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On the Quality of North Sea Cod Stock Forecasts

by

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INTRODUCTION

The assessment of fish stocks frequently requires a short term forecast of catches and stock size. In the North East Atlantic, the main management tool is the total allowable catch (TAC) and this is intended to restrict fishing mortality in order to achieve management objectives. The short term catch forecast is a critical ingredient of the assessment since it forms the basis of the TAC. If the forecast is seriously in error, then the TAC will be inappropriate for the management objective. Commonly for North sea stocks, a TAC is set which corresponds to a modest reduction in fishing mortality rate in the designated year. Given the uncertainty in most assessments this naturally raises the question as to whether a TAC intended to achieve say a 10% reduction in fishing mortality is really distinguishable from the predicted *status quo* catch, ie the catch corresponding to no change in the fishing mortality. In this paper attempts are made to calculate the confidence interval of forecasted quantities. This is done by fitting statistical models to commercial catch at age data and recruitment data. The variances of the estimated model parameters can then be used to calculate the variance of the forecast based on these parameters. A sensitivity analysis is also performed to highlight the dependency of forecasted quantities on input values using the Fourier Amplitude Sensitivity Test (FAST), (Cukier et al, 1978)

SENSITIVITY ANALYSIS

The results from the analysis are given in Fig. 1. The partial variances are the sensitivity coefficients and represent the proportion of the variance in the state variable attributable to each parameter. The results show high sensitivity of yield and TSB to recruitment estimates. If the last year for which observations are available is year T then it is noticeable that yield in year T+2, perhaps the most critical value since it is used as a basis to set TACs, is very sensitive to recruitment. The results of are not really very surprising since in a heavily fished stock, the survivors from year T into the forecast period are few, and the greater part of the forecast yield will be comprised of recruiting fish. There is a tendency for assessment working groups to devote considerable effort to the estimation of F in year T. While there is no harm in doing this it can divert attention from the important task of obtaining a satisfactory forecast where great care is needed in estimating recruitment.

SHORT TERM FORECASTS FOR NORTH SEA COD

The sensitivity analysis shows that recruitment is one of the most critical ingredients of the yield forecast. The number of surveys used in the estimates of recruitment greatly affects its precision. Three cases are examined here.

a) Only one survey, the International Young Fish Survey (IYFS), is available. This is the situation which existed for the Roundfish Working Group until more recently.

b) Only surveys available in the spring of the year - the typical meeting time for the assesssment - are used. Thus in addition to IYFS1 (ie the IYFS index for fish aged one year) , the indices for 0-group fish from the English and Dutch groundfish surveys (EGFS0 and DGFS0) are available.

c) All survey data for the year are available. This would correspond to an assessment undertaken in the autumn of the year.

Forecast *status quo* yield, spawning stock biomass (SSB) and total stock biomass (TSB) up to five years ahead (ie T+5) are given in Figure 2. This shows the standard deviation of the log of the forecast quantity plotted against year. It is apparent that the autumn forecasts are considerably superior to the two spring forecasts, this being most marked for TSB. The difference between cases (a) and (b) is generally small but is greatest for forecast yield. This relatively small improvement is due to the fact that the quality of the additional data available in the spring (case b) is low while that in the autumn is high. Figure 2 also suggests that given "autumn data", forecasts of yield up to three years ahead could be made and that for SSB up to four or even five years with acceptable precision. The ability to forecast SSB further ahead arises simply because for cod the age of first maturity is high and the forecast SSB is therefore insensitive to poor estimates of recruitment during the forecast period. In contrast, TSB is the most sensitive quantitiy to recruitment and the precision of the forecast deteriorates rapidly after the first or second forecast year. Not surprisingly, forecast yield lies between these two extremes due to the partial selection of recruiting fish.

As well as making *status quo* forecasts, assessment working groups are usually asked to consider the effect of different levels of fishing in the TAC year (ie T+2). This is done by setting relative effort, f, in year (T+1) equal to that in year T (ie staus quo) and then setting f(T+2)=f(T+3) for a range of values bracketing the *status quo* value. The conventional catch prediction arising from this procedure is given in Figure 3 where 95% confidence limits are also shown. This is the forecast based on case (c) and should therefore show the best possible forecast. The inclusion of confidence intervals illuminates the problem of trying to set a TAC corresponding to a small reduction in f. Clearly the yield corresponding to f(1989)=.9f(1987) is almost indistinguishable from the staus quo yield. This is a difficult problem and indicates the considerable demands on the data imposed by a TAC based management policy.

