Over-capacity, Regulation and Rent: A Norwegian Case Study

Frank Asche
Stavanger University College and
Centre for Fisheries Economics,
Norwegian School of Economics and Business Administration, Bergen, Norway.

Trond Bjørndal
Renewable Resources Assessment Group
Imperial College, Royal School of Mines and Centre for Fisheries Economics,
Norwegian School of Economics and Business Administration, Bergen, Norway

Daniel V. Gordon
Department of Economics, University of Calgary, Calgary, Canada and
Centre for Fisheries Economics,
Norwegian School of Economics and Business Administration, Bergen, Norway

Abstract. Traditional fisheries management schemes provide fishermen with incentives to maximise their individual share of the catch, while individual vessel quota management schemes change incentives to maximise profits from their individual share of the catch. The way that one models the fishermen’s optimisation problem in empirical studies should reflect the changed structure of the optimisation problem when individual vessel quotas are used as a management instrument. In this paper a cost function is used to model a fishery regulated with individual vessel quotas, and to derive measures of potential resource rent and over capacity for this fishery.

Keywords: Regulation, Rent, Individual Vessel Quotas, Over-capacity

1. INTRODUCTION

Traditionally, most fisheries can be characterised either as unregulated or regulated open access. Typical in a regulated open access fishery is a restriction on harvest given by a Total Allowable Catch Quota (TAC), often combined with restricted entry and input controls. Under these circumstances, the incentive for fishermen is to maximise their share of the catch. This incentive will lead to a race among fishermen to capture the largest share possible of the TAC and to over-capacity in harvesting as fishermen substitute away from those inputs restricted by regulation (Munro and Scott, 1985). These regulations can, in many cases, make the overcapacity problem more severe than in unregulated fisheries because of the race to fish (Homans and Wilen, 1997). What is more, the common property nature of the resource is essentially unaltered by these regulations and resource rents are dissipated.

During the 1990s, individual vessel quota (IVQ) schemes, where the quota may or may not be transferable, have become an important management tool. For these schemes, each participant in the fishery is entitled to a quantity or quota share of the TAC. This eliminates the race to fish as fishermen are ensured their quota share and, moreover, can lead to rent generation. However, to ensure rent generation, capacity in the fishery cannot be too high. This is a problem as there tends to be substantial overcapacity in fisheries when individual vessel quotas are introduced. In most cases, the practice has been to initially allocate quota shares to fishermen gratis, usually based on historical catch records.

Transferability of individual quota provides incentives for efficient harvesters to acquire quota from less efficient harvesters, which then leave the fishery, reducing harvesting capacity. This will improve overall harvesting efficiency in the fishery and generate rent. In principle, a well designed individual transferable quota system will allow all resource rents to be generated and reflected in the value of the quota (Arnason, 1990). An interesting question is whether it is the changed incentives due to individual quota or the capacity reduction due to transferability of quota that is most important in generating rent in individual vessel quota schemes. This question has great practical implications as several countries, including Canada and Norway, have chosen IVQ...
schemes that do not allow or have put in place strict limits on transferability of quota. Such countries risk the possibility of substantial rent dissipation through over-capacity in harvesting.

Under traditional management regimes, landed quantity is a choice variable for the fishermen. Profit functions have therefore been the preferred specifications when empirically modelling fishermen’s behaviour. Individual vessel quotas restrict the quantity the fishermen can harvest, and quantity landed is therefore not a choice variable as under traditional management regimes. However, since the quantity landed is given by the quota, the economic behaviour of the fishermen is to minimise the cost of harvesting. The appropriate specification of fishermen behaviour under management regimes with individual vessel quotas is therefore a cost function rather than a profit function.

In this study, the cost function approach is used to model the production technology for a fishery regulated with individual vessel quotas. Moreover, we will measure rent generated and potential rent in fisheries managed with individual vessel quotas at the vessel as well as the fleet level. Actual rent can be measured based on earned income and the cost of harvesting. Potential rent requires calculating a measure of optimal harvest (quota) from the fishermen’s total profit function. Furthermore, optimal vessel (quota) size combined with the TAC for the fishery allows a measure of over-capacity in the existing fleet. These measures are derived in a similar fashion to those provided by Dupont (1990) in a restricted profit function framework. In contrast to Weninger (1999) we focus on rent rather than just efficiency gains and cost reduction due to the individual vessel quotas. This is important when investigating the full potential of an individual quota system since the changed regulatory structure allows the fishermen to serve different and potentially more valuable markets. An empirical application will be provided for the Norwegian cod trawler fleet. This has been operating under an IVQ system since the mid-1990s.

