International Council for the
Exploration of the Sea

C.M 1980/G:39
Demersal Fish Committee

Ref. Pelagic and Baltic
Fish Committees

On the Quality of the TACs Recommended through ICES

Hans Lassen
Danish Institute for Fisheries and Marine Research
Charlottenlund Slot
DK-2920 Charlottenlund
Denmark

Summary

The precision achieved in the ICES recommended TACs is discussed. Three phases of the task are recognized the estimation of the population dynamic parameters and the stock in numbers by agegroup (the assessment) the forecast where the expected effects of any regulatory measures introduced and adhered to, are evaluated and the recommendation of TACs. The precision achieved is only of importance in relation to the use which is made of the recommendations.

Introduction

Total Allowable Catches (TACs) were for the North-east Atlantic introduced for the more commercially important fish stocks in the mid-seventies. These TACs were advised through the ICES mashinery of assessment working groups and advisory committee and the advised TACs are part of the background information on which the management of fisheries is based.

The problem adressed in this paper is whether it is possible to measure the quality of the ICES recommended TACs. This quality is expressed as uncertainties in the relation to the expected outcome of a regulatory measure e.g. a quota and the actual result. Such quality measure is only relevant when the actual use of the advices is considered that is whether the uncertainties inherent in relation between the recommended TAC and the desired objective are appreciated by the ICES customers.

This later problem is only dealt with rather superficially.

Other problems are present in the ICES mashinary related to the distinction between the scientific discussion as opposed to the management advice and also the competence of the ACFM is felt to be a problem (Coop. Res. Rep. No 85 (1979)).

Analysis of the tasks undertaken by ICES might be appropriate at present and could facilitate the discussions within ICES and as well as the dialogue with the ICES customers. The Chairman of ACFM (1978) reviewed fish stock assessments presented in 1978 and discussed some salient points of these assessments with such objective in mind.

The Three Phase Model

The fish stock assessments undertaken within ICES may be described in three phases, the assessment, the forecast and the recommendations. This split has been proposed at several occassions. The assessment is the estimation of the population dynamic parameters among those the stock size and mortalities

for the most recent years. Forecasting is to calculate the likely outcome of any regulatory measure which may be introduced and adhered to. Also the unchanged situation should be evaluated in this phase. The recommendation is to choose among the forecast and select the option which best will achieve a specified objective.

The ICES organisation to a certain extent reflects this split as assessment and forecasts are the tasks of the working groups while ACFM has the responsibility of producing the actual recommendations. However some overlap exists probably making the system much more effective.

The problems around the precision achieved are different for the three phases and will therefore be dealt with separately in the next sections.

The parameters which are estimated in the three phases are defined by the theorical model employed. The accepted model within the ICES assessment work is the cohort Beverton and Holt model sometimes named the VPA model. I have attempted to measure the precision of the estimated parameters within this model.

The method of isolating the accuracy achieved in each phase requires that the error introduced in the previous step must be corrected for e.g. the assessment is a prerequisite for making a forecast and the error in the assessment must be eliminated. This can only be approximately achieved.

The Assessment

The parameters to be estimated are

(a) age composition of the stock
(b) natural mortality rate
(c) fishing mortality rate
(d) weight-at-age

referring to the latest year.

The agecomposition of the stock is obtained from catch in numbers, hydroacoustic and/or trawlsurveys and estimated mortality rates.

The standard error of the catch in numbers is unknown. Pope (1978) reviewed the available information and was unable to give an estimate for the accuracy of the international catches in numbers.

It appears therefore that the problem do not lend itself to a standard error analysis.

Macer et al (1979) propose to measure the accuracy of the assessment by comparing the fishing mortality array for the latest year with the VPA result of the year some years later when the VPA has stabilized. This procedure has been adopted in the present investigation. The results of Macer et al (1979) are summarized in table 1. It will be seen that one average on accuracy of only 25 % is achieved.

The weight-at-age data are often obtained from the sampling programme giving the catch in numbers. The accuracy of these data are assumed to be better than that of the catch in numbers althrough no investigation into the matter appears to be available.

