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Demand-side fishery management: integrating two forms of input control

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Abstract

A fishery management approach is presented which combines (1) a buyback of fishing vessels, and (2) a management tax or fee on seafood going to market. Tax rate by species is set proportional to the extent of overexploitation. Tax revenue is used for several purposes, including a buyback of licenses at free-market price. Advantages and disadvantages of this policy are discussed, with specific comparison to individual transferable quotas (ITQs). This regulatory policy offers advantages (1) for multispecies fisheries, (2) with ecosystem fishery management, (3) where self-funded financing for license buyback is needed, and in place of or together with ITQs (4) where allocation, discarding and highgrading, quota setting, or enforcement of ITQs is problematic.

Keywords: Tax; Buyback; Individual transferable quotas; Ecosystem; Fishery management

1. Introduction

Among output limited strategies, individual transferable quotas (ITQs) have replaced total allowable catches (TACs), and are increasingly favoured as the fishery management strategy of choice worldwide. In an ITQ system [1–3], each license is allocated a fraction of the total catch quota for each controlled species. This becomes, effectively, part ownership or indefinite lease of the yields from that resource. These individual quotas may be traded or sold among fishers. By letting the free market establish the value at which quota may be bought and sold, ITQs are self-regulated. The reasons ITQs have been far more successful than total allowable catch quotas (TACs) which were not specified for individual vessels are generally accepted:

(1) ITQs eliminate the common property scramble among competing vessels which TACs did not reduce, or even exacerbated. The knowledge that all other fishers are limited by an individual quota ensures that everyone exercises the same restraint.
(2) Times of harvest through the quota year can be more freely choosen, when prices may be higher or in good weather.
(3) ITQs turn the right to fish into an asset with reasonably well determined value.

Often the sale price of this asset, realized when the fisher chooses to retire and the license is sold, can be several times a year's gross earnings. Thus, the financial incentive for each individual to enhance stock abundance, in particular for future prospective buyers of their license, can take precedence over yearly harvest. This provides a strong financial incentive for the fisher to support measures enhancing long-term stock conservation, successfully obviating the common property dilemma of open access and TACs.

However, some drawbacks of quotas remain partly or largely unresolved by ITQs. (i) Quotas are set by managers as an absolute harvest quantity, often resulting in a total catch that does not respond dynamically to changing levels of abundance. (ii) It is sometimes politically harmful for elected officials to lower quotas until the stock is reduced to such a low level that serious economic consequences are already widely felt. (iii) Underreporting is common and is difficult to quantify. (iv) Quota-induced discarding and high grading occur in multispecies fisheries under ITQs. (v) In some overexploited fisheries, the current level of overcapitalization is simply too severe, and there are too many boats among which any quota would be shared, to implement

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ITQs. (vi) Allocation of the quota at implementation is often highly divisive among license holders. I will also argue that ITQs lack certain desirable features for achieving objectives of ecosystem management, increasingly requested by government environmental policy makers and NGOs.

In this paper I present arguments for an input-limited approach, a fishery capacity reduction scheme. It provides a way to fund buybacks while at the same time providing a tool for balancing the levels of effort among species being harvested. This management strategy could have particular value with fisheries (1) that are multispecies, (2) where reducing overcapitalization is the principal management objective and funds are lacking for a buyback, (3) where allocation of individual quotas is not legally, politically, or socially sanctioned, or (4) where ecosystem objectives of more equal rates of human predation on species in the foodweb and removal of harmful gear types have high priority. This management scheme can be implemented in conjunction with ITQs where the drawbacks (i–iv above) of ITQs require mitigation. It acts, in part, by reducing demand rather than imposing upper limits on supply and is therefore called demand-side fishery management.

This article follows in six parts: First, I will present the details of a demand-side management policy. Second, its principal anticipated effects are enumerated, including the ways overfishing should be reduced. Third, its advantages, and fourth, its disadvantages are assessed. Some options for mitigating these weaknesses are proposed. Fifth, ITQs are compared. In Section 7, the place of demand-side management is summarized, notably for achieving ecosystem management objectives, and for surmounting the principal obstacle to previous vessel buyback input-control systems, namely increasing effective effort (capital stuffing).

2. Demand-side fishery management plan

This policy has two basic components, a buyback program of fishing vessels, and a tax on overfished species. In addition, a stock assessment component is employed.

2.1. Vessel fleet size reduction

1. Entry to the fishery is restricted to all present license holders. Open-access fisheries would be made limited access and licenses issued. A license allows fishing with a specific vessel and gear in a specific region. It does not limit access to specific species, at least within a class of fisheries such as groundfish.
2. Licenses are legally bought and sold. As with ITQs, the market for licenses will naturally determine their price.
3. The management system will itself be one of the buyers of fishing licenses, to which any fisher is free to sell, at any time, if he chooses. Each license so purchased will be withdrawn from use. In some fisheries, license buybacks would be directed towards particular vessel or gear types that may be perceived to be most damaging to stocks and the benthic habitat.
4. In issuing each license, a list will be drawn up of important vessel characteristics, verified by inspection. Engine power and make, gear configuration, sonar electronics and other capture technologies, together with the usual vessel weight and length will be specified. The license is valid only for that particular vessel and listed specifications.

