# A value-based individual transferable quota scheme- a preliminary examination of its suitability as a fisheries management technique

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**Abstract**

An ITQ scheme has been shown to create a quota-induced incentive for discarding of fish in excess of what is socially optimal. This finding is corroborated by empirical evidence in several ITQ managed fisheries. The incentive for discarding, over and above those expected in an unmanaged or input-controlled fishery, may arise because of two reasons: firstly, in the case of a single species fishery, it can be advantageous to substitute low-priced with high-priced size classes of fish thereby increasing the value of a given quota; secondly, where transaction costs in quota trading are high, species may be discarded for which no quota is held or for which catches have surmounted current quota holdings.

The proposed approach of assigning value-based individual transferable quotas (VITQs) would remove the quota-induced incentive for high grading, and can reduce costs of quota trading. Furthermore, in the case of multi-species fisheries, VITQs may allow fishermen to respond with greater flexibility to changes in species abundances than under an ITQ system, and may confer greater economic stability.

A value-based individual quota would assign a maximum landed value of the catch, which could be taken in a certain period of time (e.g. year). The catch would be composed of a basket of pre determined species or would need to be taken from one or several assigned fishing zones/areas, or a combination of both. The proposed system may depict a compensatory mechanism against excessive targeting of any one single species, but if this could result in a desirable exploitation, pattern would depend on growth rates catchability coefficients and price elasticities of the various species in the basket or fishing zone.

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**1. Introduction**

In differentiated fisheries, Ragnar Arnason (1994) and Lee Anderson (1994) have shown that individual transferable quotas (ITQs) create a quota-induced incentive for discarding of fish in excess of what would be expected from rational economic agents in an open access fishery. In a differentiated fishery, the catch is composed of more than one economic grade. Given the extent of price differentials between the grades, the costs of discarding and fishing effort, and the quota price, it can be advantageous for the fisher to either high-grade the catch, that is to discard lower economic grades and replace them with higher grades, or to discard and sell the unused quota (Arnason, Anderson, 1994). Empirical evidence for high grading has been reported from various quota-managed fisheries in several countries. However, quota-induced discarding constitutes only a small part of total global discards, which are estimated in the order of 27 million tons (FAO 1994). That presently most discarding is done on technological-economic grounds can be inferred from the fact that globally only few fisheries are managed through quota schemes.3[3] In future, quota-induced discarding may become of greater importance as more countries adopt quota-management regimes.

Arnason noted that the incentive to discard is not the result of an ITQ system as such but caused by the incomplete definition of the property rights established through ITQs. In a well-defined system, quotas would need to relate to catches rather than landings, and distinct quotas would have to be established for distinct economic grades. The costs of establishing and enforcing such well-defined property rights, however, may be prohibitive.

In a later paper, Ragnar Arnason (1995) has shown that when harvesting selectivity is introduced into the analysis, ITQs may not depict the undesirable incentive for discarding. In this case, the tendency to discarding will be determined by the shape of the cost functions of selectivity and discarding respectively. Harvesting selectivity

3[3] It should be noted that under the European Common Fisheries Policy, significant amounts of discards arise because of minimum landing size regulations. The latter are in place to discourage targeting on juveniles (Commission of the European Communities, 1992).

may hereby be affected by choices of fishing technology, and fishing grounds and seasons.

Anderson (1994) examines an income neutral scheme of taxing higher valued grades and subsidising lower valued grades, and landing restrictions as possible methods to reduce or eliminate high grading. If properly designed to account for the varying economic parameters of different fleets, both methods offer good potential to achieve their intended purposes for a wide range of conditions.

This paper presents a preliminary examination of the suitability of a value-based quota scheme (VITQ) as a fishery management technique. To the author's knowledge, value quotas were for the first time proposed by Parzival Copes as a possible means to reduce discarding in multi-species fisheries (1986). Recently, Turner (forthcoming) has demonstrated that a value quota system avoids quota-induced high grading4[4]. A simple model has been elaborated in this paper to prove the same point. This is followed by a discussion on the potential advantages of VITQs in a multi-species fisheries context. The results of some exploratory bio-economic simulations indicate the scope and limitations of applying VITQs. Finally, some practical difficulties are presented in implementing and monitoring a VITQ scheme.

## 2. A simple static model to examine quota-induced discarding

We assume the exploitation of a resource with an aggregate biomass x yielding differentiated products $y_i$ of grades i (i = 1 to n) with constant prices
$P_i = P_1 < P_2 < \ldots\ldots P_n$.

