

A framework for capacity appraisal in fisheries

Sean Pascoe¹

Abstract

The need for effective management of fishing capacity has been highlighted in recent years following the realization that many of the world's major fishing resources are overexploited. In order to manage fishing capacity, managers need to first establish the level of any overcapacity that may exist in individual fisheries. This requires an estimate of the current level of fishing capacity as well as the target, or desired, level of fishing capacity. The latter will largely depend on the objectives of management, which may vary from fishery to fishery. In this paper, a framework for assessing the extent of overcapacity in fisheries is presented. The framework consists of several steps – monitoring; assessment of existing capacity; assessment of target capacity; and, finally, assessment of overcapacity.

1. Background

Many of the major fishery resources of the world are currently being exploited by an excess number of vessels, and are in a state of decline due to over-fishing. About 50 per cent of stocks are fully exploited and are, therefore, producing catches that have either reached or are very close to their maximum limits, with no room expected for further expansion. Another 15 to 18 per cent are overexploited and are in a state of decline. A further 10 per cent of stocks have been depleted or are recovering from depletion (FAO 2000).

Within Europe, most fisheries are currently both biologically and economically overexploited. Reductions in TACs in excess of 50 per cent have been imposed for many stocks in 2002, with most other stocks subject to TAC reductions of between 10 and 30 per cent (DG Fish 2001). Removal of excess capacity is necessary to ensure the longer-term sustainability of the stocks, and to improve the economic performance of the fleet. DG Fish (2000) estimate that, in 2000, there was more than 40 per cent overcapacity in the EU fleet as a whole.

As a result of the relatively poor state of many world fisheries, the effective management of fishing capacity has become a major issue internationally. The management of capacity requires several key elements – a means to assess the current level of capacity, a means to identify the desired level of capacity (i.e. target capacity), and a mechanism to move from the current situation to the desired situation.

The objective of this paper is to outline a framework for assessing current and target capacity in fisheries. The first section will review the basic definitions underlying capacity estimation.

¹ Centre for the Economics and Management of Aquatic Resources (CEMARE), University of Portsmouth, Locksway Road, Southsea PO4 8JF, UK. Email: sean.pascoe@port.ac.uk

A framework for assessing capacity is presented, involving monitoring and the estimation of current and target levels of capacity. A number of methods for estimating output-based measures of capacity are outlined, and the use of bioeconomic modeling is proposed as a means to identify target levels of capacity.

2. Definitions and problems of over capacity and capacity under-utilization

In December 1999, a Technical Consultation on the Measurement of Fishing Capacity was held in Mexico City to define capacity and develop methods for measuring and assessing fishing capacity (FAO 2000). During the meeting, definitions of capacity were developed along with a range of methods for estimating capacity. Fishing capacity was subsequently defined as: *the amount of fish (or fishing effort) that can be produced over a period of time (e.g. a year or a fishing season) by a vessel or a fleet if fully utilized and for a given resource condition*. Full utilization in this context means normal, but unrestricted use, rather than some physical or engineering maximum.

From the above definition, capacity can be expressed in terms of inputs (e.g. potential fishing effort) or outputs (e.g. potential catch). These measures are not equivalent except under certain conditions that rarely hold in fisheries.²

A measure that has recently gained increase use in fisheries is *capacity utilization*. This is primarily an output based measure, determined as the ratio of the current output or level of fishing effort to the potential output or level of effort under normal working conditions. A similar input based measure could be defined as the ratio of current fishing effort to potential fishing effort, again assuming normal working practices and given the state of the resource.

Capacity under-utilization is an indicator of potential future problems in the fishery, as will be outlined in more detail below. The existence of capacity under-utilization may imply the existence of excess capacity.³ That is, the existing level of capacity is greater than that required to harvest the resource at the current level. Both capacity utilization and excess capacity are short run concepts only, as under different circumstances (e.g. a recovered stock), the existing fleet size may be fully required to harvest the resource at the optimal level.

Changes in capacity utilization over time can provide information on the effectiveness of management in controlling fishing capacity. Declining capacity utilization may indicate that

² Equivalence between input and output based measures of capacity requires the existence of a perfectly linear relationship between the level of inputs and the level of outputs (e.g. $C=qEB$). That is, doubling the level of all inputs would double the level of outputs. In most fisheries, this relationship is non-linear. In some cases, output may increase by a greater degree with an increase in inputs (increasing returns to scale), while in other cases output may increase by a smaller proportion than inputs (decreasing returns to scale).