2.2. Tax on marketed fish

1. A new tax, call it the 'fish tax', will be imposed on the seafood product as it leaves the wholesaler to market. This is imposed at the time of sale, either at auction, or as it leaves the processor in companies that sell directly to the retailer. The tax may be set as a fixed amount per kilo or, as hereafter assumed, as a percentage of auction price.
2. The level of the tax percentage shall be set according to the degree to which effort is excessively directed towards each species—more severely overfished species are taxed at a higher rate. This determination will be made by criteria the management plan must establish, based on the stock assessment described below.
3. These fish tax funds will, if possible, be held legally separate from general government revenues.

Where fishers are unified in management bodies, as either cooperatives or corporate purchasers, the tax can be replaced by a 'management fee', an additional cost factored into seafood wholesale price. This has the advantage of not requiring government tax bodies to collect the fee.

2.3. Stock assessment

A stock assessment program will monitor the abundance and change in population size of all regulated species. This scientific role is assigned to public or private stock assessment bodies now in operation.

2.4. Tax expenditures

The receipts of the fish tax will serve three purposes:

1. Fishing licenses will be purchased by the plan for retirement. The tax thus provides financing for a reduction in the number of vessels in the fishery.

2. Another portion of tax revenue can help pay the cost of managing this plan, including fishery stock assessment and program administration, relieving the burden on federal (and state or provincial) taxpayers.
3. In fisheries under severe financial strain, a fraction of total fish tax revenues can be allocated to all license holders as a monthly or annual subsidy. The amount of each monthly check is allocated to fishers independent of how much they fish.

3. Effects of demand-side management

1. A tax on overexploited species of fish would increase the price to the consumer, reducing consumption. Lower demand obliges processors or wholesalers to offer fishers a lower price at time of landing, which, in turn, induces a relatively lower fishing effort for that species.
2. Vessel fleet size would decline over a long-term program through license buyback.
3. The consumer who now pays a higher price for fish bears a greater share of the cost of fishery management and stock conservation in the purchase price of the seafood product.

This management regime thus provides two basic mechanisms for reducing overfishing:

(a) Reduced vessel number
(b) Lower price to fishers for overexploited stocks.

4. Advantages of this policy

4.1. Ecosystem-based fishery management

There are four ways by which this approach can enhance the health of the ecosystem:

1. The amount of fishing effort directed to different species in the marine ecosystem would become more equal. By setting the tax rate by species so that the price offered to fishers is roughly uniform, fishing effort will naturally target those stocks which are most abundant. This, in turn, should shift higher fishing mortality levels to more abundant species, and could, in some cases, allow fishing to serve as a stabilizing, rather than a destabilizing influence on the foodweb.

The tax induces more equal price to fishers among different species in two ways, directly by reducing the price for overfished stocks and indirectly by increasing the price for less intensively exploited species. Higher value and thus generally more overexploited species would bring a lower price to fishers due to the fish tax imposed as discussed above. In multispecies fisheries, untaxed species would presumably offer an alternative to the consumer who, in turning to that choice in the supermarket, increases its consumption, thus shifting it to a higher price on the demand curve. Thus where overexploited and underexploited (or otherwise untaxed) species sell into a common market, the fish tax can sometimes induce an at least marginally higher price for previously lesser-valued species.

For the fishing industry, as well as for ecosystem management objectives, stability of foodweb structure is an important goal. If small sharks have replaced haddock and cod on Georges Bank [4], the economic consequences are severe. One of the principal goals in managing the Georges Bank groundfish stocks is now seen to be to balance the levels of fishing predation more uniformly among competing top predators, for both ecological and economic reasons [5].

The demand-side multispecies pricing scheme could also provide a more precise tool in fishery ecosystems such as the North Sea, where extensive investigation of trophic structure has been undertaken [6–8] and is becoming capable of identifying specific species for greater or lower (rather than generally uniform) levels of removal [9]. The goal is often to augment total value of production or to enhance ecosystem stability. The species-specific pricing mechanism of the demand-side scheme permits multispecies fishery adjustments without inducing discarding. This will become an increasingly sought objective as ecosystem approaches to fisheries management reach further stages of development.

2. Direct harm to the ecosystem, notably the benthos [10], may also be reduced by selective license buyback. Fishing gears and vessel types may be reduced or eliminated (1) which have the most deleterious impact on the benthic habitat, and (2) which have higher probability of capturing (or lower probability of safely returning to the sea) unmarketable marine organisms.

3. The goal of raising the average age of captured fish may be partially advanced by a size-selective tax. A higher tax could be placed on smaller fish inducing a lower price to fishers. This has the advantage over a strict minimum size limit of reducing discarding for small but still marketable sizes. The most common method of size-selection, net mesh-size regulations can be difficult to enforce, particularly at sea, and their success in selecting only larger fish has been mixed. ITQs which are year-class specific have been proposed [11] to achieve this objective but the logistics of such highly specific quota partitioning are formidible and this would almost certainly increase quota-induced discarding. A size-selective tax presents fishers with a price disincentive to target smaller fish, but once captured, they can be landed if that remains financially viable. When there is no legal minimum length, this tax disincentive could be applied in addition to traditional gear regulations.

