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PROVIDING ADEQUATE FISHERIES MANAGEMENT ADVICE FOR COMPLEX FISHERIES SUBJECT TO MULTIPLE OBJECTIVES.

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Abstract:

Many of the fisheries for which ICES currently offers biological advice are multifleet, mixed species fisheries. To integrate the biological advice with advice on the economic and social consequences of management needs either some breakdown by fleet unit or some assumptions about what relationships have to remain unchanged for the advice to remain valid. These requirements may tend to make adequate advice more complex. On the other hand this there is a need to provide clear simple advice to fisheries managers. This paper considers possible approaches which addresses this dilemma in providing management advice.

Keywords:

Fisheries, Multiple Objectives, Economics, Yield, Social Objectives, Simple Advice, Multifleet, Mixed Fisheries.

Introduction

Fisheries managers commonly have a number of management objectives. While these are rarely clearly stated it is obvious that these are not simply the biological objectives of sustainability and yield maximisation typically considered by fisheries biologists.

It is reasonable to assume that objectives would include social considerations of employment in fisheries and possibly upstream employment (e.g. ship building) and down stream employment (e.g. fish processing) activities. It is also probable that some weight would be given to the equity of the distribution of benefits and the prospect of the regulation being complied with.

It is also reasonable to assume that objectives would contain economic considerations, such as viability, economic rent, return on capital and the cost of enforcement. In recent years environmental factors such as the effect of fishing activity on non target species have also needed to be considered. Moreover, changes to all of these factors need to be considered in both the short term and in the medium to long term. Currently detailed advice on the consequences of proposed changes only exists for the biological objectives. Clearly there is a need to construct equivalent social and economic advice. Equally clearly the presentation of such advice will be complex. There will thus be a need to find ways to present it which allow fisheries managers to assimilate and integrate the information and to make informed decisions. This paper discusses some simple and less simple approaches to achieving this end.

Simple approaches.

The STECF of the EU is currently attempting to construct an annual economic report to set along side the annual biological report presented by ACFM (Anon, 1995). This will contain graphs of trends in Capacity (Capital invested, Employment), Activity (Numbers of active vessels, and days at sea), Vessel economic output (Profit, calculated as the ratio Profit/Day at sea), Fisheries economic output (Gross and net added value). In the first instance these are to be produced for 6 fisheries chosen to span the fishing areas and fleets of most EU member states. These are
The Baltic Salmon Fishery.
The North Sea Flatfish Fishery.
The Demersal Fishery in the Celtic Sea.
The Demersal Fishery in the Irish Sea.
The Demersal Fishery in the Gulf of Lion and in the Gulf of Genova.
The Demersal Fishery in the eastern Mediterranean.
As well as the basic time series information proposed above the reports will also contain,
A brief overview of the current economic state of the fishery.
An evaluation of the likely evolution of the economic state of the fishery in the short and longer term according to which of the possible management measures are applied.
A management advice section, in which the likely economic consequences of a number management options would be assessed.
A comments section, in which particular characteristics of the fishery and their relevance to management would be identified (i.e. indicate whether TAC's could be used as control instruments for targeting mixed species.
A section on the origin of the data, the quality of the indices of performance and that of the information presented.

Plans are in hand to provide these analyses for the autumn 1996 STECF meeting and assuming this is found feasible and useful the idea could be extended to other fisheries and regions. When these or similar economic reports become available it will be necessary to think of summarising the results in a way which will help Ministers and fisheries officials with annual decision making. This is far from an easy task. A major problem is the orthogonal nature of biological, economic and to some extent social advice. Biological advice is necessarily by fish stock, economic advice by fleet and social advice more related to regions or ports. Clearly, except for the simplest fishery where one stock is fished with one vessel type from one harbour, this requires advice on the effects of the management options by species, by fleet, by country and possibly by port. However, such analyses would typically require model disaggregations that would be beyond the scope of current data sets. Moreover, even if models were available, it is possible that the managers they were meant to serve would not fully understand them or be able to use them make the sorts of decisions required.

Concerns for the comprehensibility of results may argue for a simpler approach where it is assumed that the relative effort of the separate fleets and ports involved in the exploitation of a series of fish stocks remained roughly in balance. In practice this condition would imply that similar management decisions were made for particular groupings of fish stocks, for example the North Sea round fish. Given this condition it would be possible to give some economic and social advice together with the more familiar biological advice.

