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Viewpoint

'Cheap and dirty' fisheries science and management in the North Atlantic

Ciaran J. Kelly[a], Edward A. Codling[b,*]

[a] Fisheries Science Services, Marine Institute, Rinville, Oranmore, Co. Galway, Ireland
[b] Department of Zoology, Ecology & Plant Science, University College Cork, Cork, Ireland

Abstract

The current system of managing fish stocks in the North Atlantic is failing: many key stocks are at historically low levels and fishing effort is being restricted while capacity remains high. The traditional scientific approach used by International Council for the Exploration of the Sea (ICES) to provide advice on fish stocks is based on complex analytical models of the fishery that require detailed, accurate and high contrast data to predict the future state of fish stocks. However, when data are unreliable or unavailable, these complex models are of limited use, as illustrated by the failure of recent assessments for important ICES stocks. Borrowing ideas from the field of process management, we suggest an alternative approach where fish stocks are managed using harvest rules based on simple empirical indicators. Such an approach is essential for 'data-poor' stocks (where analytic assessments traditionally cannot be completed due to lack of data), but we argue that they could also be adopted for other stocks, particularly where data have become 'poor'. This alternative approach using empirical indicators would fit into the current political framework of the North Atlantic where stocks are managed on a single-species basis. The approach is appropriate not only to the North-eastern Atlantic area, and we discuss its use and relevance in other fisheries around the world.

Keywords: North Atlantic fisheries; Fisheries management; ICES advice; Fisheries indicators; Empirical indicators; Harvest control rules; Process management; Uncertainty

1. Fisheries science in the Northeast Atlantic

In the Northeast Atlantic, advice on fish stocks is given annually by the International Council for the Exploration of the Seas (ICES). The traditional approach has been to try to advise on the harvest strategy in an 'absolute' sense (we refer to this as the 'absolutist approach'): a large number of the fishery and fish stock characteristics are measured annually and these data are then used in analytical models to make predictions about future fishery states. Methods such as the virtual population analysis (VPA), developed in the early to mid twentieth century (e.g. Baranov, 1918; Beverton and Holt, 1957), are still used today and fisheries scientists try to answer questions such as 'What is the optimal catch?' or 'How productive is a fish stock?' Traditional analytical methods such as VPA use a simple age-based mathematical model for the population dynamics of a single fish stock. This model is used to make predictions about the future state of the stock under various levels of fishing, and these predictions form the basis of the advice given to managers and other stakeholders. The advice is then considered (but not necessarily followed) by managers when setting annual Total Allowable Catches (TACs), see review in Daw and Gray (2005).

There is mounting evidence that the traditional approach to fisheries science and management in the North Atlantic (and worldwide) is not working. Increasing numbers of fish stocks are classified as overexploited (ICES, 2005b) or are thought to be at highly depleted levels (e.g. Pauly et al., 2002; Christensen et al., 2003; Myers and Worm, 2003). Meanwhile, problems with landings data and misreporting suggest that the fishermen themselves no longer have confidence in the system (Daw and Gray, 2005). This causes further problems for scientists who must complete assessments with unreliable data leading to further uncertainty about stock status (e.g. ICES, 2005a). One may argue that depleted fish stocks are simply due to overexploitation, but it should be understood that any management system would have limited

* Corresponding author. Tel.: +353 91 387200; fax: +353 91 387201.
E-mail address: edd.codling@marine.ie (E.A. Codling).

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success if it does not have cooperation and involvement from the stakeholders (Daw and Gray, 2005). Increasing the transparency of the assessment and management processes facilitates stakeholder interaction and underpins the success of any management strategy. The empirical indicator approach we outline here would enable this element to be incorporated in any management plan.