4. Discarding and highgrading are reduced.

4.2. Economic benefits

Under a demand-side system, a free market is preserved, i.e. the system is self-organizing, in three ways:

1. The price of licenses is market-determined, both those removed from the fishery and those transferred.
2. Microeconomic decisions by fishers, especially in multispecies fisheries of how much of each species to harvest, are less constrained (being regulated by a price disincentive rather than a fixed upper limit on supply) and so situations where the more highly regulated species happen to be caught result in less harm, mainly a relatively lower price for those fish when sold, rather than discarding. Fishers may welcome this feature.
3. The costs of fishery management and conservation are shifted to the consumer, i.e. to the demand side. Insofar as the fish product is produced naturally by the marine ecosystem, and harvest and distribution are the only tangible costs, adding population (and fishery-related ecosystem) management to the product price is a sensible redistribution of those costs from taxpayers or fishers themselves who presently pay.

A higher price is paid per kilo by consumers of taxed fish, and essentially all of this additional tax revenue is transferred back to the fishing sector. The three uses of tax revenues, (1) license buy-out (which causes license asset value to rise), (2) management costs, and (3) short-term financial compensation, represent transfers to the fishery, either directly to fishers or to the costs of stock rehabilitation/sustainability (or to both, in the case of license buy-out). The remaining revenue difference between taxed and untaxed fish, namely lower amounts of taxed fish harvested is, of course, a principal objective of the tax.

4.3. Social net rents

This plan may also claim benefits to society as a whole:

1. Government expenditures on management and enforcement, presently paid by taxpayers, could be partially or wholly replaced by receipts from the fish tax.
2. In the long run, the reduction in total numbers of vessels fishing represents a proportional reduction in total costs, both fixed and variable. Under the classical theory of fisheries economics [12–14], reducing fishing costs was a principal objective of fishery management, with the overall objective of increasing net rents. This goal is attained by a reduction in overcapitalization through vessel buy-out.

4.4. Cooperation from fishers

This management policy seeks to improve its chance of success by earning the trust and participation of fishers. As noted, it reduces regulatory control over day-to-day fishing operations. In addition, it remits to fishers a monthly subsidy, especially valuable at early stages of implementation, in part, to cover reduced revenues from the lower price they would receive for overexploited stocks. This subsidy could be important as a fraction of annual income, in particular, to the fishers on smaller vessels who struggle to earn a living wage when stocks are low.

As with all limited access fisheries where licenses are freely bought and sold including ITQs, fishers who sell their licenses receive a substantial payment, becoming their retirement pension. Others may be motivated to start a new business with this pool of capital.

The asset value of the license rises for three reasons: (1) because there is the added market of license buyback, (2) because the number of licenses is reduced, and (3) because financial prospects of owning this asset are enhanced. As total effort declines and stocks recover (if they do), catch rates and thus financial returns from fishing rise. If the total catch does not rise, not an uncommon outcome of stabilizing a declining fish stock, this non-rising catch is divided among a smaller number of vessels fishing.

Enforcement, discussed below, should be more straightforward under this plan, notably from the fishers's point of view. This instills more faith in the system to be fair for those who participate honestly. Much enforcement effort is directed to those who market the fish, in particular, in the collection of the tax.

Through the fish tax, a greater share of cost in this program is shifted to consumers and those who market the product and away from fishers, who commonly suffer risk and harsh conditions at sea for often relatively low pay.

Fishermen would not be required to discard marketable fish back in the ocean because a catch limit on that species had been reached.

Fishers increasingly recognize the need for a fair way to reduce fleet size: "Too many vessels chasing too few fish" is a refrain heard widely in fisheries trade newspapers. By making the financial interests of fishers a top concern, the demand-side system seeks to earn the support and cooperation of the people it is designed to benefit, a feature it shares in common with ITQs.

4.5. Enforcement

Enforcement in any management system must be fair and cost effective [15–17]. Enforcement costs should be lower because the incentive for fishermen to underreport

or land fish illegally is lower than under ITQs as I argue below.

The principal legal constraints apply to those who market the fish, who must satisfy two requirements:

1. The purchaser must buy only from licensed fishers.
2. He must report all sales by species and pay the corresponding tax.

Non-compliance in a demand-side fishery would primarily manifest as the sale of fish to buyers who are not remitting the fish tax. Each buyer of fish would receive a license issued by the management system. The New Zealand ITQ system has instituted "Licensed Fish Receivers" to serve this role [18]. Fishermen would sell only to licensed buyers who, in turn, would be required to report total purchases of each species with each tax payment.

Reasonable and clearly defined penalties are needed for enforcement of any management system. I suggest some here though these will vary widely in practice. In cases where sellers would attempt to market untaxed fish, both the seller and purchaser should be held legally liable, and a substantial fine levied on each to pay court costs and help as a contribution to the management tax fund. The amount of fine should be set at levels sufficient to represent a year's pre-tax revenue for both seller and purchaser, which may be paid back over several years. This should provide sufficient disincentive against selling black market fish.

Fishers attempting to sell to an unlicensed buyer would forfeit use of their license for 1 year. Repeated violations of the fishers's license agreement should result in loss of license which would be withdrawn from use as if purchased in the license buyback program.

