assessment calculations provide relatively little new information. In other cases, assessment variability may be dominated by noisy survey information, such that short-term management responses to frequent new assessments would be inappropriate. Rather, these assessments should be used as a guideline to give a precautionary advise which takes the uncertainty as to the production capacity of the stock into account and as a way of monitoring the development of the stock, perhaps together with other methods.

4. Stocks where the annual assessment is of minor importance to the final management decisions. However, there may be other reasons for doing regular assessments. These reasons may be diverse.

5. Very long lived species, where the exploitation is modest and there is no reason to expect major changes in the state of the stock from one year to the next. Examples may be the different redfish (*Sebastes* spp.) stocks. Apart from juveniles discarded in e.g., the shrimp fisheries little fishing is exerted on these species until they are 10 years old thus giving plenty of time to forecast the recruitment to the fishery. Age at 50% maturity is about age 12–15 for most of them, and in the North-Atlantic they may reach an age of more than 50 years. Late recruitment to the fishery should reduce the need of annual assessments and new advice every year. Similarly, if managed and harvested reasonably then the SSB of these stocks consists of a large number of age groups or year classes. Hence it should not be critical for such stocks if one or two year classes turn out to be weak. It is, however, essential that such stocks are monitored by surveys in order to keep track of recruitment and biomass changes as they occur in order to give the managers an early warning. Similarly, it is also important to gather the information needed to evaluate the productivity of these slow growing stocks.

6. The Study Group in addition would like to draw the attention to 'New' stocks where exploitation has started recently. These are considered in some more detail in Section 4.4.

Table 4.3.1.SSDSWG Working Group stocks

Stock	TAC area	Assess. Method	range	Recruitment		Fbar		M	Fbar/Fpa	%catch Tr+2 (***)	Categ.	State (in/out)^{0}	Possible candidate for MAP (comments)
				age	sd	age range	(95-97)						
Sole7e	VIIe	XSA	69-97	1	0.43	3-7	0.33	0.10	1.27	4	1	out	yes, recruitment somewhat variable with small influence on predicted landings
Plaice7e	VIId,e	XSA	76-97	1	0.57	3-7	0.68	0.12	1.51	16	1	out	yes, recruitment has small influence on predicted landings
Sole7fg	VIIf,g	XSA	71-97	1	0.30	4-8	0.48	0.10	1.30	5	1	out	yes, recruitment somewhat variable with small influence on predicted landings
Plaice7fg	VIIf,g	XSA	77-97	1	0.51	3-6	0.70	0.12	1.17	13		out	no, because of influence of the model selection on F
Cod7ek	VII(-a),VIII	XSA	72-97	1	0.81	2-5	0.83	0.20	1.22	27		out	no, high variability in recruitment estimates and high influence on predicted catches
Whiting7ek	VII(-a)	XSA	82-97	1	0.53	2-5	0.59	0.20	Fpa n/p	58		in	no, high variability in recruitment estimates and high influence on predicted catches
Hake-north	4 areas (*)	XSA	78-97	0	0.18	2-6	0.27	0.20	1.35	4	3,4	out	yes, considering the stability of last assessments
Pisc-north	VII / VIIIa-e $^{(1)}$	XSA	86-97	0	0.39	3-7	0.25	0.15	1.04	2		in	no, assessment stability not reached yet. Difficulties in ageing.
Bude-north	VII / VIIIa-e $^{(1)}$	XSA	86-97	1	0.28	4-8	0.19	0.15	1.73	1		in	no, assessment stability not reached yet. Difficulties in ageing.
Whiff-north	VII / VIIIa-e	XSA	84-97	1	0.18	3-6	0.32	0.20	1.07	8	3,4	in	yes, relatively stable assessment, low F though short time series
Sole -biscay	VIIIa,b	XSA	84-97	1	0.11	2-6	0.45	0.10	1.13	10	1	out	yes, R and SSB quite stable
Hake-south	VIIIc+IXa	XSA	82-97	0	0.32	2-5	0.37	0.20	1.85	4?		out	no, assessment stability not reached yet. New biological and fisheries data revision in course.
Pisc-south	VIIIc+IXa $^{(2)}$	ASPIC	86-97	-	-	-	2.0 (**)	0.15	2.0 (**)	'-		out	no, assessment stability not reached yet. New biological and fisheries data revision in course.
Bude-south	VIIIc+IXa $^{(2)}$	ASPIC	86-97	-	-	-	1.5 (**)	0.15	1.5 (**)	'-		out	no, assessment stability not reached yet. New biological and fisheries data revision in course.
Whiff-south	VIIIc+IXa $^{(3)}$	XSA	86-97	1	1.05	2-4	0.25	0.20	Fpa n/p	17	4	out	yes, small contribution to the combined megrim landings and high variability in recruitment estimates
Bos-south	VIIIc+IXa $^{(3)}$	XSA	86-97	1	0.49	2-4	0.33	0.20	1.65	11	4	out	yes, relatively stable assessment though short time series

