CAPACITY ANALYSIS AND FISHERY POLICY: THEORY VS PRACTICE

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ABSTRACT

The International Plan of Action for the Management of Fishing Capacity (IPOA-Capacity) was introduced in 1999 in response to growing concerns about excessive levels of fishing capacity and its impact on global fisheries resources. While debate in academic circles has focused on appropriate ways in which to measure capacity, the IPOA has had a more fundamental impact on fisheries management internationally. In particular, it has helped focus attention from the stocks to the industry. In this paper, the current role of capacity analysis in fisheries policy is reviewed, and its influence on policy is examined. An example from a recent UK study is presented.

Keywords: Capacity management, capacity measurement

INTRODUCTION

The decline in world fish stocks is an international phenomenon. FAO (2004) estimated that in 2003, 25 per cent of world fish stocks were overexploited or depleted and in need of rebuilding. Other studies suggest that this is an underestimate of the level of overexploitation (e.g. Myers and Worm 2003). In contrast, around 10 per cent of stocks were overexploited in the mid 1970s (FAO, 2004).

A key factor contributing to this overexploitation has been the global expansion of fishing capacity, which has grown beyond the reproductive capability of the marine resources. In many respects, the development of overcapacity is a symptom of ineffective fisheries management. This takes the form of poorly defined property rights, and in some cases, provision of economic incentives to increase capacity (e.g. subsidies).

The International Plan of Action for the Management of Fishing Capacity (IPOA-Capacity) was introduced in 1999 by FAO in response to growing concerns about excessive levels of fishing capacity and its impact on global fisheries resources. The IPOA calls on States to assess the state of capacity in their fisheries, and to develop capacity management national plans of action in order to deal with any perceived problems of overcapacity.

The IPOA has generated debate in both academics and practitioners. The academic debate has largely focused on the appropriate definition and measurement of capacity. Fisheries managers, on the other hand, have largely been concerned with determining if a problem exists, and if it does, what to do about it. A criticism of the academics by the practitioners is that the measures proposed are often inappropriate for the purposes of fisheries management. In this paper, the impact of the IPOA on capacity management and the measures predominantly being used by fisheries managers are reviewed. A means by which academic measures can be more useful to managers is also suggested, with an example from a UK fisheries study.

CAPACITY MANAGEMENT AND MEASUREMENT IN PRACTICE

Economists are well aware that the fundamental cause of overexploitation in fisheries is the lack of succinct property rights. Overcapacity is a symptom of this underlying problem rather than a problem *per se*. Effective fisheries management that addresses this underlying problem would therefore remove the need to consider capacity as a separate issue. Why then consider capacity management rather than just fisheries management?

Unfortunately, most fisheries managers are not economists. In many countries, conservation and social factors take precedence over economic considerations. For example, Mardle et al (2004) found that UK fisheries managers placed three times the weight on environmental factors than profitability, and twice the weight on employment considerations. Unfortunately, improving property rights in fisheries is often perceived to be associated with a decline in employment, and there is a reluctance to introduce such measures in many countries. Further, with greater focus on environmental considerations, measures that limit catch are often preferred over measures that improve profitability in the fishery.

The IPOA-Capacity has forced the focus to shift, at least in part, from the resource to the exploiters of the resource. While fisheries management can be considered about the resource, capacity management must include consideration of the fleet itself. An under-utilised fleet is acceptable when the stock is the primary concern, and may be a result of the management aimed at limiting catch to sustain the resource (e.g. through competitive total allowable catches). However, the existence of this excess capacity requires consideration to be given about the size of the fleet operating in the fishery.

A review of the implementation of the IPOA undertaken by FAO (2004a) found that, in the 5 years since the introduction of the IPOA, 82 per cent of States surveyed had brought capacity management into consideration. Further, only 4 per cent of States decided that a National Plan of Action (NPOA) for the Management of Capacity was not necessary. Two such States that decided not to develop a NPOA were New Zealand and Australia – both of which utilised rights-based management in their key fisheries.

From the FAO review, countries have adopted a range of capacity measures for management purposes (Fig. 1).[1] Most countries have adopted an input-based measure of capacity. In some cases, capacity is measured in terms of vessel numbers only (e.g. Malaysia), while other countries have adopted complex capacity measures combined different vessel characteristics (e.g. Poland and the UK uses a combination of vessel length and engine power). The most common capacity measure has been Gross Tonnage (GT), with the EU using a dual measure of GT and also total engine power (kW). Some States have adopted an effort based capacity measure (e.g. Philippines). However, relatively few countries have adopted an output-based measure for the purposes of capacity management.