The aggregate and individual production and profit functions of all j firms are assumed to be related to costless effort $e_j$, which is undifferentiated by grades. Thus, each unit of effort produces quantities of the different grades i in some fixed proportion.

(1) , and total yield:

(2) $\pi_j =$ , and total profit: $\pi =$

The profit per unit of output, and thus the opportunity cost $O_c$ of one unit of the resource is then given as:

(3) $O_c = \pi / Y =$ , whereby is the weighted average price of one unit of production.

We now introduce the possibility of discarding of lower valued grades at zero discarding costs, and a quota constraint Q on the total number of units, which can be sold. Q is divided up among the j firms so that:

(4) , and Q =

where denotes the sold production, and the discards.

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4[4] The author became aware of the work of Turner on value quotas in April 1996.

As zero production and discarding costs apply, and assuming no biomass constraint to take the quota, profits are maximized when the sold production comprises entirely with the highest valued grade n at price $P_n$.

(5) $\pi_{max} = Q$ , whereby $\pi_{jmax} =$ , i = n,

$=$

The profit per unit of sold production, the trading price of one unit of quota as well as the opportunity cost of one unit of the resource is then given as:

(6) $O_c = \pi_{max} / Q =$

We shall now examine if a shift to a value-based quota would reduce the incidence of discarding. Assuming that the management authority wishes to discourage discarding of low valued individuals, the total allowable value (TAV) would be established as the product of the total allowable catch (TAC), equal to the aggregate quota Q, and the weighted average price of grades i. The TAV would be further sub-divided into individual value quotas assigned to the j firms.

(7) TAV $=$ $=$ TAC $=$ Q ,

Assuming again zero production and discarding costs, (7) denotes also the aggregate and individual profit functions:

$\pi_{max} = TAV =$ $\pi_{jmax}$

The profit per unit of production sold and the opportunity cost of one unit of the resource are then given as:

(8) $O_c = TAV/TAC$ $=$

Comparing (8) with (3) shows that in a value based quota system, the opportunity cost of one unit of the resource is equal to where no quota constraint and no incentive for discarding apply. Furthermore, the quota-trading price of one dollar's worth of output is just one dollar. This implies that in value terms, the output is undifferentiated and thus, no gain can be attained by discarding low-valued individuals with the objective to either sell the unused quota or replace it with high-valued individuals. Therefore, a value based quota system does not create a quota-induced discarding incentive.

As can be easily inferred, if positive production and/or discarding costs are introduced into the model, profit maximization strictly requires that discarding should be zero under a value based quota system.

The question arises, if the above findings would hold if the restrictive model assumptions are relaxed with respect to the shape of the production function and to costless fishing effort. The generalized discarding model developed by Arnason (1994) demonstrates that quota-induced discarding behaviour is governed by the instantaneous imputed shadow price or marginal value of quotas to each firm. If the quota is defined in value rather than in quantity, quota-induced discarding could only occur if the instantaneous imputed shadow price of the right to land one dollar's worth of fish becomes greater than one dollar. This clearly cannot be the case because in equilibrium, the shadow price of a dollar's worth of fish must be equal to the profit, which can be obtained from producing it. That is the shadow price must always be lower than the corresponding quota (value).

### 3. VITQs and the incentive structure

Apart from avoiding the quota-induced discarding incentive, does VITQs alter the incentive structure of fishers compared to that in an ITQ system? In the latter, fishers behaviour can be conceptually divided on the one hand, in one to obtain the highest possible value from a given quota and, on the other hand, in one to minimise the costs of harvesting and landing it. In a VITQ system, the incentive is to minimise costs of producing a given value of the landings. This value, however, may be obtained at different quantities depending on prices. Prices may vary according to the time of landing, especially in small-scale fisheries, and according to the quality of the catch. Racing to obtain a better price is one means of increasing trip revenues and aggregate annual revenues in an ITQ system. In a VITQ system, aggregate annual revenues are fixed and thus, racing only pays if savings can be made through the avoidance of future trip and landing costs. These potential savings are the lowers, the higher being the share of annual fixed costs. There is thus a trade-off between investments in the ability to race, say through a more powerful engine, and the potential savings, which can be realised through racing. This disincentive to invest in the ability to race does not apply in the same manner to ITQs because aggregate revenues are not fixed.