³ Capacity under-utilization is not a reliable indicator of excess capacity, particularly if the under-utilization is due to market forces as detailed below. Further, the existing level of inputs may be appropriate given higher stock levels. Removal of this 'excess capacity' might adversely affect the future productivity of the fishery if it is recovering. As a consequence, capacity utilization should only be used as a 'rough' indicator of problems of excess capacity in fisheries.

management is not constraining capacity growth, just its utilization. In contrast, increasing capacity utilization may indicate that capacity management is working

The concepts of capacity and capacity utilization relate to the existing condition of the resource. In the longer term, some other level of the resource may be desirable, particularly if the stock is currently overexploited. Associated with this desired stock level would be a desired level of output that would represent the sustainable yield that could be attained, and a desired fleet size/configuration that would take this sustainable yield at lowest cost. These desired long run levels of output and fleet size can be considered as measures of *target capacity*.

A long-term output based measure of overcapacity would relate the potential output from the current fleet given the desired stock level to the target level,⁴ while an input based measure would relate the level of investment in the fishery now (in terms of boat numbers, GRT or some other unit) with the desired level of investment.

This latter measure is generally termed *overcapitalization*, and can be illustrated in Figure 1. From this figure, the current fleet size, F , is producing a current level of output, O . In contrast, a greater yield O_{msy} can be achieved with a smaller fleet size F_{msy} . The difference between the current fleet and target fleet is the level of excess capital, and is a measure of the level of overcapitalization of the fishery. The actual target level of output will depend on the management objectives for the fishery. In some cases, maximum sustainable yield may be the target level of output while in others maximum economic yield may be more appropriate.

In summary, capacity and capacity utilization are short-term concepts that relate to the ability of the existing fleet to increase their output given current conditions. In contrast, overcapacity and overcapitalization are longer-term concepts that indicate the extent to which the current fleet may need to be reduced in order to achieve a long run target level of output.

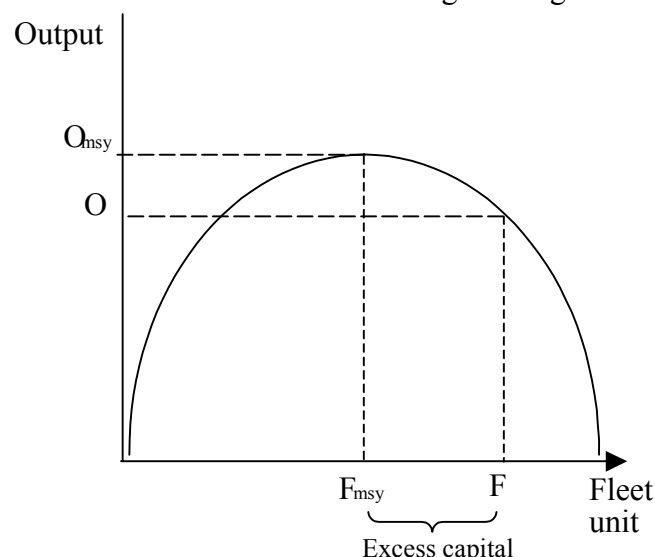


Figure 1. Overcapitalization in fisheries.

⁴ A short run equivalent measure of overcapacity could also be the ratio of the current potential catch to some target catch in the current period (e.g. a TAC). This may be an unreliable indicator of overcapacity if a TAC has been set at a low level to allow the stock to recover.

2.1 Causes and problems of capacity under-utilization

Capacity under-utilization may occur for several reasons. Management induced capacity under-utilization can occur if the fishery output is constrained, such as by a total allowable catch (TAC) limit or as a result of a restriction in the number of days that can be fished (e.g. seasonal closures, days-at-sea limits). Conversely, capacity under-utilization may occur as a result of adverse market conditions. For example, if the price of fuel increased or the price of fish decreased, the profitability from fishing would decrease and this may cause some (less efficient) operators to fish less than they might otherwise fish.

Market induced capacity under-utilization is not of concern to fisheries management as the individual fisher is operating in a rational manner. In many cases, market induced capacity utilization is self adjusting, as either prices (costs) will rise (fall) to their original levels, or less efficient vessels who cannot operate under these new market conditions will seek to exit the fishery. Management induced capacity under-utilization, however, can have implications for the effective management of the fishery.

From a pure stock conservation perspective, the existence of management induced capacity under-utilization does not pose any threat provided that the total output of the fishery is constrained to a sustainable level (e.g. through an enforced total allowable catch (TAC) quota). However, the existence of underutilized capacity creates a number of economic problems, some of which may also have implications for the success of the stock conservation measures. These include economic incentives to exceed any quota imposed, as well as incentives to race to fish, and to increase capitalization in a bid to increase individual returns.

At the aggregate fishery level, the existence of underutilized capacity indicates a waste of resources, as, by definition, the same catch could have been taken with fewer boats operating at full capacity. The additional vessels are therefore not adding any additional value to the industry, and the costs incurred by these vessels directly reflects the potential economic cost to the industry (and society as a whole) of the excess capacity.