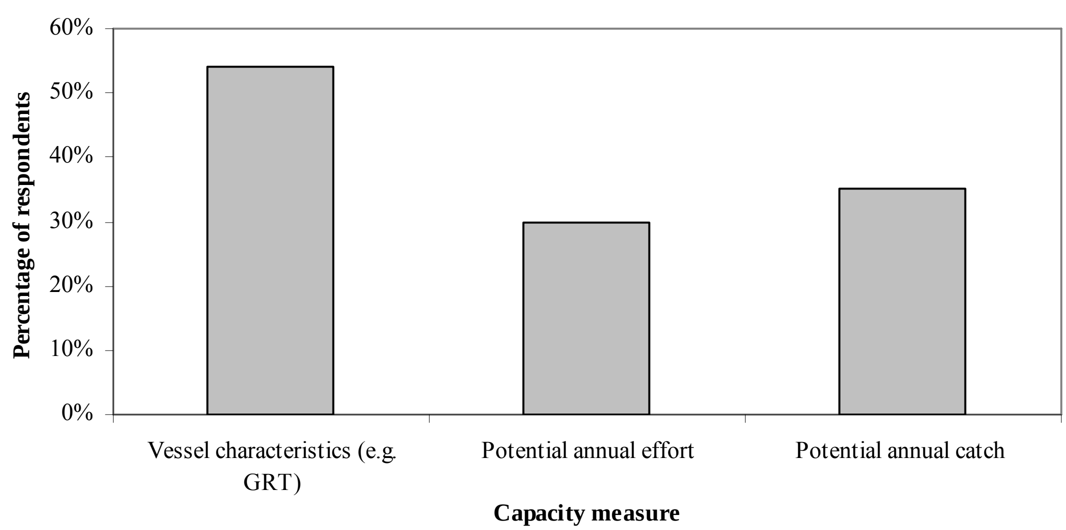

Figure 1. Capacity measures adopted by policy makers (derived from FAO 2004a)

Capacity management is not limited to national policy makers. Regional fisheries management organisations (RFMOs) are also required to monitor, assess and manage capacity operating in the waters over which they have jurisdiction. Regional plans of action have been developed by some RFMOs, again with a focus on input-based measures of capacity. For example, the Inter-American Tropical Tuna Commission (IATTC) defines capacity as the well volume of the vessels (IATTC, 2005).

The main reason that input-based measures are preferred by policy makers is that capacity management is viewed as fleet (or effort) management. In the absence of incentive adjusting management measures (such as ITQs), managers need to implement controls that directly affect the vessels. Foremost of these controls has been buyback. Around 90 per cent of respondent States in the FAO survey intended to implement buyback of either the licence or vessel to reduce capacity in overexploited fisheries. This compares with only 26 per cent of States that proposed introducing some form of ITQ system (mostly in collaboration with a buyback programme) (FAO, 2004a). Given this heavy reliance on buybacks, managers need to know how many vessels need to be removed in their fisheries.

CAPACITY MANAGEMENT AND MEASUREMENT – THE RESEARCH RESPONSE

The IPOA has also had a considerable impact on the study of capacity management and measurement. The number of published journal articles considering either capacity management or measurement in fisheries increased considerably from 2002 (Fig. 2).[2] Given the lag time between undertaking the studies and final publication, this indicates an increase in activity immediately following the IPOA.