2. MODELLING AN IVQ FISHERY

When modelling the harvesting process, an assumption of profit maximisation is often the starting point and production parameters are estimated using a profit function specification. Without restrictions on the profit function all inputs used in harvesting and the harvest level are choice variables for the fishing vessel. The total profits can be written as

$$\Pi(p, w) = Yp - \sum q_i w_i$$

where $p$ is the price of fish, $Y$ the harvest level, and $w_i$ the price of the $i$th input factor, $q_i$. This tells us that profit is the difference between revenue and cost of production. Observed profits are often taken as an estimate of realised rent in a fishery (Dupont, 1990).

In open access or regulated open access fisheries, resource rents will be dissipated by the common property nature of the fishery and profits, defined by (1), are zero. However, with individual vessel quotas fishing vessels are ensured a share of the resource, so that profits can be positive, representing resource rent.

---

1 See e.g. Squires (1987; 1988) or Dupont (1990).
2 In individual quota systems where transferability is possible, short-term leases are in most cases for one year (season). Hence, although it may be argued that with transferability the amount of quota and therefore output is a part of the fishermen’s optimisation problem, this is will not so under the systems considered here. Moreover, one may also argue that the purchasing/selling of quota is separable from other factors, since quota will be purchased/sold given the expectations of future prices, and each vessel will have a given stock of quota after transfers.
3 Cost function specifications have been used by Weninger (1999) and Bjørndal and Gordon (2000).
4 For instance, Homans and Wilen (2002) show that harvest value in the Pacific halibut fishery increase substantially since fishermen are able to sell a much larger share of their fish in a fresh product form after individual vessel quotas was introduced.
5 A potential problem with such an approach is that infra-marginal rents like skipper effects are treated as resource rent.
In many empirical applications, (1) is modified to account for restrictions in the actual harvesting process. Often capital (the vessel) is treated as a fixed factor in harvesting, recognising that regulations prevent adjustment or that second hand markets often are limited and adjustment costs accordingly high (Squires, 1988; Dupont, 1991, Bjørndal and Gordon, 1993). Under this scenario, a restricted profit function is specified where the fishing vessel is assumed to maximise profits by choosing inputs and harvest level subject to the size of the vessel used in harvesting. Total profit can be calculated from the restricted profit function, $\Pi^R(p, w; z)$, by accounting for the cost of the vessel or

$$\Pi(p, w, w_z) = \Pi^R(p, w; z) - w_z z$$

Here, $w_z$ is the user price for purchasing capital stock (i.e., the vessel), and $z$ represents the size of the vessel. Since (2) defines the long-run profit relationship, resource rents can be measured in the same manner as (1).

The equation in (2) can also be used to derive the optimal level of the fixed factor by maximising (2) with respect to the fixed factor(s) (Lau, 1976; Brown and Christensen, 1981). This was utilised by Dupont (1990), who noted that by finding the optimal level of the fixed factor, one can compute potential rent for a vessel if the regulatory system allows this factor to be adjusted to its optimal level. Hence, (2) can be used both to compute actual rent harvested under a regulatory system and the potential rent if the system is changed so that a (quasi-) fixed factor is allowed to adjust to its optimal level. Moreover, the fish stock or the TAC is in most cases is given, and total catch cannot be increased. If vessels are to operate optimally, the number of vessels in the fleet has to be reduced. Dupont (1990) shows that this can be used to calculate optimal fleet size and potential rents obtainable with an optimal fleet.

