Modelling an ITQ Scheme in the Galápagos Marine Reserve Spiny Lobster Fishery

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Santiago A. Bermeo Alvear

Department of Applied & International Economics, Massey University
PN342, Private Bag 11-222, Palmerston North, New Zealand

Summary:

This paper assesses the distributional and economic impacts resulting from a hypothetical individual quota management system in the Galápagos spiny lobster fishery. Using data from the Fisheries Monitoring Programme, an implicit function is derived and evaluated at a total allowable catch to estimate an equilibrium price for quota. By comparing this with each vessel-owner's implicit quota price, the number of fishers who will have an economic incentive to sell quota is estimated. The outcomes of the model indicate that the equity implications, as well as the economic benefits, resulting from the introduction of an ITQ system would be significant.

Keywords: Galápagos Marine Reserve, fisheries management, spiny lobster, ITQs.

1. Introduction

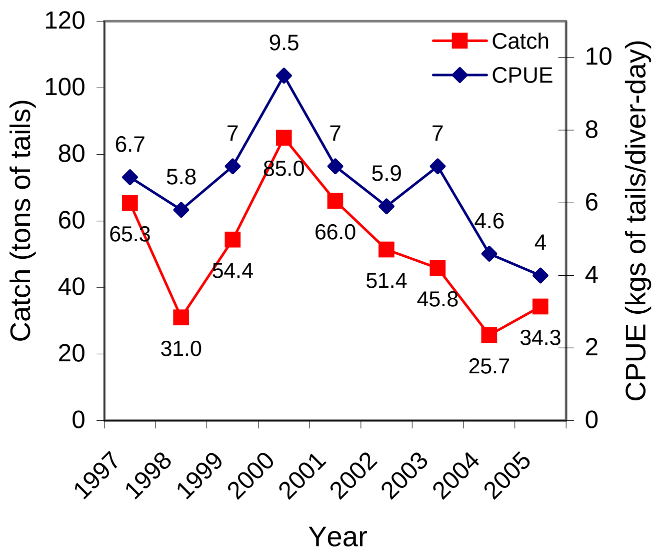
The Galápagos Marine Reserve (GMR) is a network of unique ecosystems of great natural, scientific and recreational value. Unfortunately, overfishing is threatening the stability of these ecosystems and the welfare of hundreds of fishers that depend on them. As a result of migration and extremely high population growth, the effort devoted to the local fisheries has grown considerably over the years to levels far from sustainable. The spiny lobster (*panulirus penicilatus* and *p. gracilis*) fishery, for instance, started in the early 1960s and has significantly developed. For a long time it was the most consistent source of income for local fishers, particularly after 1994 when the more lucrative sea cucumber fishery was temporarily closed (Bustamante et al., 2000). This, however, is no longer the case today given the poor biological and economic conditions of the fishery (Hearn et al., 2006). In this context, a change in the current management strategy is urgently needed. Taking this into account, this paper assesses the distributional and economic impacts, for a sample of the industry, that are likely to result from the introduction of an individual transferable quota (ITQ) management system in the GMR spiny lobster fishery.

The remainder of this section provides a brief background on the state and management of the spiny lobster fishery. Section 2 summarises literature on ITQ schemes and why one may be considered in Galápagos. Section 3 describes the methodology used. Section 4 presents the outcomes of the study and finally, Section 5 presents a discussion and concluding remarks.

1.1 State of the fishery

Although the effort devoted to the spiny lobster fishery has not changed significantly over the last four years, it is still excessive, inefficient and unsustainable, as plummeting catches and other signs of overfishing demonstrate. Figure 1.1 summarises some of the findings from the Galápagos National Park (GNP) and Charles Darwin Foundation Fisheries Monitoring Programme. Despite fluctuations[1], it is clear that catch and catch per unit of effort (CPUE) have been dropping steadily, demonstrating that the current fishing effort is beyond the self-regenerating capacity of the resource. The CPUE of 4 kg of tails per diver-day recorded in 2005 is the lowest ever recorded for this fishery (Hearn et al., 2006). The average CPUE used to be as high as 30.6 kg in the 1960s when the fishery operated well within its maximum sustainable yield (Reck, 1983). Furthermore, the progressive reduction in average size and the increasing percentage of undersized individuals and gravid[2] females within the catch also demonstrate the pervasiveness of overfishing, particularly for red lobster (*p. penicilatus*).