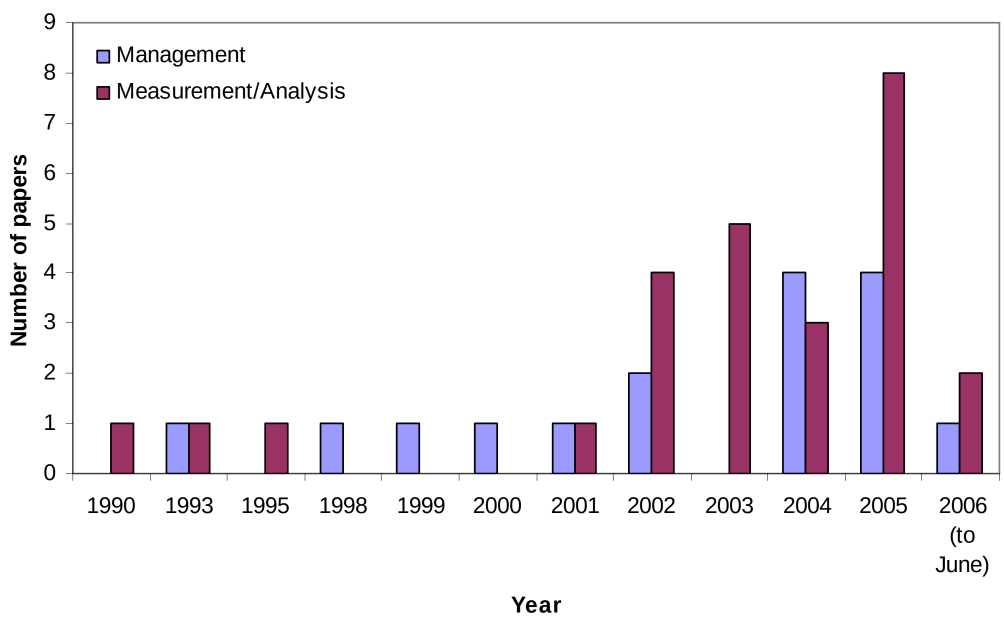

Figure 2. Papers published on fisheries capacity management or measurement in academic journals, 1990-2006

The measurement studies have exclusively focused on output based measures of capacity. This is consistent with economic theory, which defines capacity as the maximum output that can be achieved with a given set of fixed inputs. Data Envelopment Analysis (DEA) has been the key method used to estimate output capacity in these studies. DEA provides a relative measure of capacity utilisation, with capacity output being defined by the vessels with the greatest observed catches given their set of fixed inputs (usually taken as a combination of vessel size and engine power). Variations of the DEA approach have been proposed, ranging from technical-economic measures based purely on physical inputs and outputs (e.g. Pascoe et al, 2001; Dupont et al, 2002; Vestergaard et al., 2003, Tingley and Pascoe, 2003), measures based on revenues as the output (e.g. Lindebo et al., 2006), and measures based on profitability that incorporate costs of input utilisation as well as revenues (e.g. Pascoe and Tingley, 2006). The latter studies have largely shown that the technological-economic measures provide similar estimates of capacity utilisation to the measures involving the more detailed economic data, suggesting that the assumption of short-term profit maximisation that underlies all these models is appropriate.

The output-based measures of capacity and capacity utilisation provide a measure of the extent of any problems in the fishery. This is not apparent from considering the inputs on their own. For example, it is not possible to determine if the number of vessels (or GT) in the fleet is too high just by counting them. The DEA measures of capacity utilisation also provide an indication of the extent to which the fleet size could be reduced and still maintain the same catch. As a crude approximation, an average capacity utilisation of x ($x \leq 1$) implies that the same catch could have been taken with 1-x fewer vessels.

More recently, secondary analysis has been undertaken to provide better estimates of potential fleet reductions. These have taken the form of minimum fleet size (e.g. Kerstens et al., 2005, Lindebo, 2005) to consideration of different responses by fishers to buyback programs. For example, Tingley and Pascoe (2005) compared the fleet size and structure if the least efficient vessels were the first to exit the fishery under a buy-back scheme with the assumption that vessels with the lowest capacity utilisation would exit first. Pascoe and Hatcher (2006) also examined the case where the least profitable vessels were assumed to sell quota to the most profitable vessels under an ITQ scheme. These second level analyses use a simple 0-1 linear programming model to reallocate catch between the vessels.

POLICY APPLICATIONS OF OUTPUT-BASED CAPACITY MEASURES

Although theoretically sound, the output based measure of capacity has not been widely used by managers as noted previously. The measures have been used for policy formulation, however, in the US and UK. Canada is also in the process of assessing capacity in terms of output-based measures for use in policy formulation (DFO, 2006).

In the US, output-based measures of capacity were identified as the main capacity measure in the NPOA for the management of fishing capacity. Assessments were untaken for several fisheries, and an action plan as to how to reduce capacity in the problem fisheries was determined.