With individual vessel quotas harvest is an exogenous or restricted factor. For price taking fishermen, the optimisation problem becomes one to maximise profits for a given catch level, or equivalently, to minimise the cost of harvesting the given quota, assuming the quota is the only fixed factor. With these modifications the total profit for a fisherman under an IVQ scheme can be written as

$$\Pi(p, w) = Yp - C(w; Y)$$

where $C(w; Y)$ represents the cost function where the individual fishermen decide the mix of input quantities for a given quota. The cost function contains all the choice variables for the fisherman under an IVQ scheme. Moreover, these variables will contain all information about behaviour from the observed data. If (quasi-) fixed factors are modelled as variable, as one would do if a profit function specification were used, estimated parameters and elasticities will be biased (Brown and Christensen, 1981). It is well known that a cost function is a special form of a restricted profit function with (output quantity) harvest level treated as a fixed factor (Lau, 1976). Therefore, the structure of (3) is the same as for (2). The only difference is due to different decision variables for the fishermen because of the different regulatory schemes.

The equation in (3) provides total profits, and observed profits can therefore be regarded as actual or realised rents. However, in contrast to the problem considered by Dupont (1990), the regulatory scheme now restricts the output. One can find the optimal output level by maximising (3) with respect to $Y$, giving $Y^*(p, w)$. This gives the standard condition price equals marginal cost. This is then the output level that will maximise profits and therefore rents for any vessel. For a competitive firm, this will also be where return to scale is constant. Furthermore, if one knows the TAC and assumes that the data set is representative, one can find how many vessels are necessary to take the TAC. This will then be a measure of optimal fleet size. The total profits of these vessels will then be the potential rent in the fishery. This is important information in fisheries managed with IVQs, as it will provide information about the extent to which one has been able to collect the resource rent and how much resource rent is dissipated due to overcapacity in the fishery.

---

6 This condition will then also implicitly define the demand for quota (Arnason, 1990).
7 See Morrison (1985) for a good discussion.
3. DATA

An empirical application will be carried out for Norwegian trawlers fishing cod with no on-board processing. The data covers the three-year period 1997-99 and has been provided by the Norwegian Directorate of Fisheries. Annual observations are available at the vessel level on revenue and quantity as well as cost and quantity of fuel, bait, insurance, provisions, maintenance (vessel and gear), miscellaneous costs, labor. The value of the vessel, measured by replacement value and tonnage units, is also provided. This provides a total sample of 98 observations. Table 1 provides summary statistics for some key variables.

Table 1. Summary Statistics Norwegian Cod Trawlers, 1997-99

<table>
<thead>
<tr>
<th>Year</th>
<th>Number of Vessels</th>
<th>Average Days Operation</th>
<th>Average Harvest (tonnes)</th>
<th>Average Gross Register Tonnes (GRT)</th>
<th>Average Value of Vessel (million NOK)</th>
<th>Costs (mill. NOK)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1997</td>
<td>32</td>
<td>268</td>
<td>2757.7</td>
<td>636</td>
<td>52.90</td>
<td>15.34</td>
</tr>
<tr>
<td>1998</td>
<td>31</td>
<td>279</td>
<td>2134.0</td>
<td>648</td>
<td>53.62</td>
<td>17.12</td>
</tr>
<tr>
<td>1999</td>
<td>35</td>
<td>270</td>
<td>1886.3</td>
<td>648</td>
<td>56.36</td>
<td>18.78</td>
</tr>
</tbody>
</table>

Total 98 272 2249.2 644 54.36 17.13

Input expenditure data are used to build three price indices; labour, capital and miscellaneous. The price index for labour \( (w_l) \) is defined as annual labour costs including captain divided by man-years of employment. The price index for capital \( (w_k) \) is defined as the replacement value of the vessel multiplied by the interest rate plus vessel depreciation. The interest rate is set at 3% over the inter bank market rate and depreciation at 10%. Finally, the price index for fuel and miscellaneous \( (w_m) \) is defined as the expenditure on fuel, maintenance for gear, vessel provisions, insurance and other costs divided by operating days. Long run costs \( (C) \) are defined as the sum of expenditures on labour, user cost of capital, fuel, maintenance for gear, vessel provisions, insurance and other costs.

The Norwegian cod trawler fleet has been operating under an IVQ system since the mid-1990s. A system of restricted transferability of quota was put in place for 1997-98. This system allowed quota for two vessels to be combined into quota for one vessel if the other vessel was permanently removed from the fishery. However, the vessel that obtained the quota will only keep it for 13 years. For the two year period, nine vessels from a total of 44 vessels where removed from the cod trawler fleet. However, the policy was discontinued in 1999 and over-capacity in harvesting is still possible.