4.6. Disincentives to discard fish at sea

An important negative side effect of ITQs is the dumping of dead harvested fish when the quota for a particular species has been exceeded or for which no quota is held. A second related problem is high grading, throwing back lower-priced fish of a given size or quality to avoid having those fish counted in the quota. This waste, when caused by the ITQ management system itself is, for many, its most counter-productive side effect. Discarding occurs in all especially trawl fisheries, not just those under quotas [19]. Legal minimum length as a regulatory control probably causes more discarding than ITQs. But quota-induced discarding and high-grading do occur in many ITQ-managed multispecies fisheries [20], for example, school shark [19]. When a vessel in the two-species Australian shark fishery reaches its quota for school shark, the over-fished species whose quota has been lowered to rehabilitate the population, and continues to fish for gummy shark, all by-catch of above-quota school shark must be discarded. Thus, the most heavily targeted species in a multispecies fishery, those requiring the most stringent quota and usually bringing the highest price, generally incur the highest levels of quota-induced discarding. Under effort-limited policies there is no requirement to dump over-quota catch and a lower financial incentive to highgrade lower price fish.

4.7. Improved reliability of reports from commercial landings

Commercial fisheries statistics under demand-side management should be more accurate since there is no financial advantage in underreporting catches. If a sense of cooperation and trust is engendered by this system, as hoped, by shifting some of the burden of management cost and enforcement to consumers and fish processors, fishers may choose to be more conscientious in providing information.

4.8. Politics and legislation

Under quota systems, including ITQs, it is politically costly for the government to lower quotas, with their electorates in fishing communities, because of the high and certain short-term loss of earnings that this decision dictates. A demand-side system obviates this political contradiction by not asking government officials to impose reductions on output. Likewise in fisheries where a demand-side scheme is implemented in conjunction with ITQs, the reduction in numbers of vessels fishing through buyback reduces the financial hardship on those that remain if the quota does need to be lowered.

Second, because it offers some potentially substantial financial benefits, both short and long term, to fishers, this policy stands a better chance of becoming law.

Summarizing from above, support from the fishing industry may be garnered by six features of the demand-side approach:

(1) Restrictions on species landed would be reduced.
(2) Each license would acquire value, which should increase as catch rates rise due to a reduction in numbers of vessels fishing, more so if stocks recover.
(3) A monthly subsidy would provide financial support to fishers in the short term after implementation when the strain of many management schemes is most severe.
(4) By-catch, fish captured inadvertently, can be legally landed, though at a lower price.
(5) The total revenues per kilo to the fishery will increase, in both the short and long term, from the added value earned through the fish tax.
(6) The financial burden of management is spread among consumers and away from fishers and government.

5. Disadvantages of demand-side management

5.1. Buyback of more powerful vessel classes

In deciding which types of vessel licenses to buy back, the management body may, as noted above, choose to purchase licenses from the most ecologically damaging gear types. Or the class of more powerful fishing vessels which are likely to be doing the most overfishing may be targeted for buyback, in order to maximize employment, reduce fixed and variable costs, and prevent capital stuffing which is the principal drawback of all input limited regimes. These more powerful vessels generally bring greater, sometimes much greater, revenue to their license holders.

However, this highlights a weakness of this demand-side management system. It would be precisely these highliners who would have the greatest disincentive to sell their license. They are earning relatively large sums, are the most heavily capitalized, and stand to gain the most by the greater yields that could accrue if this policy were set in place and successfully increased average stock abundance. In these cases it would be practical and still fair to set a time limit beyond which those licenses would expire for that class of vessels, perhaps 5 or 10 years, and then allow regular market forces to operate as before. This finite lifespan would reduce the going price for those licenses and allow their more rapid removal from the fishery in the buyback program. Furthermore, the demand-side management agency should compensate each vessel owner in these exceptional cases where a fixed time limit is imposed for specific vessel and gear types by providing the full price of vessels and I believe, a large sum of additional compensation, an amount deemed sufficient to make up for the finite life span of the license. These fishers would then have the option of buying a license in one of the remaining gear or vessel classes.

5.2. Exceptions to self-regulation

Insofar as the market in fishing licenses determines their price, the buyback component of this policy is self-regulated. Moreover, choosing which species to target without risk of (quota-induced) discarding increases the freedom of fishermen to manage their day-to-day operations (though the other factors that often result in discarding, mainly market preferences, remain). However, one aspect of this system is not self-regulated. Demand-side managers must establish the tax rate on each species at fixed time intervals, probably annually. Six internal self-regulatory factors can aid this decision:

1. The tax should be high enough on overexploited stocks to provide a meaningful disincentive to fish. Therefore, the rate must be substantial, perhaps as much as 20–100%, so that consumers are dissuaded. The actual tax rate (amount or percentage) chosen will depend on the elasticity of demand in each market and for each seafood product. Lower elasticity, i.e. smaller reductions in fish purchased for a given price increase to consumers, will mandate higher tax rates to achieve the same disincentive in reduced price at the dock to fishers.
2. Fishers may object when they see a lower price at the dock, however, the optional annual or monthly subsidy will be greater the greater the tax, and the buy-out will increase the value of their license asset, and thus their objections may be mollified.
3. One likely default criterion for setting fish tax levels is that all species should bring a roughly equal price to fishers. In this way, effort will naturally be directed to the most abundant species. In practice, adherence to this criterion will be approximate but it provides a simple fishery-derived guideline for establishing the tax rate on each species.
4. Traditional criteria of stock assessment, based on population biology, should plainly be considered. Determining when a stock is *relatively* low in abundance has traditionally been the least difficult problem of fisheries management. Both historical catch rates together with other estimates of relative population size and analysis of yield-per-recruit provide a straightforward though, because of unreliable data and environmental fluctuation, a less than precise picture of how relatively low different stocks have declined. (It is estimation of absolute biomass, needed to set a quota, rather than relative abundance, that offers the more challenging problem in stock assessment.)
5. This stock assessment might be improved by more accurate commercial fisheries catch and effort data that could result by eliminating the incentive for fishers to underreport landings.
6. With time, as vessel numbers declined and stocks recovered or stabilized, the need for price as a regulatory disincentive would diminish, and overall average levels of fish tax could be reduced. Demand-side fisheries will take time to reach the state where calculating exact yield and yield-per-recruit optimums becomes necessary, namely when these optimums are close and underfishing becomes a potential consideration. At that point, the market price for a license will be high, and vessel numbers would, by that market self-regulatory mechanism, decline more slowly. Any optional subsidy to fishers would by then be phased out and the overall rates of tax could be gradually reduced while still maintaining the relatively higher rates for targeted species.

5.3. Consumer price increase

Consumers may oppose this program due to the higher price of fish. A number of factors may, however, mitigate their objections:

The higher price for seafood is expected to be greatest in the short term. If the stocks did recover or stabilize at acceptable levels with fleet size reduction, the overall mean rate of fish tax can be reduced. If stock population biomass rises, or at least stops declining, patience would be rewarded with a greater long-term supply bringing a lower average price for fish, though the price for the most desired species would remain relatively higher. Second, federal and state expenditures on fishery management could be reduced or eliminated, a direct benefit to all taxpayers. Third, since the consumer is always free to choose a different fish species or a different protein main course, strident opposition from consumer groups is unlikely. Consumer opposition may be further mollified by increasing awareness of the value and need for resource conservation. And lastly, in fisheries where it is a significant problem, the elimination of quota-induced discarding for what are usually the most sought after species, would act to increase supply to the consumer of previously discarded fish without increasing rates of exploitation on the population.

5.4. Practical obstacles to implementing a tax

In many cases, the principal obstacle to a demand-side regulatory framework will be the implementation of a tax collection regime. Governments may be unwilling to cede their tax collection powers to a fishery management role.

In cases where governments do agree to cooperate in this role, tax collection is a system which is well established and effective. Through existing agencies such as the IRS in the USA or Revenue Canada, the additional cost of enforcement and tax collection with this system should be small compared with a management policy that would need to establish a new independent enforcement network. Insofar as the fish tax is held legally separate from the general treasury revenue, the IRS and Revenue Canada should be compensated for the service of collecting the fish tax. A percentage would be reasonable.

Governments are increasingly designating some forms of tax revenue as 'fee for service' for specific expenditures. Where this interpretation is legally possible, the tax agencies can act to collect the fish tax under this aegis. Similarly, the license fees that fishers pay annually, are often or usually collected by the state or federal government. Portions or all are transferred to the management and scientific bodies overseeing the fish stocks in question, notably in South Australia and New Zealand. As this shift of interpretation continues, and governments increasingly see part of their role as specific social service providers, the possibilities for the fish tax to be collected by existing governmental tax agencies will rise.

In cases where governments do not permit taxes (or fees) to be kept separate from general treasury revenues, which is preferable though not necessary for a demand-side regime, an alternative way to collect the 'tax' must be devised. The most obvious is for processors and fishers to be unified as cooperatives. These are advocated as a superior regime of fishery management for a number of reasons, notably to unify managers, scientists and fishers toward greater communication and commonly understood and agreed objectives [21–23]. Cooperatives which allocate 'catch shares' through civil law private contracts among harvestors have been adopted in USA fisheries [24]. If all the fish are marketed through a cooperative that unifies management, fishers, and processors, then no governmental tax agency would be needed. Rather, the fish tax would simply be an added cost to the price of fish as it is sold by the cooperative to market. In this case, all fishers must be participants in the cooperative, i.e. it must be a condition of the fishing license.

However, it is not essential that the revenue from a demand-side fish tax be returned directly to the fishery management body. The tax on overexploited stocks can be absorbed in general tax revenues, if this is the most feasible alternative. The government would need to implement the program of buybacks, however, out of the general treasury budget, and this expenditure would doubtless be covered using some or all of the yearly fish tax revenue. In this way, the demand-side system could be implemented under conventional or current government legal and financial infrastructures.

6. Problems of ITQs addressed by demand-side management

As noted in Section 1, ITQs are being adopted in fisheries worldwide. They are a major step forward beyond TACs in eliminating its common property nature and assigning ownership of the rights to harvest the resource [2,14,25]. In many, especially single-species fisheries worldwide, ITQs have been successful, notably Australian southern bluefin tuna [26,27], USA Atlantic surf clam [28] and ocean quahog [29], British Columbia herring [30], Icelandic herring, capelin and demersal fish stocks [31], and a range of fisheries in New Zealand [32,33].

