QUOTA AND LICENSING SYSTEMS
IN THE VIII DIVISION EUROPEAN ANCHOVY[1]

del Valle I. Astorkiza. K. and Astorkiza.I.*

* Department of Applied Economics V.University of The Basque Country.
Avda. Lehendakari Agirre nº 83. 48015 Bilbao (Bizkaia)
Email: ebpvaeri@bs.ehu.es

January 2003

Abstract

In this paper quota and license based management of VIII division European anchovy fishery is analysed under an optimisation framework and complete information assumption. The optimal prices of the catch or tax quotas, license fees or taxes on effort and the prices of perpetual transferable quotas (ITQ) and perpetual transferable licenses (ITL) are also calculated and the comparative static illustrated. Finally some considerations on the applicability and implementation of the introduced regulation methods are presented.

KEY WORDS: Quotas, Licenses, Individual Transferable Quotas, Individual Transferable Licenses, Anchovy Fishery, Implementation.

1. INTRODUCTION

The main reason of divergence between the open access and socially optimal allocation is Munro and Scott's (1985) Class I form of rent dissipation. The lack of property rights in the fish stock incentives fishermen not to consider the impact of his own activities on other fishermen and on the future availability of fish. Consequently too few fish are left in the sea to contribute to future biomass growth, which implies higher harvesting costs in the future.

The obvious policy prescription to face economic inefficiency derived from mentioned Class1 problem is a Total Allowable Catch (TAC). In theory a TAC should permit a sustainable resource rent to emerge, although in practice, the race to fish push

[1] This study has received financial support from the Spanish Ministry for Science and Technology, MCYT (SEC2000-1177).

the firms to unprofitable over-investment in fishing effort and to an excess of capacity of the fleet, the well-known consequences of a Class II form of rent dissipation.

The theoretical solution to face the excessive fishing effort should then be a restricted access policy, which basically consists in directly limiting the amount of effort by only permitting the minimum effort needed to take the TAC. In practice, the real issue when implementing a limited entry program concerns which of the many inputs to restrict, because if the underlying fishing technology permits the substitution of unrestricted inputs for the restricted ones, then the intentions of the regulation will be subverted and the Class II problem accelerated.

In recent years there has been a clear movement toward property rights based fisheries management systems around the world. Special attention has been paid to the advantages and disadvantages of individual quotas (IQ). With no need to race for the fish, operators presumably would be induced to use only the most economically efficient capital and labour input configurations. Moreover, letting the IQ to be transferable quota rights would be in the long term consolidated in the hands of the most efficient operators. However, ITQ systems, besides requiring a previous TAC, seem not to improve the problem of bycatches and require a solid method of monitoring and enforcement (specially difficult when a large number of landing ports and small market distribution chain are). Besides, the determination of he initial allocation of quotas may be difficult and controversial and the regional impact on small fishing communities irreversible.

Any case, all the mentioned regulation systems have supported the theoretical proof of their efficiency, but most of them failed when being applied and implemented to real fisheries. Often similar management plans give sensible different results when they are applied to the same species depending on the socio-economic context of the area of application. Thus, the empirical validation of a management system requires also thinking about its applicability to specific fisheries industries, which undoubtedly implies learning from case studies.

In this sense, this paper analyses different regulation systems (i.e. quotas/licenses) and places the sight in the case study of the VIII division European anchovy fishery. First of all, the prices of the quotas /licenses conducting to economically efficient allocation will be calculated within an optimisation framework, to go on with the discussion on the probability of success of the mentioned mechanisms when hypothetically implemented to the mentioned fishery.

2. THE THEORETICAL BACKGROUND

As the *sole owner* (Scott, 1955) internalises the shadow value of the resource as well as the interactions or negative externalities among agents, it is assumed to determine optimal stock (S*), effort (E*) and catch levels (Y*) after solving a discounted profit maximisation problem in an infinite time horizon (1), where the aggregate fishing effort (E(t)) is the control variable and the stock (S(t)) represents the state variable. Y(t) are aggregate catches in the period t, *r* is discount rate and, f(S(t),E(t)) and g(S(t)) are respectively aggregate production and population growth functions.

$$
\begin{aligned}
&\underset{E(t)}{Max} \int_0^{\infty} e^{-rt}(pY(t) - cE(t))dt \\
&\quad s.t. \quad \dot{S} = g(S(t)) - Y(t) \qquad (1) \\
&\qquad\quad Y(t) = f(S(t), E(t)) \\
&\qquad\quad S(t), E(t), Y(t) \geq 0
\end{aligned}
$$

From the first order conditions (F.O.C) (2) for the existence of maximum, the efficiency rule (3) is obtained, which implies that the value of the marginal productivity of effort (f_E) discounted by the shadow current price of the resource ( ) is equal to the cost of fishing effort (c).

$$
F.O.C. \left\{ \frac{\partial H_c}{\partial E} = 0 \;, \; \dot{m} = \frac{\partial H_c}{\partial S} = 0 \right\} \qquad (2)
$$

$$
f_E[p - m] = c \qquad (3)
$$

Just in the opposite corner, in *open access*, no restriction is placed on fishermen wishing to enter the fishing grounds. There is no limit on the amount of fish that may be caught by individual vessels and any effective control over the fishing effort. Consequently the main agent to be borne in mind is the individual fisherman, who following a *"first come first served"* strategy tries to obtain his maximum present profits (4), not taking into account either the net social value of the resource or the effect of his own actions on the productivity of other fishermen or on the future availability of fish. The equation (5) synthesizes the Class I form of rent dissipation, implying that too few fish are left in the sea to contribute to future biomass growth and consequently higher harvesting cost will be need in the future.

