Comments by Sidney J. Holt[1]
to the Commission of the European Communities
on the

GREEN PAPER: Reform of the Common Fisheries Policy

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> ***"Since resources do not serendipitously start out at MSY conditions and, further, stochastic events continually displace resources from equilibrium conditions, MSY solutions are not in themselves the most appropriate policies for managing [the use of] resources. Rather, they provide a reference point for the design of dynamic harvesting policies, preferably feedback or adaptive policies, that can respond to unforeseen changes in the state of the resource.***
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> **Getz, W. M. and Haight, R. G. (1989)**
> Population Harvesting: Demographic Models
> of Fish, Forest and Animal Resources.
> 391pp. Princeton Univ. Press, New Jersey.

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SUMMARY AND CONCLUSIONS

More than half the consumption of marine fish products in the European Union now comes from outside waters under direct EU jurisdiction, either from EU-flagged fishing vessels operating outside the EU-EEZ or as imports from non-EU producers. This situation makes European consumers vulnerable in the long-term, and perhaps in the medium-term, to shortages arising from limitations exercised by others as a result of over-fishing outside the EU-EEZ or for other reasons related to local sustainable development and the global market for fish products. That fact alone would make the Commission's proposal that the Common Fisheries Policy should shift from mere sustainability and recovery of seriously depleted stocks from that dangerous status, towards seeking maximum sustainable yields, admirable and timely. In addition the proposed shift would eventually inevitably lead to higher catch rates (catches per effort) and hence greater potential profitability. This is notwithstanding the fact that modern scientific and technical opinion is that the concept of MSY is illusory, and even if it were not, is unreachable, and certainly not economically optimal. It is however a useful concept that can be rendered operational by redefining it and also the fundamental idea of sustainability, and seeking scenarios to approach it through exhaustive simulations of possible management procedures.

The necessary re-definition is **a high optimal average catch over an appropriately designated time horizon**; sustainability is not like diamonds – forever. Interestingly, this approach was pioneered by the International Whaling Commission (IWC) when it embarked, in the 1980s, on designing a Revised Management Procedure (RMP) for regulating the catching of baleen whales. The core of the RMP was an algorithm that had been shown, by simulation, to result in a high annual average catch while avoiding, with high probability, any accidental depletion of stocks to below a pre-defined minimum threshold level, and which – as a third objective - ensured that as far as reasonably possible there would not be very large changes in catches from one year to the next as a result of the procedure itself.

I advocate the replacement of the present EU management system, involving the application of annual TACs for every stock, by a system based on limitation of fishing effort, mediated by a limitation of fleet capacities to ensure that regulation to reduce effort does not generally lead to inefficient operations. That is, regulating by input rather than output - to maintain fishing mortality rates at, or below, levels that are expected to provide highest feasible average physical yields over an appropriate pre-defined period. This would more effectively stabilize the European fisheries but would also carry other advantages, in particular reduction of discards, especially of non-target species, and release of scientific effort for more constructive activity than annual calculation of hundreds of TACs.

These proposals would call for an acceptance that once Member States had agreed to a procedure, and committed themselves to applying it, there would be no further political negotiation of details of annual or short-period regulations;

that is, the current faux-negotiations with *Nature* (involving second-guessing of the best available scientific advice) would cease.

Any serious move towards some form of maximum yield policy will inevitably have costs in the short term while depleted stocks are allowed to recover to more productive levels and compositions. These are likely, however, to be off-set by savings from reductions in fleet capacities and in deployed fishing effort. The possible scenarios for less "painful" transitions from over-fishing to optimal fishing, and from TAC-management to effort and capacity management, should be examined by computer simulations of alternatives such as of faster or slower transitions. Such simulations would necessarily also examine the possible, and probably simultaneous transition scenario to optimal fishing mortality rates from TAC-based regulation to regulation primarily by the direct limitation of fishing effort and fleet capacity.

Finally, attention should be paid to the recent suggestions from the World Bank and FAO that, both globally and regionally there are strong economic advantages to maintaining fishing mortality rates, hence fishing effort, significantly below the levels giving optimal sustainable physical yield. (See the Banks' study entitled "Sunken Billions: the Economic Justification for Fisheries Reform"

The simple fact that if fish are allowed to grow up, get fat and produce lots of young, instead of being killed as juveniles, the consequences of our taking some of them will be better and more profitable, has been known for seventy years or more. A defining date was perhaps 1942, when the remarkable little book entitled *The Fish Gate*, written by Michael Graham (England's first post-war Director of Fisheries Research) was published in London. A few years later, when the war had ended and fishing had resumed in the North Sea, his and others' predictions of recoveries were vindicated: plaice and soles had increased more than threefold, haddock and cod more, during the respite that Graham called the ***Second Great Fishing Experiment***. (the First had been the Great War, during which similar stock increases occurred, but not so fully documented).

The European Union now has the chance to conduct the Third Great Fishing Experiment, by deliberate, systematic phased reduction of fishing capacity and effort to gain more productive yield levels. That opportunity must be grasped.

PROLOGUE

I begin with the proposition that the primary objectives of managing a fishing industry are:

- to ensure continuing supplies of high value fish;
- to ensure profitability;
- to ensure employment in fishing and associated industries and to sustain fishing communities.

In parallel with this we can define primary objectives of managing the exploitation of fish stocks as:

- to seek a high average catch over a pre-determined time period;
- to ensure that the risk is very small of accidentally depleting a fish stock to a level (and to a stock composition) substantially less than a designated optimum, and a practically zero risk of any accidental depletion to a level where the continued existence of the stock is threatened;
- to maintain stability from annual season to season insofar as that is possible in the light of natural variations in the fish stocks.

There are common problems of uncertainty about the dynamics of the systems being managed – some intrinsic, some arising simply from inadequacies of data - and others arising from external sources of unpredictable variability. For these reasons the two triads inevitably contain partial incompatibilities among different primary objectives. For example, in the latter triad – which is the subject of this comment – it is impossible simultaneously to maximise the short, medium or long-term catches and to minimise the likelihood of accidental depletion of the managed fish stock. Thus a management procedure seeking to meet multiple objectives must be such as to provide a working compromise, defined in terms of a suite of acceptable and pre-defined probabilities and priorities. To these must be added an overall decision about the desired level of precaution to be built in to the procedure.

In 2007, on the occasion of the Commission's decision to try to achieve compatibility of a revised Common Fisheries Policy with the decisions of two major UN conferences concerning Maximum Sustainable Yield as a primary management objective, I provided two documents for consideration by the European Union – a long, technical paper for the Commission's Scientific, Technical and Economic Committee for Fisheries, the other, shorter and less technical one, for The Greens/European Free Alliance in the European Parliament. These, and the text of my presentation of the second one to the Fisheries Committee of Parliament, are referenced below; copies are available.[2]

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[2] "New Policy Objectives and Management Procedures for EU Fisheries: A Commentary and Suggestions" A briefing paper for the European Policy Office of the WWF. 13 February 2007 60pp. "New Policy Objectives and Management Procedures for EU Fisheries: A Commentary and Suggestions to The Greens/European Free Alliance in the Parliament". 8 February 2007, 21pp. Statement by Sidney Holt to Fisheries Committee of EuroParliament, 11/4/07, 4pp.

These papers drew largely on the experience of the International Whaling Commission (IWC) which was the first international organization – and virtually the only one at that time – to have developed and exhaustively tested by computer simulation, a new approach to stock management.[3] Now let me try to explain briefly and non-technically the essence of the new approach; it will be familiar to modern engineers. First, to be clear, the IWC was prepared only to continue regulating whaling by setting annual catch limits, by numbers of whales, for each species and putative biological stock, rather than the more common practice in fisheries of referring to weight of catch, as a proxy for commodity production and value. This meant that any population model used need give little if any attention to the age structure of the exploited population; the only structural features in the models used were the separation of the sexes, and the distinction between mature and immature (hence older and younger) females.

Since 1975 – when the IWC formally adopted the prime objectives of seeking MSY, and allowing depleted populations to recover to abundant levels - the Commission's Scientific Committee had been using what is usually called a ***surplus production*** model – or, rather, a modified one, called BALEEN, to take the structural elements into account – to calculate supposedly "safe" catch limits. The properties of the model had largely to be assumed. The level of population giving MSY, for example, relative to the so-called "virgin" (unexploited) stock was assumed to be 60% although there was little empirical evidence to justify that, just as there is virtually no such evidence to justify various percentages that have been used – are still being used – in fisheries management of fin- and shell-fisheries. Similarly, although there was some evidence, for some species, of natural mortality and reproductive rates, there was practically none about the density dependence of those rates, which is what must be known to estimate sustainable yield rates. The result was that although the New Management Procedure (NMP), as the 1975 decision was called led to the closure of commercial whaling on greatly depleted stocks, it became evident, in just a few years, that it was almost useless for the management of whaling on stocks that were not yet depleted.