Despite this success, ITQs leave unresolved a number of drawbacks. Most notably, ITQs have been less successful with multispecies fisheries [20], including Australian south east trawl [43]. In some places such as Norway [34], ITQs have not been adopted on social

or legal grounds. In many fisheries, input controls are retained together with ITQs, and the advantages of these mixed strategies can be considerable. In this section, I outline drawbacks of the ITQ system, and suggest ways that a demand-side approach, possibly in conjunction with ITQs, may mitigate against them.

1. The financial gains from unreported landings are 100% under an ITQ system, that is, the full price of each fish sold illegally is gained as additional gross revenue. Under a demand-side system, because any fish captured may normally be sold legally, illegal sales bring only the difference between the black-market price and the lower tax-paid price. Thus, a demand-side policy yields a considerably lower financial incentive to sell on the black market.

Moreover, illegal sales bring extra costs and risk and generally the tax would have to be quite high to make it worthwhile. An analogous situation is the tax on sales of cigarettes. Only in situations where the tax reaches two or three times the untaxed price, such as black market sales of American cigarettes in Canada, does there appear to be a significant incentive to evade the legal taxed-sales system.

2. In addition to contributing to overfishing and undermining confidence in the system by fully legitimate fishers, unreported catch in quota systems results in less reliable commercial catch and effort statistics. Under-reporting is often of sufficient magnitude that fishery-independent scientific trawl surveys are implemented, at some cost. Moreover under a quota, overall catch per unit effort becomes less informative as a measure of abundance because the total catch is determined by an external decision (the level of quota set) rather than by population size or density [35].

3. Administrative and enforcement costs are relatively high under ITQs. The cost of enforcement may be higher under ITQs because the incentive for non-reporting is greater. Enforcement is particularly costly when there are numerous points of landing. Also, costs of allocating quota (especially litigation) can be high [18,36]. Walters and Pearse [37,38] note that risk avoidance results in quotas being set at precautionary low levels, reducing long-term yields. The trade-off is either lower catches or higher stock asssessment costs.

4. The allocation of quota is a highly devisive process. Conflicts frequently arise among fishers between systems that allocate on the basis of previous catch history, and those which divide the quota evenly. In recognition of the severity of this problem, several authors have proposed improved methods for quota allocation [39,40], including auction of quota [41].

5. As noted, ITQs induce two forms of dumping marketable seafood back into the sea, discarding and high grading fish of lower value (size or quality) so they not be counted in the quota. Most multispecies ITQ systems have implemented ways to reduce this problem [20]. Additional quota can be purchased by each fisher when he inadvertently hauls in species for which his quota has been reached, or for which he may happen to hold no quota. In practice these market mechanisms have not often performed as hoped. In New Zealand, this has more often resulted in the dumping of those above-quota fish at sea despite regulatory effort to avoid that outcome [18,42]. Short-term markets for quota in multispecies fisheries never had much of chance to alleviate quota-induced discarding because the quota for the more heavily protected species simply gets used up [19,43]. Even near the beginning of the season when some quota remains unfilled, skippers are reluctant to trade their remaining quota knowing that it may be needed later. In the Australian south east trawl fishery, changes from year to year in which species were abundant made quota difficult to align with changing levels of catch brought to the deck [43]. With time, most ITQ fisheries report improved ability to minimize discarding [19,44,45], though the problem, in general, persists [44,45].

6. ITQs normally provide no direct means to finance a reduction in fishing effort, only to limit output. While buybacks have been recommended and attempted in conjunction with ITQs, the lack of secure governmental funding has limited their application. For example in the early stage of ITQ implementation in New Zealand, quotas were set at a fixed absolute level rather than as a percentage of a varying TAC [42]. The high cost of buying back quota when the overall TAC needed reducing, was more than government could sensibly cover.

Nevertheless, a number of ITQ fisheries, especially those for a single species, have seen substantial reductions in the total numbers of vessels operating, thus achieving the rationalization of excess capitalization without the need for a program of buyback. In one fishery where fleet size has not been much reduced, Australian south east trawl, because of multispecies problems including discarding, quotas are set at levels that are not reached for most species. As a result, quota has little resale value and license holders have no financial incentive to sell out [43]. Additional buy-out of vessels/licenses, giving those assets value and reducing costs, would be of economic benefit. A demand-side fish tax generates revenue that pays for buyback, and could be run in conjunction with ITQs where the advantages of both systems were sought.

7. Insofar as the principal obstacle to establishing any management regime of consequence in many fisheries is political opposition from either fishers or other interest groups, in some circumstances, the demand-side plan may offer a more viable proposal by avoiding some of the more politically sensitive aspects of ITQs, such as allocation, and could permit a more equitable distribution of catch among license holders by selective buyback

as noted. However, the practical and political obstacles to imposing a tax or management fee are also very substantial, and so in many fisheries ITQs might be easier to put in place.

8. A sometimes strong political bias away from quota reduction characterizes most quota systems. A representative of, usually, the executive branch of the federal or state government must set quota annually. Usually this is the responsibility of the Minister managing national or state fisheries. The short-term political costs of reducing quota (and thus gross incomes) are high, especially in rural electorates where fishing holds a dominant economic position, and historically, reductions in quota have been frequently delayed until the long-term consequences are already incurred, as in the case of the (TAC not ITQ) Newfoundland cod stock collapse [46]. New Zealand ITQ quota holders have shown a strong tendency to oppose quota reduction when scientific assessment showed a need for reduction in the face of serious fish stock declines [47]. In Europe, a climate of shared multi-nation management makes timely quota reductions more difficult still [48]. Thus the political realities of reducing quota make that a less likely response.