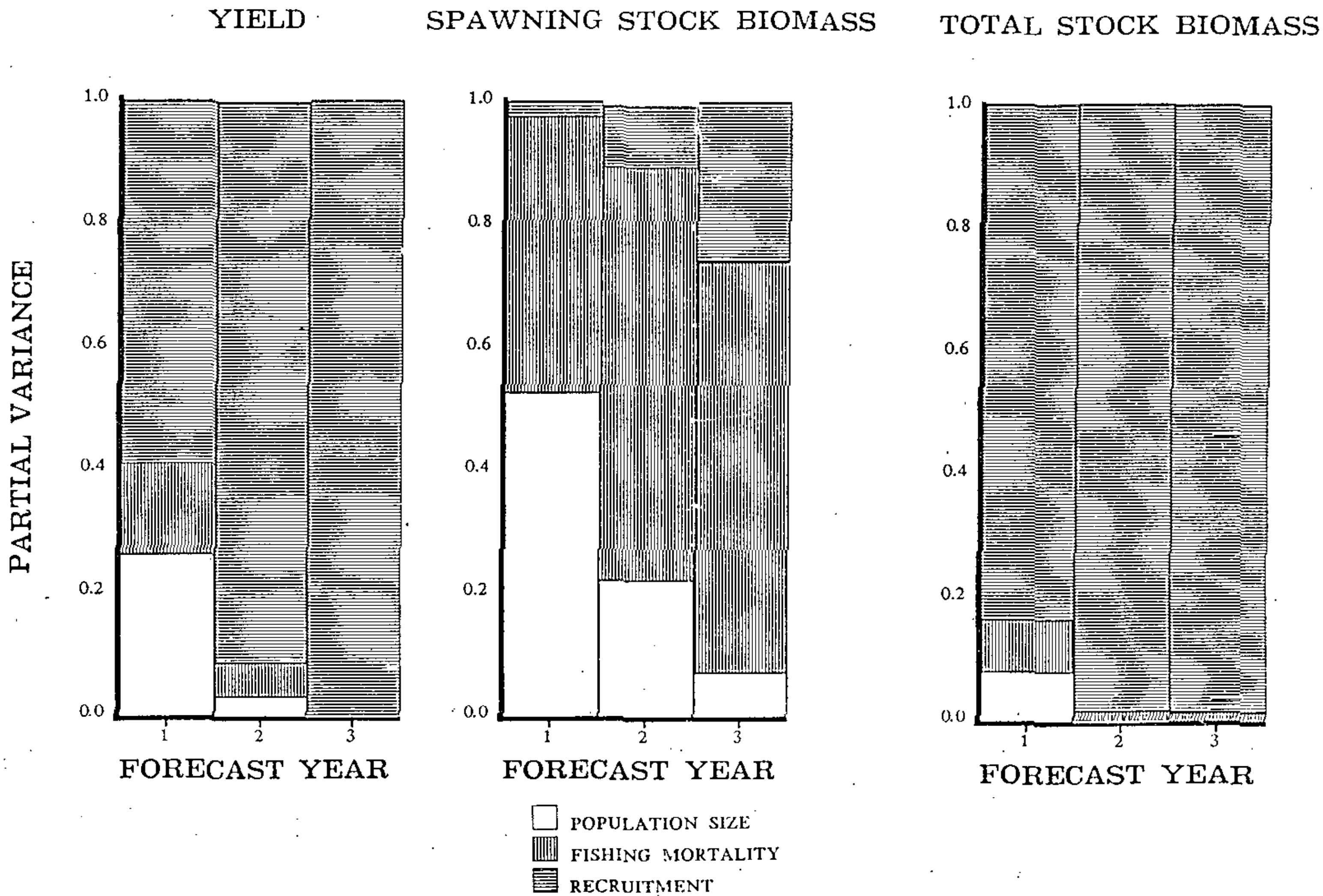

Figure 1. Partial variances for recruitment, fishing mortality and population size contributing to the variance of yield, spawning stock biomass and total stock biomasss. In each histogram, the proportion of the variance in the state variable (eg yield) can be attributed to the parameters (ie recruitment etc).