As well as imposing a direct economic cost on the industry, the existence of underutilized capacity can produce other incentives that are detrimental to both the stock and the longer-term profitability of the industry. When the harvesting capability of the fishing fleet exceeds the available catch, incentives are generated to increase investment in the industry in a bid to get a larger share of the catch. This may take the form of a larger boat and/or a larger engine, and the use of more fishing gear in order to maximize the individual catch. In the short term, undertaking such investment is likely to increase the profitability of the investor. However, in the longer term other fishers will be forced to either increase their investment to increase their (now reduced) share of the catch or exit the fishery. As a consequence, the 'race to fish' arising from the existence of excess capacity may result in further increases in excess capacity, with detrimental effects on both the stock and profitability of the fishery.

The alternative to increasing investment to maintain catch shares under such a scenario is to exit the fishery. However, the lack of alternative uses of fishing vessels makes exiting the

fishery difficult. If the revenue from the restricted level of catch is not sufficient to cover existing fixed costs, incentives can be created to exceed any quota imposed. The actual extent of illegal landings will depend on the level of surveillance and expected fines, but it is likely that levels of illegal landings will be correlated with the level of excess capacity.

A related problem that can result in apparent capacity under-utilization is the existence of part time fishers. These vessels will be identified as underutilized when compared with full time vessels, but their potential to increase their level of fishing activity may be limited while they remain in the control of the current owners. However, as it is possible for these owners to change their operation to full time, or to sell the vessel to a new fisher who would use it on a full time basis, it is appropriate to treat these as vessels as having underutilized capacity for the purposes of capacity management.

In summary, the existence of underutilized capacity imposes direct costs on the industry through forgone economic profits, and indirect costs through the incentives created to increase investment (and thereby further increase excess capacity) and increase illegal landings.

2.2 Causes and problems of overcapitalization

The existence of overcapitalization is often attributed to the lack of property rights in fisheries. Without well defined property rights, individuals will increase their effort, and in fisheries without license limitations, new fishers will enter, provided that greater profits can be earned in the fishery than in other industries or activities. As a consequence, the resource rent (the implicit value of the resource used in the production process) is dissipated. Further, depending on the actual harvest costs, the level of investment in the fishery can exceed that required to harvest the resource at its greatest productivity level (e.g. maximum sustainable yield), and also the level required to harvest the resource to achieve its greatest economic value to society (maximum economic yield).

A major problem with overcapitalization is the loss of potential resource rent that could be obtained from the fishery. This rent could be returned to the local community to improve local facilities, or retained by the fishers in the form of increased profitability. The loss of this rent therefore leads to lower incomes of the fishers and their crew, which can lead to lower incomes in the regional as a whole through reduced use of local services.

Overcapitalization is also generally associated with lower levels of output, which may have effects on processing and retail sector performance. Excessive levels of overcapitalization can result in stock collapse.

2.3 Input versus output based measures of capacity

Management of fishing capacity requires some estimate of the existing level of fishing capacity in a fleet and the corresponding level of excess capacity in the fishery. To this end, many countries have developed a range of capacity indicators, mostly based on physical attributes of the fleet (FAO 2000). Key indicators of capacity applied in many countries are

measures such as gross tonnage (a measure of the volume of the vessel), engine power, and the number of boats. In some countries, engineering measures such as vessel capacity units,⁵ generally based on a combination of characteristics, have also been developed. More recently, output based measures of capacity have been developed that relate to the potential level of output of a fleet.

Input based measures of capacity involve an implicit assumption that the level of output is related to the level of physical inputs employed in the fishery. If these inputs were fully utilized, then the capacity of the fleet would be a function of these inputs. The level of utilization in this case would relate to the level of activity (e.g. days fished). Hence, the capacity of the fleet is related to the fixed inputs employed, e.g. capacity = $f(\text{boat size, engine power etc})$ on the assumption that they are fully utilized. As a consequence, changes in effort levels do not change the *potential* output of the fleet, so do not directly affect the capacity (just capacity utilization).

The link between the level of inputs and the level of outputs is generally the basis for management of fisheries using input controls. Changing the level of inputs (e.g. through decommissioning) or their utilization (e.g. through days at sea restrictions, seasonal closures), is assumed to have a proportional effect on the level of output. However, as noted previously, this assumes that the fisheries are subject to constant returns to scale. Several studies (e.g. Pascoe and Coglán 2000, Pascoe, Coglán and Mardle 2001) have demonstrated that input measures are often not equivalent to output measures of capacity, and changes in the distribution of the inputs can have a substantial effect on the output in a fishery even if the total input-based ‘capacity’ is unchanged.

Output based measures of capacity attempt to measure the potential output and/or the level of capacity utilization directly, usually at the individual vessel level. Implicit in the estimation of the output based capacity measure is also a relationship between the level of fixed inputs, their level of utilization and the level of output. However, the methods for estimation do not generally impose the same assumptions that are implicit in the input based measures. As a result, the measures are not affected by the distribution of inputs.