(^{0}) - Inside/Outside safe biological limits
(*) - IIIa; IV; VI+VII, VIIIa,b,d,e
(1,2,3) - combined species TAC's
(**) - F_{97}/F_{MSY}
(***) - according to predictions based on the last year in the assessment
n/p - not proposed

Table 4.3.2 Overview of some key numbers that should be considered as indicators of the feasibility of MAP for the stocks covered by MHMSA WG

Working Group:
MHMSA

Stock	TAC area	Assessment Method	years range	R age	lnR (sd)	F last year age range	Fbar (95-97)	Fbar/Fpa	M	F projections	%catch Tr+2	ACFM (in/out)*	Categories number**	Candidate for MAP (comments)
NEA Mackerel	NEA	ICA(1)	84-96	0	0.28	4-8	0.265	1.51	0.15	0.22	10	out	2	?
Western Horse Mack.	V,VI,VII, VIIIab	Bayesian ADAPT	82-97	0	0.73 (2)	5-14	0.21(6)	(5)	0.05-0.12 (7)	F=M	?	out	3	?
Southern Horse Mack.	VIIIc, IXa	XSA	85-97	0	0.44	1-11	0.18	1.06	0.15	0.17	16	in	1, 4?	?
North Sea H. Mackerel	NS, IIa	none	87-97										3	?
Sardine VIIIc+IXa	VIIIc, IXa	ICA	77-97	0	0.56	2-5	0.52	(5)	0.33	0.50 (3)	18	out	none	NO
Anchovy VIIIabc	VIII	ICA	87-97	0	0.64	1-3	0.82	0.82 - 0.68	1.2	0.81	10	in	none	NO
Anchovy IX	IX	none	88-97 (4)	0		none							none	?

*) Inside/outside safe biological limits
**) See section 4.1

(1) 97F calculated without updating the assessment

(2) without the 82 yearclass

(3) F96

(4) Catch data from 1947-97, Catch-at-length 88-97

(5) Precautionary F reference points not proposed yet
For sardine ICES recommends that fishing mortality be reduced to F = 0.20

(6) Value for F/M * Expectation value for M in Bayesian posterior

(7) 5 - 95 percentile range in Bayesian posterior

4.4 New' stocks where Exploitation has started recently

Experience has shown that fisheries on "new" stocks can develop rapidly and that these resources may be especially vulnerable to overfishing. Many of the "new" stocks are assumed to be long lived, slow growing species with slow turnover, which call for a very cautious advice. Examples of such stocks are several deep-water species. There is often little specific information on the general biology of these species, in particular on age and growth, seasonal behaviour, migration, and stock discrimination. Those stocks that hardly have been exploited so far, provide an opportunity to obtain measures of e.g., natural mortality and of biological parameters in the virgin state, which will be difficult to get later on.

According to the FAO Code of Conduct for Responsible Fisheries, fishing should not be allowed to expand faster than the acquisition of information necessary to provide a basis for sustainable exploitation.

Yield-per-recruit has been used as basis for mesh-size regulations (e.g., the new Norwegian Lophius fishery in ICES Sub-areas II-IV). Precautionary reference points based on CPUE data may also be considered. Another alternative may be to set a very low preliminary TAC and agree on adjustment procedures based on CPUE data as the fishery goes on (a "roll over" TAC).