The NMP was rooted in the idea that each stock could be "classified" according to its assessed conservation status - Protection Stocks would be a few percentage points below the assumed MSY level; Sustained Management Stocks would be fairly close to the MSY level, and Initial Management Stocks would be somewhat above MSY level. It turned out that this sort of classification called for knowledge that far exceeded what was actually available, so there was endless argument at both scientific and administrative levels about the catch limits for stocks that were close to, either above or below, a classification boundary, with a

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[3] Since then the scientific development of this approach to management has been pursued, and examples are given, but the stage has not yet been reached elsewhere, as in the IWC, of having been formally approved (if not implemented) by management authorities.

corresponding temptation to distort science for essentially political reasons. It is important to ensure that the EU, in revising the CFP, does not fall into that trap.

Other unforeseen difficulties arose but these illustrate the main ones. In applying the NMP the Scientific Committee was obliged to spent almost all its time and energy in trying to calculate catch limits for every whale stock every year. This of course meant the assessments were not as good as they could have been, even with limited data. ICES, in providing advice to the EU Commission on annual TACs, has encountered the same problem, on an even larger scale. As a side effect of the declaration in 1982 of an indefinite moratorium on all commercial whaling the IWC's Scientific Committee was at last released to put its skills to devising a "Revised" Management Procedure (RMP). This was indeed one of the conditions that, when attained, would open the door to possibly modifying the moratorium; the other condition was that depleted stocks would have substantially recovered. The approach taken by the IWC scientists was to use population models (with BALEEN as the default) to generate artificial "data" that would be used in simulations of candidate procedures for calculating catch limits, to test them for efficiency and robustness, and to match data requirements with practical reality. A prime need was for a procedure that was not dependent on either the parameter values of a particular model or on which model was used of all conceivable models. The philosophy was the engineers' "testing to destruction". It soon became obvious that procedures that called, for example, for classification of stocks as "over-exploited", "under-exploited" or "optimally exploited" were unsuitable, at least in those simplistic versions.

A second realization was that sustainable yields could only be discussed usefully in a finite, pre-established time-frame. A stock does not, at a particular point in time, (during a year?) have a sustainable yield; that had been made clear in many scientific papers. A sustainable yield can only be thought of as an average or cumulative) yield over a certain time – and not an infinite time. Hence the suggestions for a revised procedure were intended to maximize the cumulative yield – in the whaling case this was in a period of 100 years: I will discuss later the criteria for deciding the length of the period - the management horizon. In the IWC case this was determined by a combination of computing power, and the life-spans of whales and humans, having in mind also the likely life-span of any social instrument charged with implementing the procedure. This last is important because the use of regulatory methods such as that devised by the IWC scientists depends on an initial agreement by managers, after which catch limits are set automatically, without annual negotiation. (Of course there has to be some kind of fail-safe to deal with very exceptional situations, but that too should be specified in advance. These details are explained further in the account of the RMP by Dr Justin Cooke, who was the "winner" of a prolonged and strongly refereed competition among different development groups in the IWC, encompassing very severe tests of efficiency and robustness to unknowns and unforeseeable events, including strong environmental changes.[4]

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[4] J. G. Cooke (1999) Improvement of fishery-management advice through simulation testing of harvest algorithms. *In* Confronting Uncertainty in the Evaluation and

The problem of avoiding accidental depletion during the management period came down to specifying a lower bound and the acceptable probability that the stock would be accidentally pushed below that bound at least once in the period. The IWC scientists chose – with the agreement of the Commission – not to define a lower bound related to any supposed dangerously low stock where extinction might be threatened, but a much higher level, at 54% of the estimated virgin stock, that is at what had been the boundary between Protection stocks and Sustained Management Stocks in the old system. The assigned probability for testing by simulation was 99% in 100 years, that is no more than one time in the management period. The problem of compromise between conflicting management objectives is easily seen here: if either or both the thresholds was set lower, or the acceptable probability of depletion higher, bigger short-term catches would be obtained at the expense of a higher risk of depletion. (It was later realized that tests must be made also of alternative distance of the management horizon: if the period were to be made longer then bigger catches could be made in the short-term - but recovery of depleted stocks would only be achieved after a long delay). I should say, too, that the end-game has to be specified: it is not allowed, as the horizon is approached, to catch most of the recovered the stock in order to boost the long-term average! Naturally, the more depleted is the target stock, or all the stocks in a management area, the longer will the recovery period necessarily be. It would seem to be commonsensical that the time horizon should extend to, probably beyond, the time when recovery will have been more or less completed, which depends on both the degree of depletion and the life-span and general dynamics of the target species.

In my two 2007 advisory documents I sought to explain how the IWC approach might be applied to fishery situations in which the aim is to maximize the average catch during a specified period (I wrote usually about <u>cumulative</u> catch but one can, of course, equally consider <u>mean</u> catch). The main change is to use multi-cohort models, with an age/size structure to provide test ”data” for simulation runs. This is obviously necessary when one is trying to maximize average catch in weight, where fish growth has to be taken fully into account. But there is an additional essential reason for this approach. It is that even if the simplistic idea that there exists, for a stock, a peaked curve of sustainable yield against fishing mortality (fishing effort) or population size (biomass) the location and the height of that peak depend crucially on the ages to which the fishing mortality is applied – which vary with, for example, mesh size in trawls, hook size in lines, location and season of fishing for practically all methods. In fact if there is an MSY it would be obtained – approximately - by catching <u>all</u> the surviving fish in every cohort (year class) in a very short time when they reach an optimum age. This would, however, normally require a practically infinite fishing effort, extremely narrowly focused, and is entirely impracticable except perhaps in a few special cases (some anadromous species, perhaps).

Implementation of Fisheries-Management Systems. *Edited by* A. I. L. Payne. ICES J. Mar. Sci. **56**: 797–810.

I suggested, for a start, the model I proposed with my colleague Raymond Beverton in our 1957 book that we called a self-regenerating model (S-RM).[5] This is a combination of a model that expresses the sustainable yield-per-recruit as a function of fishing mortality rate (fishing effort) with specified selectivity or, equally, as a function of stock biomass. (the curves sometimes being peaked, but not necessarily so, depending on the values of the parameters specifying individual growth and natural mortality rates), with a model specifying the expected numbers of recruits arising from a parent stock of specified size. The yield curves of such self-regenerating models are always peaked, but the location of the peak varies greatly with the population parameter values, and the curves can be "kinked", a feature the importance of which we shall see later. The stock-recruitment relationship used was the familiar B&H asymptotic model, and I illustrated this for the two papers to Parliament and the STECF in a simplified form in which the age of first liability to capture by the trawl-type gear in use is the same as the median age at sexual maturity, with males and females having the same parameter values.

In future studies a more flexible stock-recruitment relationship should be used. There are several published candidates for this and the well-known model by John Shepherd is perhaps the most suitable.[6] Another that has been used in some applications is that by W. Ricker; this is particularly applicable if it is believed that at very high population densities recruitment begins to decline with increasing abundance of spawners/larvae/eggs.[7] Shepherd also found an easier way to compute the self-regenerating models than that originally used by Beverton and me. More recently further advances have been made in modeling by L. Kell and his associates[8] and also by A. J. Constable and W. K. de la Mare, the latter authors having published a *General Yield Model* (GYM) of apparently universal application although it was developed in the context of managing fishing in the Southern Ocean.[9]

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[5] "On the Dynamics of Exploited Fish Populations". 1957, HMSO, London, 533pp. The fourth printing of this, dated 2004 and published by Blackburn Press of New Jersey, contains a historical resumé by me.

[6] Shepherd, J. G. (1982) A versatile new stock-recruitment relationship for fisheries and the construction of sustainable yield curves. *J. Cons. Int. Explor. Mer* **40**: 67-75.

[7] Ricker, W. E. (1954) Stock and recruitment. *J. Fish. Res. Board Can*. 11:559-623.