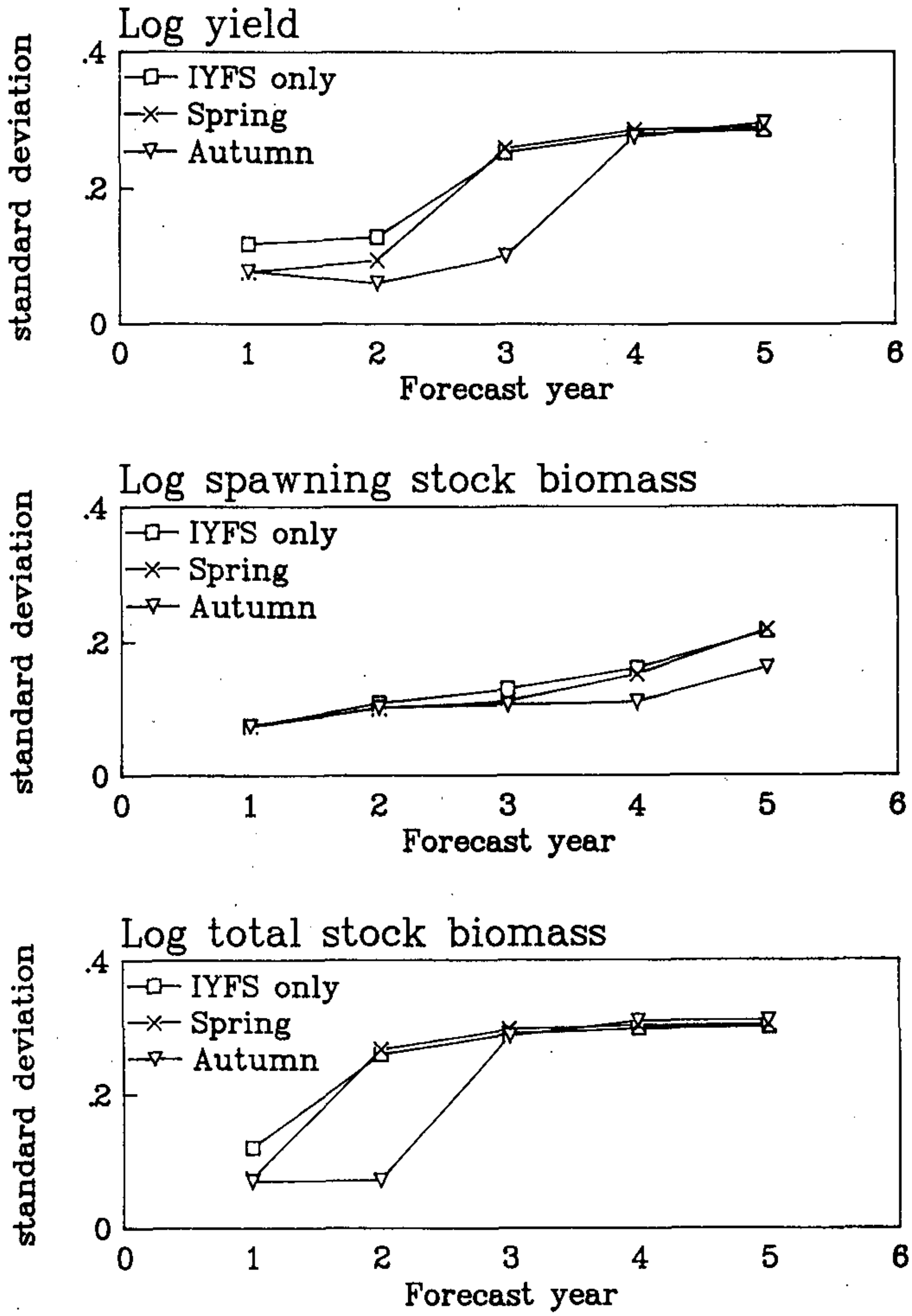

Figure 2. Standard deviation of forecast quantity plotted against forecast year for three possible scenarios of recruitment survey availability. The standard deviation is approximately equal to the coefficient of variation.