While providing a better estimate of capacity and capacity utilization in fisheries (FAO 2000), the output-based measures are not as useful for the purposes of management. As noted above, most fisheries are managed using some form of input control. In order to reduce capacity under such a management system, inputs need to be withdrawn so some input based measure is necessary. Consequently, there is a need for both types of measures in fisheries management, with identification of the relationship between the different measures an important component of the management information system.

3. Capacity assessment framework

The capacity assessment framework is illustrated in Figure 2. An over-riding activity that is required for any capacity assessment is a monitoring program to collect appropriate data for

⁵ For example, the UK define vessel capacity units (VCUs) as: $VCU = length * breadth + 0.45 * kw$. VCUs are used as the basis for capacity management in the UK, including decommissioning.

any subsequent analysis. Given the existence of appropriate data, capacity appraisal involves the estimation of the current level of capacity and capacity utilization, the assessment of target capacity levels, and the potential fleet reduction, if any, that is required to achieve the target capacity levels.

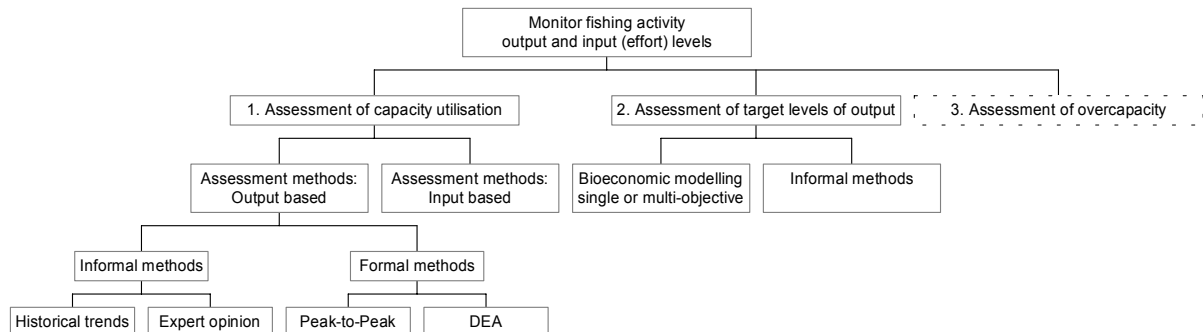


Figure 2. The capacity assessment framework.

The process of assessing current and target capacity can be either formal (i.e. using a quantitative modeling approach) or informal. Examples of these approaches are outlined in the following sections.

3.1 Monitoring and data needs

The data requirements for capacity assessment are no different to those that are required for the effective management of a fishery, and are routinely collected in many countries already.

3.1.1 Input data

Input data are required for the estimation of both input and output measures of fishing capacity. Input data can be divided into two main types: measures of physical capacity and levels of activity. Measures of physical capacity provide, as the name suggests, an immediate input-based measure of capacity. Measures include, for example, total boat numbers, engine power (e.g. kW or Horsepower), length, and Gross Registered Tonnage (GRT). In most fisheries, it is possible to identify several different fleet segments (e.g. defined by different gear types, target species or fishing location), and vessels can be allocated to these fleet segments where possible.⁶ In order to estimate appropriate output-based measures of capacity, the vessel information ideally should be collected at the individual boat level. Input based measures, however, can be derived from totals for the fleet segments (e.g. total GRT, engine power etc).

Fishing activity information includes days/hours fished as well as the quantity of gear used (e.g. km nets, number of traps, etc.). Again, this is required at the individual vessel level for output-based measures. It is also useful to have this information at the boat level in order to estimate potential fishing effort (an input based measure).

⁶ This becomes complicated in fisheries where the vessels are multi-purpose, and may operate using several gear types over the year.

3.1.2 Output data

Output data are ideally required at the level of the vessel, and also disaggregated into species. This information is collected in many countries already through vessel logbooks, and is used for monitoring landings.

3.1.3 Economic data

Economic data are required for the assessment of target capacity,⁷ but provide useful information on the status of the fishery in their own right. Key economic information that is required includes the price of each species, and the costs and earnings of the individual fishing boats. The key cost information required includes a measure of the running costs (e.g. fuel, ice, bait etc), crew costs, annual fixed costs (e.g. harbor dues, administration costs, license fees, maintenance etc) and capital costs (e.g. value of the boat and gear).

3.2 Estimation of capacity and capacity utilization

The estimation of input-based measures capacity and capacity utilization is relatively straight forward as the information collected on the physical attributes of the fleet forms the measures directly. This section will therefore focus on estimation of output-based measures. Depending on the degree of data availability, either informal or formal methods of assessment may be appropriate.