Figure 1.1 - Catch and CPUE for the Galápagos Marine Reserve Spiny Lobster Fishery (Source: Hearn et al., 2005; Hearn et al., 2006; Murillo et al., 2004).



The economic performance of the fishery is also believed to be deteriorating. Although information on the fishery's costs of production is limited, a reasonable expectation is that these would have been increasing over the last few years together with the price of fuel. Nonetheless, the price paid to fishers has remained relatively constant over the last five years at an average of US$ 23 per kg of tail. This, in addition to decreasing catches, would have resulted in decreasing net benefits.

1.2 Management of the fishery

In 1998 the Law for the Conservation and Sustainable Development of Galápagos was introduced. It assigned the control of fisheries management to an

[1] El Niño in 1998 and 2000, and a clash with the sea cucumber season in 2004, affected the lobster fishery, which is why catches in those years differ from the overall decreasing trend.
[2] Egg-bearing

Inter-Institutional Management Authority (IMA). It also introduced principles of participatory and adaptive management by vesting decision-making in the Participatory Management Board (PMB), composed of fishers, scientists, conservationists, and representatives from the tourism industry and the government. The PMB must decide, by consensus and subject to the approval of the IMA, the specific regulations under which the fisheries will be managed each year. Since then, the spiny lobster fishery has been managed through a limited season, normally open from September to December, minimum size restrictions, a prohibition to harvest gravid females, a permit system, and no-take zones. A total allowable catch (TAC) has not been set (Bustamante et al., 2000).

Although this arrangement has the merit of being participatory and represents an improvement on the typically confrontational relationship between fishers and authorities, insufficient enforcement and the relatively lax regulations applied have failed to improve the state of the resource or to limit catch to sustainable levels. It seems that the fishery is being "conveniently overfished" (Froese, 2004) by users and managers that risk its collapse by maintaining unsustainable catch and effort levels in order to avoid social and political conflict. If this situation continues, a collapse of the lobster fishery would result. This would have major negative implications for the welfare of the local fishers and the stability of ecosystems. A new management system that reduces the fishing effort devoted, by effectively limiting entry and reducing catch to sustainable levels, is thus urgently needed.

An ITQ scheme is an alternative to the current management system. It can, in theory, achieve these objectives of limiting entry and reducing catch, provided that the regulations imposed are sustainable and are enforced appropriately. ITQs were applied successfully, in terms of conservation, to the sea cucumber fishery in 2001 but their use was suspended the following year due to limited planning by quota owners, which resulted in a poor economic performance of the fishery. The use of property rights for fisheries management in the Galápagos has been suggested as an alternative before but, except for the 2001 sea cucumber fishing season, has not been considered further.

2. ITQs in Galápagos: is the context suitable?

ITQ systems, by vesting the quota-owner with a transferable right to harvest a percentage of a set TAC of a particular specie, have the potential to efficiently allocate resources in a fishery and to make their operation sustainable. If the quality of the right is high and regulations are consistent with sustainability, expected benefits from this scheme include economic efficiency and increased participation of the industry in management, and, indirectly, conservation of the resource (Arnason, 1990, 1998; Grafton, 1996; Hannesson, 1996; Neher et al., 1989). Nonetheless, criticisms of the ITQ system include the fact that economic efficiency, if achieved, is necessary but not sufficient for conservation and therefore that this objective needs to be explicitly addressed through other means (Copes, 1986; Copes & Charles, 2004; Fujita, 1999; Fujita & Bonzon, 2005; McCay, 2004; Munro et al., 1998; Pauly, 1997). Similarly, ITQs have been questioned for unjust social outcomes particularly with regards to the distribution of benefits among different users of the fishery. The concentration of quota and resources among a reduced number of vessel-owners is an unavoidable effect from ITQs, which often has contentious implications for equity (Adelaja et al., 1998; Arnason, 2000; Copes & Pálsson, 2000; Davis, 1996; McCay, 1995, 2000; Orebech, 2005; Pauly, 1996, 1997). Furthermore, various authors are sceptical about the feasibility of applying ITQs in developing countries given institutional limitations to effective management, monitoring and enforcement (Chavez & Salgado, 2005; Panayotou, 1989; Pauly, 1995, 1996). Some of these observations apply to Galápagos as well. For instance, Bustamante et al. (2000, pp. 217-218) question the capacity of the GNP, responsible for the implementation of fisheries management in the GMR, to administrate, monitor and enforce a quota system. Nonetheless, ITQs present an opportunity to improve the state of a fishery, given certain conditions are met and despite various limitations they may have in practice.

