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# A Critical Review of the Individual Quota as a Device in Fisheries Management

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## 1. INTRODUCTION

Economists were sensitized to the common property problems of the fishery by H. Scott Gordon's seminal article that appeared in 1954. Ever since they have searched for effective measures of management that would lead to economically rational fisheries exploitation. From the start it was recognized that fishery problems were related to the absence of individual property rights in the fish stocks. Nonexclusiveness of access robbed fishing operators of the incentive to husband the resource, leading almost invariably to excessive levels of exploitation. The fugitive nature of most fish stocks, together with the multiple resource use of their water habitat, made it usually impractical, if not impossible, to solve the problems by dividing fish stocks into discrete units for which effective property rights would be assigned. Consequently, economists' solutions have been limited to devices that bestow at most partial property rights on fish resource users, supplemented by various regulatory mechanisms designed to promote improved resource allocation, perhaps modified by considerations of distributional equity.

Until recently the advice from economists on fisheries management tended to focus on various forms of limited entry licensing. This was designed to restrict inputs of manpower and/or capital in the fishing industry and to circumscribe their use. In addition, "buy-back" programs were advocated to remove existing excess capacity from the fishing industry. Limited entry, indeed, has been used on an increasing scale over the last two decades. The salmon fishery rationalization program in British Columbia, that was introduced in 1968, was the first scheme of note to incorporate a buy-back program. Initially it was widely acclaimed as a prototype for rational fisheries management.

In the end the British Columbia salmon rationalization program has come to be considered a failure. While there is room for debate on the full analytical detail, there is substantial agreement on the major features of the scheme's failure (cf. Pearse and Wilen 1979; Copes and Cook 1982). The buy-back operation resulted in the removal of vessels accounting for no more than five percent of the catch. But investment in technological improvements of vessels remaining in the fleet (so-called "capital stuffing") caused effective capacity to increase greatly.

Many examples can be given where limited entry licensing appears to have increased the net benefits derived from a fishery and to have helped attain biological conservation objectives. However, the degree of success achieved overall with limited entry schemes has been sufficiently modest for economists to cast about for an alternative approach to fisheries rationalization. If limitation of inputs into the fishery cannot be made foolproof, it was argued, why not go for limitation of outputs?

## 2. QUOTA ALLOCATION

One form of fisheries output limitation indeed has long been used by both national and international management authorities. They

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have frequently sought to meet conservation objectives by imposing a total allowable catch (TAC) in fisheries subject to heavy exploitation pressure. Usually this meant monitoring landings and closing the fishery when the year's TAC was reached.[1] However, the annual TAC helped little to achieve economically rational exploitation. The usual result was a "race for fish" as soon as the annual season opened, with each operator attempting to get as much as possible before the season was closed. Management by TAC has been marked by severe overinvestment in fishing capacity and idleness of manpower and equipment during an often long closed season.

The race for fish could be observed at two levels. In international fisheries it was marked by the competitive build-up of national fleets, often heavily subsidized by their respective governments. At the operational level the race was among individual vessels attempting to outdo one another in fishing power and intensity of operation during the open season. The solution proposed has been to divide the TAC into country quotas at the international level and into individual quotas for fishermen, vessels, or enterprises at the operational level.

With a secure quota, a country would no longer have to strive for its share of the international harvest by increasing its fleet capacity in competition with other countries doing the same. A country could then take its allocated catch in the most economical fashion available to it. The Convention concluded by Canada and the U.S. that established the International Pacific Salmon Fisheries Commission in 1937, provided for a 50/50 quota split of the harvest under the Commission's jurisdiction. This arrangement was a prerequisite for the salmon rationalization program introduced by Canada in 1968.

A country quota in an international fishery is of limited use if a country fails to manage the effort of its own fleet. For it is then still faced with an economically wasteful race among its own flag vessels for shares of the national quota. This, of course, is the same problem any country faces in its domestic fisheries that are subject to a TAC, but that allow unfettered competition for shares of the catch among individual operators. In the final analysis, then, rational exploitation requires management of the fishing effort put out by individual operators.