[8] Kell. L.T., C.M. O'Brien, M.T. Smith, T.K. Stokes, and B.D. Rackham. – 1999a. An evaluation of management procedures for implementing a precautionary approach in the ICES context for North Sea plaice *Pleuronectes platessa* L. "In Confronting Uncertainty in the Evaluation and Implementation of Fisheries-Management Systems. Payne, A..L (Ed.). *ICES Journal of Marine Science* **56**: 834-5. Also: Kell, L.T., Fromentin, J. M., Gauthiez F. and Restrepo, V. R. (1999b). A simulation framework to evaluate management strategies for Atlantic tunas: a preliminary example based on East Atlantic bluefin tuna. *ICCAT Working Document* SCRS/99/11 2095-116.

[9] A. J. Constable and W. K. de la Mare (1996) A Generalised Model for Evaluating Yield and the Long-Term Status of Fish Stocks under Conditions of Uncertainty. *CCAMLR Science* **3**: 31-54

Almost all population models that have been used in fish stock assessments as a basis for managing fishing contain a usually unstated assumption, that the fastest rate of population growth occurs when the stock has been reduced close to extinction. It has also commonly been assumed that the peak sustainable yield can be taken when the stock is well below half its pre-exploitation size, usually at about 30-35% of it. It is therefore not surprising that, given the huge uncertainties in assessment methods, and the assumption about high increase rates at low stock levels possibly not being correct, many fish stocks have been rapidly reduced to levels at which their survival might be in doubt.(Of course, such problems have been acerbated by the unfortunately common practice of administrations to set TACs higher than the best available scientific advice would support – what I call trying to negotiate with *Nature*.) Attempts to avoid such situations have been made, involving setting a reference point at a level below which the spawning stock is considered not to be viable. But such reference points, for minimal viable spawning stock, have no empirical basis and, like the MSY reference point – whatever it might be – are entirely arbitrary, though sometimes presented as "best scientific opinions".

The phenomenon of rates of increase beginning to decline as the stock is reduced is called depensation. Early studies indicated that, where the few available data had any meaning, there was no evidence of the existence of depensation. However, that conclusion of "no significance" is an artefact of the statistical methods used. In more recent studies it has become clear that depensation is not at all uncommon; in nearly half the cases where useful data exist it has been concluded that the presence of depensation cannot be ruled out.[10] This suggests that in simulation models the possibility of depensation must be acknowledged, and that if a reference point for minimum spawning stock size is to be defined (with regulatory implications such as shutting down the fishery) it must be set much higher than has been customary.

Another hidden assumption in most models is that the number of recruits depends on some measure of the size of the spawning stock from which those recruits were derived each year. This is, superficially, reasonable but at least two developments in population dynamics suggest that it might not be. One has been described by Lev Ginsburg and Mark Colyvan, and called the ***Maternal Effect Model***. In this model the survival of young (in fisheries the precursor of the recruitment process) is dependent not only on the numbers and "quality" of parents but in part on the quality of the previous generation, especially through the maternal line which transmits the genes to the egg that contribute to good or poor survival probabilities.[11] The maternal effect induces *inertial population growth*, which leads to long-duration population cycles. The likely existence of such cycles has, of course, profound implications for the notion of sustainable exploitation.

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[10] See e.g. Hutchings, J. A., (2000), who has reviewed the fisheries literature and demonstrated that slower recovery of depleted stocks than expected is common: "Collapse and recovery of marine fishes" *Nature* **406**: 882-5, 2000.

[11] "Ecological Orbits" (2004), Oxford University Press, 166pp.

Another type of inertial growth leading to long-term cycles has been presented by Lars Witting.[12] It rests on the idea, related to that of Ginsburg and Colyvan, that there are genetic difference in the survival probabilities of individual eggs and larvae and of young animals which impel evolution to an intrinsic hyper-exponential growth rather than the intrinsic exponential (geometric) growth that has dominated population dynamics theory since proposed by Malthus and Verhulst in the mid-nineteenth century. Witting's models also predict cyclic population change, especially in long-lived species, and his application to, for example, the grey whale has made sense of otherwise inexplicable population recovery data.[13]

Other well-known features of interactions between different species, especially predator-prey interactions, are responsible for population cycles and these ultimately must be taken into account in any multi-species management scheme or "ecosystem approach to management". A special predator-prey interaction is common in the form of cannibalism in the bony fishes – teleosts - between different stages of the same species (for example adult cod are major predators on their own young.)[14] Dr Alan Longhurst is on record as claiming "There is plenty of support for Walter Nellen's suggestion that a transfer of energy occurs along a food chain from small to large individuals of many teleost species. For these, we might conclude that the function of large incoming year-classes is not to enable rapid population growth, but rather to contribute to the nourishment of the entire adult population by transforming food particles that are too small to be useful to adults - even smaller fish, euphausiids, hyperiids, etc. - into items of food large enough to be consumed profitably. Perhaps the main function of young gadoids in high latitudes is to nourish their elders and their betters!" Longhurst's reference here to "their betters" is to the finding that in many species the contribution to the next generation by older and bigger spawners is high, beyond being merely proportional to their weight. This adds strength to my belief that assessments and regulatory procedures must take special care to maintain the proportion of older fish in the stock, beyond the fact that they are usually more valuable in the market than smaller ones.

In the development of the IWC's RMP the candidate catch limit algorithms (CLAs) that would be used to calculate annual catch limits were tested against "data" generated by a variety of models and suites of parameter values. But in fact the choice of alternative models (made in the effort to ensure that the

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[12] "A General Theory of Evolution: By Means of Selection By Density Dependent Competitive Interactions". (Peregrine Publisher, Arhus, Denmark, 332pp, 1997).

[13] In a recent (29 October 2009) contribution to an open-ended *Nature Network Forum* on **Theoretical Population Dynamics**, Dr Martin Chester has contributed a theorem demonstrating that cycles should be expected in population size without necessarily the involvement of inter-specific inter-actions, time lags, or particular genetic considerations. This can be followed by joining the Forum on http://network.nature.com/groups/populationdynamics/forum/topics/5854?p

[14] A. Longhurst (2006) The Sustainability Myth. *Fisheries Research* **81**: 107-112. This is an advance version of the extended text of a talk delivered to a meeting on Western Groundfish, at Santa Cruz, California, in February 2008..

performance and robustness of a selected CLA would be as free as possible from dependence on the data-generation model) was somewhat limited but because the accepted management criteria (MSY-level: acceptably low probability of accidental depletion; lower cut-off level), were extremely precautionary such limitation has probably not undermined the usefulness of the adopted Procedure. But in applying this process to fin-fisheries management a wider range of different population models would have to be tested.

In seeking a way of managing the exploitation of individual stocks and species the IWC scientists had to confront the problem of interactions between the target and other whale species, and other – competitive - predators on the same food resource, a well as unexpected environmental changes The approach to the latter problem was quite straightforward – simply conduct simulations in which hypothetical gross changes in the environment,, short- and long-term, were assumed. The problem with species interactions is more complicated. There is, I think, a near consensus among scientists engaged in conservation and management research that we are still very far from being able to model such multi-species interactions or having adequate empirical data for safe management purposes, and even further from practical means for "ecosystem management", no matter how desirable those may be in principle. In these circumstances those scientific groups agreed that a single-stock approach – what has been called, pejoratively, "extreme reductionism= - was the only practicable one at this time. Hence there is a need for continuous monitoring of the other elements of the ecosystem, especially those known to have a direct biological connection with the target species, so that adjustments can be made from time to time to the details of the management decisions so as to deal with any detected changes.