In the UK, both DEFRA (the Department of Environment, Food and Rural Affairs) and the Scottish Executive commissioned studies of capacity utilisation in the UK and Scottish fisheries respectively. Both studies have largely been concerned with the potential regional impact of removing excess capacity from the fishing fleet.

The Scottish analysis (Tingley and Pascoe, 2005) was aimed at estimating the level of excess capacity in the Scottish fishing industry, and the potential economic profit and employment implications from removing this excess capacity. The analysis used an economic DEA model to estimate capacity output and capacity utilisation of each vessel, with the additional costs of increasing output (e.g. the cost of more days at sea, higher crew payments etc) taken into consideration. A second stage analysis was undertaken with regards to re-allocating quota following the removal of the surplus vessels, although the cost of quota trade was not taken into consideration (a weakness of the analysis). Various scenarios were examined with regard to restricting quota trade between different groups. For example, in one scenario, quota held by vessels in the Highlands and Islands could only be transferred to other vessels based in this region. The analysis was used by the Scottish Executive in the development of their quota management strategy and assess the potential implications of further reductions in quotas.

In the UK-wide study sponsored by DEFRA (Pascoe and Hatcher, 2006), the key aim was to identify main ports that were potentially "vulnerable" to the introduction of ITQs. Ports were considered vulnerable if they had a high dependency on the fishing industry for employment, and were likely to have a high reduction in vessel numbers if ITQs were to be introduced. The capacity utilisation of each individual vessel was estimated using a profit maximising DEA model. That is, output would only increase is the additional revenue exceeded the additional costs. Quota trading costs were included in these costs.[3] The effect of including quota trading costs was to reduce capacity output relative to a purely technical-economic approach, as the cost of increasing output was greater under a quota system than under a non-quota system. Quota was "traded" in the second stage adjustment model. Three assumptions were considered – 1) the least efficient vessels would be the first to sell; 2) those with the lowest capacity utilisation would sell first (as they required the most quota to achieve full capacity); and 3) the least profitable would be the first to sell quota. The impact of the different assumption on the resultant mix of vessels was not substantial. The analysis has contributed to the on-going debate in the UK regarding moving towards a full ITQ system.

These examples illustrate that the output-based measures can provide useful information for fisheries management, and that such information is actively sought by policy makers. However, in both the UK and Scottish examples, the main point of interest was the number of vessels to be removed rather than the capacity output per se. This reinforces the need to translate output-based measures into an input use equivalent for managers to be able to use them for policy development.

TARGET CAPACITY

The focus of capacity analysis in the literature over the last 5 years has largely been on assessing current capacity and the extent of any excess capacity in fisheries. However, excess capacity in the studies to-date has been defined relative to the current level of output, not the desired or target level of output. A shortcoming of the DEA approach to capacity analysis is that it is very short term in nature. That is, it is based on observed outputs under prevailing conditions. Where fisheries have overcapacity, then capacity reduction will (presumably) result also in increased stock size. Full capacity in a fishery with a depleted stock may not be equivalent to full capacity in a fishery with a healthy stock. That is, it would be expected that vessels would catch more per unit of effort, and hence experience a higher level of output given the set of fixed inputs. As a result, even fewer vessels may be required to take the target output level.

Assessment of overcapacity in fisheries therefore requires a longer-term perspective and a method that can account for changes in stock conditions. Bioeconomic models have been proposed as an approach to help identify target capacity levels, both in input (e.g. vessels numbers) and output (e.g. catches of each species) terms (see Pascoe et al., 2002). Multi-objective models in particular can provide useful for defining target capacity, as these take into account both a range of objectives and the differing importance (i.e. weights) ascribed to each.

There appears to be, however, even greater reluctance for policy makers to use bioeconomic models for policy formulation than DEA models. Bioeconomic modelling are perceived to be difficult to develop and often unreliable, largely due to the uncertainty in the biological relationships and the lack of good economic data. Further, they are time consuming to construct and then have limited life if the fishery changes e.g. as a result of increase in fuel or other costs, global warming etc. Policy makers and stakeholders also often poorly understand the complexity underlying most bioeconomic models. As a consequence they often have little faith in the model results. Finally, they are slow to provide information (due to the time to develop the models) and are often limited in terms of what they can provide.