$$\underset{E_i(t)}{Max} \int_0^{\infty} e^{-rt} (pY_i(t) - c_i E_i(t))dt \tag{4}$$

$$s.t. \qquad S_i(t), E_i(t), Y_i(t) \geq 0$$

$$pY = cE \tag{5}$$

To face the consequences of Class 1 rent dissipation and help ensure sustainability of the resource and meet socio-economic objectives fishery managers regulate the fisheries. As well as direct economic regulation methods (i.e. input restrictions (on fishing days, fishing capacity, etc. and output restrictions (TAC)) are based on the coactive limitation of the fishing activity, indirect methods (i.e. taxes (on inputs, outputs or on time) and rights (quotas, licenses) try to affect the incentives on behaviours.

In the case of quotas or taxes against catches[2] the regulatory agency would have to choose the quantity of the resource the firms are allowed to catch for each of the fishing season or periods, which ought to be compatible with the socially optimum aggregated catches (Y*). Total allowable catches could then be distributed among different countries, firms, fishing communities, etc. in the form of quotas. Let (T_p) be the price of the quota per tonne that would leave the fishermen to select the socially optimum allocation (6) in the open access framework, implying the solution (7). T_p could also be interpreted as optimal value of the tax per unit catches or the optimal equilibrium price that should reach the quota in the market.

$$\left. \begin{array}{l} \underset{E_i(t)}{Max} \int_0^{\infty} e^{-rt} (p - T_p)Y_i(t) - c_i E_i(t))dt \\ \qquad s.t. \qquad S_i(t), E_i(t), Y_i(t) \geq 0 \end{array} \right\} \Rightarrow (S^*, E^*, Y^*) \tag{6}$$

$$\frac{Y}{E} = \frac{c}{p - T_p} \tag{7}$$

T_p can be obtained from equalising (3) = (7)using two alternative procedures[3] with logically the same solution. Thus,

[2] Under the assumption of complete information it is well known that per boat quotas and taxes on the catch are equivalent, and consequently the optimal price of the quota an the optimal tax on catches are equal.

[3] Procedure a

$$\left. \begin{array}{l} c = \dfrac{Y[p - T_p]}{E} \\ c = f_E[p - m] \end{array} \right\} \Rightarrow [p - T_p]AP_E = MP_E[p - m] \Rightarrow T_p = p - \frac{MP_E[p - m]}{AP_E}$$

Procedure b

$$T_p = p - \frac{MP_E[p-m]}{AP_E} \tag{8}$$

or alternatively

$$T_p = m + \frac{c}{MP_E} - \frac{c}{AP_E} \tag{9}$$

where AP represents the average productivity of fishing effort and MP the marginal productivity.

In the regulation system based on licenses or taxes against fishing effort[4] the regulator agency emits a number of licenses compatible with the socially efficient level of fishing effort (E*). The licence gives its owner the right to fish and consequently only licence holders are allowed to operate. In this case the agency distributes fishing permissions per day, month, year or fishing season pushing the firms to choose the level of effort compatible with the socially desirable sole owner solution. Let (T_l) be the price of the licence or tax on effort that would leave the fishermen to select sole owner allocation (10) in the open access framework leaving to the rent dissipation condition (11).

$$\left.\begin{array}{l} \underset{E_i(t)}{Max} \int_0^\infty e^{-rt} pY_i(t) - c_i E_i(t)) + T_l E(t) dt \\ \qquad s.t. \qquad S_i(t), E_i(t), Y_i(t) \geq 0 \end{array}\right\} \Rightarrow (S^*, E^*, Y^*) \tag{10}$$

$$\frac{Y}{E} = \frac{c + T_l}{p} \tag{11}$$

T_l can be obtained from equalising (3) = (11) with two alternative procedures[5] with logically the same solution. Thus,

$$T_l = pAP_E - MP_E[p-m] \tag{12}$$

$$\left.\begin{array}{l} p = \frac{cE}{Y} + T_p \\ p = \frac{c}{f_E} + m \end{array}\right\} \Rightarrow \frac{c}{AP_E} + T_p = m + \frac{c}{MP_E} \Rightarrow T_p = m + \frac{c}{MP_E} - \frac{c}{AP_E}$$

[4] Under complete information licences on effort and taxes on effort are equivalent, and consequently the optimal price of the quota on effort (licence) and the tax on effort are equal.

[5] Procedure (a)

$$\left.\begin{array}{l} c = \frac{pY}{E} - T_l \\ c = f_E[p-m] \end{array}\right\} \Rightarrow pAP_E - T_l = MP_E[p-m] \Rightarrow pAP_E - MP_E[p-m]$$

Procedure (b)

$$\left.\begin{array}{l} p = \frac{(c+T_l)E}{Y} \\ p = \frac{c}{f_E} + m \end{array}\right\} \Rightarrow \frac{c+T_l}{AP_E} = m + \frac{c}{MP_E} \Rightarrow T_l = AP_E\left[m + \frac{c}{MP_E}\right] - c$$

$$T_l = AP_E\left[m + \frac{c}{MP_E}\right] - c \qquad (13)$$

It is worth mentioning that there are important similarities between licences or taxes on effort for one side, and quotas or taxes on catches for another. All of them have the same theoretical consequences.