4. EMPIRICAL ANALYSIS

A translog flexible functional form is used to specify the long-run cost function in the empirical application. The cost function can then be written as

\[
\ln C = \ln \alpha_0 + \sum_{i=1}^{n} \alpha_i \ln w_i + \frac{1}{2} \sum_{i=1}^{n} \sum_{j=1}^{n} \alpha_{ij} \ln w_i \ln w_j + \alpha_{qq} \ln Y \\
+ \frac{1}{2} \alpha_{qq} (\ln Y)^2 + \frac{1}{2} \alpha_{q} \ln w_i \ln Y + \epsilon
\]  

8 This is only a part of the vessels fishing for cod as there are also larger vessels with on board processing facilities as well as a number of smaller vessels utilizing different kinds of gears. However, the vessels considered here is a distinct group that as a group receives an allotted share of the total Norwegian cod quota.

9 The data does not allow us to follow the vessels over the years, and hence, we cannot estimate firm specific effects.

10 The inter bank rate is used as the base rate on loans to the fishing industry as well as most other industries. For different industries one then adds a premium, which for fishing vessels normally is 3% (personal communication with K. Giskeødegard in Nordea).
and its associated cost shares

\[ S_i = \alpha_i + \sum_{j=1}^{n} \alpha_{ij} \ln w_j + \alpha_{iQ} \ln Y + u_i \]  \hspace{1cm} (5)\]

where \( C \) is long-run cost, \( i,j = l, k \) and \( m \), \( Y \) is aggregate output and \( e \) and \( u \) is random error term assumed to be i.i.d. The following restrictions were imposed:

Homogeneity: \( \sum_{i=1}^{n} \alpha_i = 1 \), \( \sum_{j=1}^{n} \alpha_{ij} = 0 \), \( \sum_{j=1}^{n} \alpha_{ij} = 0 \), \( \sum_{i=1}^{n} \alpha_{iQ} = 0 \)

Symmetry: \( \alpha_{ij} = \alpha_{ji} \)

The price and harvest variables used in estimation are centred on the mean of the variable in the data set. (4) is combined with the cost share equations for labour and capital and estimation is carried out using an iterative Seemingly Unrelated Regression procedure.\(^{11}\)

The estimated parameters are provided in Table 2, and with a system R\(^2\) of 0.988 the fit of the model is reasonable. In Table 3 the price elasticities are reported. All elasticities are statistically significant at a 5% level. All own price elasticities are negative and rather inelastic, as expected, and all input factors are substitutes. Hence, the model performs well and we can turn to the main topic of the paper, rent generation and capacity.

| Table 2. Estimated Coefficients Long-Run Cost Function |
|-----------------|-----------------|-----------------|-----------------|
| \( \alpha_o \)  | 9.962 (*)       | 0.109 (*)       | 0.92E-4 (*)      |
| \( \alpha_{lf} \) | (0.05)         | (0.009)        | (0.16E-4)       |
| \( \alpha_{ll} \) | 0.286 (*)      | 0.134 (*)      | -0.12E-4 (*)     |
| \( \alpha_{kl} \) | (0.02)         | (0.013)        | (0.011E-4)      |
| \( \alpha_{qk} \) | 0.274 (*)      | 0.135 (*)      | 0.26E-4 (*)      |
| \( \alpha_{mem} \) | (0.0003)       | (0.009)        | (0.14E-4)       |
| \( \alpha_{mq} \) | 0.439 (*)      | 0.0555 (*)     | 98              |
| \( \alpha_{Qk} \) | (0.005)        | (0.007)        |                 |
| \( \alpha_{Qm} \) | 0.255 (*)      | 0.0555 (*)     |                 |
| \( \alpha_{lQ} \) | (0.089)        | (0.007)        |                 |
| \( \alpha_{QQ} \) | -0.38E-7 (*)   | -0.079 (*)     |                 |
| \( \alpha_{QQ} \) | (0.17E-7)      | (0.009)        |                 |

\(^*\) Standard error in parentheses
\(^{**}\) Statistically significant at the 95% level.