I shall for the moment accept the statement. The sums of product check normally carried out by the assessment working group to some extent mask the errors if these are random.

The natural mortality rates are only known with very large uncertainties and are in several cases quesswork based on general ecological considerations. No measure of accuracy can be assigned to these M-vaues apart for some special cases.

The estimated stocks sizes are obtained from VPA and the relative error in these estimates are therefore the same as for the fishing mortalities plus an unknown contribution from the natural mortality Pope (1972).

There may be part of the stock which is pre-recruits. These may be assessed using trawl or hydroacustic surveys. The precision of such surveys are unknown but Pennington and Grosslein (19789 investigated a groundfish trawl survey and found a standard error of 25 %. This however is probably a lower bound on the standard error achieved by the survey carried out in the ICES area.

Forecast.

The forecast involves the results of an assessment plus

(a) future recruitments

(b) mortality rates in the coming years dependent on management measures, fluctuations or trends in the mortalities etc.

(c) weight-at-age changes due to biological or changes in fishing practise

Measurement of the precision of the forecasts done by directly comparing the catch composition predicted and reported will involve the errors in the assessment.

The reported catch data are subject to sampling errors and therefore some discrepency between observed and reported catches the situation could be quite satisfactory. Evaluation of the effects of such discrepencies will have to take the management measures into account as the required accuracy of any TAC advice is dependent on the actual measure considered. Such intervenience by outside parties, e.g. the TAC related to an increase of mesh size which is actually not implemented, obviously invalidates any forecast independent of the accuracy of this procedure.

Therefore the catchcomposition is not suitable for measuring the accuracy of the forecast independent of the assessments.

The future recruitments are in most cases assumed to be of average strength as stock-recruitment relationships generally are of little predictive value. If average recruitment is assumed, the variance of the yearclass strength, assuming this to be random fluctuating, will be evident in the forecasts. Hennemuth et al (1979) studied 18 stocks and found that the yearclass strength is log-normally distributed with a standard error of about 0.08 x log(mean recruitment).

The accuracy of predicting the recruitment and the influence on the TAC's is related to the actual exploitation pattern; for some stocks the importance of the recruiting yearclass is negligable.

In terms of TAC the relevant quantity is the catch in weight constituted by the recruiting yearclass. This contribution is, for the 25 stocks analysed in table 2, 5-10%. However for recommending TAC forecasts over two years are required at the present organisational setup. Therefore the high uncertainty of forecasting the recruiting yearclass will influence the two youngest agegroups. Table 2 shows the importance of the two youngest agegroups relative to the total catch in weight.

The comparison may also be done by numbers. Table 2 shows that, on average, the predicted catch of the youngest agegroup is uncertain by 85%. The accuracy attained in the forecast for other yearclasses than those recruiting may be measured by applying the forecast procedure to a set of stocks in numbers and fishing mortalities where the assessment errors have been removed. It will be obvious that such data cannot be constructed as we always work on estimates of the true situation. Some approximation to this situation may be to accept the 1976 estimates of F and stock in numbers given in the 1980 assessment working group report. From this 1975 situation we go back to the 1975 assessment working group report and on the basis of our present knowledge make forecasts applying the 1975 procedure. The results are compared with the outcome. Table 3 shows the mean percentage difference for North Sea cod. On average an uncertainty of 29% in the fishing mortalities seems evident. It should be noted that when major overshooting of the TAC or other unpredicted events occur, this will invalidate the forecast.

Accuracy of the assessment and forecast combined

The precision of a fish stock assessment may be measured by comparing the forecasted and reported age composition of the catches. Diviations between the predictions given in the working group reports and the observed catch in numbers by agegroups may either differ in absolute level or by a shift within the agecomposition or both.

The prognoses form the basis of TACS, wich in some cases are enforced as quotas. Therefore the simple check of predicted catch in tonnes with the reported catch to a certain degree is a self-fulfilling prophecy.Several examples with the ICES area can be found where quotas have been over or undershot, but even so the TAC may have set some target. Therefore the calculations presented use revised prognoses such that the reported catch in tonnes is forecasted. The forecasted and reported agecompositions of the catches are compared by the average age of the catches in numbers and a mean error, table 2.