## 3. RATIONALE FOR THE INDIVIDUAL QUOTA

The individual quota may be thought of as a fixed share of the catch allocated in advance to individual operators (i.e., recognized fishermen, fishing units or fishing enterprises). Allocations may be made for a single season (e.g., year), for a longer period, or in perpetuity. While an individual quota may be set as a stated percentage of the total catch, administrative practicality dictates that it will usually involve setting a specific quantity that a fishing operator may take in a particular season. Of course, once a TAC is set for a season, a percentage of the catch translates into a fixed amount in any case.

In the fisheries rationalization debate that economists have conducted over the last few decades, the notion of the individual quota has long been present, though serious consideration of it as a major device for rationalization was initially slow in coming. A considered proposal for the introduction of individual quotas was put forward by Francis T. Christy, Jr., in 1973. Good examples of more recent and more elaborate rationales are those provided by Moloney and Pearse (1979) and by Scott and Neher (1981). In practical management terms, some early instances can be found of the application of individual quotas, e.g., in the Prairie Lakes fisheries of Canada where they have been used since the 1930s. The deliberate application of individual quotas (i.e., quotas at the operational level as distinct from country quotas) to achieve goals elaborated in recent theoretical discussions is still at an early stage of development, though there are now several fisheries—e.g., in Canada, New Zealand, Iceland, Norway and South Africa—where this device is being applied. As yet there appears to be no adequate assessment

[1] An early example of such TAC management is that introduced in 1930 in the Pacific halibut fishery by the joint Canada-U.S. International Fisheries Commission (later called the International Pacific Halibut Commission).

of the results on which firm general conclusions may be based.

The purported advantages of management by individual quota allocation lie in the elimination of important external diseconomies, both among those associated with open-access fisheries and those peculiar to fisheries subject to limited entry licensing. The guarantee of an individual quota—it is contended—means that fishing operators do not have to race one another to secure their share of the catch as quickly as possible before the TAC is filled and the fishery is closed. When they are assured of their quota—so it is held—fishermen can take their time, spreading their effort optimally across the entire season and using the most economical configurations of equipment and manpower in the process. Gone will be the need for competitive escalation of speed and fishing power, requiring large capital inputs and driving up costs unnecessarily. As a further advantage operators will find little need to fish in bad weather or under other dangerous circumstances in order to keep up their share of the catch. In addition, harvest gluts can be avoided or reduced and a higher value of sales achieved by meeting optimally the time patterns of demand over the year of both fresh fish consumers and processors.

With no need to race for the fish, operators presumably would be induced to use only the most economical capital and labor input configurations. This would avoid some of the regulatory problems encountered in limited entry licensing. There regulators are caught on the horns of a dilemma. If they allow free play to technological change, it will be used, at least in part, for capital stuffing and thus for a socially inefficient increase in fishing capacity.[2] If, on the other hand, they restrict technological change, they are likely to suppress socially efficient cost-reducing technology along with socially inefficient capacity-increasing technology. The resources used in administering the regulation process, of course, represent a further social loss.

The allocation of individual quotas in fishing has been referred to as "stinting the commons," by analogy with the allocation of quantitative pasturage rights on the medieval commons. Proponents emphasize that stinting introduces a system of property rights or quasi-property rights to the fishery. They imply that this should help solve the problems of common property resource exploitation which are linked to the absence of property rights in the fish stock.[3] Related to this, advocates of the individual quota usually also emphasize a need to make it an "individual transferable quota" (ITQ). Transferability is an obvious characteristic of ownership. It means that fishing operators may sell either their entire quota, or parts of their quota, to other operators. The sale could involve the quota for a given season only, or for a number of seasons, or it could be in perpetuity.

The evident advantage of transferability is that it further facilitates rationalization. If there is surplus capacity of capital and manpower in a fishery in relation to the TAC, there will generally not be enough fish to keep vessels operating at full capacity throughout the season. Rents could then be generated in the longer term by withdrawal of some fishing units from the fishery. There should be a reasonable expectation that the prospect of rents will lead more efficient operators to buy out the quota entitlements of less efficient operators. Thus quota rights would be consolidated in the hands of the most efficient operators who would be able to fish full time and reduce unit costs of operation. In the process both buyers and sellers of quota rights could share in the net benefits of the rents that would be generated.