Lastly, the CLA, which was devised for managing the exploitation of a single population of a species, had to be integrated into an overall procedure by which possible - but not well defined or understood - groups of populations of the species occupied an extended geographical region. This danger - of applying catch limits mistakenly to a large area in which one population was presumed to range when in fact there might be several populations, and applying a single catch limit, would possibly lead to the over-fishing or even the extermination of one or more of them - has for years plagued fishery managers as well as managers of whaling. The IWC scientists tackled this by dividing large management regions into numerous "small areas" – arbitrarily – and then testing, again by simulations, the consequences of various ways of applying the CLAs to all those areas. A similar approach could - and I think should - be taken to management of fisheries generally. But a warning about this problem of managing the exploitation of separate, but possibly geographically over-lapping stocks is timely. H. Reiss and colleagues have recently demonstrated that in fishes such as herring, cod, hake, haddock, there is a mismatch between biological and fisheries management units. They emphasise the need for a revision of these units and question the appropriateness of current management measures. They conclude that: "The implementation of complex and dynamic population structures into novel and less static management procedures should be a primary task for future fisheries management approaches.” [15]

I end this Prologue by a brief consideration of the means of ensuring the third objective of the fishing management system, namely maintenance of stable catches from year to year insofar as the natural variability of the stock permits this. This was not achieved in the IWC case although the problem was recognized. Since then other assessment and regulatory agencies have approached it by making another decision rule- that catch shall not be allowed to change – except in specified unusual circumstances – by more than a certain amount or percentage from one season to the next (or at the times of regular surveys and re-assessments – five year intervals in the IWC case. by providing that catch limits shall not change by more than a certain amount from one year to the next. ICES has followed a similar course in some of its advice to the EU Commission. There is however a danger in such a simple solution: it could be that the unexpected change in the stock, or to the assessment of its state, is so large that a simple proportional limit to the permitted change in a catch limit will maintain catches bigger than they should be to avoid continued reduction in the stock. This appears to have happened in past actions under the CFP. So a supplementary rule is needed to prevent the stability rule from leading to catch limits higher than the calculated sustainable limits. But, further, if the management objective is to obtain the biggest practicable average catch over an extended period, as advocated here, then the supplementary rule must take that into account, and cannot properly take the form of a simple adjustment of the current catch limit.

GENERAL ADVICE

The Commission should follow the path pioneered by the IWC Scientific Committee by defining MSY as the maximum feasible *average physical catch over a pre-determined period* - the *management horizon* - that is compatible with a defined probability of any accidental depletion to a predetermined lower bound of the biological stock. The length of that period should not – as it was a decade ago in the IWC case – be affected by computing limitations; the relevant factors are the life-spans of the target fishes, reasonable appraisal of the economically and politically determined duration of the management institution, and assessment of the likely time required for substantial recovery of depleted stocks.[16]

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[15] Reiss, H, Hoarau, G., Dickey-Collas, M. & W. J. Wolff, W. J. (2009). “Genetic population structure of marine fish: mismatch between biological and fisheries management units.” *Fish and Fisheries* **10**: 361–395

[16] William de la Mare has offered the opinion (*in litt, 17 Nov. 2009)* that for short-lived species the horizon needs to be at least 30 years, and for long-lived species considerably longer. He has suggested a starting rule might be 10/natural mortality rate M, which would imply about 50 years for many commercial fishes, and up to two centuries for whales. Additional rules would have to ensure that no tricky operating decisions were made that would allow unreasonably large catches in the early years with the thought that that bad behaviour could be made up for in the very distant future. It is, nevertheless, clear that the horizon has to be far enough to accommodate more than one population cycles if the data and models have such a property.

Alternative values for all of these decisions – probabilities of depletion, threshold reference points, duration of the horizon - should all be tested by simulations. Criteria for evaluating the results of those simulations must be agreed before they are undertaken. Simulations are needed also to decide whether those decisions should be made for each target species, or a universal set of rules devised that would be applicable, but probably not optimal, to several or all species. Similar consideration must be given to alternative properties of the data-generation models, such as whether they allow the possibilities of depensation and cycles, and what is the range of putative MSY levels to be examined. But the important expansion of the simulations like those undertaken by the IWC scientists is that a range of selectivity of fishing gears and operations has to be chosen.

In the *Prologue* I have mentioned several types of "data"-generation models: Beverton and Holt with alternative stock-recruitment functions, Shepherd, de la Mare and Constable and there are perhaps others. It probably does not much matter which is used – convenience and flexibility are the key features. However the output will necessarily include not only the size of the average catch by weight but also some measure of the size of fish in it, such as the mean length or weight and also an appropriate measure of the statistical dispersion of the size distribution. This should make possible the calculation of an index of the relative value of the average catch as well as its size.

THE STOCK MANAGEMENT ALGORITHM

Generation of this algorithm is by far the scientifically most creative part of the process of developing an operationally satisfactory stock management procedure., and advice on how to go about that is best given by one or more of those experts who have themselves done something similar. The output from the algorithm is naturally the defined primary aim of management, which I propose to be either an average catch over a pre-defined period, or such an average weighted by the market or other relative values of fish of different sizes or other qualities. However, the regulatory data for applying the algorithm (and the input for the simulation tests) are not necessarily of the same kind. In particular we should not necessarily be inputting putative annual catch limits (TACs) in order to predict average catches; in fact I shall suggest that is possibly the worst way of limiting fishing in order to prevent over-fishing or allow recoveries of depleted stocks, even though it is by far the most common approach to regulation today.

The main, and far better, alternative is the limitation of ***fishing effort***, and the arguments favouring that have been made in many scientific studies. It is quite possible to create an economically very inefficient industry by limiting fishing effort but not limiting ***fishing power***, or ***fishing capacity*** as it has been called, though defined rather loosely. Documents of the European Commission and others frequently refer to this notion of *capacity*. Unfortunately it has been defined by FAO as: *"The amount of fish (or fishing effort) that can be produced within a period of time (e.g. a year or a fishing season) by a vessel or a fleet if fully utilised and for a given resource condition."* To use such an important term alternatively as a quantity of fish (output) or an amount of fishing effort (input) introduces counter-productive ambiguity into discussions of management. I avoid it, preferring to use well-defined terms in the scientific literature of fisheries management. But if "capacity" is to be used at all it should probably be as a quasi-synonym for "power". The fishing power of *a fishing unit* is the fishing mortality rate it would cause in the target population(s); it is not to be confused with the engine power of fishing vessels: hp or kW. Thus the fishing power of the fleet should, by management, be adjusted so as to cause, when normally deployed, the desired fishing mortality rate that will ensure sustainability according to the management algorithm. In this case the mortality rate must be defined as an exponential (not a percentage) so that the rates exerted by the various units are additive with regard to the effective power of the fleet. Fishing effort and fishing power must be properly matched, otherwise vessels are kept idle as and when it becomes necessary to reduce effort in order to reduce the fishing mortality rate. The aim of regulation is to generate an appropriate level and pattern of fishing mortality rate in the stock. TACs seem to provide an indirect way of doing that, fishing power control is a direct way, and for that reason alone is preferable in principle.

Let me further clarify definitions. Fishing power requires calibration to deal with differences among vessels in the fleet and with changes (usually improvements in efficiency) over time. The methods for doing this when only one type of unit is being deployed (beam trawl or long-line for example) are fairly well established; two methods can be used – comparative fishing experiments and analysis of catch and effort statistics – and both are generally desirable. Determining relative fishing powers of different types of fishing unit employed in the same fishery is more complicated but possible; the main difficulties arise from the different selectivities (by fish size, for example) of the different types of unit – remembering that the unit is defined with respect to the vessel, the gear, and the mode of operation, including the location and less tangible skill factors, especially coming from skippers' experience

Article 3(m) of Commission document COM(2002) 185 final 2002/0114 (CNS) of 28.5.2002 "Proposal for a Council Regulation on the conservation and sustainable exploitation of fisheries resources under the Common Fisheries Policy" defines *fishing capacity* as "a vessel's tonnage in GT and its power in kW, as defined in Council Regulation (EC) N° 2930/86. For certain types of fishing activity, capacity may be defined in terms of the amount and/or the size of a vessel's fishing gear". Elsewhere in that document, for example Article 10, (and in the corresponding CouncilRegulation, the term is used almost always to refer to the capacity of a fleet, and presumably that is the arithmetic sum of the capacities of all licensed fishing units. I am indebted to the Pew Environment Group for permission to append to this document the review by Ms Hélène Bours of the history of the use of ideas about fishing capacity and effort by the European Commission (Annex 2).

In 1983 the European Commission launched a series of Multiannual Guidance Programmes (MAGPs) concerned with fleet structure and especially the matter of reducing excess capacity and hence excessive potential fishing effort. A report

by the European Court of Auditors[17] summarized the effect of the series of MAGPs:
"… the combined effects of over-modest objectives, management problems, and the use of structural funds for shipbuilding and modernisation resulted in the failure of these programmes. This led the Commission to abandon this approach in 2003."

Ms Bours concludes her review thus:
"As mentioned in this report, the EU has abandoned programmes to decrease capacity. Excess fishing capacity has been identified as one of the major drivers of over-fishing, legal or not. The FAO has adopted an International Plan of Action on the Management of Capacity which, even though not very forceful, is not implemented. Even worse, there is strong resistance from Member States to have such programmes imposed again. Various management tools such as TACs and quotas, technical conservation measures, etc are bound to fail or be undermined as long as the amount of fishing capacity is far superior to what is needed to exploit fish stocks sustainably."