One approach to this might be to present data so that managers had to chose one line of a table of options which addressed all the main decision points. This might be useful as it would indicate to fishermen and to the general public the fuller consequences of a choice. For example that a smaller TAC had been chosen to achieve better long term profitability or that a larger TAC had been chosen despite the risk to sustainability.

In the UK and undoubtedly elsewhere, consumer publications and news papers present the results of quite elaborate comparisons of consumer products in tabular form which present the good and bad features of various products with ticks, crosses, star rating etc. It seems at least possible that such an approach might be used to present options in ways that fisheries managers could simply comprehend. Such information would not all need to be numerical and indeed likely trends in various outcomes might be indicated even if numerical data were not available.

An example of such a decision table is shown at Table 1. This attempts to show some of the factors which might have been influenced by the decision of the management regime for North Sea cod in autumn 1995. It would of course only be valid if equivalent decisions were also made for North Sea haddock and whiting but at least such a table would indicate to the managers the several consequences of the decision to be made and would indicate to the world the factors that had been balanced in the decision arrived at. It might be argued that the necessary condition of linkage between the management of stocks exploited by the same fleets would make certain of this information redundant or at least repetitive and so it might be tabulated by fleet elsewhere perhaps in more detail. However there does seem some virtue in presenting all details of a decision in one simple table.

Fleet based approaches

Management actions that may have differential effects on different stocks or on different fleet components will require more elaborate models and presentations than those proposed in the previous section. The common currency of such models is usually the age disaggregated fishing mortality that each fleet (and if social considerations are to be addressed possibly each port/sector) imposes on each stock in a fishery. Such information allows the consequences of management actions at a stock level to be mapped onto each fleet. Hence it allows predictions to be made of the likely changes in catch and in the economic outcome that a fleet is likely to sustain as a result of the measure. Equally it allows the effects of management actions imposed upon each fleet to be assessed in terms of the consequential effects to the various stocks it harvests and hence to allow calculation of the concomitant changes generated in other fleets. This in turn allows calculation of the economic and biological and possibly some social consequences of various measures. A number of such models exist for the better research fisheries of the world. A number of examples were presented to the ICES Multispecies Symposium. Anon. 1989a. and a biological/economic model was developed by the STCF Sub Group on Improvements of the Exploitation Pattern of the North Sea Fish Stocks.

The problem with such models is that they require extensive data sets of disaggregated catch-at-age data as well as the appropriate biological detail of the stocks and the economic characteristics of the fleets. Such data are often not available. In particular the catch-at-age data is almost invariably collected with coarser disaggregations in mind and extending the level of its disaggregation is equivalent to blowing up a photograph beyond the grain size of the film. That is to say the necessary detail cannot be distinguished. In the case of the STCF Working Group model it was attempted to break down catch-at-age data C(s, a, q, f, n, r, y) in to a disaggregation by species s, age a, quarter year q, fleet (i.e. gear type) f, nation n, rectangle r and year y. Since for the North Sea there were about 10 species with an average of about 8 ages for about 5 gear types for 8 countries and about 200 rectangles this amounted to a potential data set of 10*8*5*8*200 = 640000 terms per year. It is true that the disaggregation by rectangle used by the STECF Working Group was a convenience aimed at achieving a data set which could be reaggregated to form catch-at-age data for a relatively few large groupings of rectangles. This was done so any closed area could be considered. Thus in practice the actual model might only have to carry, say 6400 terms, if only two sub areas were considered (e.g. the catch-at-age within a closed region and the catch-at-age without). However, the full disaggregation is obviously required if, for example, the data set is to be able to handle all possible area closures. Thus such a model puts almost impossible strains on existing catch-at-age sampling systems and a future system designed to achieve such a level of sampling would be several orders of magnitude larger than the existing system and hence prohibitively expensive.

It is interesting to consider whether other, more achievable, approaches to catch-at-age disaggregation might be possible. One approach might be to separate catch-at-age or partial fishing mortality into a product of less disaggregated terms. For example we might write

C(s, a, q, f, n, r, y) = N(a, s, q, y)*R%(a, s, r, q)*Q(s, f, q)*E(f, r, q, y)*SEL(s, a, f, q)

Where:-
N(a, s, q, y) is the numbers-at-age in the stock by quarter by year (perhaps available from VPA?).
R%(a, s, r, q) is the proportion of the stock of age a in rectangle by quarter (perhaps available from quarterly groundfish surveys?)
Q(s, f, q) is the catchability of the stock by fleet f by quarter. (this might be estimated from VPA results? or if not directly estimable might be calibrated against aggregate catches?)
E(f, r, q, y) is the fishing effort by fleet by rectangle by quarter by year. (possibly available from fisheries statistics?)
SEL(s, a, f, q) is the selection proportion of age a of the stock by fleet f by quarter (possible available as the result of selection experiments?)