Short-term rationalization would be promoted by the flexibility of short-term transfers of quotas, or parts thereof. If in a particular season an operator was unable to use his entire quota (e.g., because of illness or vessel breakdown), he could sell all or part of his quota rights for that season to other operators who

[2] Excessive capacity build-up under limited entry licensing is commonly marked by technological advances involving higher capital inputs. Theoretically, of course, capacity could also be increased by "labor stuffing," though this does not appear to occur often.

[3] A thorough exploration of the property rights aspects may be found in Scott (1985). Earlier on Bell and Fullenbaum (1973) interestingly proposed the issuing of "stock certificates" to establish fishermen's property rights.

had exhausted their own quotas before the end of the season, or anticipated doing so.

The introduction of individual quotas may be difficult and controversial. There are many different criteria that could be used in determining the initial allocation amongst individual operators. The quota shares could be auctioned, sold at a fixed price, or given away free. Except for the case of auction, a determination would have to be made as to how large a quota each operator would receive. Operators could be given equal shares, or shares based on historical catch performance, or on fishing vessel and gear capacity, or numbers of crew, or various combinations of these and/or other criteria related to considerations of equity, rationality or practicability. A discussion of the options is beyond the purpose of this paper. Suffice it to say that the introduction of any new scheme of fisheries management is likely to be controversial, but that this has not necessarily robbed new schemes of their inherent merit or prevented them from being implemented.

## 4. WHAT CAN GO WRONG

One of the arguments that is often used in promoting individual quota management is that limited entry licensing is inherently deficient as a management device because of the skill fishermen show in circumventing the rules or defying the intent of entry limitation. The capital stuffing process, whereby additional capacity enters the industry despite, or because of limited entry, is mentioned in evidence. Certainly, the externalities inherent in the common use of a pool resource drive fishermen to act in accordance with their individual interests, where often this is contrary to their collective interest. That they show great ingenuity in doing so is beyond doubt. As a result one may well proclaim that fisheries are exceptionally vulnerable to Murphy's Law: "If anything can go wrong with a new fisheries management scheme . . . it will."

Ironically, when it comes to promoting individual quota management, its proponents often fail to apply the sharp insights gained in exposing the deficiencies of limited entry licensing. There is no reason to assume that fishermen, where confronted with the rules of individual quota management, will lose either their ingenuity at circumvention or their incentive to promote individual interest at the expense of collective interest. Recognizing such to be the case, this paper will explore a variety of problems that should be anticipated with the introduction of individual quota management. Without claiming to be exhaustive, problems will be identified in fourteen areas under the following headings: (1) Quota Busting, (2) Data Fouling, (3) Residual Catch Management, (4) Unstable Stocks, (5) Short-Lived Species, (6) Flash Fisheries, (7) Real Time Management (8) High-Grading, (9) Multi-Species Fisheries, (10) Seasonal Variations, (11) Spatial Distribution of Effort, (12) TAC Setting, (13) Transitional Gains Trap, and (14) Industry Acceptance.

### *Quota Busting*

For many fisheries, enforcement is likely to be one of the most difficult problems with an individual quota system. Obviously, there is a material incentive for fishermen to engage in "quota busting," i.e., catching a larger amount of fish than the individual quota allows. The extent of compliance with quota limits will be influenced by such factors as individual conscience, community culture and social sanctions, effectiveness of official monitoring and enforcement efforts, severity of penalties on conviction for infractions, and extent of gain from cheating on quotas. Analysis of the trade-off between potential gains and losses from legal infractions may be found in the literature on the economics of crime (see e.g., Polensky and Shavell 1979).

In different fishing communities distinctly different attitudes towards enforcement of fisheries conservation and management regulations prevail. Thus in the South Australia rock lobster fishery there is strong pressure from fishermen for rigorous enforcement of limits on the number of traps allowed to be fished, including severe penalties for infractions (Copes 1978). In contrast, in the lobster fisheries of the Canadian Maritime Provinces infringement of the regulations on size limits and permitted number of traps is known to be endemic. Attempts by fisheries officers to enforce the regulations have provoked violent

reactions (e.g., Anon. 1983a). In the face of community pressure the courts there have dealt leniently with violators. Obviously, enforcement of fisheries regulations is impeded if there is a noncooperative attitude towards such enforcement by the community at large. Where, on the other hand, the community favors regulations, enforcement is enhanced and may be reinforced by social sanctions applied against violators, such as ostracism or reporting to the authorities of observed infractions.