These past actions regarding limitation of fleet capacity began with moves to limit the operations of new entrants to the EU and then started to address the problem of comprehensive over-capacity. Here I am proposing a far more sophisticated use of the notion of capacity, translated into effort, as the prime means of regulating fishing to attain high sustainable yields, reduce the probability of accidental depletion of the stocks, and facilitate the controlled recovery of depleted stocks. But before going further into that matter we should look at some other definitions in the Commission's 2002 document cited above.

Paragraph 3(g) defined *fishing effort* as "the product of the capacity and the **activity** of a fishing vessel; for a group of vessels it is the sum of fishing effort exerted by each vessel of the group". That is essentially the same as my usage if the capacity of a vessel is taken to mean the calibrated fishing power of a fishing unit.

Paragraph 3(e) defined *fishing mortality rate* as "the catches of a stock over a given period as a proportion of the average stock available to the fishery in that period." This is a quantity more commonly referred to in fisheries technical literature as the *harvest rate*. For regulatory purposes the fishing mortality is better defined as an *exponential* rate, ***F***, not as a proportion, so that the sum of the rates induced by each fishing unit is equal to the overall rate induced by all vessels on the stock. (A common source of confusion in this matter is lack of clarity about whether one is talking about fishing mortality applied to the entire stock or to that part of it that is "available" to the fishery.)

Lastly, paragraph 3(f) defined a *stock* as "a living aquatic resource that occurs in a given management area". This purely geographical concept is only partially satisfactory for management purposes since a management algorithm is basically applicable to a single biological population and there might be several, of the same species, in any large management area. The IWC scientists have shown us

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[17] Special Report No 7/2007 on the control, inspection and sanction systems relating to the rules on conservation of Community fisheries resources. It can be found at http://eca.europa.eu/portal/pls/portal/docs/1/673627.PDF

how that problem may be approached by defining many small areas within the large one, more or less arbitrarily if there is no empirical information available about boundaries and mixing of populations, and applying the algorithm to them individually. This could be more difficult if the algorithm concerns effort limits rather than catch limits.

Evidently the efficient way to use direct control of the desired fishing mortality rate by limitation of the fleet fishing effort is through the limitation of capacity supplemented by such time-to-time limitation of its deployment as found to be necessary. The capacity of the fleet is not something that can be changed from year to year except as part of a process of transitional and continuing renewal but the degree to which it is deployed, particularly in terms of time at sea or on fishing grounds or operating can in principle be adjusted. The common mistake, in some fisheries in other regions has been to adjust time by designating fishing seasons without limiting capacity. This not only forces inefficiency but also provides opportunities for evading regulations, and practically encourages such behaviour.

It is reasonable to ask how efficient, in terms of catches, would be a management system aimed at high average catches with very low probability of accidental depletion during the defined horizon. There is no universal answer to that, naturally, but Dr Justin Cooke, the inventor of the catch limit algorithm with the best overall performance, devised by the IWC, has written that in extensive simulations with parameter sets appropriate for cod, herring, orange roughy, bluefin tuna and capelin:

"The average catches achieved range from 27-81% of the theoretical MSY. On the face of it this does not appear to correspond to full utilisation of the resources. However, this is achieved with a management procedure that ensures negligible risk of stock collapse, keeps stock biomass close to natural levels, and provides catches that are relatively stable within the constraints imposed by the level of available data and the natural variability of the stock. Additionally, fishing costs are kept low by maintaining the stock at levels which provide a high catch per unit effort. Currently managed fisheries typically do not realise a greater proportion of the theoretical MSY, because most of the stocks are overfished."

We shall look a little later at the other advantages of such an outcome. Cooke's suggestion, which I think is reasonable, is that the aim should be to try to keep fish stocks in the region of 75-80% of their unexploited level, and that this would be achieved by keeping the fishing mortality rate at roughly one half of that which would theoretically provide MSY.[18] It is interesting, and more than a coincidence, that the authors of a recent booklet published by the World Bank and FAO concluded that a bit less than the relatively stationary global catches could be obtained with about half the present fishing effort, and yield substantial profit rather than overall economic loss, countered only by subsidies.[19]

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[18] J. G. Cooke "A precautionary approach to fishing". March 1995 Unpublished manuscript, 25pp. This document, provides, as an Annex, the results of simulations of a catch limit algorithm fitting the suggested criteria.

[19] World Bank (2009) The Sunken Billions: the economic justification for fisheries reform. 100pp. The World Bank and FAO, Washington DC and

I should perhaps explain here that in my opinion management to seek high average net economic yield rather than high average physical yield, is entirely in conformity with the requirement of the UN Convention on the Law of the Sea (UNCLOS) in which Articles 61.3 and 119.1(a) seek, through an MSY objective, to:

*"…ensure through proper conservation and management measures that the maintenance of the living resources in the exclusive economic zone/on the high seas is not endangered by over-exploitation, [and] designed to maintain or restore populations of harvested species at levels which can produce the maximum sustainable yield**, as qualified by relevant environmental and economic factors …** "*

Furthermore, sustainable exploitation at the lower fishing mortality/effort level implied by sub-maximization of the difference between the value of the catch and the cost of taking it resulting in higher catches-per-unit fishing effort, must be expected to be more economically beneficial to the individual fishing unit.

WHY REGULATE INPUT RATHER THAN OUTPUT?

The idea that catch limitation is a simpler and more reliable instrument of governance than limitation of calibrated fishing power (capacity) and effort is an illusion. It stems primarily from the apparent simplicity and universality of collecting catch statistics. In fact even the veracity of normal official records is illusory. How many users realise that, for example, several of the statistical series archived by FAO on the basis of submissions from governments have been constructed by applying conversions factors (multipliers, actually) to records of a derived commodity such as fishmeal or fillets? More important, however, is the prevalence and scale of Illegal, Unregulated and Unreported fishing (IUU) . But there are more fundamental reasons for preferring power/effort regulation, and they have to do mainly with the scale and types of uncertainties, both in acquired knowledge about fishes from relevant scientific research and from a vast assortment of sources of natural variation, as well as the relation between these and human activities.

W. M. Getz and R. G. Haight [20] , in their discussion of how the stochastic reality of fish populations [that is, the fact that growth, mortality and reproduction

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Rome, Italy. [The authors of this study were Rolf Willmann, Kieran Kelleher and Ragnar Arnason. A digital, pdf, version is available as an e-book.] In my published critique of that document I have concluded that their data show that the economic benefits of reducing fishing capacity would be substantially greater than they claim and that the sustainable catches, from recovered stocks, would be higher than the present global catch. [Holt, S. J. (2009). Sunken Billions - But how many? *Fish. Res.* **97**: 3-10.

[20] Getz, W. M. and Haight, R. G. (1989) Population Harvesting: Demographic Models of Fish, Forest and Animal Resources. 391pp. Princeton Univ. Press, New Jersey. Several other titles in the literature of the science of fisheries management refer to the advantages of limiting fishing power or effort. R. J. H. Beverton did so in a post-humously published lecture. Getz and Haight cite E. K. Pikitch's study of a US West Coast demersal fishery as a successful example: "Use of a mixed-species yield-per-recruit model to explore the consequences of various management policies for the Oregon flatfish fishery" *Can. J. Fish. Aq Sci.* **44**, (Supp. 2): 349-59.

parameters are subject to random variation as well as possible trends over time and uncertainties in estimating them *sjh*], may detract from the efficiency of regulation based on single species deterministic models characterize three general approaches as follows:

> "1. A *fixed-escapement* policy [that is, one designed to permit the catching of all the stock except a residual needed to ensure future recruitment *sjh*] is designed to stabilize the stock but only at the expense of the catch, possibly even closing down the fishery in years when the stock is particularly weak.
> 2. A *constant-catch* policy requires that we allow the stock to fluctuate and, in the long run, and if a constant-catch policy does not respond to severe weaknesses in the stock, it can destroy the fishery altogether.
> 3. A *constant-effort* policy has the advantage of stabilizing labour and capital invested in the fisheries operation, but at the expense of transferring variability from the stock to the catch.

Results from various case studies…indicate that constant-effort policies exhibit less yield variability than fixed escapement policies , and greater stock stability than constant-catch policies."