At the aggregate level, the effect of racing on the average landed price may cancel itself out in the sense that what is to the benefit of one is to the loss of the other. The effect of qualitative improvements, however, could be cumulative so that the average landed price goes up (as for example observed in some New Zealand fisheries following the introduction of ITQs). In this case, the total quantity, which could be landed in a VITQ system, would be less than the target quantity established through the total allowable value. If 'qualitative improvements' have been obtained through high-grading, a landed quantity lower than the target could be a desirable feature because it would limit expendable fishing effort. If the price increase is due to real quality improvements, the missing of the target landings may entail commercial and social losses, and an adjustment of the value-quota may be desirable within the season or fishing year. Mid-season upward adjustments of the value-quota may not create undue problems to the fishers and fishing industry.

More problematic is the case where prices, say due to sudden changes in supply (e.g. imports), decline significantly below the target price. In this case, the allowable landings are higher than the target quantity. The management agency may then be required to lower the total allowable value in the face of reduced profit margins of fishers. This clearly is the worst case scenario for the management agency because politically, it will be very difficult to obtain agreement on a reduced quota. A possible means to avoid this situation to arise is to index the total allowable value to, for example, the price of the most common commercial category. This though may result in undesirably frequent changes of the TAV. Alternatively, the TAV may only be adjusted once the reference price has surpassed a lower or upper threshold level.

## 4. Multispecies fisheries

For our purposes, a multi-species fishery may be defined as one where a fisher has limited control over the species composition of his catch, or where such control would be costly to achieve. In such a situation, the fisher's portfolio of quota holdings is unlikely to match his catches, and he would be required to buy or sell quotas in the course of the fishing season or year, or to discard those fishes for which no quotas are available or can be procured. As quota trading is not costless5[5], the discarding (or cheating) behaviour of the individual operator is evidently influenced by such costs. Costs in quota trading encompass the purely administrative costs of exchange, financial costs as well as the economic risk associated with the holding of an asset whose value may depict considerably inter-annual fluctuations. The higher is the risk, the greater is the uncertainty about the future TAC, fish price and harvesting costs. To some extent, these costs to the individual firm can be reduced through quota leasing instead of outright purchase, as observed for example, in New Zealand's ITQ fisheries. Future markets for quotas would also allow reducing the investment risk and thus the cost to the individual firm.

The required frequency of ITQ trading is likely to depend on the number of species under quota management, the degree of accuracy in the setting of the annual TAC for each species, and the extent to which the individual operator can accurately anticipate the rate and composition of the catch of different species. The frequency would also depend on the number of individual operators and their relative shares in quota holdings: the greater is the numbers of operators and of individual shares, the greater is the expected frequency of required quota trading. In situations where the costs and required frequency of ITQ trading are substantial, a shift to a VITQ system may significantly reduce the incidence of discarding (and possibly cheating) by fishers.

Various methods have been proposed to deal with the quota over-run and bycatch problems in quota-managed fisheries, including the issue of multi-species quotas (e.g. considered by the European Commission), the swapping of target-species quotas for bycatch species, or the setting of surrender prices which, while encouraging fishers to land bycatches, do discourage their targeting (e.g. see the description of New Zealand's ITQ system by Clark, Major and Mollett, 1989). While multi-species quotas would encourage species-highgrading, quota-swapping and punitive surrender prices entail the concept of 'valued-quotas'.

The most notable example of increasing the flexibility of an ITQ system is reported from Iceland. Here, provisions have been made, though within a quantitative limit of 5% of individual quota holdings, for exchanging a catch quota for one demersal species for that of another. The exchange is calculated on the basis of cod equivalents which are established through value factors based on market prices at the beginning of the fishing season [6]. Quotas of cod cannot be exceeded, however. In describing this system, Skarphédinsson (1993) noted that there are neither scientific nor economic reasons for these rules because free transferability of quotas would be able to resolve any difficulties, which these rules aim to address. He also reported that this system fared badly in 1989 because many vessel owners converted cod quotas for Greenland halibut whose price rose

5[5] In New Zealand, for example, quota trading has become a specialised profession (Clark, Major and Mollett 1989).

[6] Turner (forthcoming) has demonstrated that a VITQ system based on relative prices does also avoid a quota-induced discarding incentive while possibly facilitating implementation

greatly on markets abroad and significantly surpassed the price applied for calculating its cod equivalence.

Flexibility

In situations where quota trading is costly, ITQs may lead to inefficient choices of production technologies and fishing strategies because these are governed by the nature of ITQ holdings rather than by the available production possibilities. Value-based quotas may avoid undue technological specialisation, thereby increasing the flexibility of fishers to re-act appropriately to changes in species abundances. Value-based quotas would also take advantage of the fact that predictions of the abundance of individual fish stocks may depict a higher degree of uncertainty than predictions of the biomass of the aggregate species assemblage.

A compensatory mechanism?