Informal methods of estimation of capacity utilization and capacity output can include an examination of historical trends or the use of expert advice. Examination of catch per vessel over time can provide a crude measure of how much an individual vessel could catch. The highest observed catch rate can form a measure of capacity output, and hence capacity utilization is the ratio of the current output to that capacity output. However, this ignores changes in stock conditions and also possible changes in technology that could have affected the catch rate over time. Discussion with fisheries experts could also provide estimates of capacity output. These experts may include scientists and/or industry members. Based on their experience, they could provide estimates of what different types of vessel should catch if fully utilized given the current stock conditions. This information may be collected either on an *ad hoc* basis (e.g. through discussion with key players in the fishery), or systematically through some form of survey of industry members. Other formal mechanisms for extracting information from experts include the Delphi Technique, which is an iterative process involving collecting opinions from a group of experts, feeding back the compiled information to the group and then eliciting modified opinions. The process is repeated until the group reaches a final consensus.

⁷ Economic information can also be used for the estimation of capacity utilization directly. Incorporation of cost and price information into the capacity utilization provides an economically efficient measure of capacity rather than just a technically efficiency measure of capacity.

More formal methods for estimation capacity and capacity utilization include peak-to-peak analysis and data envelopment analysis (DEA).⁸

3.2.1 Peak-to-peak analysis

A key advantage of peak-to-peak analysis relative to other methods for estimating capacity utilization is that it requires minimal data. Peak-to-peak estimates of capacity and capacity utilization are estimated at the fishery level, so require information on only total fishery output and the level of physical inputs.⁹ Catch per unit of physical inputs are estimated, and it is assumed that peak output levels indicate full capacity utilisation, and lower levels indicate capacity under-utilization.

Changes in peak catch rates are assumed to be due to technological change. The average rate of technical change is applied to derive a full capacity rate. Capacity output is estimated by multiplying the capacity rate by the number of fishing units. Given capacity output, capacity utilization can be derived.

This can be illustrated with a simple example using data from the Dungeness crab fishery in the US (Table 1 and Figure 3).¹⁰ The peak catch rates were observed in 1959 and 1968. Average technical change between these periods was subsequently estimated 10.79 (i.e. $(520.4 - 423.3)/9$, the trend indicated in Figure 3). This technical change rate was used to derive the capacity catch rate – the catch rate if boats were operating at full capacity. For example, the capacity rate in 1960 was estimated as the catch rate in 1959 (assumed to be equivalent to the capacity rate) plus 10.79. The potential catch was estimated by multiplying the capacity catch rate by the number of boats. Capacity utilization can then be estimated by dividing the current catch by the capacity catch. From Table 1 and Figure 3, the fishery was subject to long periods of low capacity utilization.

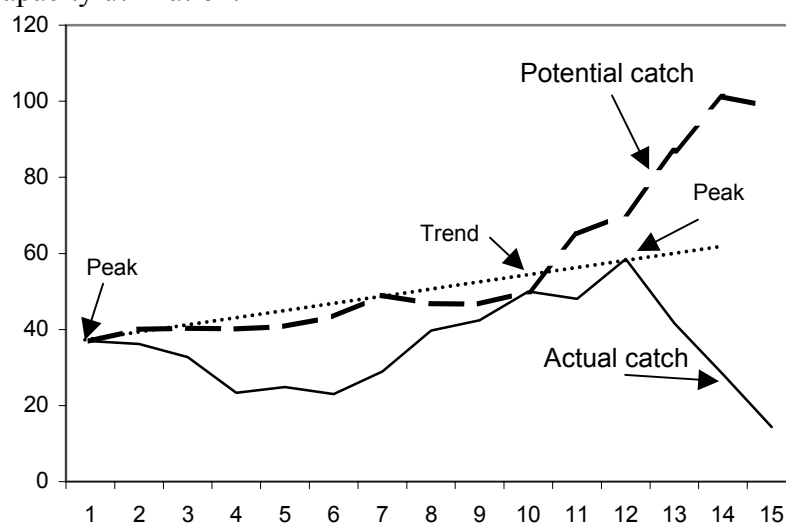


Figure 3. Peak-to-peak analysis of the Dungeness crab fishery.

⁸ Other methods are also available, including the use of stochastic production frontiers. A detailed overview of methods available for estimating capacity and capacity utilization is given by Kirkley and Squires (1999).

⁹ Peak-to-peak estimates can also be made at the species level.

¹⁰ Data for this example were taken from Kirkley and Squires (1999). Other examples of the technique are presented by Hsu (1999)

Table 1. Example: Peak to Peak analysis of the Dungeness crab fishery.

Year	Catch	Boats	Catch rate	Capacity rate	Potential catch	Capacity utilization
1959	36.95	87.3	423.3	423.3	37.0	100.0%
1960	36.16	92.3	391.8	434.0	40.1	90.3%
1961	32.7	90.55	361.1	444.8	40.3	81.2%
1962	23.36	88.01	265.4	455.6	40.1	58.3%
1963	24.86	87.49	284.1	466.4	40.8	60.9%
1964	23.04	90.82	253.7	477.2	43.3	53.2%
1965	28.91	100.36	288.1	488.0	49.0	59.0%
1966	39.72	93.91	423.0	498.8	46.8	84.8%
1967	42.44	91.7	462.8	509.6	46.7	90.8%
1968	49.97	96.03	520.4	520.4	50.0	100.0%
1969	48.06	122.44	392.5	531.1	65.0	73.9%
1970	58.51	130.08	449.8	541.9	70.5	83.0%
1971	41.61	157.43	264.3	552.7	87.0	47.8%
1972	28.25	179.52	157.4	563.5	101.2	27.9%
1973	14.37	171.45	83.8	574.3	98.5	14.6%

Source: Kirkley and Squires (1999).