Essentially the same resultant characteristics arise from corresponding policies that permit regulatory actions to change from one year or period to the next. The present CFP may be regarded as a blend of Getz and Haight's policies 1 and 2 in variable form. Thus the setting of annual TACs is a form of policy 2 and the change of decision (which can be as drastic as temporary closure of a fishery) when a stock is below a threshold of minimum spawning stock biomass is a form of policy 1. We need to look more closely at this latter aspect of current EU governance.

The threshold level of the spawning biomass (its <u>composition</u> is hardly ever mentioned, beyond the obvious fact that it consists of sexually mature or about-to-become-mature fish, possibly adjusted to the sex ratio) is a pseudo-scientifically determined quantity. That is to say it is one proposed by scientists but having practically no basis in empirical studies, by which I mean "information gained by means of observation, experience, or experiment". Two questions may be asked about it – does a threshold exist? And, if so, where is it? The Present CFP presumes its existence, and sets special rules for management decisions when a stock is found to be – or more usually <u>suspected</u> to be – below the threshold. But it goes further. In paragraph 3(h) of the 20 December 2002 Council document, - REGULATION (EC) No 2371/2002 - the threshold is defined in terms of ***safe biological limits***, meaning "indicators of a state of a stock or of its exploitation above which there is a low risk of transgressing certain limit reference points". Article 5 deals with Recovery Plans and in its Paragraph 2 we see that they "shall be to ensure the recovery of stocks to within safe biological limits"; in the original Commission proposal for this regulation there was a substantively different formulation.[21] Paragraph 6 requires that

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[21] As follows: "*…for stocks outside safe biological limits, ensure their* ***<u>rapid</u>*** *return within those limits,* and *for stocks at or within safe biological limits, maintain them within those limits"*

Management Plans shall be multi-annual, "be drawn up on the basis of the precautionary approach to fisheries management", "take account of limit reference points recommended by relevant scientific bodies" and "indicate the expected time frame for reaching the targets established". Paragraph 2 provides that "Management plans shall include conservation reference points such as targets against which the maintenance of stocks within such limits shall be assessed.

ICES, as scientific advisory body to the Commission, has given much attention to reference points, and specifically to that defining the *safe biological limit* threshold. Although the correct approach is to look at the properties of appropriate self-regulatory models, and their behaviour at low population abundances, it is common to consider simply the relationship between recruitment and spawning biomass. Whichever of these is the focus of attention one natural lower threshold of stability and continuity of the population is provided by a point of inflection in the relevant curve of sustainable yield against stock size, indicating the existence of depensation (positive density-dependent feed-back). This reference point, if it can be found, identifies a threshold below which the population will proceed to extinction even if fishing pressure is reduced or ceases. But in practice it is usual to try to fit data for recruitment and stock size to a simple continuous function, of which the most common are those by Ricker, Beverton and Holt or Shepherd. Except for curves with certain parameter values in Shepherd's model signaling depensation these are practically indistinguishable for small population sizes. They do not in themselves give any clear indication of where a practical threshold might lie.

C. M. O'Brian and D. L. Maxwell have proposed an ingenious way, called segmented regression, of fitting such data to a discontinuous graph, in which for lower stock abundances the recruitment is directly proportional to the stock size, and for higher abundances the recruitment does not change with stock size.[22] The break point between the two regressions suggested to those authors a possible threshold for a safe biological limit to be adopted for management purposes. In 2002 they applied their method to several species-stocks for which there were fairly good data – anchovy in the Bay of Biscay, mackerel in the Northeast Atlantic, herring in the Thames Estuary, herring in ICES SubArea IV and Divisions IIIa and VIId, plaice in Division IIIa, cod in Divisions VIIc-k, VIIa, Via, in IV, IIIa and VIId, and in Sub-Areas I and II Northern hake, saithe in Sub-Areas I and II. What was evident was that where a break could be identified statistically its location on the stock-size axis varied enormously as between species and stocks. In some cases it was at around 20-25% of the largest stock size historically encountered, in others well over half of that stock size.[23]

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[22] See the ICES Advisory Committee on Fisheries Management, Document *ICES CM 2002/ACFM:10 Ref. ACE, D* "Report of the Study Group on the Further Development of the Precautionary Approach to Fishery Management". Lisbon, Portugal 4–8 March 2002

[23] O'Brian, C. M and Maxwell, D. L. (2002). "Towards an operational implementation of the Precautionary Approach within ICES – biomass reference points." *In* Report of Study group… [see above. Annex 2, Working Document 8]

One problem with the segmented regression approach is that if the break is taken to be the threshold where the management rule changes then one is already too near to a collapse point, since movement below it will set in train – in theory – a steady decline of the stock because the recruitment will decline proportionately, which will only happen with a continuous function when the stock has been reduced to extremely low levels. Such considerations have led scientists to try to define "precautionary reference points" which are safer, more conservative, perhaps by a certain fractional value than the basic ones. [24]In fact, the IWC scientists tried to do just that when the IWC adopted in 1975 its New Management procedure – so.called safety factors were that the permitted catch would never be set at more than 90% of the estimated MSY, although at the same time the risky procedure was used to allow catch limits to be non-zero even when the stock was judged to be up to 10% less than the MSY level. These simplistic subsidiary rules were disastrous, not least because the scientists' ability to estimate stock size and biological productivity was nowhere near to what would be required properly to implement such "safety" and "risk" factors.

In some management practices it has been assumed that the cut-off point might be about 20% of the unexploited size. Such evidence as there is suggests it should be higher than that (The IWC scientists assumed a threshold between regulatory stock classifications at 54%, that is 10% below the assumed MSY level of 60%.) From where came the "traditional" 20% is obscure, but apparently from another assumption not supported by empirical evidence, that the MSY-level for dish populations – or at least teleost (bony-) fish populations - is at about 40% of the unexploited stock size and that "safe" fishing operations would keep the stock at rather more than half that. This however is virtually "scientific hand-waving" and is reduced to absurdity if statements are then built on it about the expected probabilities of excessive accidental depletion.

The approach by the IWC scientists is by far preferable: to set a threshold at which catch limits become zero (if TACs are the means of management) or where a moratorium is called for under a fishing effort limitation regime, which is not so much a dangerous minimum but a desirable high level not far, if at all, below the presumed MSY. But preferable to such provisions for "classification" of stock "conservation status" is to adopt algorithms that provide continuous fall in risk if the stock declines (or falls into a less productive state by change in composition).

Maintenance of stocks at high levels, and with compositions not too far from their unexploited compositions, simply by limiting fishing mortality rates by fishing capacity limitation and effort control, brings more benefits (catch rates, profits and substantial long-term catches) than do the lower catches obtained by

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[24] William de la Mare has reminded me that in this connection he devised a decision rule which used probability criteria for setting regulations based on the probabilities of being above or below "reference points". This is described in Logan, G., de la Mare, W., King, J. and Haggarty, D. (2005) "Management Framework for Strait of Georgia Lingcod". *CSAH Research* Document 2005/048, Fisheries and Ocean Canada, 102pp.

taking a larger percentage of a smaller biomass every year. One of those benefits that has long been recognized is the ***buffering effect*** of exploiting a stock with more age-classes surviving for longer than would be found in intensely fished stocks. And, in addition, such management would automatically greatly reduce the problem of discards of target fish species. If TACs are not used to regulate catches then there is little point in forcing the discarding of truly accidental "excess" catches. Control of the undesirable catching of juvenile fish is better done by regulating the gear type and the locations and times of fishing than by discarding. The incidental kills of non-target animals such as marine mammals, turtles and sea-birds, as well as of practically and unintentionally endangered species such as skates, are likely to decline at least in proportion to the reduction of fishing effort to meet revised objectives – a major saving. Similarly the inevitable habitat destruction caused by heavy gears like bottom-trawls should decrease in proportion to the reduction of effort.

At this point it is appropriate to quote *in extenso* Justin Cooke's advisory paper of 1995 cited above:

"The mainstay of precautionary fishery management should be to keep fishing effort under control, so as to limit the impact of fishing on the target species and the ecosystem. Limitation of fishing effort brings several advantages in the longer term. As fishing intensity increases, the target species will make up a smaller proportion of the total catch. By-catches of other species of fish and wildlife will increase, in both absolute and relative terms. According to conventional ecological models, the biodiversity of the marine ecosystem can be expected to decrease with increasing fishing intensity. In the shorter term, the loss in biodiversity is mainly quantitative, as reflected in standard indices of species diversity (an increasing proportion of the standing biomass consists of a decreasing number of species), without there necessarily being any actual loss of species. In the longer term, prolonged heavy fishing would eventually be expected to lead to a reduced diversity of species.