2. Problems with the absolutist approach

2.1. Understanding and communication of model and system uncertainty

There has arguably been a fundamental misunderstanding of the role and limitations of analytical models and the absolutist approach in general. This is down to the way the inherent variability and uncertainty of the real world is included in the model and how results are interpreted and communicated (e.g. Patterson et al., 2001). The original mathematical models on which most analytical methods are based (e.g. VPA in Beverton and Holt, 1957) were made deliberately simple and deterministic so that the system was tractable and easily parameterised, and relevant results could be determined and quantified. Like the internal combustion engine, many of the analytical models used in fish stock assessments today are highly evolved in complexity, but fundamentally based on these early simple models. Many important assumptions were made when setting up the original mathematical models of the fishery system and these assumptions need to be considered when any model results are used. For example, recruitment dynamics are not well understood and it is possible to fit a large range of models to the available data (see review in Needle, 2002).

Analysis of the early deterministic VPA models led to ideas such as maximum sustainable yield (MSY), where it is theoretically possible to optimise catches. However, deterministic MSY has been shown to be something of an illusion (Larkin, 1977; Mace, 2001), and is shown to fail as a strategy when uncertainty and variability are included in the underlying models. It has long been recognised in the ICES community that deterministic models are not appropriate to fully understand the fishery system, but most assessment models currently in use only include some element of stochasticity (Patterson et al., 2001). New assessment methods based on an underlying probabilistic model are being considered. This new approach uses a Bayesian framework (e.g. Punt and Hilborn, 1997) based on 'prior' distributions, and results are given in terms of likely outcomes with related probabilities. However, this approach has not been widely accepted and used, mainly because the methods require a high level of expertise. Furthermore, the Bayesian approach is still highly dependent on the level of data availability and quality – if the 'prior' history of the stock is not well understood or the wrong assumptions are made then results may not be reliable.

The problem of dealing with uncertainty has been further exacerbated by a communication problem between scientists and managers/stakeholders. Assessment results are usually presented as absolute deterministic values (e.g. expected spawning stock biomass (SSB) levels or expected catches are given to the nearest tonne) with little discussion of the uncertainty in the prediction. To non-scientists, this creates an illusion of certainty that simply does not exist, and it is unsurprising that managers implement strategies requiring such accuracy. This way of presenting results in deterministic forms is now entrenched in the annual 'TAC-and-quota-bargaining' between EU fisheries ministers that forms part of the Common Fisheries Policy (CFP) (Daw and Gray, 2005). The over-reliance by managers on seemingly highly precise data has led to unrealistic management strategies being implemented, which inevitably lead to failure (for example, see discussion of the Irish Sea cod recovery plan in Kelly et al., 2006).

2.2. Data-intensive models with unreliable or unavailable data

Analytical methods require a large amount of data. For example, in a VPA model, stock characteristics such as population numbers, stock weights, relative exploitation levels, natural mortality, maturity, etc., are required for every age class in the population; data on recruitment history and historical catch levels are also required. Clearly, if data used in an analytical model are unreliable then the results of the model will be unreliable (e.g. Punt, 1997). The more data that are required in the assessment model, the more sensitive the assessment will be to missing or unreliable data.

For the results of an analytical model to be useful, data are required that are reasonably precise, accurate and high contrast (high contrast means observations are available over a wide range of system states – for example, high and low population levels). Many fisheries data sets are inaccurate, imprecise and low in contrast and there is usually limited information about the historical state of a fish stock (Scandol, 2004). The variability in key parameters such as natural mortality is not well understood (e.g. Myers and Cadigan, 1995) and few data are available so that additional assumptions are usually required in order for progress to be made with the model. Schnute and Richards (2001) suggested the novel term '*fishmetic*' to describe the way that the usual laws of arithmetic seem to be distorted when used in typical analytical fishery models. Their main point was that analytic models used in fisheries science have developed to a form where their complexity is too great relative to the amount of reliable observational data that are available. Because of this, arbitrary assumptions cannot be avoided, even though different choices can greatly influence the outcome of the model analysis.

For stocks which are considered data poor, e.g. deep water stocks in the Northeast Atlantic, in the absence of extensive data there has been an almost complete failure to progress any