There are, however, various characteristics that make the GMR spiny lobster fishery suitable for an ITQ regime. First, the current state of overfishing and overcapitalisation has been caused by behavioural rather than biological motives. This contributes to successful implementation of ITQs since alternative management measures are necessary to address biological motives. Furthermore, the stock of lobster is relatively healthy. According to Stone et al. (2006), the current catch level for red lobster is only 30% in excess of its bioeconomic optimum as opposed to the sea cucumber's catch which is four times larger than its bioeconomic optimum. A relatively healthy stock is necessary for an ITQ regime to ensure that extraction will not outstrip biological productivity from the outset (Steelman & Wallace, 2001, p. 372). These characteristics are met in the spiny lobster fishery.

Second, the fact that this is an artisanal dive fishery means that high-grading, discarding and by-catch, as described by Copes (1986), will be minimal given the high-specificity of the fishing techniques used.

Third, given the relative smallness of the fishery, effective monitoring and surveillance, necessary for the success of the scheme, are feasible. The number of fishers, vessels, landing ports, and buyers in the fishery are small enough to be managed through an ITQ system. The large fishing area of the GMR could potentially be a problem for surveillance. However, the fact that all the catch is exported to the continent through the two main airports of the archipelago provides an opportunity for effective paper trail-type monitoring. Despite Bustamante et al.'s (2000) observations, the experience and monitoring capabilities developed with the sea cucumber quota scheme are useful for an eventual extension into the lobster fishery. An upgrade of the already existing administration, research and monitoring services will be necessary though, to minimise opportunities for quota busting.

Fourth, although there are some knowledge gaps, the biological information available is sufficient to set a reasonably accurate TAC. The essential task would be to ensure that these are sustainable and effectively monitored and enforced. In the past, TACs for other species have been set too high and regulations for all species have not been tight enough because of economic impacts on fishers. If successful, an ITQ scheme will have significant economic benefits; these can permit setting sustainable TACs and regulations that are consistent with the state of the resource.

Although the context of the GMR spiny lobster fishery is suitable for an ITQ scheme, its costs and benefits need to be assessed in order to determine whether or not a change of management scheme will be desirable. Despite the potential benefits of sustainability and efficiency, a significant effect from ITQs in Galápagos could be contentious equity implications. This paper therefore aims to determine the extent of these two impacts on a sample of vessel-owners.

3. Data and Methodology

After quota allocation, but prior to exchange, each unit of quota has an implicit economic value to the vessel-owner. This is equal to the present value of the net benefits derived from a unit of quota. This value varies among vessel-owners according to the output and input prices they face. The most efficient vessel-owners will place a higher value on a unit of quota than the inefficient ones. Quota exchange progressively narrows the value placed on quota between vessels until unit quota rents are equalised at the last unit traded, and an equilibrium quota price is formed (Lanfersieck & Squires, 1992, p. 2315).

The model developed in this paper is for a hypothetical quota scheme for red lobster using data from the Fisheries Monitoring Programme Report for the 2005 season and from a monitoring database for vessels based in Puerto Baquerizo Moreno for the same year. An implicit supply function is derived and evaluated at a TAC to estimate an equilibrium price for quota. By comparing this with each vessel-owner's implicit quota price, the number of fishers who will have an economic incentive to sell quota is estimated. Quota rent and gains from trade in quota are also calculated. These provide an estimation of economic benefits and equity implications resulting from an ITQ scheme.