The demand-side approach reduces this political liability by (1) not asking elected officials to set fixed (or to lower) upper limits on economic output. When implemented in combination with ITQs, reducing the number of vessels shares a reduced catch among fewer vessels, so that those remaining in the fishery stand a better chance of remaining profitable when quotas are lowered for any reason.

9. In effort (i.e. input) regulated fisheries, including demand-side systems, catch is expected to vary roughly in proportion to fish density. If stock abundance declines, often owing to environmental variability resulting in one or several years of weak recruitment, catch-per-unit-effort, and thus catches will also decline.

In quota-regulated fisheries, when downward fluctuations in stock abundance occur, fishers will often exert the additional effort required to reach their allocated quota which in good years had presumably limited effort as the chosen method of limiting overfishing. Thus as the stock declines due to environmental, usually recruitment, mediated causes, a greater harvest proportion is removed. Thus with quota, because it is set as an absolute quantity of catch, downward fluctuations are amplified by fishing. Quotas are, in this sense, destabilizing. If overfishing is already taking place, this resulting increased level of overfishing can be catastrophic as the case of Newfoundland cod exemplified.

Even when political bias is not acting and managers are doing their best to adjust quotas, the often high uncertainty in absolute stock size, the approximate 2-year time lags in management response from lowered recruitment to reduced quota, and the high levels of exogenous annual variability in marine populations make the decision of what absolute level of harvest to set a relatively difficult one.

7. Discussion

ITQs have a history of successful implementation in fisheries worldwide. This record assures that they will continue as a management tool in higher value fisheries where enforcement and quota decision making is feasible and affordable. However, in a number of fisheries, ITQs are not employed for a wide range of reasons (e.g. Norway [34]).

The most important advantage of the demand-side system, as an alternative to or in combination with ITQs, is that it raises revenue for maintaining itself and reducing the fleet through a tax that is, itself, a potentially powerful instrument for reducing overfishing. Buybacks in the past [49,50] had been financed by federal governments. The fish tax allows the attainment of five objectives: (1) it pays for vessel buyback, (2) it distributes the rates of human predation more evenly among species in the ecosystem, (3) it pays for management and stock assessment, (4) it provides non-governmental financial support for fishermen in the time of transition, and (5) it is an important component in reducing overfishing. These goals are achieved, at least in part, by shifting the financial burden of management and effort reduction from fishermen and taxpayers to consumers of fish.

The biological and economic benefits of reducing particular gear types and or total capitalization could thus be achieved prior to or while quotas were held in place. Once fleet size were reduced, the potential risks of quota amplifying sudden decreases in abundance are diminished. The assumption of this approach is that reducing fleet size is often advantageous, with or without ITQs, since many fisheries worldwide are overcapitalized [51,52], and that a fish tax is a good way to raise revenue for vessel buy-out.

In general, the advantages of quota apply to fisheries that are relatively prosperous, where there is less danger of sudden declines in stock abundance, and where fleet size is not excessive. A demand-side approach is relatively more advantageous in fisheries where financing is sought for fleet size reductions.

Currently governments in North America, Europe, and Australia are urging ecosystem-level fishery management. New tools will be required. The scheme described here enhances this capability by (1) providing economic incentives for balancing levels of human predation among different species in the trophic web, (2) eliminating gear types that cause the greatest incidental damage to the ecosystem, and by (3) avoiding regulatory incentive for discarding or high grading.

An econometric model of the effects of a demand-side scheme would require assumptions about the market price for licenses, and the number sold each year. When combined with test choices of how much revenue would be raised from the tax, and how much allocated to management costs or to the fishers' monthly subsidy, this could be used to simulate a budget over time. A model would need to consider three relationships: (1) the elasticity of demand (how consumption of fish varies with price in the supermarket, and thus the tax), (2) how the price to fishers declines with reduced consumption, and (3) the elasticity of supply (how the supply of fish to the dock, or effort, by fishers is affected by the reduced price they receive for taxed fish).

One notable feature of this dynamic is that when elasticity of demand for taxed seafood is high, implying that consumption reduces substantially when the price rises, only modest fish tax levels would be needed to reduce catch. This will occur when other seafood or protein (primarily meat) products are readily substituted by consumers. When the contrary applies, then a considerable price increase to consumers is needed to staunch demand for the taxed (and thus overexploited) species. In this case, a higher tax provides higher tax revenue per kilo, notably for vessel buyback. Thus, there are management advantages to a demand-side scheme under either high or low elasticity scenarios.

Most aspects of the demand-side scheme have been proposed previously. Gordon [12] recommended that the best way to reduce overfishing is to reduce the number of vessels in the fleet and stated that, "A taxation system could be devised that would reduce fishing effort on particular grounds to the optimum point. The proceeds of the tax could, of course, be redistributed to the fishermen, if desired". Crutchfield [53] recommended a combination of landings taxes and effort reduction, in particular, one in which fishers were compensated with a cash payment for leaving the fishery, and advocated a tax system that influenced both the level and gear composition of effort. The landings tax considered by Scott [14] also varied among species according to the degree of overfishing. McConnell and Norton [54] suggested a scheme similar to the plan presented above employing vessel buy-out and price adjustments. Burg [55] recently proposed a system that combines a fish tax much like that proposed above, ITQs and a premium paid to fishers for each tonne of quota-reported fish taken.