5 CONCLUSIONS

The Study Group indicated that its main objective was to investigate what methods, if any, could be used to provide a better quality advice at a lesser cost, whether all assessments need to be done every year, and if not, how to choose those that could be done at a lower frequency.

A brief review of methodological considerations indicated that there is not any obvious widely-applicable scope for improving assessment quality at lower cost. Some improvement may be achievable in some circumstances, but this requires careful case-specific testing.

Almost inevitably, reduction in assessment frequency would result in lesser provision of information to management, except in cases where the value of new information in assessments is low relative to the use to which the assessment is put.

The issue of change in frequency of assessment and advice cannot be disconnected from the question of the nature of the advice. As such, there is limited scope for change so long as advice is provided in the form of deterministic catch option tables. Advice should preferably take account of uncertainties in the assessment process and be expressed in terms of risks with respect to stock conservation. One should expect that such advice should be more robust.

Within such constraints, guidelines are provided by the Study Group on cases in which advice of acceptable quality may still be provided without necessarily recalculating all population parameters annually.

6 RECOMMENDATIONS

The SG recommends that the MAP concept should be further clarified by ACFM.

Any further development and evaluation of methods for MAP should be referred to the ICES Methods WG. The SG did not fulfil the TOR b «provide software for the assessment tools which are not currently available at the ICES Headquarters. Nor was it the position to evaluate the methods for a wide range of stocks. Both TOR b and this tasks should eventually be carried over to the ICES Methods WG.

The recent concentration of research into methods for estimating uncertainty in assessment parameters will lead to revised perception of robustness of estimates of the trends in stock dynamics. One priority area for this research should be the replacement of ICES deterministic management option tables with stochastic option tables giving the risk associated with the taking of future catch levels.

Changes in assessment frequencies should not imply decrease in present monitoring of the respective stocks. The WGs should be requested to update stock assessment data annually and include it in the WG report even if the stocks are not assessed with that frequency

Other WGs than WGSSDS and WGMHSA should have a look at criteria for applying MAP to their respective stocks.

ACFM should consider altering the phrasing of terms of reference to assessment working groups to admit the possibility that multiannual forecasts may be provided. An example phrasing might be:

1. provide catch forecasts for 2000 and for as many future years as considered feasible, and
2. update the catch forecasts as considered appropriate using new information as available...

The SG strongly sees the need to get easier access to all relevant assessment programs and related documentation particularly for software developed outside ICES. The SG recommends that the ICES Secretariat be given the responsibility to store the last updates/versions of software and related documentation. The secretariat should organise standardisation and secure quality control of the software used by WGs. This would also give the scientists, whether working in WG, SG or at their home laboratories, easier access to the software which should promote correct use and stimulate investigations related to stock vs. assessment procedures.

7 WORKING DOCUMENTS FOR SGMAP

Azevedo, M. 1999. Summary of assessments methodology and options for the southern anglerfish and hake stocks (WGSSDS). WD1

Basson, M. 1999. Evaluation of likely implications of multi-annual Assessment Procedures for catch and stock biomass dynamics. WD 2

Fariña, C. and Borges, M.F. 1999. Listing of the available data and current stock assessments methods of Div. VIIIc and IXa. WD 3

Kolody, D., and Patterson, K. 1999. NE Atlantic mackerel fishery simulations: A comparison between annual and triennial ICA assessment performance. WD 4

Nicholson, M. And O'Brien, C. 1999. Simple state space models for forcasting TACs of fish stocks. WD 5

Patterson, K. 1999. Historic review of model assumptions for stocks assessment by the mackerel, horse mackerel, sardine and anchovy working group. WD 6

Skagen, D. W. 1999. Predictability of assessments in a separable model. WD 7

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ANNEX 1

WD 1 Azevedo, M. 1999. Summary of assessments methodology and options for the southern anglerfish and hake stocks (WGSSDS). WD 1

WD 2 Fariña, C. and Borges,M.,F. 1999. Listing of the available data and current stock assessments methods of Divisions VIIIc and IXa. WD 3

WD 3 Patterson, K. 1999. Historic review of model assumptions for stocks assessment by the mackerel, horse mackerel, sardine and anchovy working group. WD 6

WORKING DOCUMENT NO. 1

WD for the Study Group on Multi-Annual Assessment Procedures (SGMAP). Vigo, 22-26 February I 999

Summary of assessments methodology and options for the southern anglerfish and hake stocks (WGSSDS)

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It is presented a brief summary of the assessments carried out since 1990 for the southern anglerfish, when these stocks were assessed for the first time and since 1992 for the southern hake stock.