First, implicit quota prices for each vessel-owner are estimated. Assuming that fishers who made positive profits in the last season have a planning horizon of five years (T), consistent with the current 5-year fishing calendar, quota is allocated for that period. Fishers that made losses in the last season are assumed to remain operating only for one more fishing season. The implicit price is equal to the present value of the net benefits of a unit of quota. Once a TAC is set, a unit of quota vests the owner with the right to harvest 1 kg of red lobster tail, assuming that the TAC remains constant. The implicit value of this right to vessel-owner i is therefore equal to τ_i, where P is the expected price per kg of lobster tail, MC_i is the expected marginal (or average) cost to extract 1 kg of red lobster tail for vessel-owner i and r is the discount rate, set at 20% to reflect the conditions of the fishery as described by Stone et al. (2006).

$$\tau_i = \sum_{t=1}^{T} \frac{P - MC_i}{(1+r)^t} \qquad (1)$$

Second, an inverse supply function is estimated by regressing τ_i on individual quota allocation (y_i), determined as a percentage of each vessel-owner's historical catch times the set TAC, a dummy variable reflecting vessel type[3] (v_i), the percentage of trips in which the vessel was towed by a mother boat (b_i), the average CPUE for the season ($cpue_i$), the percentage of trips in which there was limited underwater visibility (vis_i) and the percentage of trips in which there were rough sea conditions (sea_i). All these variables are expected to explain each vessel-owner's efficiency, and therefore their implicit quota price as follows:

$$\tau_i = c + \alpha_1 y_i + \alpha_2 v_i + \alpha_3 b_i + \alpha_4 cpue_i + \alpha_5 vis_i + \alpha_6 sea_i \qquad (2)$$

[3] The two vessels used in this fishery are p*angas,* wooden dinghies, and *fibras,* slightly larger fibreglass dinghies.

Third, the inverse supply function is evaluated at *Y* to estimate an equilibrium price for quota τ^*, where *Y* is the TAC, also equal to the sum of all individual quota allocations, and *N* is the total number of vessels in the sample.

$$\tau^* = c + a_1 \frac{Y}{N} + a_2 \sum_{i=1}^{N} \frac{v_i}{N} + a_3 \sum_{i=1}^{N} \frac{b_i}{N} + a_4 \sum_{i=1}^{N} \frac{cpue_i}{N} + \alpha_5 \sum_{i=1}^{N} \frac{vis_i}{N} + a_6 \sum_{i=1}^{N} \frac{sea_i}{N} \quad (3)$$

Fourth, by comparing τ^* with τ_i it is possible to forecast whether a vessel-owner will have an economic incentive to sell quota. If τ_i is less than τ^*, the vessel-owner will find if more profitable to sell his or her quota allocation. On the other hand, if τ_i is larger than τ^* a vessel owner will benefit from buying quota from others. By doing this comparison for the whole sample the extent of quota concentration is determined. This is an indication of the equity implications of the scheme.

Fifth, the quota rent generated by the ITQ scheme after quota trade is equal to τ^*Y. The gains from quota trade can also be estimated as the difference between the quota trade after trade and the quota rent before trade. The latter is equal to the sum of $0.5(\tau_i y_i)$ across all vessel-owners.

The TAC for the entire fishery was set at 25,432.13 kg of red lobster tail. This was determined to be the maximum sustainable yield using Schaefer's formula (1954 cited in Bautil et al., 2003). This is a slightly more conservative TAC than the bioeconomic optimum of 29,336.80 kg of red lobster tail suggested by Stone et al. (2006).

A sensitivity analysis for changes in the costs of hiring a towing boat is performed. Price and operating costs are not expected to change considerably given minimal fluctuations in the past and decreasing levels of inflation. On the other hand, the cost per day of using a towing boat was estimated from Murillo (2002) and Wilen et al. (2000) however this information is relatively outdated which is why the effects of variations in this factor are analysed.