In the case of bottom-trawling, higher fishing effort means more frequent disturbance of the benthos, which changes the structure of benthic communities, reduces benthic biodiversity, and can make conditions less favourable for the reproduction of commercially important fish species, including those which are not themselves fished demersally. A further advantage of keeping fishing effort low and maintaining stocks at high levels is that the annual catch can easily be obtained by fishing in only a limited part of the area inhabited by the fish stocks. Thus, extensive closed areas can be established covering 50% or more of the stock area with little or no loss to the fishery. This is in contrast to the current situation in some over-fished grounds where virtually the entire grounds have to be swept, sometimes several times in a season, in order to attain a TAC. The designation of protected areas (no-fishing zones) will protect natural benthic communities or, in the case of previously disturbed grounds, enable them to re-establish themselves. The limited evidence available suggests that benthic communities can recover quite rapidly provided they receive protection in the near future while the constituent species are still present in the environment."

TRANSITION

Finding ways of moving from an over-fished situation to a good sustainable high productivity one relatively painlessly, in economic and social terms, is as important as deciding on better management objectives and procedures. And in some respects it can be more difficult. Declaration of a species or species group or area moratorium can make things easier provided there are alternative uses for the temporarily unemployed fishing units. This is a problem that should be tackled by conducting simulations of alternative rates of change (mostly of reduction, considering the number of already over-fished stocks), either of TACs or, as recommended here, of fishing capacity and effort. As far as I know no such simulations have yet been made for any fishery, but perhaps some are, somewhere, being undertaken. The reduction of capacity and effort is probably easier than that of TACs, though in both cases catches will inevitably fall until stocks have begun to recover. But in the case of catch reduction, which involves dealing reasonably with annual variations in recruitment and stock availability, the economic disruption is likely to be greater.

The Commission's present recovery plans are specifically intended only to move depleted stocks out of the danger zone bounded by the zone of *safe biological limits*. This will take a shorter time than needed for real recovery to the high level and new more stable composition of stocks demanded by recovery towards highest feasible average sustainable catch; recovery to economically optimal state will take rather longer.. Thus any temptation to re-open or increase a fishery prematurely by upgrading the fleet capacity would have to be resisted. Just as attainment of the desired modified MSY target depends on getting agreement on a tested procedure and then refraining from negotiation either of annual TACs or changes in fleet capacity, there would have to be advance agreement on any ways in which, and reasons for, any adjustment of regulations and fleet limits and deployment would be negotiated – in exceptional circumstances – during the recovery period of the management horizon.

If the suggestions in this paper were to be accepted then there would be two, presumably simultaneous transitions: one from management merely for sustainability to management for high average physical yields, the other from TAC-based regulation to fishing effort and capacity regulation as the primary management process. This would, of course make simulation of various options and scenarios more complicated but still feasible.

ACKNOWLEDGEMENTS

Although the views expressed here are my own I must acknowledge the suggestions and encouragement I have had from several colleagues in recent years: Justin Cooke, William de la Mare, and especially Michael Earle who read the penultimate draft with an eagle eye and helped me clarify certain parts of it. In particular Ms Bour's unpublished document entitled "Evaluating options for strengthening the European Union (EU) Common Fisheries Policy (CFP)", dated 29 March 2008 has been a most useful reference. I am further indebted to the European Marine Program of the PEW Environment Group and its associates for financial support and encouragement.

ANNEX 1

SHORT BIOGRAPHY OF THE AUTHOR.

I am an English marine biologist, born in 1926, educated at the University of Reading, England and now resident in Umbria, Italy. Now in retirement, I was the co-author, with the late R. J. H. Beverton, of a book – *On the Dynamics of Exploited Fish Populations* – published in 1957, which has been has been described by my peers, flatteringly, as: "…the most widely cited fisheries book ever published. . . a great work (that) created a solid foundation for one of the two major global visions of the science of fisheries. This book was the genesis of the modern age-structured approach to the optimal management of fishery resources." The fourth printing of that book, with a historical introduction and update by this author, appeared in 2004.[25] I have published more than 200 other documents, scientific papers and book chapters on various aspects of marine living resources research, conservation and management.

I served with the UN System for 25 years, including as Director of FAO's Fisheries Resources and Operations Division, in Rome. I have also worked for UNEP Regional Sea Programme, for Unesco/IOC (as Secretary of the Intergovernmental Oceanographic Commission) and for the UN (during the conference that led to UNCLOS) and have held chairs/fellowships at the Universities of Malta, California Santa Cruz, Rhode Island and Cambridge, England. As a UN staff member I was associated with many of the international regional and specialized fisheries management organizations, being involved in the establishment of some of them, and also with the negotiations that led to the UNCLOS..

I have received several awards - Gold Medal of WWF; Blue Planet award of IFAW; Global 500 of UNEP; Royal Netherlands Golden Ark - for my contributions to fisheries science, to marine conservation, to the protection of marine mammals and to animal welfare.

I have served, and still serve from time to time, as marine policy and science consultant to several NGOs and a few Governments.

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[25] For an idea of scientific developments since then see Alida Bundy's Review (*Fish and Fisheries* **10**(4): 476-8, 2009) of "Advances in Fisheries Science: 50 Years on from Beverton and Holt". Edited by Andy Payne, John Cotter and Ted Potter. Wiley-Blackwell, Oxford, UK, 2008, 546pp.

ANNEX 2 EXTRACT FROM:

Evaluating options for strengthening the European Union (EU) Common Fisheries Policy (CFP)

by
Hélène Bours
29 March 2008

4.2 Management tools (input vs. output control):*c) Effort Control*

The history of effort control in the EU is long and complicated and to understand how it evolved requires consideration of the accession of Spain and Portugal in 1986. The ten existing Member States were worried about the impact of giving unlimited access to these fleets, so a transition period, to last until 31 December 1992 (later extended to 2002), was agreed to allow for the gradual incorporation of these two fleets. The Act of Accession of these two countries in 1986[26] thus included limits to the number of Spanish- and Portuguese-flagged vessels allowed access to certain waters under the jurisdiction of the existing Member States (the zone later became known as the "Western waters", see map below). The waters around Ireland[27], referred to as the Irish Box, were excluded from this access until 31 December 1995. From certain other waters, such as the North Sea, these two fleets were excluded entirely.

Among the controversial debates during the run-up to the reform of the CFP in 1992 was the continuation of the various derogations to the Treaty's principle of free access, including the prevention or limitation of access for Spanish and Portuguese vessels to certain fisheries. Access negotiations with Norway, taking place in the mid-1990s, provided an opportunity for Spain and Portugal to revisit their own conditions of access. A new Regulation[28] was adopted in 1994 that politically paved the way for the creation of an effort limitation regime in those waters[29], which was then created the following year by the so-called Western waters regulations[30]. That scheme created a list of vessels that could participate in the fisheries in ICES zones Vb, VI, VII, VIII, IX and X and CECAF areas 34.1.1,

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[26] Act of Accession of Spain and Portugal (1985) see Articles 156-164 for Spain and 347-353 for Portugal.

[27] Waters south of 56°30' N, east of 12° W and north of 50° 30' N

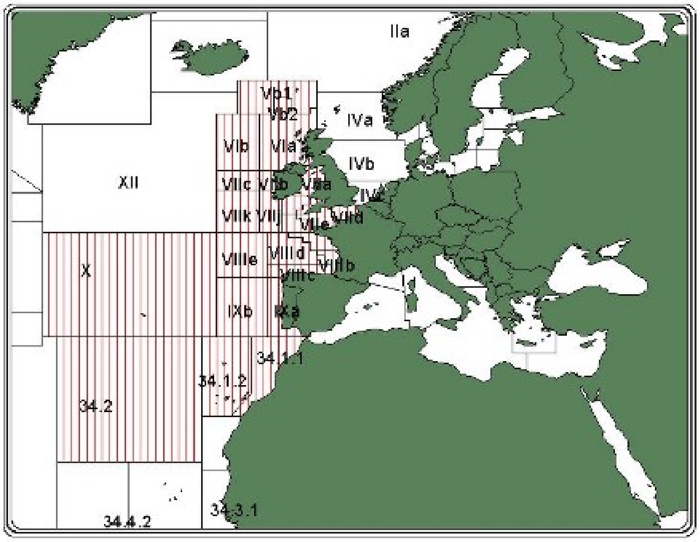
[28] Council Regulation (EC) No 1275/94 of 30 May 1994 on adjustments to the arrangements in the fisheries chapters of the Act of Accession of Spain and Portugal

[29] It was also to propose conditions for access of Spain and Portugal to other EU waters, but this was never done.