Anglerfish Southern Stocks (ICES Div VIIIc+IXa)

1990

First stock assessment trial (1990 ICES WG meeting).

Length cohort analysis (Jones, 1984) applied to mean period 1986-1989. Biological parameters (length-weight relationship, growth parameters, length at maturity, natural mortality) lacking for southern stocks: adopted those of the northern stocks.

1991

Information on biological parameters not yet available: 1990 assessment not updated.

1992

First estimates of southern stocks growth parameters presented to the Assessment meeting based on indirect method (SLRCA).

Length cohort analysis (MSFL) applied by stock to 1986-1991 period and long-term yield projections carried out by stock and for stocks combined.

1993

Catch and fleet length composition converted to age matrix by applying "slicing", using new growth parameters obtained from age reading *(L. piscatorius)* or from SRLCA (L. *budegassa).* Same procedure applied to Spanish fleet data.

Trial runs of Separable-VPA were made on the estimated age compositions of total landings and using tuning data for 3 trawler fleets. Outputs showing, for both stocks, high standard errors and residuals of the estimated catchabilities and the various fleets giving conflicting indications on the level of F.

1994

Improvement on basic data carried out for both stocks, namely, the revision of landings length composition, effort data and new growth parameters estimates, based on age reading and larger samples.

This year the "Kimura-Chikuni" numerical conversion method was applied to annual (1986-1993) landings length composition: plus group set at age 10+. Iterated ALK's for each year also applied to annual length compositions of 3 fleets.

Separable-VPA, Laurec-Shepherd tuning runs and XSA performed by stock but with plus group set at age 9+. Catch forecast and yield per recruit also performed by stock.

Outputs indicated less severe problems but anyway assessment considered tentative.

1995

Landings and fleets length composition updated to 1994. Age conversion procedure as in 1994 ("Kimura-Chikuni"; same growth parameters) but the plus group set at age 9+.

XSA run performed. The outputs revealed high differences between previous year assessment, when plus group was equally set at 9+. Therefore, additional XSA runs, with the following plus group options were carried out: 8+, 7+. High variability in the XSA estimates was observed, whichever plus group option was considered, being concluded that the age conversion procedure was causing this noise.

A run using ICA was also performed, but even greater differences in the estimates were observed.

1996

Same problems as previous year.

1997

An alternative assessment methodology to XSA was used for these stocks by applying a new length-VPA analysis (Cadima and Palma, 1997).

Nevertheless, it was concluded that although the general methodology is good the method is still being refined, particularly in what concerns the optimisation of the iteration process, which in the case of southern anglerfish stocks has shown that local maxima may occur. There were also problems with regard to selecting a final **Et** on the basis of coefficient of determination, since estimates of biomass appear to be very sensitive to the choice of final E values. Therefore, the Working Group decided not to use the results for predictions.

1998

This year, a Surplus Production model Incorporating Covariates (ASPIC, Prager, 1994, 1995) was used to provide guidance on MSY and 0.1 reference points, as well as a perspective of the evolution of total biomass and prediction of landings under different fishing mortalities. Data used were total landings of the stock and total effort between 1986 and 1997, estimated from La Coruña CPUE and the catch of both species combined. In the analysis carried out, the option of admissible errors on fishing effort was used since it is considered that landings are known more precisely than effort. Bootstrapping for bias correction and construction of approximate non-parametric confidence intervals is also allowed in ASPIC. It was emphasized that the results presented are dependent on how well the relative changes in CPUE reflect the stock changes and that modifications to the analysis should be explored to improve input data such as the effort standardisation and incorporation of independent estimates of biomass.

For the first time ACFM accepted the assessments performed and used the results to propose new TAC'S.