In both mechanisms (quotas/licenses), after arranging the initial allocation of quotas or licenses the regulator could incentive a quota market. Assume that the regulatory agency issues an amount of permanent[6] quota $q_i(0)$ for each fisherman, while the rest until reaching the total allowable catches is placed at each moment t in a quota market. Individual transferable quotas (ITQs) are dividable and transferable in a quota market, which is supposed competitive. Let $Z_i(t)$ the amount of quota acquired by fisherman i at each t, while $q_i(t)$ represents the total quota hold by the representative fisherman i at each moment (14), that is to say, the maximum catches the representative fisherman i is allowed to, which also determines his quantity of fishing effort (15).

$$q_i(t) = q_i(0) + \int_0^t Z_i(e)de = 0 \qquad (14)$$

$$Y_i = f(E_i, S) = q_i(t) \Rightarrow E_i = g(q_i, S) \qquad (15)$$

The fishermen determines $Z_i(t)$ after solving the optimisation problem (16), whose first order conditions are illustrated in (17).

$$\underset{\{Z_i\}}{Max_i} \int_0^\infty e^{-rt}[(pq_i(t) - c_i(t)E_i(t) - s_i(t)Z_i(t)]dt \qquad (16)$$

$$s.t \quad \dot{q}_i(t) = Z_i(t)$$

$$F.O.C.\ \left\{\frac{\partial Hc_i}{\partial Z_i} = 0; \quad -\frac{\partial Hc_i}{\partial q_i} = \frac{\partial g_i}{\partial t}\right\} \qquad (17)^7$$

Assuming that the marginal value of the quota (MV_q) is equal to the average value of the quota (AV_q)[8] and solving the differential equation (18) the optimal price of the perpetual quotas ($s_i(0)$ can be obtained.

---

[6] In the case of a transitory quota it is well known that the optimal price of the quota will be equal to the shadow price of the resource.

[7] With transitory ITL the optimal price of the licensing should be

$$l_i = m\frac{Y}{E}$$

$$\left.\begin{array}{l} (17.1)\ \dfrac{\partial Hc_i}{\partial Z_i} = 0 \Rightarrow -s_i + g_i(t) = 0 \Rightarrow s_i = g(t) \\ (17.2)\ -\dfrac{\partial Hc_i}{\partial q_i} = \dfrac{\partial g_i}{\partial t} = \dot{g}_i(t) \Rightarrow -(p - c_i\dfrac{\partial E_i}{\partial q_i}) = rg_i(t) \end{array}\right\} \Rightarrow \dot{s}_i(t) - rs_i(t) = -\left[p - c_i\frac{\partial E_i}{\partial q_i}\right]$$

$$\dot{s}_i(t) - rs_i(t) = -\left[p - c_i \frac{\partial E_i}{\partial q_i} \right] \tag{18}$$

In the case of a perpetual quota at (n =)

$$s_i(0)_{n=\infty} = \frac{1}{Q_i} \sum_{i=1}^{J} \int_0^{\infty} (pq_i - w_i E_i) e^{-rt} dt = \frac{pY_i - w_i E_i}{Y_i} \frac{1}{r} \tag{19}$$

When the quotas are emitted for a finite period their price will be:

$$s_i(0)_n = \frac{1}{Q_i} \sum_{i=1}^{J} \int_0^{n} (pq_i - w_i E_i) e^{-rt} dt = \frac{pq_i - w_i E_i}{Yr_i} \left[1 - \frac{1}{e^{rn}} \right] \tag{20}$$[9]

Another theoretically equivalent regulating system is permanent[10] individual transferable licenses (ITL). Following the same methodology the prices for the licenses $l_i(0)$ at n= and finite period are synthesised in equations 21 and 22.

$$l_i(0)_{n=\infty} = \frac{1}{E_i} \sum_{i=1}^{J} \int_0^{\infty} (pq_i - w_i E_i) e^{-rt} dt = \frac{pY_i - w_i E_i}{E_i} \frac{1}{r} \tag{21}$$

$$l_i(0)_n = \frac{1}{E_i} \sum_{i=1}^{J} \int_0^{n} (pY_i - w_i E_i) e^{-rt} dt = \frac{pq_i - w_i E_i}{rE_i} \left[1 - \frac{1}{e^{rn}} \right] \tag{22}$$[11]

8

$$MVq = \left[p - w_i \frac{\partial E_i}{\partial q_i} \right] = AVq = \left[\frac{pq_i - w_i E_i}{q_i} \right]$$

9

$$s_i(0)_n = \int_0^n \left[\frac{pq_i - w_i E_i}{Y_i} \right] e^{-rt} dt = A \left[\frac{e^{-rt}}{-r} \right]_0^n = A \left[\frac{e^{-rn}}{-r} - \frac{e^{-r0}}{-r} \right] = \frac{A}{r} \left[1 - \frac{1}{e^{rn}} \right] \quad whereA = \left[\frac{pq_i - w_i E_i}{Y_i} \right]$$