[30] Council regulation (EC) No 685/95 of 27 March 1995 on the management of the fishing effort relating to certain Community fishing areas and resources <u>and</u> Council Regulation (EC) No 2027/95 of 15 June 1995 establishing a system for the management of fishing effort relating to certain Community fishing areas and resources

34.1.2 and 34.2.0 (effective 1 January 1996) and adopted ceilings for the effort that could be expended by each Member State. The unit of effort that was used was kiloWatt-days in the area, so for instance the Belgian fleet could participate in the trawler fishery for demersal species in ICES area VIIa to a limit of 1,917 kiloWatt-days. These values were derived from data on historical effort that were submitted by the Member States. Spanish access to the Irish Box was limited to 40 vessels at a time.

Western Waters



ICES Areas and CECAF Divisions

That scheme was revised in 2003[31], following the reform of 2002, and accomplished two major tasks:

- Spain and Portugal were finally fully integrated into the CFP, following the end of the transition period on 31 December 2002 and the discriminatory treatment of these two countries (meaning Spanish and Portuguese vessels have access to all EU waters, though outside the Western Waters they are limited to fishing for non-quota species), and
- the effort ceilings applicable in the Western Waters were updated to reflect the deteriorating status of certain of the stocks there.

There were other changes as well. The Western Waters zone was expanded to include all of ICES area V, so the zone extends from the Canaries and Azores north to the waters northwest of Ireland and the UK. New effort ceilings were

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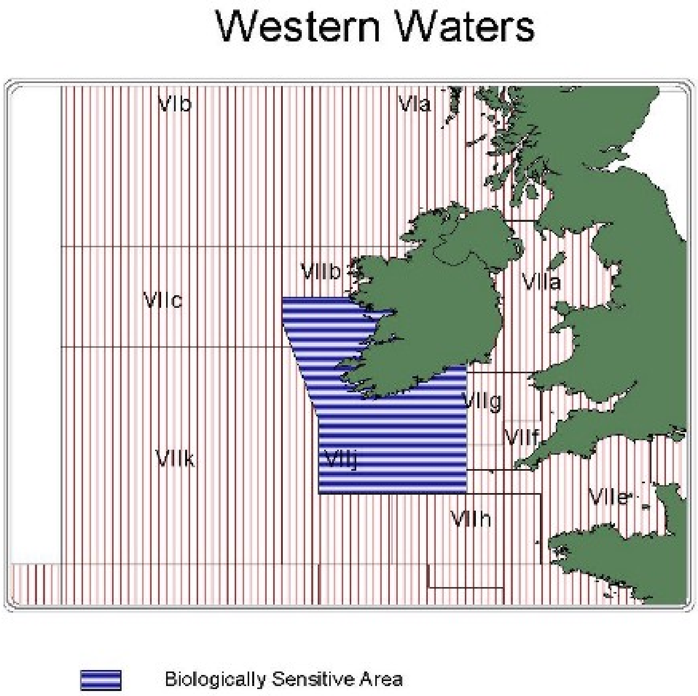
[31] Council Regulation (EC) No 1954/2003 of 4 November 2003 on the management of the fishing effort relating to certain Community fishing areas and resources and modifying Regulation (EC) No 2847/93 and repealing Regulations (EC) No 685/95 and (EC) No 2027/95 <u>and</u> Council Regulation (EC) No 1415/2004 of 19 July 2004 fixing the maximum annual fishing effort for certain fishing areas and fisheries

calculated on the basis of actual effort expended during the years 1998-2002 (the first limits from 1996 were not, apparently, based on historical data, so they were too high and did not serve to limit effort; this was the Commission's way of getting more realistic figures), which led to a significant reduction in the ceilings. The Irish Box was replaced by a much smaller "Irish Conservation Box" to the south and west of Ireland (see map below; current zone is approximately a third the size of the previous Irish Box), described as a "biologically sensitive zone" due to its high concentrations of juvenile hake. Access is limited to vessels that had fished in the area during the period 1998-2002[32]. These rules apply to vessels greater than 15 metres in length, except in the biologically sensitive area, where vessels over 10 metres are covered.



Previously, dating from the 1986 Act of Accession, the waters around the three island groups of Azores, Madeira and the Canaries, out to 200 nautical miles, had been zones with access limited to primarily locally-registered vessels. The Azores, in particular, had a strict management regime that banned trawling for instance and consequently were very worried if vessels from other Member States would gain access. While Portugal fought to have the entire 200 mile zone around the Azores restricted to Azores vessels, the new Western Waters regime opened up three quarters of that area - the zone between 100 and 200 nautical miles from the coast - to the other Member States. The Azores government took the Council to court over that decision but no judgement has been delivered. Meanwhile, the EU has adopted a ban on the use of gears that come into contact

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[32] The Commission is to present a report on the Irish Conservation Box by the end of 2008 and the Council may adjust the effort regime accordingly.

with the bottom (trawls, gillnets, etc) for two areas that include large parts of the EEZs around the Canaries, the Azores and Madeira[33].

Thus, at present, the Western Waters regime consists of limits to the amount of fishing effort that can be exerted in Atlantic waters from the Canaries to the Faroes in ICES Areas V, VI, VII, IX, X, XI and CECAF divisions 34.1.1, 34.1.2, 34.2.0. It applies to demersal stocks (except those covered by the deep-sea stocks regulation[34]) and certain crustaceans (scallops, crab). The effort is expressed in units of kiloWatt-days.

In the Article 3.3 of the Western Waters regulation it is specifically noted that any effort regime adopted under recovery plans shall adapt the Western Waters regime if they overlap in terms of area covered.

A number of recovery and management plans have, indeed, been adopted by the Council (see Section 4.2.b on TACs and Quotas) which include effort limitation regimes. These include various stocks of cod, hake, sole and Norway lobster. There are currently four effort limitation regimes included in Annex II of the annual TACs and quotas regulation[35]:

- Annex IIa - fishing effort for vessels in the context of the recovery of certain stocks in ICES zones IIIa, IV, VIa, VIIa, VIId and EC waters of ICES zone IIa
- Annex IIb - fishing effort for vessels in the context of the recovery of certain southern hake and Norway lobster stocks in ICES zones VIIIc and IXa excluding the Gulf of Cadiz
- Annex IIc - fishing effort for vessels in the context of the recovery of western channel sole stocks ICES zone VIIe
- Annex IId - fishing opportunities and fishing effort for vessels fishing for sandeel in ICES zones IIIa and IV and in EC waters of ICES zone IIa

These annexes run to 35 pages of text with many detailed rules, derogations, etc. In Annexes IIa, IIb and IIc there is geographical overlap with the effort regime included in the Western Waters regulation, but the units are different. The recovery plan regimes are in terms of days-at-sea whereas the Western Waters regulation is in terms of kiloWatt-days. While the latter includes an implicit differentiation according to the size (or power, more specifically) of the vessel, the recovery plans make no such distinction, though they do consider different gear details (gear type, mesh size, etc.).

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[33] Council Regulation (EC) No 1568/2005 of 20 Deptember 2005 amending Regulation (EC) No 850/98 as regards the protection of deep-water coral from the effects of fishing in certain areas of the Atlantic Ocean.

[34] Council Regulation (EC) No 2347/2002 of 16 December 2002 establishing specific access requirements and associated conditions applicable to fishing for deep sea stocks.

[35] The 2008 version is Council Regulation (EC) No 40/2008 of 16 January 2008 fixing for 2008 the fishing opportunities and associated conditions for certain fish stocks and groups of fish stocks, applicable in Community waters and, for Community vessels, in waters where catch limitations are required

Having such different ways of regulating effort obviously complicates the implementation of the systems and the Commission intends to make a proposal to resolve this.

Finally, there was a third programme that considered fishing effort, which is dealt with in the next section on fleet management. From 1997 to 2001, as part of the plan to reduce fleet capacity, Member States were given the option of reducing fishing effort instead.

As opposed to previous EU capacity-reduction programmes, new programmes should establish clear conditions to ensure that sustainability targets are met (to be considered in the context of the subsidy policy as well as the allocation of national quotas) and that priority is given to energy-efficient vessels using low-impact fishing gears and methods so that those segments of the EU fleet are given an economic advantage.