Hake Southern Stock (ICES Div VIIIc+IXa) - WGSSDS

This item presents a brief summary of the assessments carried out since 1992, when this stock was assessed for the first time using XSA. Between 1989 and 1991, assessments changed from length cohort analysis (1989) to VPA (1990, when length compostion was converted to age for the first time by applying kimura and Chikuni) and to LaurecShepherd (1 99 1, tuned using 2 surveys and 2 trawl cpue series).

Since then numerical age conversion has always been used to convert length compositions to age compositions.

1992

XSA tuned using data from 5 commercial fleets and 2 surveys (Portuguese October and Spanish September). Plus group set at age 8. Final Options: Time series weight: power 3 over 20 years; catchability independent of stock size for all ages, catchability independent of age for ages ≥ 6. Shrinkage and s.e (0.3) taken as default. All of the different methods (L/S shrunk, L/S non-shrunk, XSA shrunk, XSA non-shrunk) showed consistent results. The stock was considered outside safe biological limits.

1993

Revised length composition data for landings during 1982-1992. Revised L-W relationship. New maturity ogive. XSA tuned with data from 5 commercial fleets and 3 surveys (Portuguese July and October and Spanish September). Plus group set at age 10 in order to avoid an accumulation of a large number of fish in the plus group. Different s.e of shrinkage were tried, indicating similar mean F trends. Final options: Time series weight: power 3 over 20 years; age 0 as recruits, q plateau at age 7, s.e=0.5 adopted. The different methods showed again consistent results and the stock was considered outside safe biological limits.

1994

Input data for 1991 revised for the spanish trawl and small gillnet fleets. No biological data update. Same tuning fleets initially used. High residuals observed for some fleets, exluded from the final run. Plus group set at age 8 and 10 (age 8 selected since the rectospective analysis provided a more consistent pattern, particularly in SSB). XSA with shrinkage 0.8 since seemed to provide a marginally more consistent pattern in the rectospective analysis. The stock was considered outside safe biological limits.

1995

First attempt to include discard data (mainly age 0 and 1) but decided not to use this data in viewing the small differences in mean F and SSB estimates and because including discard data in the time series caused discrepancies. Same biological parameters as

Previous year. High residuals observed for some fleets, excluded from the final run. Plus group set at age 8. XSA options equal to 1994. F estimates similar to those obtained in

1994, except for F in 1993, being revised downward (0.31 to 0.25). The stock was considered outside safe biological limits.

1996

Spanish length distributions and landings revised for the period 1982-1984 and Portuguese length distributions for 1983. Same biological parameters. XSA with same options except that ten years of tuning data were used with no time series weighting. Some discrepancies as to last year. Rectrospective bias again observed and again adopted shrinkage (s.e) of 0.8. Rectrospective tendency to overestimate terminal F. Recruitment estimates showing a different trend and the 1991-1993 recruitment estimates strongly revised upwards. An IMAL was determined.

1997

Basic data updated one year. Seven tuning fleets and same XSA options. The F values estimated in 1995 were slighly higher than those estimated in 1996, because of the addition of catch at age data for 1996 and tuning data. Nevertheless, recruitment estimates for 1993 appeared much smaller (40%) than in 1996 estimates. Pointed out once again that recruits (ages 0 and 1) are poorly represented in the age compositions, underestimating R from XSA and therefore affecting SSB-R relationship.

1998

Plus group kept at age 8 but different XSA options following ACFM recommendations to investigate lower shrinkage s.e and lower age at q plateau: shrinkage (s.e) of 1.0, mean logq model, q plateau at age 6, all years tuning data and no weighting. An overall increase in F and decrease in SSB was observed as well as a strongly revised upwards relative to the 1995 and 1996 year classes when compared to 1997 assessment (95 year class: 33 to 115 million fish and 96 year class: 83 to 122 million). The changes in the R estimates gave a different perception on the SSB-R relationship: MBAL couldn't be estimated.

Conclusions

Assessment stability not reached yet.

It should be taken into account that an LTE project is in course (Study Contract 97/015: "New Assessment and biology of the main commercial fish species: hake and anglerfishes of the Southern demersal stocks in the South Western Europe" DEMASSESS) which accounts for new biological data (maturity ogive, age-length keys,

....) as well as data base revision (effort standardization, ...) and new assessments in 2000.