It might also be possible to build in discard proportions in a similar fashion. Estimates or guesstimates of these multiplicative factors might be obtained more cost effectively than a full catch-at-age sampling and allow estimates of partial fishing mortality F(s, a, q, f, n, r, y) to be estimated as

F(s, a, q, f, n, r, y) = F(s, a, y)*C(s, a, q, f, n, r, y)/Sum of (C(s, a, q, f, n, r, y)) for all f, n, r)

These would then form the building blocks of models designed to estimate the impact of catch management measures applied to fish stocks on fleet catch and catch rate results and of the impact of technical measures or effort restrictions applied to fleets on fish stocks and on fleet catch and catch rate results. They would also be a necessary but not sufficient requirement for modelling the impact of economic management measures. This would also require knowledge of the behaviour of fleets under such measures.

Presuming that it is possible to construct meaningful fleet stock models using the approach outlined above (or in other ways) the problem remains of how to present the ensuing results to administrators in an understandable form. Where simple questions are posed or simple "what if" options presented, such as what would be the effect of a general mesh increase or what effect an overall effort reduction would have, it should be possible to present fleet catch results. These might be presented as aggregate fleet results along the lines of the proposed STECF economic report. It might also be worth considering summary international reports and detailed national reports since managers might wish to see the consequences to their home industries in greater detail than those of other countries.

Where more complex questions are asked or where "what's best" questions are asked, rather than "what if" questions, then presentation of the results may be less straightforward. A possible approach in this case is to seek for a simple approximation to the results such that control variables can be easily manipulated and preferably such that the simplification has a structure which allows of the analytically investigation of its properties.

Such a simplification has two main uses. Firstly it may be used to present the problem to managers in the form of a hands on model which they could manipulate to see the consequences of possible actions. Secondly, it allows objectives to be optimised in an analytical fashion.

As an example of this approach a simple multispecies model was presented by the Multispecies Working Group as an approximation to the results of the Multispecies Dynamic Pool Forecast Model (MFFOR). Anon. 1989 This simulates the effect on long term catch and SSB results consequent on changes in the level of effort of the 7 main fleet groupings in the North Sea. Results are virtually instantaneous and presented as graphs of changes in fleet catch and stock SSB. The model used is

$$Y(s_i, f_j) = \alpha_{i,j} \bullet E_{f_j} + \sum_{all\ k} \beta_{i,j,k} \bullet E_{f_j} \bullet E_{f_k}$$

where α and β are stock and fleet specific constants and E refers to fleet effort subscript s refers to stock s, subscript j refers to the fleet in question and subscript k may refer to all fleets.

The constants of this model may be estimated from runs of MSFOR where each effort in turn is altered by a small fixed percentage. That is to say by estimating

$Y(s_i, f_j)$ at current effort levels and $\dfrac{\partial\, Y(s_i, f_j)}{\partial\, E_{f_k}}$

Experience with MSFOR results suggest that this model gives reasonable approximations at least in the direction of effort reduction. Clearly if simple mathematical expressions can be established for the cost of fishing effort and the value of fleet species catch then such a model can also be used to approximate economic results. In fact, with simple linear relationships for these factors it is possible to analytically solve the problem for reference points such as Fmax and Maximum Economic Yield. See for example Anon 1989.

We are not aware of equivalent approximate models being developed for mesh change. It is interesting to speculate whether a model such as

$$Y(s_i, f_j) = \alpha_{i,j} \bullet E_{f_j} + \ldots$$

$$\sum_{all\ k}(\beta_{i,j,k} \bullet E_{f_j} \bullet E_{f_k} + \delta_{i,j,k} \bullet E_{f_j} \bullet Mesh_k + \varepsilon_{i,j,k} \bullet E_{f_j} \bullet E_{f_k} \bullet Mesh_k)$$

or some equivalent in transformed variables might approximate to a multifleet multispecies model. Such an approach would obviously need at least a factorial experiment on MSFOR for changes in each fleets effort and mesh to estimate all the constants.