Many of the factors underlying community attitudes towards fisheries regulations are most competently analyzed by anthropologists and sociologists. But one important factor should be mentioned here. The attitude of fishermen is evidently influenced by the credibility of enforcement, including particularly the likelihood of detection of infractions. The early experiments with individual boat quotas in the Bay of Fundy herring fishery were abandoned under pressure of skippers who knew that colleagues were cheating on their quotas without being caught (Anon. 1983b). The Director-General of Fisheries for the region reported (Crouter 1983) that "attempts to enforce vessel quotas proved to be largely unsuccessful." He added that the experience was "that each and every fisherman will attempt to 'cheat' on his quota and processors promote that attempt through collusion in falsifying records."

The chance of detection of quota busting is enhanced where, in relation to the size of the catch, the number of vessels and the number of points of landing is small. Thus a small number of inspectors can easily monitor the catches from the fleet of a few hundred large groundfish trawlers operating on Canada's Atlantic coast. They must land their fish at one or another of a limited number of processing plants. It is difficult to hide a trawler-load of fish and penalties can easily be made prohibitive for large fishing companies with substantial investments at risk. The cost of a few inspectors can be met easily from the public revenues generated by a high volume fishing operation.

In contrast, consider the British Columbia salmon fishery with over 5,000, mostly small boats. They can potentially land their catches at hundreds of places along an indented coastline that measures thousands of miles. While most salmon fishermen now sell to a few large companies, there are substantial numbers of smaller fish handlers eager to take their catch and they can sell also directly to the public at numerous wharves. Monitoring and enforcing individual quota limits under those circumstances would appear well-nigh impossible. While the individual boat quota has been proposed for the British Columbia salmon fishery, it is no wonder that it has not been accepted and implemented. It is easy to conclude that the individual quota will be very difficult to enforce in a fishery characterized by many small vessels, numerous actual and potential marketing channels, and geographically widely dispersed activity.

### *Data Fouling*

Fisheries managers require reasonably accurate reports on catch and effort from vessel operators as a basis for their estimation of stock strengths and optimal exploitation rates. But if the individual quota system results in fishermen taking catches in excess of their quotas, they are almost certain to underreport their catches in order to evade detection. They may also falsify their reports on effort in order to make these appear compatible with their incorrect catch reports. It has already been observed by fisheries scientists that the introduction of quotas in some places has led to severe deterioration in the quality of data that fisheries managers have to work with (Gulland 1985). In the common fisheries zone of the EEC country quotas are allocated. It is claimed that an internal EEC Commission report has found that Dutch fishermen have systematically cheated on Common Market catch limits with the connivance of some Dutch officials (Lichfield 1984). As a result of this and other suspected transgressions, EEC fisheries scientists have started to add in an often large adjustment factor for "unreported catches" in their calculations (Brander and Gulland 1984). Needless to say, such reliance on guesswork will result in unreliable stock estimates and fishing effort controls.

If an individual quota system results in eva-

sive reporting on catches and effort by fishermen, it is equally likely to lead to distorted reporting on cost and earnings data in order to complete the cover-up. Thus socioeconomic studies on the condition of the fishing industry may also lose in reliability with the data fouling that accompanies the introduction of individual quotas. This will impair efforts to monitor the effects of the individual quota system and to determine relevant social policy.

### *Residual Catch Management*

The greatly varying nature of different fish stocks and of fishing operations on those stocks, calls for distinctly different techniques and regulations in fisheries management. In most fisheries, managers each season, implicitly or explicitly, must determine a desired division of the stock into catch and escapement. According to the nature of the fish stock and the fishery, managers may find it distinctly more effective in one case to set a TAC for the catch, so that escapement becomes the residual, and in another case to set escapement as the target, thus making catch the residual.