WD 3

Working Document, ICES SGMAP, Vigo February 1999

LISTING OF THE AVAILABLE INPUT DATA AND CURRENT STOCK ASSESSMENTS METHODS OF DIV. VIIIc AND IXa, NEA Mackerel, NEA Blue whiting, and Northern Hake.

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STOCKS	EFFORT	CPUE FISHERY	SURVEYS *	RECRUITMENT	ASSESSMENT TYPE	TUNING
Blue Whiting	Yes	Yes	Acoustic, bottom trawl	Guess	XSA, ICA	Acoustic, CPUE, bottom trawl
Northern Hake	Yes (Partial)	Yes (Partial)	No	Guess	XSA	CPUE
Southern Hake	Yes	Yes	Bottom trawl	Survey	XSA	CPUE, Survey
Megrim, Div. VIIIc & IXa	Yes	Yes	Abundance indices by age	Survey	XSA	CPUE, Survey
Four spot Megrim, Div. VIIIc & IXa	Yes	Yes	Abundance indices by age	Survey	XSA	CPUE, Survey
Nephrops FU31-Cantabrian Sea	Yes (Partial)	Yes (Partial)	Bottom trawl*	No	LCA	No
Nephrops FU25-Galicia N	Yes	Yes	Bottom trawl*	No	LCA, VPA	CPUE
Nephrops FU26+27 GW+Portugal	Yes (Partial)	Yes (Partial)	Bottom trawl*	No	LCA	No
Nephrops FU30-Gulf of Cádiz	No	No	Bottom trawl*	No	No	No
Iberian Sardine	Yes	Yes	Acoustic	VPA/Acoustic (1 Year)	ICA	Acoustic, CPUE, Daily Pr. Method
Horse mackerel, Div. VIIIc & IXa	Yes	Yes	Bottom trawl*	Guess	XSA	CPUE, Survey, Egg SSB
Anchovy Subarea VIII	Yes	Yes	Acoustic (relative), Eggs	Survey (Eggs, Acous., Upw.)	ICA	Egg SSB, Acoustic, Upwelling
Anchovy Div. IXa	Yes	Yes	No	No	No	No
North East Atlantic Mackerel	Yes (**)	Yes (**)	Eggs	Guess	ICA	Egg SSB
L.piscatorius, VIIIc & IXa	Yes	Yes	Bottom trawl*	No	PROD (IFOX-ASPIC)	No
L.budegassa, VIIIc & IXa	Yes	Yes	Bottom trawl*	No	PROD (IFOX-ASPIC)	No

(*) Abundance Indices
(**) only Southern Area

WORKING DOCUMENT NO. 6

Historic Review of Model Assumptions for Stocks Assessment by the Mackerel, Horse Mackerel, Sardine and Anchovy Working Group

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Working Documentfor the Study Group on Multi-Annual Assessment Procedures. Vigo,

Spain, 22-26 February 1999

This document is prepared as background information to document how key stock assessment model assumptions have changed for stocks assessed by the Mackerel, Horse Mackerel, Sardine and Anchovy Working Group and its predecessors in the period 1985-1998. Revisions to data are not considered here.

Western mackerel assessments have been generally stable in pronciple. The main difference has been in the choice of whether, and how, to include recruitment estimates in in assessment calculation and in forecasts. Other alterations have been in the choice of treatment of separability, in terms of the choice of the terminal selection, and ofwhether selection isbest modelled in one or two periods. Some changes have been made to th year-range over which the egg surveys are fitted, and the age-range included in the age-structured assessments increased after 1983.

Southern horse mackerel assessments have been relatively very stable in model formulation, with some alteration mainly in the choice of tuning indices.

Western horse mackerel assessment have been highly problematic. For many years no formal assessment procedure was made, but in the last four years an ADAPT- based assessment calculation using firstly Monte Carlo and later a Bayes approach to incorporate perceived uncertainties has been used.

Sardine assessment model structure has beenr evised several times for a number of reasons. It was only stable in the period 1995-1997.

Age-structured anchovy assessments began in 1994 with an exploratory analysis. The model structure was unchanged from 1995-1997 but in 1998 a new weighting structure was adopted and an upwelling index of recruitment was included in the assessment.