In a multi-species VITQ system, individual property rights are less well defined than in an ITQ system because the right to a certain landed value of the catch is imprecise in regard to the amounts of landings of individual species. This is the principal drawback of a value-based quota system, and the only way it can be partially circumvented is by carefully selecting the species-basket, or fishing zone, to which a VITQ system applies. Under ideal conditions, the exploitation of each species would need to converge to its optimal level in response to changes in stock abundance and catchability, prices and harvesting costs. Such convergence could occur to some extent through a compensatory effect between unit harvesting costs and sales prices. As prices would be influenced by the level of supply and as harvesting costs per unit of fish would be affected by the abundance of the species (assuming that the catchability coefficient does not vary greatly with abundance), fish prices and unit harvesting costs would develop in opposite directions. If one species was overly targeted, higher supplies would tend to lower the market price while a decreasing catch per unit of effort would result in increasing harvesting costs per unit of fish. Average prices may also decline if the share of young individuals carrying lower unit prices increases in the catch as the exploitation rate goes up. The consequent decline in the net price of the species (price net of harvesting costs) would encourage a shift in the target species.

The questions to ask are, however, if such a compensatory mechanism would indeed arise in reality, and given it occurred, if it was of the right magnitude to ensure the optimal exploitation of the species mix. While the affirmative may apply to the first question in many instances, the latter appears to be unlikely to be met for various reasons including the fact that fish prices are also influenced by external supplies to the specific fishery (e.g. imports) and that the catchabilities of different species may develop differently, in response to changes in species abundance, and may vary due to environmental conditions.[7]

In a highly simplified manner, the potential magnitude of one component only of the compensatory mechanism was explored for some North Sea demersal species with a bio-economic simulation model based on Thompson and Bell (the detailed structure of such a model is given, for example, in Spare and Willmann 1993). The demersal fisheries of the North Sea usually either target on a mixture of round fish

[7] Unexpected changes in catchability are among the main causes of gross errors in the assessment of fish stocks.

species (cod, haddock and whiting), or a mixture of flatfish species (plaice and sole) with a bycatch of roundfish (ICES, 1995). Based on growth, natural mortality and length-weight parameters of cod, haddock, plaice and sole derived from FISHBASE (ICLARM, 1995), average recruitment and fishing mortality parameters for the last two decades from ICES (1995), and EU fish guide prices for 1996 (World Fish Report, November 1995). The development of the profit per unit of effort was modelled in response to changes in fishing effort. The same arbitrary values were used for the catchability coefficient and cost per unit of effort. Assuming biological equilibrium, the simulation results suggest that the profit per unit of fishing effort may converge for haddock, plaice, and sole within reasonable levels of fishing mortality. This is not the case for cod whose comparative profit potential per unit of effort is much higher given the assumptions of equal catchability and unit cost of effort across all four species. The implication for a value based quota system is that the cod stock would tend to be overly targeted and could be driven down severely prior to a shift to other target species. More precise and extensive modelling work would be required to establish the feasibility, or not, of applying a value-based quota system to these fisheries.

## 5. Value-based quotas in small-scale fisheries

This is general agreement that ITQs are not suited for widely dispersed multi-species small-scale coastal fisheries. Apart from the practical problems of monitoring and enforcing a system of ITQs, there is also concern about the possible distributional consequences of ‘privatising’ a common resource (on the latter point and the role of rural communities in common property resources management see, for example, Balland and Plateau, 1996).

The prevailing, and most promising concept of managing such fisheries is through some form of territorial use right (TURF) held by groups or communities of fishers who collectively decide on the appropriate management system (Christy, 1982). Value-based quotas may be a desirable technique of the TURF owners to manage their fisheries as an alternative to controlling and limiting fishing effort by individual fishers. The latter is difficult because of the great variety of fishing craft and gear. Furthermore, this variety may often preclude using fishing capacity as a criterion to arrive at an acceptable mechanism of sharing the common resource. A sharing system based on value of output, possibly net of certain costs, would circumvent this problem and furthermore would provide the appropriate incentive of restraining investments in redundant fishing equipment and of fishing effort by fishers.

That the concept of a value-based quota (i.e. share) may not be entirely foreign to fishers, it is borne out by examples of the pooling of revenues (and costs) in Japanese co-operative inshore fisheries. In the case of the stardust shrimp fishery in Suruga Bay, for example, it is reported that co-operative fishermen co-ordinate the aggregate amount of daily catches, for reasons of price stabilisation and resource conservation, and pool the revenues of all fishing units which are then shared among the crews and owners upon deducting certain operating costs (Stardust Shrimp Fishery Co-operative Association, 1993).