The key advantages of the method are its simplicity and relatively low data requirements. However, the method has a number of problems that need to be considered. Firstly, in multi-species fisheries, analysis of capacity utilization at the species level may become problematic if fishers are able to target individual species and effort is switched between species. In such cases, there is the potential for ‘under-utilization’ to appear as a result of switching between species. In some cases, it may appear that all species are under-utilized when considered separately, even though the fleet may be fully utilized.

The method also ignores changes in stock conditions. Lower catch rates in some years could indicate smaller stocks rather than under-utilization of boats. Conversely, peak catch rates may coincide with above average stock levels. Actual capacity utilization may be high in the intermediate (normal stock condition) periods, although will appear low if the peak periods are affected by above average stock levels. This is particularly a problem if stocks are highly variable, such as often occurs with small pelagics (e.g. sardines, anchovies). In the case of the Dungeness crab example above, the low capacity utilization in the last 4 or 5 years most likely represented a decline in the stock rather than capacity under-utilization per se. As a consequence, the interpretation of the results needs to consider these factors.

3.2.2 Data Envelopment Analysis (DEA)

DEA is an output-based measure that can provide information on both a species by species basis as well as a fleet segment basis. Estimates of capacity and capacity utilization can be made at the fleet level directly, or, preferably, at the individual vessel level and aggregated up to the fleet level.

DEA is a ‘frontier’ based method: the outputs of individual boats in the fleet are compared, with the ‘best’ set of vessels used as a benchmark. The ‘best’ boats are those that have the greatest level of output per unit of input. These boats determine the ‘frontier’. For example, in Figure 4, the two axes represent the average catch per unit input (e.g. kg/GRT) of two species. The points *A*, *B*, *C* and *D* represent the catch composition of four boats. These boats define the frontier as no other boats have greater catches per unit input. Point *E* represents a boat with a lower catch per unit input of both species. If the boat was operating at the same level as the other vessels, it could potentially catch more of each species. Based on the catches of the other vessels, the boat at point *E* could potentially operate at point *E**. This latter point defines the capacity output of the boat at point *E**, and the ratio of the distances OE/OE^* is a measure of its capacity utilization.¹¹

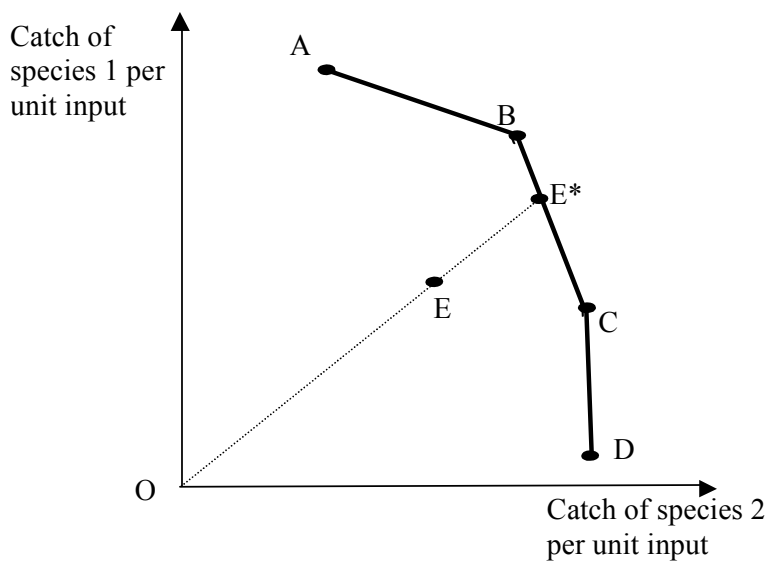


Figure 4. Two-output production possibility frontier.

DEA is a non-parametric technique, solved using a linear programming model, so cannot directly deal with random error (e.g. “luck” in terms of catch). However, the method that has been developed and applied in fisheries is not affected by random error,¹² making it suitable for use in even highly variable fisheries.

The Technical Consultation on the Measurement of Fishing Capacity (FAO 2000) suggested that DEA is the preferred method for estimating capacity and capacity utilization in fisheries as it can directly accommodate multiple inputs (e.g. boat size, engine power, gear and area fished etc) and multiple outputs (i.e. catches of different species). Hence, it can be used for multi-species fisheries without the problems experienced using peak-to-peak. Further, capacity utilization is assessed in each time period separately, so is not affected by stock fluctuations. Industry capacity can be estimated as the sum of the individual capacity output

¹¹ Technical efficiency is also estimated in a similar way, with variable inputs also considered in the analysis. The estimation of capacity utilization used information only on fixed inputs.