As an example, salmon management in the Northeast Pacific clearly requires the latter technique, as getting the "right" number of fish of each stock to escape up-river in the annual spawning run is the crucial factor in achieving optimal reproduction. Consequently, when it has been determined that the right number of fish have escaped, the fleet must be encouraged to quickly mop up the remainder, both to provide for a better catch and to prevent a deleterious overloading of the spawning grounds. At that point it may be essential to utilize the full extent of fishing capacity available in order to mop up the residual of the spawning run in the available time, which may be a matter of a few days or hours. To parcel out individual boat quotas at such a point in time is patently absurd. With an unknown size of residual catch the quotas could not be calculated in the first place. And the need of the moment obviously is to use all available fishing effort and not constrain any operator. Individual quota management is inherently unsuited to fisheries where the catch is residual to a managed escapement target.

### *Unstable Stocks*

Relating to the preceding point, it may be more generally observed that individual quota management does not work well when the TAC cannot be determined with certainty at the beginning of a fishing season. With relatively slow-growing stocks of relatively long-lived species an appropriately set annual TAC is likely to amount to a rather modest part of total biomass. There is then some leeway in setting the size of the TAC without any serious danger to conservation. Given relative stock stability there is ample time to adjust estimates of permissible TACs from one season to the next. It is then possible to set a firm TAC at the beginning of an annual fishing season and stick to it. Most groundfish stocks in the North Atlantic are probably susceptible to firm TAC determinations in this fashion.

Species that are prone to producing highly variable year-class strengths are characterized by serious stock instability, particularly when they are short-lived. Several pelagic species (e.g., herring) fall into this category. Determining annual TACs for stocks of these species is a hazardous undertaking. It is frequently essential to set only a tentative TAC at the beginning of the fishing season, to monitor stocks and catches constantly during the season, and to adjust fishing plans and allowable catches at short notice, accordingly. But adjusting the TAC, and thus the individual quotas based on it, in mid-season is incompatible with the rationale for the individual boat quota. Fishermen must be confident that they have the entire season in which to decide where and when to fish without fear of losing any part of their quota. Uncertainty as to whether the initially allocated quota will still be allowed later in the season, will cause fishermen to "race for the fish" at the beginning of the season with as much equipment as they can muster. The presumed advantages of the individual quota are lost. Cancellation of an initially allocated quota just once is enough to induce many fishermen never to trust fisheries managers again. It may be concluded that relatively unstable stocks, even where they are managed by catch targeting, will require frequent fishing plan adjustments which make them ill suited to an individual quota system.

### *Short-Lived Species*

In some fisheries there is no observable relationship between size of catch and subsequent recruitment, i.e., the accession to the stock of catchable fish. This appears to be the case particularly with species of high fecundity where even a small number of surviving spawners is sufficient to fully restock the available ecological niche each season. The adequacy of a spawning stock for this purpose in some cases may be aided by gear selectivity that leaves a sufficiently large stock beyond the reach of the fishery. Or it may be helped by a spawning stock in a sanctuary not touched by the fishery.

Many stocks of crustaceans are believed to have recruitment that for practical purposes is independent of parent stock size. Among these are tropical prawn and shrimp stocks that are short-lived and that are each year available to the fishery as mature individuals for a short period of a few months or weeks only. Obviously, during this period it is important to fish the stock hard in order to mop it up before it succumbs to natural mortality. Under such circumstances it would be irrational to impose individual quotas. In the first place it would be impossible to determine the TAC to be divided, when all of an unknown biomass should be taken. It would also be counter-productive to force any vessel to quit fishing because its quota is taken, when all of the available fishing capacity should be utilized to secure quickly a catch that will otherwise be lost to natural mortality.

### *Flash Fisheries*

Some specialized fish products can be obtained only if the fish yielding the product is caught in a particular condition that occurs over a very short period only. The British Columbia herring fishery provides an example. The priority product of that fishery is roe for the lucrative Japanese market. To meet the exacting standards of that market the roe must be taken as the fish are moving inshore to spawn. In each spawning location there is a window of opportunity that may be as short as a few hours only. Fisheries officers sampling the fish at each spawning site determine the right moment to open and close the fishery at each site and signal the waiting fleet accordingly. Under these circumstances a "race for the fish" is a necessity. There is no time to fuss with quotas. The fishery cannot wait for the unlucky or unskilled fisherman who is not able to take his full share of the catch before the fishery is closed again.