1. Western Mackerel

There are three data sources : Recruitment surveys, catches at age, and egg survey estimates of biomass. The table below records the treatment of each of these by year from 1998 in reverse historical order.

Year of WG meeting	Recruitment Survey	Catches at Age	Egg Biomass Index
1998	Assessment not updated; validation checks made.		
1997	Not used	Two-Separable periods model, S(11,1)=1.2, S(11,2) = 1.2 w.r.t.S(5)	Absolute (log lsq fit to 1989-1985 surveys)
NB: Perceptions of stock structure were revised in 1996 and advice was based on an aggregated North East Atlantic Mackerel stock complex rather than individual stock units.			
1996	Not used	Two-Separable periods model, S(11,1)=1.0, S(11,2) = 1.2 w.r.t.S(5)	Absolute (log lsq fit to 1989-1985 surveys)
1995	Not used	Two-Separable periods model, S(11,1)=1.0, S(11,2) = 1.2 w.r.t. S(5)	Absolute (log lsq fit to 1989-1985 surveys)
1994	Not used	Separable-initiated VPA, S(11) = 1.2 wrt S(5)	Absolute (lsq fit to 1977-1992 surveys, by hand)
1993	RCT3 prediction	Separable-initiated VPA, S(11) = 1.0 wrt S(5)	Absolute (lsq fit to 1977-1992 surveys, by hand)
1992	Assessment not updated; validation checks made.		
1991	RCRTINX2 prediction	Separable-initiated VPA, S(11) = 1.0 wrt S(5)	Absolute (lsq fit to 1977-1989 surveys, by hand)
1990	Ad-hoc calculation (Dawson et al.)	Separable-initiated VPA, S(11) = 1.0 wrt S(5)	Absolute (lsq fit to 1977-1989 surveys, by hand)
1989	Ad-hoc calculation (Dawson et al.)	Separable-initiated VPA, S(11) = 1.2 wrt S(4)	Absolute (lsq fit to 1977-1986 surveys, by hand)
1988	Not used	Separable-initiated VPA, S(10) = 1.0 wrt S(4)	Absolute (lsq fit to 1977-1986 surveys, by hand)
1987	Ad-hoc calcualtion	Separable-initiated VPA. S(10) = 1.0 wrt age 4	Absolute (lsq fit to most recent survey, by hand)
1986	Ad-hoc calculation	Separable-initiated VPA. S(10) =0.87 wrt age 3	Absolute (lsq fit to most recent survey, by hand)
1985	Qualitative remarks	Separable-initiated VPA. S(10) =0.8 wrt age 3	Absolute (lsq fit to most recent survey, by hand)

2. Western Horse Mackerel

There are two sources of information only: Egg survey estimates and cacthes at age. Changes in the assessment procedure are documented in the table below:

Year of WG Meeting	**Assessment**	**Assumptions about egg surveys**	**Other**
1998	Bayesian ADAPT with constrained selection pattern in last year	Absolute; all years used	Natural mortality and some maturity parameters admitted uncertain
1997 (Bayes-ADAPT assessment introduced)	Bayesian ADAPT with constained selection pattern in last year	Absolute; all years used	Natural mortality and some maturity parameters admitted uncertain
1996	Monte-Carlo ADAPT with constained selection pattern in last year	Years 1992 - 95 of egg survey alone used	
1995	Monte-Carlo ADAPT with constained selection pattern in last year	Absolute; all years used	
1994	Deterministic projection with flat exploitation pattern from most recent egg survey		
1993	No assessment or forecast		
1992	No assessment or forecast		

3. Southern Horse Mackerel

This stock has been assessed using XSA from 1993-1998, for which the principal choices made each year are listed in the table below :