10 In the case of transitory ITL

11

$$l_i(0)_n = \int_0^n \left[\frac{pY_i - w_i E_i}{E_i} \right] e^{-rt} dt = B \left[\frac{e^{-rt}}{-r} \right]_0^n = B \left[\frac{e^{-rn}}{-r} - \frac{e^{-r0}}{-r} \right] = \frac{B}{r} \left[1 - \frac{1}{e^{rn}} \right] whereB = \left[\frac{pq_i - w_i E_i}{E_i} \right]$$

3. THE CASE STUDY OF THE EUROPEAN ANCHOVY

The bio-economic diagnosis resulted from the simulation[12] of the anchovy fishery under maximum and zero profit scenarios is not very optimistic. Moreover, the results question the validity of the rules limiting its access and exploitation (del Valle et a. 2001). The evolution of the fishery is a long way from reaching economically optimal solutions and it comes very close to an open access allocation. The stock was found to be well below what would be considered the optimal interval, the number of vessels is extremely high, and catch levels show signs of being unsustainable in the long term. The bio-economic TAC proposal derived was between 18,000 and 26,000 tonnes, while the recommended number of licenses was no higher than 222 (Table I).

-TABLE I- Optimum reference values

	S*	E*	TAC*
BASE CASE*	[98,000 - 100,000]	[131 - 140]	[21,000]
REALISTIC INTERVAL**	[78,000 - 115,000]	[90 - 222]	[18,000, 26,000]

* c/p = 70; 0.05 <r<0.1

* *c/p=[40, 100]. 0.05<r<0.1

Source: del Valle et al. (2001)

Since the mid-eighties there is a precautionary TAC of 33,000 tonnes. By virtue of the historic rights and the principle of relative stability 90% of the TAC goes to purse seine Spanish fleet (250 vessels), while the rest 10% is shared by the french pelagic (150 vessels) and the testimonial French purse seine fleet. The access to fishing grounds

---

12 The development of the bio-economic model demands a previous estimation of the population and production functions as well as the ratio c/p. The *population model* takes the form $\ln(S_{t+1}+Y_t) = \ln a + bLnS_t$ (a>1 and 1>b>0). The OLS regression results indicate that both coefficients are significant at the 5% level and the signs are both correct. The adjusted R^2 is 0.61. Durbin Watson and Box Pierce tests did not detect autocorrelation while Jarque-Bera test let us accept the normality o f the residuals. The R^2 of the auxiliary regressions is practically 0, so we considered that the degree of multicolinearity is acceptable. The functional form thereby obtained is $g(S(t))= 72.2549S(t)^{0.645} - S(t)$. The MSY is 27,571.7 tonnes, the required biomass for MSY is 50,095 and the MCC is 172,479 tonnes. The *production function* is a Cobb Douglas where the number of vessels represents fishing effort. The estimated function takes the form $\ln Y = \ln q + \alpha LnS_t + \beta NB_t$ α>o, β>0. The model, estimated by OLS, fit the data fairly well. All the variables are significant at the 5% level and the signs are correct. The model seems to be jointly valid (F test) and the adjusted R^2 is acceptable (0.78). Durbin Watson and Box Pierce test do not detect autocorrelation, while Jarque-Bera test let us accept the normality of the residuals. The R^2 of the auxiliary regressions is practically 0, so we consider that the degree of multicolinearity is acceptable. The estimated function is $Y(t)= f(S(t),E(t))= 0.319915S(t)^{0.68226}E(t)^{0.66562}$. *Cost and price data* to derive the ratio c/p were collected from "Anuario Estadístico del Sector Agroalimentario" (various years). As data were on an annual basis (disregarding the fact that many fisheries work seasonally) we calculated the proportion of total costs attributable to anchovy fishing, considering the time devoted to it. The derived values of c/p range between 40 and 100 and the average value is 70. Finally, a discount rate from 0,05 to 0,1 is considered acceptable for the purposes o f the study.

is restricted by a licensing system[13]. Anchovy catches are rather variable and in several years the Spanish purse seine did not reach the owned quota, which has evolved quota transfers to the french fleet in return of operating exclusivity of the purse seine fleet during the spring season.

Different alternatives to the natural reinforcement of the present regulation system consisting in a lower TAC and a real restricted entry programme complemented by a financial aid for the withdrawal of remaining vessels and workforce could also be considered to be applied to the anchovy fishery. In the case of an additional input limitation programme to restrain overcapacity, as concluded in the production analysis[14] developed by del Valle et al. (2003), fishermen could counteract a limitation on one input with increments in other inputs, although the high proportion of vessels with the Allen Elasticity of Substitution (AES) and Morishima Elasticity of Substitution (MES) ranged between [-1,1] indicated limited substitution possibilities between the inputs making up fishing effort[15]. The detected asymmetry for MES suggests that an input limitation program based on the reduction in the boat days would be more efficient than an equivalent one limiting the gross registered tonnes (GRT) or the horsepower (HP).

Any case, different alternatives could be also considered to improve the fishery from a biological and economical point of view. Although the complexities involved in obtaining a consensus between states can be an important barrier to achieving major changes, in the next section the quota and licensing systems introduced in section 2 will be applied to anchovy fishery. First the prices of the quotas/licenses will be calculated. Afterwards the real implementation of the system will be discussed and other management alternatives considered.

