Marine Resource Economics, Volume 22, pp. 83–87
Printed in the U.S.A. All rights reserved

0738-1360/00 $3.00 + .00

Capacity Analysis and Fisheries Policy: Theory versus Practice

SEAN PASCOE
CEMARE, University of Portsmouth and CSIRO Marine and Atmospheric Research

Key words *Capacity analysis, capacity policy, data envelopment analysis, bioeconomic models.*

JEL Classification Codes Q22, Q28, D24.

Introduction

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

The answer to this is unfortunately simple: most fisheries managers are not economists. In many countries, conservation and social factors take precedence over economic considerations. 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 FAO International Plan of Action for the Management of Fishing Capacity (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 to involve only the resource, "capacity management" must also include consideration of the fleet.

A review by FAO (2004) found that in the five years since the introduction of the IPOA-Capacity, 82% of States surveyed had brought capacity management into consideration. Further, only 4% of States decided that a capacity management plan was unnecessary. Two such States that decided not to develop a separate capacity management plan were New Zealand and Australia—both of which utilized rights-based management in their key fisheries.

Most countries were found to 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 that combine

Sean Pascoe is an economist with CSIRO Marine and Atmospheric Research (CMAR), 233 Middle Street, Cleveland, 4163, Australia, email: sean.pascoe@csiro.au. The study was undertaken while working with the Centre for the Economics and Management of Aquatic Resources (CEMARE), University of Portsmouth, Burnaby Terrace, 1-8 Burnaby Road, Portsmouth, PO1 3AE, UK, as part of the European Commission 6th Framework Project: CAFÉ – Capacity, F and Effort (Contract No. 022644).

different vessel characteristics (*e.g.*, Poland and the UK use 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.*, the Philippines). However, relatively few countries have adopted an output-based measure for the purposes of capacity management.

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% of respondent States in the FAO survey intended to implement buyback of either the license or vessel to reduce capacity in overexploited fisheries. This compares with only 26% of States that proposed introducing some form of ITQ system (mostly in collaboration with a buyback program) (FAO 2004). Given this heavy reliance on buybacks, managers need to know how many vessels need to be removed in their fisheries.

Capacity Analysis—The Research Response

The IPOA-Capacity 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 from an average of 1 or 2 a year up to 2001 to 12 articles in 2005, with a total of 33 papers produced from 2002 to June 2006. Around two-thirds of these post-2001 papers involved capacity measurement issues. Although most of the theoretical work originated in North America (*e.g.*, Kirkley, Morrison Paul, and Squires 2002), around two-thirds of the papers were based on European fisheries. Research is also being undertaken by governments in North America, Europe, and elsewhere, so the published journal articles reflect just part of the research activity in the area.

The measurement studies have focused exclusively on output-based measures of capacity. Data Envelopment Analysis (DEA) has been the key method used to estimate output capacity in these studies, although stochastic production frontiers (SPF) have also been proposed as an alternative approach. DEA is a (non-parametric) linear programming based approach, whereas SPF is a (parametric) statistical based approach. Both DEA and SPF are frontier-based methods. That is, they estimate the production possibility frontier, with capacity output being defined by the vessels with the greatest observed catches given their set of fixed inputs. Both techniques require catch and input information on individual vessels and can be used to estimate the potential output of each vessel separately. SPF allows for some of the differences in output between similar boats to be explained by random error, whereas DEA assumes differences between similar vessels to be due to a combination of inefficiency and underutilized capacity. An overview of both approaches is given in Kirkley, Morrison Paul, and Squires (2002).

DEA has been the preferred method for estimating capacity in the literature due to its relative ease in incorporating multiple outputs; its lack of assumptions regarding functional forms and single technologies; and its ability to readily incorporate other information, such as fisher behavioral assumptions, prices, and costs. While earlier DEA models were based purely on the assumption of output-maximizing behavior (*e.g.*, Pascoe, Coglan, and Mardle 2001; Kirkley, Morrison Paul, and Squires 2002, Dupont *et al.* 2002), more recent models have incorporated either revenue-maximizing (*e.g.*, Lindebo, Hoff, and Vestergaard 2007) or profit-maximizing behavior (Pascoe and Tingley 2006) directly into the estimate of capacity. DEA estimates of capacity that exclude efficiency effects have also been found to be as robust as SPF-based estimates in the presence of random error (Holland and Lee 2002).