The first measure of relevance to capacity considered here are returns to scale. The scale elasticity is found to be 3.92, which indicates very substantial scale economies. This is in contrast to what is reported in most of the literature on fishermen behaviour (e.g Squires and Kirkley, 1991, Salvanes and Squires, 1995). However, it may not be too surprising if one takes the change in regulatory structure into account. When modelling fisheries with a profit or revenue function, the fishermen mostly operate under a regulated open access structure with a race to fish. One then often finds substantial diseconomies of scale.\(^{12}\) In the fishery considered here, on the other hand, there is no longer a race to fish. However, there are few incentives to reduce capacity, and given that regulated open access fisheries often will have a very high overcapacity (Homans and Wilen, 1997), this capacity to a large extent still exists within the fishery. The high returns to scale is therefore probably just a sign of substantial overcapacity in this fishery. It is also of interest to note that Weninger (1999) and Bjørndal and Gordon (2000), who also investigate fisheries managed by individual vessel quotas, find increasing returns to scale.

\(^{11}\) We also investigated whether there where structural differences between the years in the data set. However, the specification without annual dummies was preferred.

\(^{12}\) For instance, Salvanes and Squires (1995) report a short-run returns to scale at 0.26.
Table 3. Estimated Elasticities at mean values

<table>
<thead>
<tr>
<th></th>
<th>Labour</th>
<th>Fuel &amp; miscellaneous</th>
<th>Capital</th>
</tr>
</thead>
<tbody>
<tr>
<td>Labour</td>
<td>-0.330</td>
<td>0.082</td>
<td>0.248</td>
</tr>
<tr>
<td></td>
<td>(0.032)</td>
<td>(0.026)</td>
<td>(0.025)</td>
</tr>
<tr>
<td>Fuel &amp; miscellaneous</td>
<td>0.086</td>
<td>-0.235</td>
<td>0.149</td>
</tr>
<tr>
<td></td>
<td>(0.027)</td>
<td>(0.033)</td>
<td>(0.032)</td>
</tr>
<tr>
<td>Capital</td>
<td>0.162</td>
<td>0.093</td>
<td>-0.254</td>
</tr>
<tr>
<td></td>
<td>(0.016)</td>
<td>(0.020)</td>
<td>(0.029)</td>
</tr>
</tbody>
</table>

* Standard error in parentheses.

We then turn to optimal landings for a vessel.13 As noted in section II, to find the optimal output one puts (4) exponentiated into (3), and maximises this with respect to \( Y \). The translog does not have an analytical expression for optimal levels of fixed factors (Brown and Christensen, 1981). The optimal level therefore has to be found numerically. We find that optimal landings at average prices are 6,296 tonnes, about three times the average quantity actually landed in the fleet. Hence, as expected there seems to be substantial overcapacity in this fleet.

5. OPTIMAL HARVEST AND FLEET SIZE

When investigating the potential rents in this fishery we start by looking at the vessel level, and compute all measures for average prices (Table 4). All measures are reported both for the full period and at the prevailing prices and quotas for each of the three years.

Table 4. Actual and potential rents at the vessel level *

<table>
<thead>
<tr>
<th></th>
<th>Full period</th>
<th>1997</th>
<th>1998</th>
<th>1999</th>
</tr>
</thead>
<tbody>
<tr>
<td>Output</td>
<td>2249.2</td>
<td>2757.7</td>
<td>2134.0</td>
<td>1886.3</td>
</tr>
<tr>
<td>Actual revenue</td>
<td>17.6</td>
<td>15.4</td>
<td>17.7</td>
<td>17.8</td>
</tr>
<tr>
<td>Actual rent</td>
<td>-1.7</td>
<td>-2.2</td>
<td>-1.5</td>
<td>-0.9</td>
</tr>
<tr>
<td>Potential revenue</td>
<td>49.2</td>
<td>35.1</td>
<td>52.3</td>
<td>59.5</td>
</tr>
<tr>
<td>Potential rent</td>
<td>29.9</td>
<td>17.5</td>
<td>33.0</td>
<td>40.7</td>
</tr>
<tr>
<td>Rent as % of potential revenue</td>
<td>60.8</td>
<td>49.8</td>
<td>63.1</td>
<td>68.4</td>
</tr>
</tbody>
</table>

* Values are in million Norwegian kroner and quantities in metric tonnes.