¹² Details on the equations underlying the DEA methodology are given in Kirkley and Squires (1999). See Holland and Lee (2002) for details on the sensitivity of the results to random variation.

levels, although this is an underestimate of the actual industry capacity output level as it may be possible for higher catches to be realized through a different allocation of inputs.

3.3 Assessment of target capacity

The management of fishing capacity requires not only some measure of the existing level of fishing capacity, but also some measure of the desired level of capacity. A wide range of sustainable yields can be achieved in a fishery. Indeed, even an overcapitalized fishery, as illustrated in Figure 1, can produce a sustainable yield that may be considered ‘optimal’ under some circumstances. The target capacity therefore relates to the objectives of management, and the ‘optimal’ yield is that which best achieves these objectives. In fisheries where employment is considered a key consideration, lower yields and income levels may be considered an acceptable trade-off. Conversely, in industrial fisheries, resource rent generation may be considered of greater importance, accompanied by higher yields but lower employment levels. Hence the maximum economic yield may be an appropriate target output capacity. Where the fishery is a main provider of food, the maximum sustainable yield (MSY) may be considered the target output level.

In fisheries managed through input controls, the assessment of target levels of capacity requires estimates both in terms of outputs and inputs.¹³ For example, if the objective of fisheries management was to maximize the sustainable yield, then both the output at MSY and the fleet size/configuration required to achieve it need to be estimated.

The estimation of the ‘optimal’ yield can be undertaken either through a formal assessment using some form of model when sufficient data are available, or informally through the use of reference points/periods when data are limited.

3.3.1 Informal approaches

As with the estimation of current capacity, expert opinion can be used to derive a ‘rough’ estimate of the target level of capacity. This may involve consideration of the output and input levels in the fishery when it was believed to be operating at a sustainable and optimal level. Similarly, the average output over an extended period of time may be considered as an initial indicator of the target yield in the absence of more appropriate information.

3.3.2 Formal approaches

Stock assessment techniques are well established that allow for the estimation of sustainable yields in fisheries, provided sufficient data are available to estimate the required model parameters. These models are sufficient to estimate both target output capacity and input levels provided biological sustainability is the only objective of management.

¹³ This is also true for fisheries managed using a combination of input controls and aggregate output controls (e.g. TACs) as the main mechanism for capacity management will still involve the use of input controls (e.g. decommissioning schemes). The only management system in which just an output-based measure of target capacity may be appropriate is a system of individual transferable quotas.

Where other factors are considered important, such as incomes and employment for example, some form of bioeconomic model is required. Optimization model can be used to estimate the optimum yield and fleet size that are both sustainable and also improve fisher incomes. Multi-objective models can be developed that allow the ‘optimal’ to be defined in terms of several criteria (e.g. employment, profitability, etc).¹⁴

Bioeconomic models are particularly useful for the analysis of optimal fishing capacity in multi-species, multi-gear and multi-purpose fisheries. To determine the optimal target capacity, consideration needs to be given to all activities undertaken by the vessels. The overall optimal level of output of any species may not be optimal for each species individually. That is, the optimal fleet size for the fishery as a whole may result in some species being harvested at beyond their individual optimal level, while others harvested below their individual optimal level. These synergistic effects cannot be adequately addressed solely in biological models. Costs and revenues, and the technical interactions that may exist between the species given the gears employed, affect the behavior of fishers, and subsequently the distribution of fishing activity in response to any management change.

The use of any model – biological or bioeconomic – for the purposes of estimated target capacity, however, requires some caution. There is generally considerable uncertainty about many of the biological and economic parameters that are used in these models. As a consequence, the results need to be considered as indicative rather than prescriptive. That is, they can act as a guide, but should not be used as a recipe for capacity management.

3.4 Capacity appraisal

The process of capacity appraisal involves both qualitative and quantitative approaches based on the analyses undertaken and knowledge of the fishery. The principle objective of capacity appraisal is to identify how much overcapacity exists, if any, and also where the overcapacity may exist. For example, are all fleet segments in a fishery overcapacity or just some? Can fleet reduction reduce overcapacity on all species or does an ‘optimal’ fleet involve some overcapacity still for some species?.

The estimates of capacity utilization provide a short-term indicator to the existence of overcapacity in a fishery. However, the appraisal needs to take into consideration a range of other factors. For example, in highly fluctuating stocks, some degree of capacity under-utilization may be required in an average (or poor) year in order to allow sufficient capacity in the fishery to take advantage of a good year. Similarly, if capacity under-utilization is a result of temporary adverse market conditions, then under more normal conditions the fleet may be operating at full capacity. Finally, if capacity under-utilization is the result of management interventions (e.g. a restriction on the number of days that can be fished) with the aim of allowing the stock to recover, then the existing fleet may operate at full capacity once the stock has recovered and the restrictions removed. Consequently, the interpretation of capacity under-utilization needs to be made in the broader context of information on what is happening in the fishery.