Calculation of optimal prices of quotas and licenses requires technological, population and cost/price data. We are using the estimates of the Cobb Douglas production function, Cushing population function and c/p ratio in del Valle et al (2001),

---

[13] Vessels applying for access to the fishery must be included in a national census and be inscribed in the basic lists of vessels claiming an interest in participating in the fishing. Likewise, there is an upper limit on the number of vessels that may be allowed to remain at any one time in the fishing zone (160). In order to make the most of the licenses issued, these are shared by two or three vessels. In fact, it is a system for issuing fishing permits, which has, in practice, failed to place any great restriction on entry. Proof of this is that 150 additional pelagic vessels have gradually been incorporated into the fishery since mid 80s. Although this expansion seems to be a bit odd with only the %10 of the TAC belonging to France (3,300 tonnes), the real participation of the French pelagic fleet is greater. This is due to the transfer of 6,000 tonnes from Portugal and 9,000 tonnes from the Spanish non-captured quota (result of the bilateral agreements of 1992 between France and Spain).

[14] A primal formulation was used to estimate a translog production function at the vessels level in order to study the substitution possibilities among inputs making upthe empirically validated fishing effort aggregate input.

[15] This inelastic nature needs to be interpreted carefully, because even if the estimated elasticity of substitution is low, it is very difficult, with no price information, to determine how much substitution will in practice occur.

(briefly included also in footnote 5). The base case and realistic interval shown in Table 1 will be considered.

Table 2-5 summarise the prices of the non-transferable quotas (Tp) and licenses (Tl) for different c/p ratios and discount rates, which have been calculated starting from equations (8 or 9)[16] and (12 or 13)[17] The optimal and open access levels of effort (E)[18], stock (S), catches (Y) and relative shadow values ( ) for different c/p ratios have also been included. Graph 1 illustrates variations on quota and license prices as a result of cost, prices and discount rate changes[19].

Table 6-9 summarises the optimal prices of the permanent[20] ITQ ($s(0)_n$) calculated from equation (19), while Table 10-13 summarises the optimal prices of the permanent and transitory ITL (($l(0)_n$ using (22). In both cases different reference anchovy prices (P=1,500, P=3,000, P=4,500, P=6.000) and emission periods (n=5, n=15, n=25) had been considered. Graph 2 and Graph 3 show respectively the comparative static of transferable quota/licence prices as a consequence of changes in the price of fish (p), the cost of effort (c), the discount rate (r) and the quota emission period (n).

-TABLE 10- Illustrative optimum reference prices for the IQ, IL, ITQ and ITL

			$s(0)_n$			$l(0)_n$		
	Tp	Tl	$s(0)_5$	$s(0)_{15}$	$s(0)_{25}$	$l(0)_5$	$l(0)_{15}$	$l(0)_{25}$
BASE CASE*	1,655 1,702	258,443 275,320	6,513 7,529	12,860 17,959	15,194 24,286	1,017,145 1.218,010	2,008,261 2,905,358	2,372,873 4,391,050
REALISTIC INTERVAL**	740 2,004	111,582 307,715	2,912 8,865	5,749 21,146	6,793 28,895	309,320 1,361,322	866,842 3,247,204	1,024,221 2,681,603

* c/p = 70; p=3000; 0.05 <r<0.1

**c/p=[40, 100]. 0.05<r<0.1, p=[1,500, 3

[16] In the case of a Cobb Douglas production function ($Y=q S^{\alpha}E^{\beta}$) equations (8) and (9) are respectively

$$\left\{T_p = p[1-b]+bm \quad ;T_p = m+\frac{c}{qS^a E^{b-1}}[\frac{1}{b}-1]\right\}$$

[17] In the case of a Cobb Douglas production functionequations ($Y=qS^{\alpha}E^{\beta}$) equations (12) and (13) are respectively.

$$\left\{T_l = \frac{Y}{E}[p+b(m-p)] \quad ;T_l = \frac{mY}{E}+c[\frac{1}{b}-1]\right\}$$

[18] For the purpouses of the study the proxy for fishing effort is the number of boats (NB). In schooling fisheries like anchovy searching for schools is of predominant importance. Accordingly, in such fisheries the number of participating vessels may be an appropriate measure of effort.

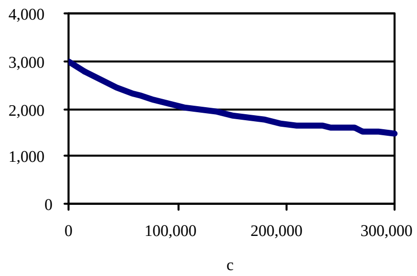
[19] As $\Delta p>0 \Rightarrow [\Delta E>0, \Delta S<0] \Rightarrow \Delta AP<0$. Consequently, whenever $AP> p*(\Delta AP/\Delta p) \Leftrightarrow \Delta Tl/\Delta p >0$. Similarly, whenever $c*(\Delta AP/AP^2\Delta p)<1 \Leftrightarrow \Delta Tp/\Delta p >0$. Cost variation implies an inverse relation on average productivity of effort. Thus, $\Delta c >0 \Rightarrow [\Delta E <0, \Delta S >0] \Rightarrow \Delta AP >0$, which implies that whenever $p*(\Delta AP/\Delta c)>1 \Leftrightarrow \Delta Tl/\Delta c >0$ and analogously $c*(\Delta AP/\Delta c)<AP \Leftrightarrow \Delta Tp/\Delta c <0$. To understand the comparative static of changes in the discount rate it is worth mentioning that $\Delta r >0 \Rightarrow [\Delta E >0, \Delta S <0]\Rightarrow \Delta AP<0$. Consequently both Tp and Tl should increase when r increases.