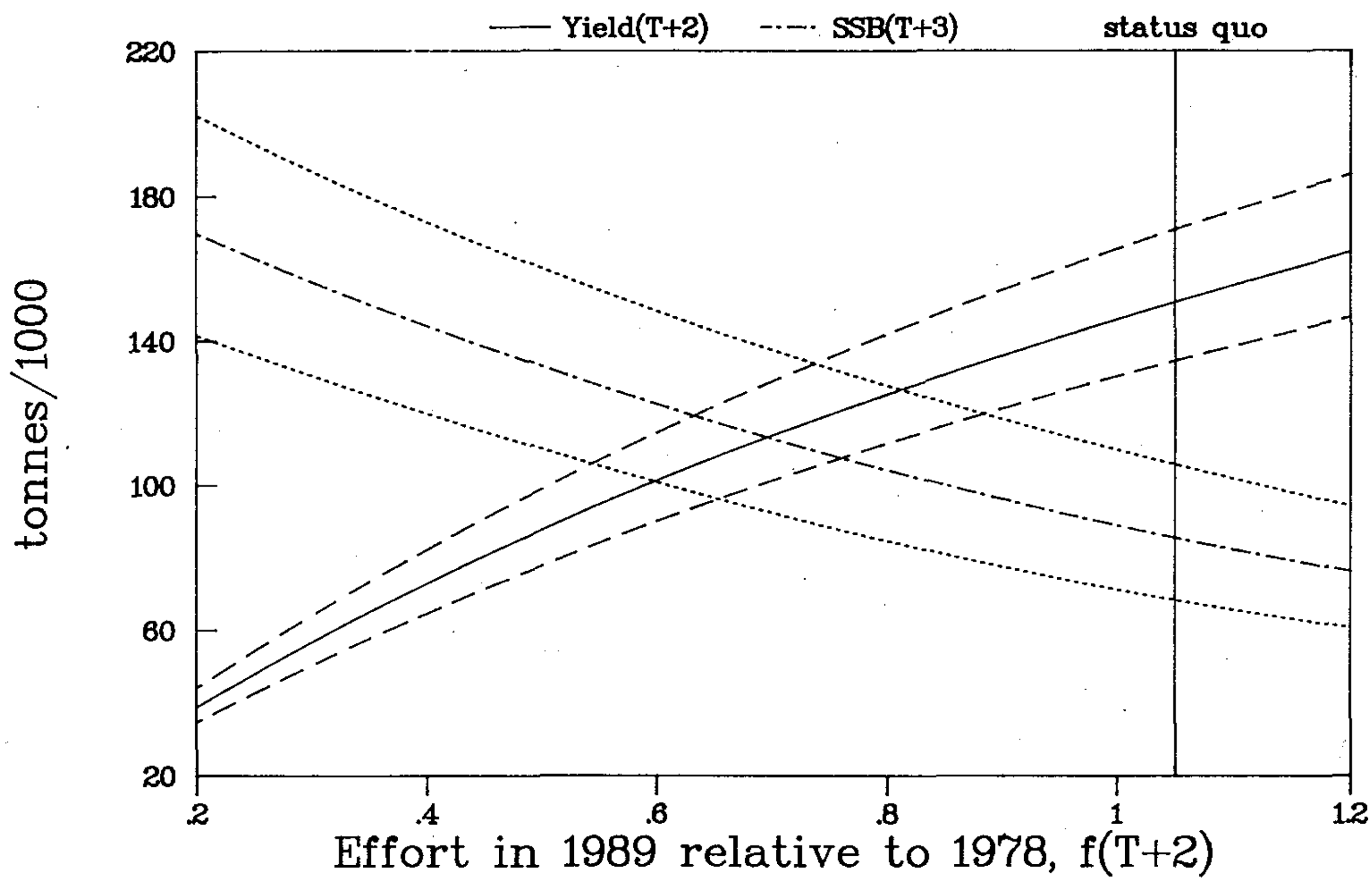

Figure 3. A typical ICES yield and spawning stock forecast plot for North Sea cod. 95% confidence limits are shown and the status quo postion indicated.