The average age is calculated straight forward, while the mean error is the average percentage error calculated

$$\frac{1}{n} \sum \frac{\text{predicted - observed}}{\frac{1}{2}\text{ (predicted + observed)}} \times 100$$

The sum is taken over the n agegroups for which the cumulated numbers caught is between 5 and 95 per cent of the total number, excluding the recruiting agegroup. The youngest yearclass is excluded from the cumulations.

The tail of the agecompositions are excluded from the calculations as it was felt unreasonable to include agegroups, which do not contribute significantly to the catches.

The mean error is of course dependent on the difference between the absolute level of the forecast and the reported catches in tonnes or in numbers. The mean age of catches is independent of the difference.

In some cases the predicted agecompositions are not given in the assessment working group reports, but have been calculated from information given in the report.

The fish stocks represents some of the working groups, where Danish colleagues have attended the meetings, several other stocks were excluded from the analysis as the working groups themselves express grave doubts about the validity of their assessments.

The comparison of predicted and reported catches is not in every case fair to the working groups. The North Sea roundfish assessment working group in the 1980 report has revised the exploitation pattern and the level of fishing mortality together with a revision of its database.

When the catch in tonnes differs markedly from that expected by the working group it is likely that factors not considered by the working group have been of importance and therefore invalidating the assupmtions made. This is the case for the western mackerel stock. In the Baltic in this year report the grouping of subdivisions into stock areas were reconsidered for the herring stocks and the subdivisions 27 were grouped together with subdivision 25 and 26 and not as previously with subdivision 28 and 29 south.

The Recommendations

The recommending of TAC includes the introduction of managment objectives. These have been formulated as maintaining the spawning stock biomass, above some minimum level, bringing the exploitation rate to Fmax or Fo.1, rebuilding depleted stocks or avoiding diversion of effort into an area whether by actual fishing in the area or misreporting landing from that area. However as ICES is not the management agency it is diffecult to know whether the adoption of the biological advised TAC as a quota actually is an acceptance of the biological objective. It is therefore difficult to evaluate the quality of the ICES recommendations.

If one however make the assumption of the persuing the biological objective by the management bodies we could measure the quality of the ICES recommendations by finding some stock where major changes in the exploitation pattern is desired and compare this objective with the actual result. This is presented below for the North Sea Cod where a major reduction in the fishing mortalities is desired (10% per year). It may be premature to arrive of a conclusion.

Weighed mean fishing mortalities for North Sea Cod

1976	1977	1978	1979
1.04	0.94	1.06	0.91

In 1978 the recommended TAC for North Sea after version was 210000 tonnes with an actual catch of 260000 t.

The recent proposed mesh size changes are not all adopted nor implemented and therefore have to await a later analysis.

Also the rebuilding of herrings stocks may be somewhat too early to evaluate the eventual success.

Conclusion

It seems possible to evaluate the quality of the ICES assessment work. This task should be included into the standard procedures for assessment working groups as a vehicle to make certain that the accuracy of assessment and forecasts are kept under constant surveillance.

Literature

Anon — The relevant ICES assessment working groups reports for 1979 and 1980 were consulted.

Hennemuth, R.C., Palmer, J.E., Brown, B.E., Patil, G.P. and Taillie, C. (1979). Recruitment Distributions and their Modality. C.M. 1979/H:57

Macer, C.T., Jones, B.W. and Bannister, R.C.A. (1979). Factors affecting the accuracy of catch Predictions in some demersal Fish Stocks. C.M. 1979/G:34

Pennington, M.R., Grosslein, M.D. (1979). Accuracy of abundance indices based on stratified random trawl surveys. C.M. 1978/D:13

Pope, J.G. (1972) An investigation of the accuracy of virtual population analysis using cohort analysis. Res. Bull. int. Comm. N W Atlant. Fish., No 9 65-74.

Pope, J.A. (1978) A review of sampling methods in fishery research. C.M. 1978/D:8

Table 1. Percentage by which the original estimates of fishing mortality[1] differ from the latest estimates[2]. A negative value denotes an underestimate originally and a positive value an overestimate. From Macer et al (1979).