### *Real Time Management*

Improved knowledge of fish stock dynamics, together with up-to-date monitoring techniques, sophisticated data processing and advanced fleet communication networks, are allowing the introduction of "real time" management in increasing numbers of fisheries. Real time management may be effected by continuous stock monitoring in conjunction with quick-response time and area closures or gear restrictions. This would be in pursuit of objectives such as the protection of critical spawning activity, the avoidance of immature stock components, and targeting on high yield stock components. Real time management responses may be particularly important in fisheries where optimal exploitation is sensitive to the precise timing and pattern of stock migrations and to the variable mixing of targeted and protected stock components.

In the conditions referred to, an individual quota regime would not likely be suitable. It could not avoid a race for fish, for fishermen would not want to be caught with an unfilled quota at the time of a sudden closure. In those cases where closures did prevent some fishermen from filling their quotas, there would be protests and pressure for a reopening in the name of equity. Also, when managers identify isolated stock components that are suitable fishing targets, optimal harvesting strategy may call for the rapid application of all available fishing power to such stock components before they are lost through migration or natural mortality. The constraints of individual quotas at such a time would only lead to waste of available fish.

### *High-Grading*

A fishing operator whose catch is confined to a given individual quota will wish to obtain

the greatest net value from that quota. Usually this means that he will want to fill the quota with the best quality of fish only. If fish of a particular size or condition (e.g., with or without spawn) fetch a significantly better price, he may well be induced to "high-grade" his catch by discarding fish of lesser quality.[4] As mortality of discarded fish tends to be high, this practice may be expected to lead to a waste of fish that diminishes the aggregate net revenue obtainable from the fishery. As discards normally are not reported it will also lead to data fouling, depriving fisheries resource managers of accurate data on fishing mortality.

To some extent high-grading is an alternative strategy to quota busting for fishermen. Once a fisherman is retaining fish in excess of quota, he might as well retain and sell both his higher quality and lower quality catch that is in excess of quota and therefore stop high-grading. It is possible, however, that a fishing operator will wish to engage in both practices. When a catch excess can be eliminated by discarding lower quality fish, the risk of retaining it may not be worthwhile. When an excess catch of high quality fish is taken and retained, lower quality fish may be dumped to make more hold room for the better fish.

An "enterprise quota" has been introduced in the Canadian Atlantic groundfish trawler fishery, with individual quotas for fish processing companies that operate the trawlers. Landings are easily monitored at the limited number of plants where the fish is processed. Relatively stable stocks allow firm TACs to be set at the beginning of each season. The fishery, consequently, has been considered well suited to the individual quota system. Recently, however, fisheries managers have discovered that there is a significant discard problem, though they are unable to determine how serious it is.[5] The initial optimism regarding the suitability of the individual quota in this fishery may now be called in question.

### *Multi-Species Fisheries*

Multi-species fisheries are notoriously difficult to manage. An effort level that is optimal for one species in the mix is likely to be too high or too low for other species. A directed management of effort on one species inevitably involves by-catches of other species. A general discussion of multi-species problems is beyond the scope of this paper, but it is appropriate to comment here on some extra problems that individual quotas may create for management of multi-species fisheries.

Fisheries managers may attempt to set separate sets of individual quotas for different species in a mixed-stock fishery. The chances that a fishing operator's catch would conform precisely to the proportions of the various species quotas allotted to him are almost nil. Inevitably he will fill some quotas before others and will find himself with excess catches of some species when he continues to fish in order to fill all his species quotas. He may either retain the excess catches, which would be illegal quota busting, or discard them, either of which would interfere with rational management and lead to socially undesirable results. Some improvement might be effected where quotas are allowed to be exchanged or traded among operators, but even then it is unlikely that a precise match could be obtained, as chances that the aggregate catch mix would precisely reflect the TACs for the various component species would be remote. Managers will likely be induced to be tolerant to an extent with regard to excess by-catches of species that are not primary targets. But the more tolerant they are in order to prevent discard waste or quota busting, the more fishing operators will contrive to "accidentally" take larger excess by-catches, particularly of the more valuable species in the mix.[6] In a fishery managed by seasonal closure a stop can be put to this when the aggregate catch for all species is about right. But to retain management cred-

[4] The term "high-grading" here is appropriately descriptive of the fishery phenomenon to which it refers. It has a somewhat different meaning in the mining industry.

[5] Information obtained from (non-quotable) sources in the Canadian Department of Fisheries and Oceans.