Initiated in 1969, the vessel buyback program in British Columbia salmon [49] represents the closest attempted application, where it was explicit that the rationalization program would extract rent (through licenses) to help pay for management [56] and the beneficiaries were intended to be fishers themselves [57]. However, the license fees ($100–$400) were too low to capture substantial benefits, being only about 1% of landed value [56]. The consensus [14,56–59] is that in spite of a reduction by 23% in the number of vessels [56], the total amount of capital invested and the overall fishing power of the fleet have continued to rise. The British Columbia salmon fishery is comprised of three gears: gillnet, seine and troll. Fraser [56] reported real increases of 49% in capital value of the fleet from 1968 to 1977, spent on increases of 6%, 10% and 11% in vessel length for the three gear types respectively, and increases of 47%, 43% and 36% in the average horsepower of the engines. Moreover, a substantial shift occurred to purse seiner as the preferred gear type which is the most powerful and requires the largest vessel and crew.

Holland et al. [50] reviewing fishery case studies concluded that despite fishing capacity reductions of about 10–40%, buybacks have not achieved their objectives. All were partly or entirely government subsidised. The Australian examples were the most successful of those reviewed by Holland et al., and these were more self-financed. The two principal features of the failure to meet their objectives that Holland et al. identify could arguably be ascribed to (1) inadequate funding, and (2) relatively greater levels of government rather than self-management of these schemes. These are, in theory, addressed by demand-side self-financing.

Rising effective effort per boat is addressed by making the license valid for the vessel and the specific gear, engine, and fish-finding electronics specified at the time of program establishment. Initially, no further changes are allowed, since the license applies to that specific vessel and gear configuration. Subsequently, these restrictions on fishing power could be strengthened or loosened depending on how severely they reduce capture cost efficiency and on the recovery rate of the stock as the total number of licenses declines. Small improvements should be left unregulated since they improve efficiency per vessel which should be more than compensated by reduced numbers of vessels and because they cost relatively little. Likewise changes that improve safety should be encouraged. Eventually, under tight constraints on vessel and gear specifications, all vessels would presumably rise to similar, and thus nearly equivalent levels of technology and power, and thus of overall capital investment.

Moreover, by targeting buyback to the most damaging class of vessels (which are likely to be the most costly to purchase), a demand-side program could achieve substantial reductions in fishing power and, where desired, more equitable distribution of earnings. The revenue stream from a fish tax available for license buyback affords this advantage over previous buyback schemes, including those reviewed by Holland et al. [50].

Much of the scramble for greater and more costly fishing technology investment has been driven by the substantial increases in price at the dock under limited

entry, including the cases of British Columbia salmon and roe herring [56] and Australian rock lobster and prawn [60]. In the plan proposed above, the price to fishers for more highly sought after, and thus generally lower abundance stocks declines, reducing this incentive for capital investment.

Holland et al., did not examine the buy-out example of the southern zone rock lobster fishery in South Australia, whose effects have not previously been documented but which was widely considered successful. The scheme began in September 1987, authorised by an Act of Parliament. A total of 41 licences (2455 pots) out of 238 licences were bought back. For the first 15 months the scheme was self-funding, licence surrenders matched levies imposed on licensees. Funds were then borrowed from the (Commonwealth) National Fisheries Adjustment Program and the South Australian Government Financing Authority. Fishers remaining in the fishery repaid the loans after 7 years, 3 years less than planned. The resale value of a single pot rose from the buy-out price of $2500 to approximately 10 times that price by the time the loan was repaid due to a rising price for lobsters in Asia and to the buy-out. Subsequently, ITQs were introduced and have also proven successful.

To speed the purchase rate of vessels and thus reduce overfishing and costs rapidly, it would be sometimes be advisable to finance a large buyback of vessels at the outset of a demand-side management plan with revenue bonds. These would be paid back in subsequent years with fish tax revenues. A large-scale buyback prior to ITQ implementation is likely to be advantageous in some fisheries where there are too many vessels and rapid reduction in over-capitalization is desirable.

The demand-side approach presented can thus be implemented either together with ITQs, or in place of them in cases where practical, social or legal obstacles impede the implementation of an ITQ approach. Squires et al. [20] recommend a mixed strategy in multispecies fisheries. This demand-side scheme offers an approach complementary to ITQs particularly in multispecies fisheries. Hughey et al. [61] have noted the shift of New Zealand ITQ fisheries to a more financially unified corporate management structure where the fishing industry is the principal stakeholder. This cooperative/corporate model allows for relatively natural implementation of the demand-side tax in the form of a variable fee placed on different species in the seafood product sales list.

In return to fish consumers for their increased price of seafood, the greater income to the fishery should, in the medium term, through reduced fleet size and tax disincentives, provide a more reliable supply of fish and substantially reduce the public costs of fishery management, now largely borne by state and federal governments.

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