[20] For completeness the optimal prices of transitory ITQ and ITL have also been included.

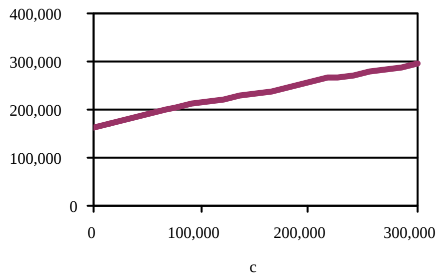
These quota prices should be carefully interpreted. It is not easy to involve fishermen and fishing firms in a deeply changed fishery governing system, asking them to pay high prices for quotas or licences. Besides, quota and prices are subject to change conditions depending variations of prices, cost and productivity. Nevertheless, the calculated optimal prices introduce a long-term rationalisation criterion.

-GRAPH 1-

Comparative static of quota (Tp) and license prices (Tl)



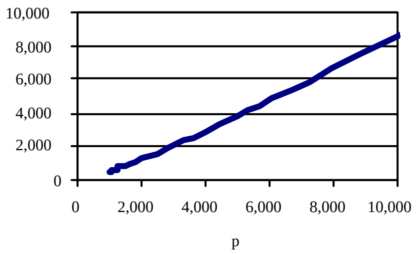
[r=0.1 p=3,000]



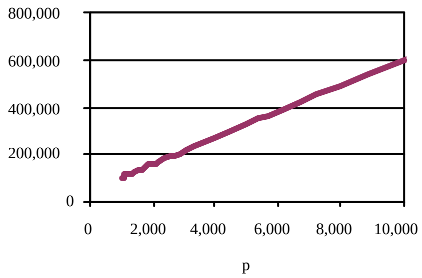
[r=0.1 p=3,000]

$$\frac{\partial T_p}{\partial c} < 0$$

$$\frac{\partial T_l}{\partial c} > 0$$



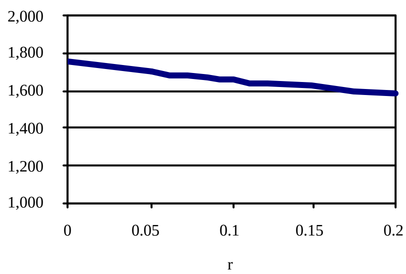
[r=0.1 c=100,000]



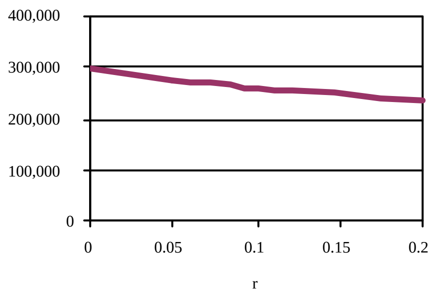
[r=0.1 c=100.000]

$$\frac{\partial T_p}{\partial p} > 0$$

$$\frac{\partial T_l}{\partial p} > 0$$



[c/p=70]



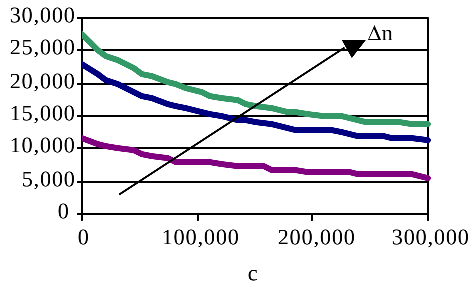
[c/p =70]

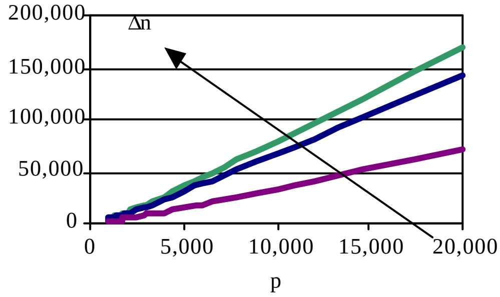
$$\frac{\partial T_p}{\partial r} < 0$$

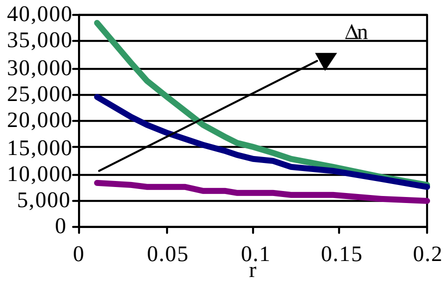
$$\frac{\partial T_l}{\partial r} < 0$$

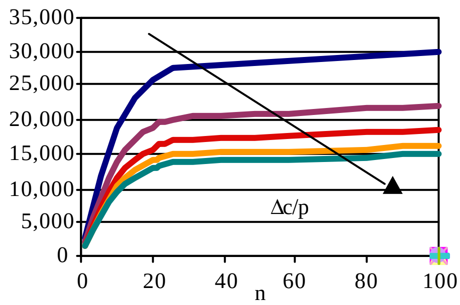
-GRAPH 2-

Comparative static of ITQ prices ($s(0)_n$)