Assuming this or some other model could provide reasonable approximations to the more complex dynamic pool prediction model then it should prove useful in exploring the multidimensional multispecies yield isopleth diagram and hence of providing indications of where various objectives might be maximised subject to constraints on other objectives.

Such simplified models might be a good basis for collaboration between biologists, economists and sociologists.

Clarity in advice

What ever model of complex multispecies, multifleet, multiarea fisheries is adopted it will be of little use in the real word unless its results can be presented to the managers in as clear and unambiguous fashion as possible. This remains the most challenging problem. It is difficult for administrators to cope with options because each option is likely to favour particular countries, regions and fleets more than others. The complex multidimensional options likely to be presented when multispecies, multifleet, multinational are addressed are thus likely to cause administrators considerable problems. One solutions to this problem would be, to establish by dialogue the objectives and constraints that administrators hold. Specialists could then seek narrow ranges of specific solutions that optimise managers objectives subject to their constraints or, more realistically, which optimise objectives subject to as few constraints being violated as possible.

An alternative approach, where the group of managers is small and have reasonably coherent objectives would be to present them with a relatively simple interactive model which they could explore to find their own preferred solutions.

The likely success of either of these approaches is likely to be enhance if results are limited to those of direct relevance to the decision makers and if they can be viewed in the context of historic time series of the variables. Administrators may thus wish to be presented with results such as the risk to the viability of fish stocks, the value and profitability of specific fleets aggregate catches and the likely regional impacts of various measures. They would wish to compare these with historic series of such results for stocks, fleets and social groups of interest. They might wish to see options chosen to improve such results in the medium term subject to constraint on short term losses and on equity.

Conclusions

To be useful to managers quantitative or at least qualitative advice needs to be presented on the consequence of particular management options to relevant social, economic and biological factors. Beyond models appropriate to simple fisheries this requires joint models which disaggregate the data such that the separate consequences to fish stocks, fishing fleets and regions and social groups can be considered. Under most existing approaches this may make unrealistic demands for data. Consequently an approach which may be less exacting is proposed.

Complex models are difficult to present quickly and simply and some simple approximation to the more complex models are discussed. It is, however, noted that to be useful for fisheries management, an absolute requirement for these or other models is the maximum clarity and the minimum of ambiguity.

References

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Table 1 Example of an integrated choice table for cod in Sub Area IV (North Sea)

TAC 1995	TAC 1994	Catch in 1994	Average catch 1985-94	SSB in 1994	Average SSB 1985-94	Current Fishing /Fmax	Current Fishing /Fmed	SSB/R as % of Unfished	Current SSB as % of MBAL	Midterm SSB as % of MBAL	Discarded % by weight	Discarded % by number	Missreporting % in 1994
120	102	88		75		340	104.9	3	50	66.67	NK	NK	

Options	Catch 1996	Fishing level change	Relative to Fmed	SSB as % MBAL 1997	SSB as % MBAL in midterm	Yield next year	Yield in Medium term	Employment next year	Employment in midterm	Profit next year	Profit in midterm	ACFM Prefered Option	STECF Prefered Option	Prospect of Complience
TAC's														
81	81	-60	42	113		↓↓↓	↑↑	↓↓↓	↑	↓↓↓	↑↑			✖✖✖
113	113	-40	63	96		↓↓	↑↑	↓↓	↑	↓↓	↑↑			✖✖✖
127	127	-30	73	89	187		↑↑		↑		↑↑	★	★	✖✖
141	141	-20	84	81		↑	↑↑	↑	↑	↑	↑↑			✖
165	165	0	105	69	67	↑	-	↑	↓	↑	-			✔
185	185	20	126	59		↑↑	↓↓↓	↑↑	↓↓↓	↑↑	↓↓↓			✔
Effort														
-60	81	-60	42	113		↓↓↓	↑↑	↓↓↓	↑↑	↓↓↓	↑↑			✖✖
-40	113	-40	63	96		↓↓	↑↑	↓↓	↑↑	↓↓	↑↑			✖
-30	127	-30	73	89	187		↑↑		↑↑		↑↑	☆		✔
-20	141	-20	84	81		↑	↑↑	↑	↑↑	↑	↑↑			✔
0	165	0	105	69	67	↑	-	↑	-	↑	-			✔
20	185	20	126	59		↑↑	↓↓↓	↑↑	↓↓↓	↑↑	↓↓↓			✔