The actual rent in each of the years is negative. This is most likely caused by the fact that we use opportunity cost of capital rather than actual cost. Many of the vessels are old (on average, boats were constructed in 1976), and most of them received subsidies when they were acquired. As noted above, the optimal landings for the average vessel are found to be 6,296 tonnes, about three times the quantity actually landed by each vessel. It is then not surprising that the vessel earns a substantial rent if it is allowed to increase landings. On average, potential rents are 60.8% of total revenues, although there is some variation between the years.

Let us then turn to the fleet. We here follow the approach of Dupont (1990), and assume that our sample is random, and use the mean of the prices in our sample as an estimate for the mean of the population. Given that we know the number of vessels in the population, we can derive aggregate measures. However, since the quota is set based on biological considerations, the actual landings cannot exceed the total quota. Hence, the optimal fleet is the number of vessels landing an optimal quantity necessary to land the whole quota, rounded to the nearest integer. The results are reported in Table 5. On average, 64.4% or almost two thirds of the vessels are redundant. However, this varies substantially over the years as the quota in 1997 is almost twice the quota in 1999. These results gives at least three insights; a) there is substantial overcapacity in the fleet, b) no rent is generated so that in this fishery, overcapacity is the main problem, as ending the race to fish has not allowed rent to be generated, and c) given that the total quota varies substantially, it is not possible to have a stable number of vessels and at the same time harvest optimal resource rent.

13 With our data set we are not able to model vessel heterogeneity. This is often reckoned to be of importance in the fishery literature through the notion of skipper effects. However, we are in line with Dupont (1990) and Bjørndal and Gordon (1993) in the fisheries literature and the technical efficiency literature in general (Kumbhakar and Lovell, 2000) in that heterogeneity disappears for an optimal industry if it is not characterised by constant returns to scale.
That almost two thirds of the vessels are redundant and that on average 60% of the revenues is potential rent seems rather dramatic. The predicted optimal harvest is higher than what is observed in the data set, which indicates that the numbers should be regarded with some caution.\(^{14}\) However, in fisheries regulated with individual transferable quotas, the price of a one year lease of quota will be equal to rent per unit of fish that the quota gives an entitlement to. We have therefore collected average ex-vessel prices and one year quota lease prices from the Icelandic cod fisheries, as these can provide some evidence with respect to the reliability of the results. The Icelandic cod fisheries are regulated with individual transferable quotas, but have otherwise many similar characteristics with the Norwegian fisheries. The prices are shown in Table 6 together with the share of rent in revenue. As one can see, this is very high as it varies between 72% and 84%, which is higher than our estimates for the Norwegian cod trawlers. There are several signs that the Icelandic quota market has not reached long-run equilibrium (Asche, 2001), and one can also argue that the willingness to pay for an additional unit of quota in the short run may be higher than the long-run rent, as fixed costs may not be relevant. However, even if the price of a quota lease id somewhat higher than rent, it is fair to say that it indicates that the share of rents in total revenue is substantial, and it may well be higher than our estimates for the Norwegian cod trawlers.

Few studies have empirically investigated the potential for rent or efficiency gains in a fishery, with Dupont (1991) and Weninger (1999) as two exceptions. Although their results are not strictly comparable, it is of interest to mention some of their results that shed light on some of the issues we consider here. In particular, Dupont (1991) finds that in the Canadian Pacific salmon fishery, potential rents are about 42% of total revenue. Weninger (1999), for the US surf clam and quahog fisheries, finds that a fleet of 128 vessels can be reduced to between 21 and 25, i.e., a reduction of about four-fifths of the number of vessels when individual vessel quotas were introduced. Hence, it seems clear that both the potential rent and the overcapacity in most traditionally regulated fisheries are substantial.

The total allowable catch quota (TAC) varied substantially in the three year period under investigation. As a consequence, optimal fleet size also varied over time. A constant optimal fleet size relies on the notion of a steady state for fish stocks. However, natural variations are likely to make stock size variable, even in a well managed fishery.\(^{15}\) The questions of optimal capacity and potential resource rent generation over time in a fishery with natural fluctuations in stock size are not considered here, but represents an interesting avenue for future research.