In several cases, DEA models have been linked with fleet adjustment models to provide better estimates of potential fleet reductions. These combined models have incorporated varying assumptions, from minimum fleet size required to harvest the catch (*e.g.*, Kerstens, Squires, and Vestergaard 2005), to different behavioral responses by fishers to buyback programs (*e.g.*, Tingley and Pascoe 2005).

The focus of capacity analysis in the literature over the last five 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 both the DEA and SPF approaches 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. Bioeconomic models are an alternative approach to help identify target capacity levels, both in input (*e.g.*, vessels numbers) and output (*e.g.*, catches of each species) terms.

There appears to be, however, even greater reluctance for policy makers to use bioeconomic models for policy formulation than DEA models. Bioeconomic modeling is perceived as difficult to develop and often unreliable, largely due to uncertainty in the biological relationships and the lack of good economic data. Further, bioeconomic models are time consuming to construct and have a 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.

Discussion and Conclusions

The approaches to capacity measurement being developed in the academic research environment do not appear to have had a major impact on policy formulation. In contrast, policy makers have largely adopted input-based definitions of capacity. These two measures are only equivalent under restrictive circumstances (*i.e.*, constant returns to scale). Linking inputs (*i.e.*, boats) to outputs (*i.e.*, catch) is important if capacity analysis is going to influence capacity management.

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

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, and buyback programs often seen as the preferred capacity reduction instrument, managers are more concerned with how many vessels may need to be removed rather than the potential output of the existing fleet. The use of fleet adjustment models linked to DEA models has proved a useful means to translate output-based measures of excess capacity into vessel numbers. These analyses 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. Pragmatism needs to be mixed with education.

There is a role for both DEA and bioeconomic modeling in providing relevant information for capacity management. A key advantage of DEA is that it is easy to run and requires only limited data. While economic data improves the capacity estimates, the empirical studies to date suggest that even catch and effort data alone 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 is a need to continue the development of bioeconomic models, in data poor environments considerable progress in capacity assessment and appraisal can be made using the simpler DEA models.

Capacity analysis is still relatively new in fisheries. Most of the capacity research activity has 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 been undertaken at either US or European universities and government institutions. Policy makers, as well as researchers in developing countries, have few examples that they may relate to. Further, the studies published in journals are predominantly produced by universities rather than government research agencies, the latter mostly producing reports with only limited accessibility outside the country. This limits the number of case studies from which policy makers may become familiar with the approaches. Further, as publishing in "better" journals often means writing in a style that is not accessible to non-economists, the relevance of the approaches is 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.

References

Dupont, D.P., R.Q. Grafton, J. Kirkley, and D. Squires. 2002. Capacity Utilization Measures and Excess Capacity in Multi-Product Privatized Fisheries. *Resource and Energy Economics* 24(3):193–210.

FAO. 2004. Progress on the Implementation of the International Plan of Action for the Management of Fishing Capacity. Technical Consultation to Review Progress and Promote the Full Implementation of The IPOA to Prevent, Deter and Eliminate IUU Fishing and the IPOA for the Management of Fishing Capacity, Rome, Italy, 24-29 June.

Holland D.S., and S.T. Lee. 2002. Impacts of Random Noise and Specification on Estimates of Capacity Derived from Data Envelopment Analysis. *European Journal of Operational Research* 137(1):10–21.

Kerstens, K., D. Squires, and N. Vestergaard. 2005. Methodological Reflections on the Short-Run Johansen Industry Model in Relation to Capacity Management. *Marine Resource Economics* 20(4):425–43.

Kirkley, J., C.J. Morrison Paul, and D. Squires. 2002. Capacity and Capacity Utilization in Common-Pool Resource Industries. *Environmental and Resource Economics* 22(1-2):71–97.

Lindebo, E., A. Hoff, and N. Vestergaard. 2007. Revenue-Based Capacity Utilization Measures and Decomposition: The Case of Danish North Sea trawlers. *European Journal of Operational Research* 180(1):215–27.

Pascoe, S., L. Coglan, and S. Mardle. 2001. Physical versus Harvest Based Measures of Capacity: The Case of the UK Vessel Capacity Unit System. *ICES Journal of Marine Science* 58(6):1243–52.

Pascoe, S., and D. Tingley. 2006. Economic Capacity Estimation in Fisheries: A Non-Parametric Ray Approach. *Resource and Energy Economics* 28(2):124–38.

Tingley, D., and S. Pascoe. 2005. Eliminating Excess Capacity: Implications for the Scottish Fishing Industry. *Marine Resource Economics* 20(4):407–24.