<table>
<tr>
<td>


[r=0.1 p=3,000]
</td>
<td>


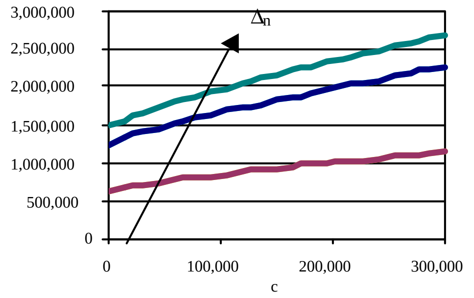
[r=0.1 c=100,000]
</td>
</tr>
<tr>
<td>$\frac{\partial s(0)_n}{\partial c} < 0$</td>
<td>$\frac{\partial s(0)_n}{\partial p} > 0$</td>
</tr>
<tr>
<td>


[c/p=70]
</td>
<td>


[r=0.1]
</td>
</tr>
<tr>
<td>$\frac{\partial s(0)_n}{\partial r} < 0$</td>
<td>$\frac{\partial s(0)_n}{\partial n} > 0$</td>
</tr>
</table>

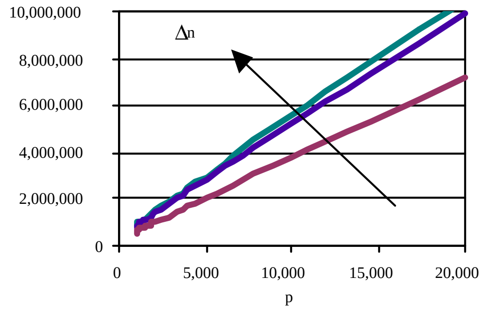
-GRAPH 3-

Comparative static of ITL prices ($l(0)_n$)



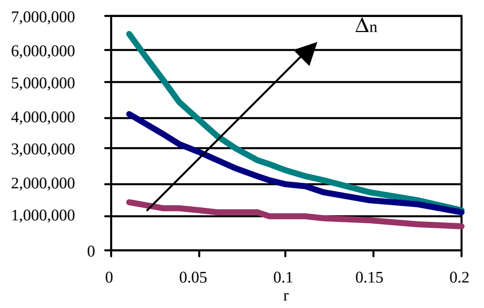
[r=0.1 p=3,000]

$$\frac{\partial l(0)_n}{\partial c} > 0$$



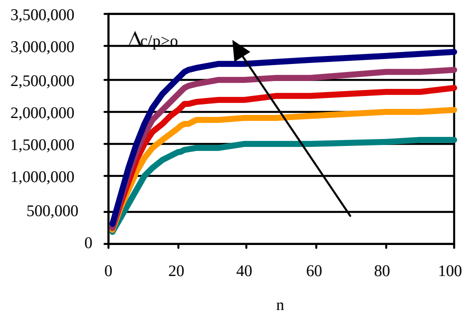
[r=0.1 c=100,000]

$$\frac{\partial l(0)_n}{\partial p} > 0$$



[c/p=70]

$$\frac{\partial l(0)_n}{\partial r} < 0$$



[r=0.1]

$$\frac{\partial l(0)_n}{\partial n} > 0$$

4. SOME CONIDERATIONS ON IMPLEMENTATION OF QUOTA AND LICENSING SYSTEMS ON ANCHOVY FISHERY

Although theoretically ITQ system eliminates a part of incentives for racing in investments, and consequently it could become a positive element in the improvement of fisheries productivity, it's important to consider that its potential virtual ties can fail in its empirical application, as it has important economic, political and social consequences.

One of the most controversial points when designing ITQ systems seems to be initial allocation of quota rights. Often the historical rights have been used to arrange initial allocation; being thus penalized those with new investment projects or those with more productive fleets but less historical rights. Another discussion element is the rate to pay for each quota. Several ways could be taken: from being freely distributed or being charged by a quantity depending on average prices, costs, effort and stock abundance, to being auctioned. Of course different options would have different distributional results.

Under the principle of stability restriction, initial allocation of anchovy quotas should be distributed between the involved states according to the present quota shares of the TAC. Afterwards different criteria could be used to distribute the quota to individual fishermen (egalitarian, discrimination by the dimension of the vessel, related to historical catches of he vessel, etc). The next step is to affront the dimension of quota transferability: from been non-transferable, to limiting transferability only among fishermen of the same country or fishing gear. Once again one decision or other would probably imply important regional impact on the coastal areas.

Special attention deserves the monitoring plan design. If fishermen can contravene regulations with impunity, the potential advantages of the system are lost. Experiences of ITQs in different countries (Canada, Icelandic, Australia and New Zeland) recommend including random surveillance and dockside monitoring, data entry and analysis, and investigation of reports of non-compliance of quota regulations. One of the mayor hurdles faces is the large number of fishing vessels and ports where anchovy is landed. Besides, an institution and its composition should be arranged to implement the effective controls. Choosing a neutral agency or committee may be rather difficult, but experiences in European Union fisheries suggest that delegating control tasks to European member states is not very effective.

Last but not least, economic, biological, social and regional potential effect should be tried being anticipated. As well as the effect on profits or the effects on biomass and harvests, the ones concerning to industry concentration ought to be analysed taking into account a multi-species approach and the interactions among different kind of fleets (i.e. artisan, industrial). ITQs tend to concentrate capital, production and commercial chain. This concentration could push to eliminate previously existing fishing activity, which might carry important changes in geographical distribution of the industry and employment related to fishing.