Year of WG meeting	**Abundance indices used in Assessment**	**Shrinkage CVs (mean and minimum)**	**Weighting options, Power=**	**Age range for catchabilities constrained equal**	**Age range for catchability power model**
1998	West+East trawl, Oct Pt Survey, Oct Sp. survey. Jul Pt. survey	1.0, 0.3	3, 20yr	9-11	0-2
1997	As 1998	1.0, 0.3	3, 20	9-11	0-2
1996	West trawl, East trawl, Jul. Pt survey	1.0, 0.3	3, 20	9-11	0-2
1995	West trawl, East trawl, Jul. Pt survey	1.0, 0.3	3, 20	9-11	0-2
1994	West trawl, East trawl, Jul. Pt survey	1.0, 0.3	3, 20	9-11	0-2
1993	Pt. Oct survey, Oct. Sp. survey, Pt. July survey, Spanish CPUE	0.5, 0.3	3, 20	12-14	None
Laurec - Sheperd Assessments used prior to 1993					
1992	Pt. Oct survey, West trawl, east trawl, Pt. trawl	Surveys included with equal weight. F(oldest) = Mean of 5 younger ages.			

4. Sardine

Year of WG meeting	Abundance indices used in Assessment	Age-range in assessment	Assessment Model	Principal Assumptions
1998	Pt. March Ac. Survey (1996-1998 only), Sp. March Ac. Survey, DEPM, Sada CPUE, Vigo CPUE	0 - 6+	Separable, 2 periods [1986-1990; 1991-1997]; Flat selection	Linear catchability for Ac. surveys, absolute catchability for DEPM, power catchability for CPUE indices.
Stock unit redefined to include the Gulf of Cadiz				
1997	Pt. March Ac. survey , Sp. March Ac. Survey	0 - 11+	Separable, single, domed selection pattern allowing for emigration	Domed selection pattern allowing for emigration. Linear catchability models for Ac. surveys
1996	Pt. November Ac. survey, Sp. March Ac. Survey	0 - 11+	Separable, single, domed selection pattern allowing for emigration	Domed selection pattern allowing for emigration. Linear catchability models for Ac. surveys
1995	Pt. November Ac. survey, Sp. March Ac. Survey	0 - 11+	Separable, single, domed selection pattern allowing for emigration	Domed selection pattern allowing for emigration. Linear catchability models for Ac. surveys
1994	Pt. November Ac. Survey, Sp. March Ac. survey	0 - 6+	Separable, single, flat exploitation pattern	high weighting factor for plus-gp
1993	Pt. November Ac. Survey, Sp. March Ac. survey	0 - 6+	XSA	Catchability 4+ constrained equal. shrunk with s.e.of mean, 0.5, min fleet s.e. 0.5
1992	Sp. March Ac. survey, Portuguese CPUE, Vigo CPUE, Sada CPUE, Santoña, Portuguese Nov. survey (as recruitment index in RCT3)	0 - 7+	Laurec-Shepherd	F(6) = 1.0*mean F 3-5

5. **Anchovy in the Bay of Biscay**

Year of WG meeting	**Abundance indices used in Assessment and catchability model**	**Selection Options**	**Weighting options**
1998	SSB(DEPM), *absolute*; Age-struct(DEPM), *absolute*; SSB(acoustic), *linear*, Age-struc(acoustic), *linear*; Upwelling index of recruitment, *power*	S(2)=S(4) =1	age-structured data downweighted; catch at age 0 downweighted=0.1
1997	SSB(DEPM), *absolute*; Age-struct(DEPM), *absolute*; SSB(acoustic), *linear*, Age-struc(acoustic), *linear*.	S(2)=S(4)=1	No survey downweighting; catch at age 0 downweighted=0.1
1996	SSB(DEPM), *absolute*; Age-struct(DEPM), *absolute*; SSB(acoustic), *linear*, Age-struc(acoustic), *linear*.	S(2)=S(4)=1	No survey downweighting; catch at age 0 downweighted=0.1. Years 1987,1988 downweighted=0.5
1995	SSB(DEPM), *absolute*; Age-struct(DEPM), *absolute*; SSB(acoustic), *linear*, Age-struc(acoustic), *linear*.	S(2)=S(4)=1	No survey downweighting; catch at age 0 downweighted=0.1. Years 1987,1988 downweighted=0.5
1994: First age-structured analytic assessment, for trial purposes	SSB(acoustic), *absolute*; Age-struct(DEPM), *absolute*	S(4) = 0.6 S(2)	Various ad-hoc options explored.