Adjustments to the data were necessary. Observations that were considered to be outliers due to extreme CPUE values and single fishing trips were removed from the sample.

4. Results

The average value for τ_i is estimated to be US$7.70. Only 52% of vessel-owners in the sample have positive implicit prices for a unit of quota. This is consistent with the number of vessel-owners that had negative estimated profits in the 2005 fishing season. This demonstrates the poor economic performance of the fishery.

The results show considerable differences between the vessels that regularly used a towing boat and those that did not. In this sample the use of a towboat increased total costs on average by 25%, however it also increased catch significantly, up to 169%. Summary outputs for both groups are presented in Tables 4.1 and 4.2. The variables that explain implicit quota price differ between the two groups. The CPUE is more significant in determining the implicit quota price for vessels that did not use a towboat. Individual quota allocation is only significant for those vessels that used a towboat and visibility and sea conditions are insignificant for both groups, even at the 10% level.

To forecast the quota rent generated, it is assumed that monitoring and enforcement will be effective and therefore that quota busting will not distort the scheme, also that the previous level of prices, costs and CPUE will prevail. Although the fishery is expected to recover and CPUE to increase as a result of restricted catches, a conservative assumption of constant CPUE holds since it is difficult to forecast how it will actually change as a result of the scheme. Taking these assumptions into account, the quota rent generated after quota allocation, but prior to trade, for the sample of 48 vessels is estimated to be US$24,663.40. After quota trade it is estimated to increase by US$5,428.63 to US$32,092.03. There will be significant efficiency gains resulting from a considerably smaller fleet catching a slightly smaller amount of lobster.

Table 4.1 – Summary Output, Dependent Variable: Implicit Quota Price. No Towboat Use.

Variable	*Coefficient*	*Std. Error*
Constant*	-19.9651	1.8948
CPUE*	4.1155	0.2393
% low visibility	-4.3877	3.3782
% rough seas	4.6605	3.3221

Equilibrium Quota Price: US$ 6.84

R-squared: 0.9471

Std. Error: 3.7818

** significant at 1% level*

Table 4.2 – Summary Output, Dependent Variable: Implicit Quota Price. Regular Towboat Use.

Variable	*Coefficient*	*Std. Error*
Ind. quota allocation*	0.1065	0.0201
% tow boat use*	-21.6333	3.0525
CPUE*	2.1782	0.3880

Equilibrium Quota Price: US$ 8.75

R-squared: 0.8422

Std. Error: 4.9984

**significant at 1% level*

Interestingly, within the group of vessel-owners that did not use a towboat regularly, gains from trade are actually negative given their inferior economic performance. Nonetheless, this does not seem to significantly impact on the overall economic performance of the scheme.

As expected, the equity implications of the scheme will be important also. More than 60% of vessel-owners in the sample will have an economic incentive to sell quota. This means that the right to extract the resource will be concentrated in the remaining 40% of vessel-owners.

Table 4.3 – Sensitivity Analysis: Cost of Towboat

Cost of towboat/day	$ 100	$ 125	$ 150
Quota rent after trade	$ 30,092.03	$ 21,473.26	$ 14,437.72
Quota rent before trade	$ 24,663.40	$ 19,555.37	$ 14,945.19
Gains from trade	$ 5,428.63	$ 1,917.89	-$ 507.47
Percentage selling quota	60.4%	64.6%	66.6%

Table 4.3 summarises the outcomes from the sensitivity analysis. It shows that the costs of hiring a towboat, obviously impacting only on those who used one, have an effect on the implicit quota price and therefore on the number of vessel-owners that will be selling quota. At a higher cost, there are more owners willing to

sell quota and a lower quota rent, eventually resulting in negative gains from trade also.

5. Discussion and Concluding Remarks

There are various limitations and weaknesses in the data that should be taken into account when considering the outcomes of this study. Many of the total values from the Fisheries Monitoring Programme are extrapolations of the monitored catch as not all of it was actually monitored. There is therefore the possibility of catch being underreported, which distorts the information used. Furthermore, the monitoring database used has information for vessels based in Puerto Baquerizo Moreno only. Taking into account the differences in fishing practices and costs between ports, the outcomes of the study should therefore not be generalised, without further analysis, to vessels based in other ports.