Area	Species			1972	1973	1974	1975
North Sea (IV)	Cod			-31	+ 3	ND	- 36
	Haddock			-47	+ 6	+10.6	ND
	Whiting			ND	-12	ND	- 4
	Plaice	Age 2-4	♂	-31	-32	-40	+109
			♀	0	- 9	-25	+ 85
		5-10	♂	-18	-23	-16	- 29
			♀	+18	+27	- 5	- 20
		11+	♂	-15	+21	-39	- 17
			♀	-23	-24	-29	- 47
	Sole	Age 2-6	♂	+ 2	+14	+18	+ 34
			♀	+41	+25	+23	+ 22
		7-12	♂	- 7	0	-16	- 11
			♀	+27	+91	+79	+ 48
West of Scotland (VIa)	Cod			ND	+12	ND	+ 16
	Haddock			ND	- 5	+23	ND
	Whiting			ND	0	ND	+ 13

ND No data

1 As used for catch prediction in Working Group reports

2 From 1978 Working Group reports

Table 2. Average age of forecasted and reported catches in numbers for 1979 together with an average mean error on predicting the catch of a specific agegroup for 25 fish stocks in the North East Atlantic, North Sea and the Baltic Sea. For the calculation of the mean error (ME) see text.

Species	Stock Area	Average age		ME	Error (%) in numbers recruiting yearclass	Influence of 2 youngest yearclasses on catch in weight (%)
		Forecast	Reported			
Saithe	N-E Arctic I+II	3.5	3.5	32	116	5.9
	North Sea IV+IIIa	3.8	4.0	21	67	6.6
	Iceland Va	6.3	6.2	41	35	a0.8
	Faroe Vb	5.6	6.9	32	100	1.7
	W. Scotland VI	3.8	4.9	52	149	3.6
Mackerel	Western Stock	5.1	4.6	25	164	7.9
Cod	North Sea IV	2.5	2.1	69	49	8.9
	Baltic subdiv. 22	2.3	2.2	36	181	59.2
	Baltic subdiv. 24	2.5	2.4	4	53	35.5
	Baltic subdiv. 25	3.4	3.5	25	123	4.8
Haddock	North Sea	1.6	1.3	41	58	19.7
Whiting	North Sea	1.6	1.5	71	51	29.3

Table 2 (cont'd)

Species	Stock Area	Average age Forecast	Average age Reported	Mean error %	Error (%) in numbers Recruiting yearclass	Influence of 2 youngest year-classes on catch in weight (%)
Plaice ♀	North Sea	4.4	4.3	13	3	11.3
♂	North Sea	3.9	4.0	25	20	
Sole ♀	North Sea	3.5	3.8	6	68	7.1
♂	North Sea	3.5	3.6	13	66	
Herring Baltic Sea	Subdiv 22-24	1.8	2.3	49	120	4.1
	Subdiv 25+26	1.9	3.4	60	88	4.6
	Subdiv 27-28-29S	4.3	4.8	29	120	0.5
	Gulf of Riga	2.0	3.2	61	169	6.1
	Subdiv 29N-30-31	4.7	4.8	19	48	1.2
	Subdiv 32	3.2	3.4	24	101	5.2
Sprat Baltic Sea	Subdiv 22-25	2.0	1.9	25	100	18.3
	Subdiv 26+28	3.3	3.0	30	24	13.8
	Subdiv 27+29+32	4.1	4.4	40	35	2.9

Table 3.

Comparison between the 1975 and 1976 exploitation pattern as given in the 1980 assessment Working Group report. The prediction on unchanged exploitation pattern was 210000 t while the actual reported catch is 214000 t.

Age	F-1975	F-1976	% of mean 75-76
0	.002	.000	100
1	.184	.068	46
2	.849	1.086	-12
3	.832	.991	- 9
4	.761	.875	- 7
5	.809	.632	12
6	.682	.792	- 7
7	.541	.779	-18
8	.671	.296	39
9	.887	.524	26
10	.437	.809	-30
11	.985	.156	73
12	.66	.7	- 3