In the case of licensing, the regulatory agency should establish a TAC based on stock evaluation and afterwards emit the number of licenses compatible with the TAC. Once again the initial allocation of licences should be arranged. In this case the relative stability restriction is more controversial, because the present regulation of the anchovy fishery is based on quotas. Consequently, an equivalence criterion should be accorded.

In relation of the rate to pay for each of the licenses, it could be freely distributed or being charged by a quantity depending on average prices, costs, effort and stock abundance, or even auctioned. Any case special withdrawal programs should be considered. The dimension of the license transferability should also be decided (not transferability, limit transferability only among fishermen of the same country or fishing gear, etc). Of course the decision would probably imply important regional impact on the coastal areas.

As well as the fishermen the regulatory agency could as well take part in the market, buying and selling titles. This way the agency has an essential instrument to intervene and to regulate the license market and thus it makes the necessary adjustments about the number of licenses available in the market. The stock variations have reflection through TAC in the number of optimal licenses. When there is not equilibrium in the market, the optimal number of licenses is reached in the market with regulator intervention

One of the most remarkable advantages is that licensing lets the regulatory agency a dynamical evaluation of the stock and the stabilisation of a changing TAC in accordance to the real abundance of the resource, which is very interesting for short lives species, like anchovy, subject to great oscillations in recruitment. In this sense, licensing allows affording regulation problems tailored as case studies, with special insight to environmental context and with particular answer to specificities of each case. So it promotes a regulation made to measure of necessities.

It is also remarkable that controlling and monitoring should not be very difficult, despite the great dimension of the initial fleet and the number of the landing ports implied in the fishery. As it was mentioned in the case of regulation by quotas, an institution and its composition should be arranged to implement the effective controls, instead of delegating control tasks to the states.

However, if licenses do not go accompanied by complementary measures, they can stimulate the race of investments reported specially with inputs that are not stipulated in the license contract. Moreover, firms could still race to catch the greater amount of fish in the smaller time, because they know that TAC size is the upper limit to catch between all participants firms in the fishery. Consequently, it would be necessary to design other appropriate harmonizing measures to face the inefficient consequences of the *race to fish*. Besides, capacity increment associated with technological advances should be avoided and contemplated in the evolution of the number of licenses.

From economic efficiency criterion view, it's necessary to indicate that this method appears like one that can be in some aspects less effective than those based on exclusive stock rights negotiated in a market of titles. Licenses regulation system gives preferences to several optimising criterion (economic, social, political, etc). Its objective does not consist to guarantee the efficiency exclusively in the economic sense, although letting the licences to be transferable efficiency gains could be expected in the long term.

Whatever the regulation system to be adopted it is important to take in mind the degree of implication each of the systems allows. The best method can fail if the institutional framework does not give chance to the operators to understand and to involve themselves with the global objectives of the management system.

4. BIBLIOGRAPHY

Astorkiza K. Del Valle I. Astorkiza I. (2000) 'Regulatory capacity of the Cofradías in the Cantabric Region' Management Institutions and Governance Systems in European Fisheries. Proceeding of the third Concerted Actino Workshop on Economics and the Common Fishery Policy. Vigo 28-30 october1999, CEMARE. Miscellaneous Publication nº 48.

Arsason, R. and Gissurarson, H. (1999): Individual Transferrable Quotas in Theory and Practice. University of Iceland Press. Reykjavic.

Clark, I.N. (1993): Individual Transferable Quotas: The New Zeland Experience. Marine Policy. September, pag 340-342

Copes, P. (1986) A Critical Review of the Individual Quota as a Device in Fisheries Management. *Land Economics* 62: 278-291.

Del Valle, I. Astorkiza, K. and Astorkiza, I. (2001): Is the Regulation on Anchovy Fishery Optimal? "*Environmental & Resource Economics*".Vol 19, pag 53-72

Del Valle, I. Astorkiza, K. and Astorkiza, I. (2003): Fishing Effort Validation and Substitution Possibilities among Components: The case study of the VIII Division European Anchovy Fishery. *Applied Economics.* Vol 35 Number 1, pag 63-77.

Hanesson R. (1996) 'Fisheries mismanagement. The case of North Atlantic Cod'. Oxford Fishing New Books.

Munro, G.R. and Scott, A. (1985): The Economics of Fisheries Management. Pages 623-676 in *Handbook of Natural Resources and Energy Economics*, volume II. A.V. Kneese and J.L. Sweeney. Amsterdam: North-Holland.

Neher, P.A. Arnason, R. and Mollet, N. (editors) (1988): *Right Based Fishing*. Kluwer Academic Publishers.

Grafton, Q. (1996): Invidividual Transferable Quotas and Canada's Atlantic Fisheries. In *Fisheries and Uncertainity: A Precautionary Approach to Resource Management.* D.V. Gordon and G.R. Munro Editors.

Scott, A. (1955): The fishery: The objectives of sole ownership. *Journal of Political Economy.* Pag 116-124.

Scott A. (1993): Obstacles to Fishery Self-Governance'. *Marine Resource Economics* 8(3): 187-99.

Townsend, R.(1990): Entry Restrictions in the Fishery: A Survey of the Evidence.
Land Economics. Vol (66,4) pag 359-378.

Varela, M., Suris, J. Garza, Mª D. and Iglesias, C. (2000): *Economía de la Pesca. Presente y Futuro de la Regulación Pesquera en Galicia*. Instituto de Estudios Económicos. Fundación Pedro Barrié de la Maza.