The simulation makes various assumptions, which may not necessarily hold in reality. The cost functions are assumed fixed and marginal costs are assumed to be equal to average costs. Marginal costs could be considered to be zero if an additional kilogram of lobster tails can be captured in the same fishing trip. However, considering the low CPUE value, this would be unlikely and an additional trip, or at least an additional dive, would be necessary to capture an additional kilogram. The average cost in this case is more relevant to capture the value of quota. Furthermore, in reality vessel-owners may adjust their production to change their costs without necessarily having to leave the industry. These adjustments, however, are not directly observed in this model. Studies by Dupont (2000), Salgado & Aliaga (2002) and Lanfersieck & Squires (1992), on the other hand, use linear programming models to observe the vessel-owner's demand for quota, allowing them to adjust their production accordingly. The model also assumes a perfectly competitive quota scheme and fails to recognise that in reality a single long-run equilibrium ITQ price will not develop immediately. Instead, equilibrium ITQ prices form over short-run periods as individual vessel-owners exchange quota (Lanfersieck & Squires, 1992, p. 2314). Moreover, the equilibrium quota price is likely to differ from vessel to vessel because of different transaction costs, access to information, risk and uncertainty. In this case the only difference observed is between those that used a towboat and those that did not. Reality is more complex and flexible than what the model depicts.

In this model, many of the factors that are likely to influence quota price were included, though not all the possible ones. Factors that may affect a quota market include substitutability between species (Squires & Kirkley, 1995), weather, ecological and demographic patterns, and differences in equipment, knowledge or expertise (Anderson, 1989). Squires (1990) points out that econometric studies for fisheries suffer from the possible failure of the model to be well behaved given that an explicit functional form must be imposed on the data. Likewise, Dupont (2000) points out that a parametric solution bundles up very different functions, different vessels for instance, in a single regression, potentially causing distortion. The relatively high standard errors of the model may demonstrate these limitations.

Regardless of these, the model shows that there is a high probability that an ITQ scheme for the Galápagos spiny lobster fishery will have considerable economic benefits as well as serious equity implications by making many vessel-owners sell their quota allocations. Retiring vessel-owners will receive some compensation when they sell their quota allocation but the lack of alternative economic activities and the poor state of other fisheries in the archipelago will make it difficult for them to invest those funds in a sustainable business. Their employees, divers and crew, will also be out of work with no compensation or viable economic alternatives to engage in. An ITQ scheme will therefore have to be complemented by a robust effort to engage retiring fishers in alternative economic activities through credit provision, training or other forms of support. This additional support will increase the cost of the scheme but if it is not provided, the industry will eventually disagree with the ITQ system and it will fail. Nonetheless, the expected economic benefits are large enough to justify a more in-depth consideration of an ITQ regime in this context.

The support of the industry is crucial for the success of the scheme. A grandfathered allocation of quota and assistance for retiring fishers will be vital in this regard. Also, strengthening of the participatory character that fisheries management in Galápagos has developed recently would be essential for any change in fisheries management. This change would need to be driven in part by the industry, and not imposed by the authorities. The GNP will however, need to lead the process by departing from the current state of "convenience overfishing", aiming towards a sustainable fishing sector. Responsible setting of TACs will be particularly important within an ITQ scheme to achieve this.

Considering the current state of the fishery and the considerable value of the GMR, it is reasonable to expect that the benefits of improved fisheries management will outweigh its costs. Nevertheless, further research is necessary to assess the costs of implementing the scheme, which would involve enhancing the existing administration, monitoring and enforcement capabilities and, as mentioned earlier, supporting the retiring fishers. If the scheme passes this cost-benefit test and provided mitigating actions are taken against the possible adverse effects of quota and resource concentration, then an ITQ system could potentially rationalise the fishery by making it sustainable and efficient.

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