### Table 5. Actual and potential rents at the aggregate level \(^{a}\)

<table>
<thead>
<tr>
<th></th>
<th>Full period</th>
<th>1997</th>
<th>1998</th>
<th>1999</th>
</tr>
</thead>
<tbody>
<tr>
<td>Actual rent</td>
<td>-199.7</td>
<td>-97.4</td>
<td>-60.3</td>
<td>-33.0</td>
</tr>
<tr>
<td>TAC</td>
<td>265,405</td>
<td>121,338</td>
<td>83,226</td>
<td>66,020</td>
</tr>
<tr>
<td>Potential rent</td>
<td>1,257</td>
<td>332</td>
<td>429</td>
<td>407</td>
</tr>
<tr>
<td>Actual no. of vessels (population)</td>
<td>-</td>
<td>44</td>
<td>39</td>
<td>35</td>
</tr>
<tr>
<td>Optimal no. of vessels</td>
<td>-</td>
<td>19</td>
<td>13</td>
<td>10</td>
</tr>
</tbody>
</table>

\(^{a}\)Values are in million Norwegian kroner and quantities in metric tonnes.

### Table 6. Ex-vessel price and quota price, Iceland, Icelandic kroner, pr/kg

<table>
<thead>
<tr>
<th>Year</th>
<th>Quota price</th>
<th>Ex-vessel price</th>
<th>% quota price of Ex-vessel price</th>
</tr>
</thead>
<tbody>
<tr>
<td>1997</td>
<td>82</td>
<td>98.3</td>
<td>83.4</td>
</tr>
<tr>
<td>1998</td>
<td>88</td>
<td>119.6</td>
<td>73.5</td>
</tr>
<tr>
<td>1999</td>
<td>100</td>
<td>137.4</td>
<td>72.7</td>
</tr>
</tbody>
</table>

Source: The Icelandic Fresh Fish Price Directorate

---

\(^{14}\) The maximum catch level observed in the data set is 4140.5 tonnes. However, the regulatory system discriminates agains larger vessels, and hence this is below the maximum capacity of the vessel.

\(^{15}\) For instance recruitment and mortality will be dependent on a number of variables including water temperature, abundance of food and predators etc.
6. CONCLUDING REMARKS

In this paper we investigate over-capacity and potential rent in a fishery regulated with individual vessel quotas. Since the quotas limit the quantity of fish each vessel can harvest, a cost function is appropriate when investigating fishermen’s behaviour. For each vessel optimal output can be estimated. This will give the optimal quota for the vessel and allow us to derive the potential rent for the vessel and the fishery, as well as optimal fleet size.

An empirical application is provided for Norwegian cod trawlers that are regulated with individual vessel quotas, but with very limited transferability. This is of interest since it provides some evidence with respect to what is the most important factor for rent dissipation in traditionally managed fisheries – the incentives due to the race to fish or overcapacity. The empirical results indicate that no rent is generated for this fleet. Hence, in this fishery overcapacity is the main problem and ending the race to fish has not allowed rent to be generated. The results indicates that the rent potential is substantial at between 60 and 70% of total revenues, and that there is substantial overcapacity as the number of vessels in the fishery should be reduced by about two thirds. However, due to natural variations that influence the TAC and harvesting conditions, potential rent and optimal capacity change substantially from year to year. Hence, if vessels cannot move between fisheries, as is often the case, the issue of optimal fleet size becomes an important one.

Despite the focus on resource rent, rent dissipation and capacity in the theoretical literature in fisheries economics, surprisingly little work has been done empirically measure the size of these effects. This is important because it allows measuring the waste of resources that are due to inappropriate management. Together with Dupont (1991) and Weninger (1999) the results in this paper offer insights to the magnitude of these two problems. First, the excess capacity resulting form open access or regulated open access regimes is substantial and as large as two-thirds of the fleet. Second, although variation between different fisheries are likely to be substantial, 'Wilen’s Rule of Thumb' that potential resource rent is about 50% of total revenues is not far off the mark.

Acknowledgements: The authors wish to acknowledge the financial support of the European Commission (FAIR contract no. CT 2001-01535). The views expressed herein are those of the authors and not to be attributed to the European Commission.

References