¹⁴ A detailed review of the use of multi-objective models in fisheries is given by Mardle and Pascoe (1999).

Deriving output-based measures of overcapacity is considerably more complex than input based measures. It is not appropriate to compare the existing capacity to the optimal capacity estimated using bioeconomic models in order to derive a longer-term measure of overcapacity. For example, a fleet may be operating at full capacity in a depleted fishery and producing an output less than the long-term target output, but that same fleet, if operating under conditions of stock recovery could produce an output well in excess of the target output. As a result, in order to estimate the extent of any overcapacity, the models developed above need also to be used to estimate the capacity output of the existing fleet under the long-term stock conditions (i.e. when the stock has recovered). This is illustrated in Figure 5, where the current fleet has a capacity output O under current stock conditions, but could catch O^* if the stocks were at the level that could produce maximum sustainable yield.

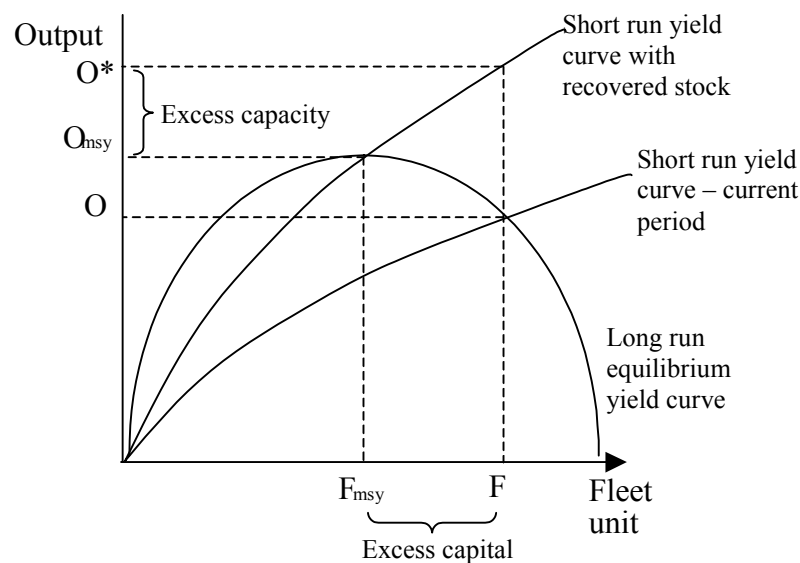


Figure 5. Estimation of overcapacity in the longer term.

In contrast, the level of excess capital can be more easily estimated using bioeconomic (or biological) models, as the difference between the current fleet size and the ‘optimal’ fleet size.

4. Summary and conclusions

The capacity appraisal framework can be summarized as consisting of four main steps. Essential to any capacity management program, and indeed any fisheries management, is the monitoring of the current level of exploitation. This involves collecting information on the vessels that are operating in the fishery, their level of activity and their level of output. These data can then be used to estimate the level of capacity utilization to provide a short-run indicator of where problems may exist in different fisheries and fleet segments.

The data can also be used to develop models of the fisheries in order to estimate target levels of capacity. The ‘optimal’ level of capacity will depend on the objectives of management.

In some cases, data will not be available in order to either assess capacity utilization or develop models for assessing target levels of capacity. In such cases, expert opinion can be used to derive estimates as an interim measure while data are being developed for more formal assessments. Lack of data should not be considered a valid reason to ignore potential problems in fisheries, particularly as they can result in greater problems in the longer term if not addressed.

The final capacity appraisal process involves using the information developed in the previous steps to determine the extent of any overcapacity in a fishery. As the methods outlined previously provide indicators only, any appraisal of overcapacity needs to take into consideration the assumptions underlying the formal analysis.

The capacity appraisal framework does not provide information on how target capacity levels can be achieved. Management plans need to be developed and implemented that will move the fishery from the current situation to that identified as the target. This in itself will present difficulties, as capacity reduction plans may be unpopular with the industry, which may create challenges in its implementation. FAO have recently held an Expert Consultation on Catalyzing the Transition away from Overcapacity in Marine Fisheries (Metzner and Ward 2002) to address these issues.

The purpose in this paper was to present an overview of the capacity appraisal framework. The methods for capacity assessment have only been briefly summarized in this paper. The estimation of output based measures of capacity and capacity utilization in fisheries is still relatively new, and now doubt will continue to evolve in the future. In contrast, the development and application of bioeconomic models has been well established, although the use of these models for the capacity appraisal has also been limited. The need to effectively assess and manage capacity, however, is going to stimulate increased research efforts in these areas in most countries over the coming years.

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