Despite these shortcomings, the development of bioeconomic models will be important for assisting in the determination of target capacity. The alternative to such models is the use of qualitative methods such as reliance on expert opinion. An advantage of models over expert opinion is that the process by which a result is obtained is transparent and open to scrutiny. The sensitivity of various assumptions in a bioeconomic model can be explicitly examined in order to determine the robustness of the results. Even though inexact, models can provide useful guides to target capacity formulation.

DISCUSSION AND CONCLUSIONS

From the FAO review of the implementation of the IPOA-Capacity, it would appear that the approaches being developed in the academic research environment have not had a major impact on policy formulation. In most instances, policy makers have adopted input-based definitions of capacity. These are only equivalent to the output-based measures under restrictive circumstances – namely constant returns to scale.

A difficulty with working in a policy environment is that policies need to be developed taking into consideration a number of factors. These include historical activity levels and participation in the fishery, and the tools currently being used to manage the fishery (DFO, 2006). Communicating the policy to stakeholders is also an important consideration. Where these tools have predominantly been input-based, and stakeholders are used to operating in an input based environment, then it is only logical that capacity management policies are developed on a consistent basis.

The experience of the managers themselves also influences policy formulation. Despite the inroads that economics has made in influencing policy over the last decade, fisheries managers and policy makers still predominantly come from an administrative or natural science background. The objectives of fisheries management are still weighted towards conservation of the stock, and the means by which this is to be achieved is through either limiting total catch or restricting vessel activity or numbers. These incentive-blocking approaches that are imbedded in most fisheries management policies are partially the reason that the concept of capacity management evolved.

Given these constraints, the results of any capacity analysis need to be translated into measures relevant to management. With fisheries management still largely dominated by input controls, this means estimating how many vessels may be surplus to requirement. The second stage industry allocation models have proved a useful means to translate output-based measures of excess capacity into vessel numbers. Further, the second stage analysis can also provide information on potential economic impacts such as profitability and employment changes that can further influence policy.

Catering to the needs of managers in terms of providing information applicable to input-based capacity management does not mean that economists should not also promote incentive enhancing approaches to management. Indeed, most FAO reports on capacity management have indicated that the most effective form of capacity management is to create incentives for the fishery to adjust itself.

There is a role for both DEA and bioeconomic modelling in providing relevant information for capacity management. A key advantage of DEA is that it is easy to run and requires only basic data. While economic data theoretically improves the capacity utilisation estimates, the empirical studies to date suggest that even catch and effort data on its own can be used to derive fairly reliable estimates. Bioeconomic models, on the other hand, require considerably more detailed data, and are difficult and expensive to construct. While there will be a need to continue the development of bioeconomic models for the purposes of capacity management, in data poor environments considerable progress in capacity assessment and appraisal can be made using the simpler DEA models.

Although DEA has been used for capacity estimation in other industries for some time, it is still relatively new in fisheries. Most of the capacity research activity has only been published since 2002, and the number of publications is still relatively small compared with other aspects of fisheries management. Further, a definitive methodology has yet to evolve, with some papers based on purely technical information (i.e. catch and effort data), while others include prices and/or cost information. Although these studies have demonstrated a fair degree of consistency despite the data used, lack of a definitive methodology may reduce the confidence that policy makers have in the technique.

Most of the studies to date have also been undertaken by either US or European institutions. Policy makers as well as researchers in developing countries have few examples that they may relate to. Further, in most instances by universities rather than government research agencies. This perceived bias in the literature may reflect the publication strategy of the institutions, as universities have a greater incentive to publish in peer reviewed journals. This limits, however, the number of case studies from that policy makers may draw upon to become familiar with the approach. Further, publishing in "better" journals often means writing in a style that is not accessible to non-economists. The relevance of the technique is therefore less apparent.

These are largely transitional problems that face any new school of thought. For some time, the idea of ITQs or co-management was considered purely theoretical. Now both are commonly applied in a wide range of fisheries throughout the world.

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ENDNOTES

[1] As States could respond with more than capacity measure, the totals implicit in Fig. 1 add up to more than 100 per cent.

[2] This was based on a search in ScienceDirect (www.sciencedirect.com) and ECONLIT using “capacity” and “fisheries” as the key words. It excludes conference papers, book chapters or other reports, of which there have also been many. 2006 includes papers in print that have been pre-published on the web as at the end of June.

[3] The quota trading prices were the annualised quota purchase price. The assumption underlying the analysis was that, under and ITQ system, fishers would purchase rather than lease the additional quota.