A value-based quota system would also take advantage of the frequently found feature in small-scale multi-species fisheries that it is easier to determine the value of landings rather than their total weight or the weight of individual species (see for example Kurien and Willmann, 1982). However, this advantage should not hide the fact that the implementation of a value-based quota system would be difficult to monitor and enforce in most small-scale fisheries.

Regarding transferability, it is believed that in a TURF setting the member-owners would often wish to restrict transferability of quotas to themselves or to their offsprings. This would be in accordance with the restrictions on transferability of use rights frequently observed in traditional management systems of natural resources.

## 6. Implementation of a VITQ system

A VITQ system would require the appropriate setting of the total annual (seasonal) allowable value (TAV) and the monitoring and enforcement of individual quotas.

### Setting of the total allowable value

The TAV would be established on the basis of the target catch, i.e. the total allowable catch, for each species (or just one species in a single species fishery), multiplied by the expected average landing price of each species. An individual VITQ would either confer a right to exploit a certain share of the TAV, or an absolute amount. The latter would be largely impractical because of the expected variability of the TAV from year to year because of changes in prices and species abundance. The species basket, or fishing area, whose exploitation the VITQ would entitle to, would need to be carefully defined taking into account the prevailing fishing technologies and their selectivity, multi-species interactions, seasonal and age-specific variations in catchability, the profit potential per unit of effort of different species and the elasticity of profit in response to variations in fishing effort. A system of a multi-species VITQ may need to be operated in conjunction with a single-species VITQ for specific species whose exploitation is greatly more profitable than that of other species.

The task of determining the appropriate species baskets, or appropriate delimitation of fishing grounds, and of establishing the annual TAV, is clearly of a multi-disciplinary character and requires the involvement of fisheries biologists and economists, as well as the fishing industry. At present, the total allowable catch is usually determined on the basis of biological advice and political expediencies.

### Quota trading

If transferable, no difference is foreseen in the arrangements for quota trading, except for the possible consequence that the required trading is significantly less than in an ITQ system. The required information for establishing reasonable expectations on future quota prices may be higher in the case where quotas apply to a species mix. On the other hand, as the abundance of individual species may depict greater variability than the aggregate abundance of a species assemblage, quota prices may be more stable than would be the case for the prices of species-wise ITQs. This would lower the risks associated with holding a capital asset. As recently observed by Arnason (1996), it would be desirable if fishers take an interest in the entire eco-system rather than in individual species. Multi-species value quotas would tend to provide such an incentive though not to the same extent as might be achievable, if feasible, through the share-quota system proposed by Arnason.

Monitoring and enforcement

The task of obtaining species-wise catch statistics would remain, of course, for purposes of stock assessment. However, this task could be delinked from the usual requirement of ITQ systems to monitor species-wise landings of individual quota holders, which may greatly improve data quality. Instead, at this desegregated level it may suffice to monitor the value of the landed species-mix. A practical difficulty is hereby the avoidance of under-reporting of the sales prices. This could occur because of collusion between the seller and the buyer of the catch and evidently in the case of transactions within vertically integrated companies. Auctioning may largely avoid collusion but where fish is sold directly to individual traders or processors, or is destined for further processing within vertically integrated companies, the possibility of fraud is considerable. In these instances, there may be the need to monitor the exact composition, weight and prices of individual species and size categories so that unexplained discrepancies between the sales prices and the 'allowable prices' can be detected. Once detected, an obvious difficulty would be to actually prove that fraud has been committed and legally establish this fact in the court.

The scope for fraud could be limited, to some extent, by assessing the value of landings based on a set of minimum prices which is derived from those markets/auctions where the potential for cheating is small or absent. Then, however, the problem of monitoring catches of individual fishers/boats re-emerges on an even more complex level than with ITQs because for species where prices differ widely by size categories, the need arises also to determine these weights.

A further difficulty arises for vessels where the entire or parts of the catch are processed on board. If typical conversion rates can be applied to convert processed to unprocessed quantities, the landed (unprocessed ex-vessel) value could be established with the help of the set of minimum prices. Alternatively, as these are often medium and large industrial vessels, they would need to be required to maintain catch/landing statistics.

In conclusion, the monitoring requirements in a VITQ system are not necessarily higher than those needed in an ITQ system. Where catches are auctioned and collusion between sellers and buyers is difficult or absent, these requirements are likely to be smaller in a VITQ system. Where collusion is easy, the opposite applies but then assumably even an ITQ system may experience significant levels of under-reporting. However, with ITQs fraud is likely to be more easily detected and legally prosecuted.

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