[6] The problem could possibly be attenuated by allowing by-catches, while taxing them at a level where it was just worth bringing in a by-catch, but not worth targeting on it. However, such precision would be almost impossible to achieve, particularly as the tax level that would induce the desired behavior would vary among fishermen.

ibility in an individual quota fishery, the season must be left open for all operators who have not filled all of their quotas.

It is possible, alternatively, to manage a mixed-stock fishery through a single, all-species, individual quota for each operator. But this is likely to result in an extensive effort at high-grading, with operators racing for the higher-value species, while discarding lower-value species along the way. In a fishery managed by seasonal closure, racing for the fish would also take place, but there would be less incentive to high-grade as there would be no individual quota limit to induce discarding.

### *Seasonal Variations*

As discussed above, a major advantage claimed for the individual quota is that it obviates the need for fishermen to "race" for fish at the beginning of the season. But as Christy (1973) has acknowledged, this advantage might not materialize, or not fully so, if a stock is naturally subject to significant intra-seasonally declining yields. It is generally more profitable to the individual operator to fish when stocks are concentrated and the catch per unit of effort is high, than when they are dispersed or thinned out later in the season. All participants in the fishery then may attempt to fill their quotas from denser stocks at the beginning of the season, engaging in capital stuffing to prepare themselves better for the early-season race to the fishing grounds.

Of course, some operators may still keep part of their quota for the late season in order to benefit from price advantages at a time when landings are down. Nevertheless, the tendency for operators competitively to concentrate effort in the season with highest yields is bound to be excessive (i.e., socially nonoptimal) and thus to find expression in external diseconomies. While the individual quota may attenuate the tendency to race for fish, it is unlikely to eliminate the practice entirely.

### *Spatial Distribution of Effort*

Many fisheries are characterized by different grounds, with different revenue yields per unit of effort when initially exploited. This may result from different stock densities on the various grounds, from different qualities of sub-stocks, or from their more or less advantageous location relative to ports and markets. In an open-access fishery the tendency is for the most profitable grounds to be exploited first, resulting in declining revenue yields per unit of effort on these grounds. Additional grounds are brought under exploitation when their revenue yields per unit of effort match the declining yields of the grounds first exploited (Gordon 1954). The intramarginal grounds are thus inevitably overexploited resulting in dissipation of the rents they could yield.

This pattern of spatial maldistribution of effort is not broken by an individual quota regime. For the boats with unfilled individual quotas still have open access to any grounds within the fishery. They will still tend to overexploit the higher-yield grounds, fully dissipating any rents available there in excess of those on the grounds last to be brought under exploitation. There will also be a tendency towards capital stuffing as operators prepare to race each other to the best grounds. This racing, of course, will also contribute to a seasonally nonoptimal concentration of effort. Even so, with an appropriately restricted TAC there may be a margin of rent left on all exploited grounds. But the aggregate rent will be below that attainable because of the socially nonoptimal spatial and time distribution of effort. Indeed, if an individual quota regime is effective in reducing aggregate effort, it will tend to sharpen the concentration of effort on the higher yield grounds. Exhaustion of quotas in fishing those grounds would cause other grounds to go unexploited even when they are capable of yielding at least a low level of rent. In this case again, the individual quota might reduce the loss of rent that occurs in open access fisheries, but not eliminate it.

### *TAC Setting*

An individual quota system hampers the targeting of a precise annual total catch (Clark 1985). No fisherman is allowed to take more than his quota. However, for various reasons some fishermen may not be able or willing to

take all of the quota allocated to them. Of course, if their quotas are transferable they may sell or otherwise dispose of them. However, they will not always have the time and opportunity to transfer unused portions of their quotas to other fishermen. If in an individual quota fishery the authorities succeed in suppressing quota busting, they will likely experience an opposite problem. With no fishermen exceeding his quota, while some fail to fill theirs, the total catch will fall below the TAC. If the TAC is set to mark the optimal catch, any shortfall will result in a nonoptimal catch. In anticipation of a shortfall, the authorities could set a TAC above the optimum—but obviously with an uncertain outcome, as the size of the shortfall cannot be determined in advance.

### *Transitional Gains Trap*

As discussed above, the individual quota cannot achieve its full purpose of rationalization unless it is a transferable one (ITQ). However, transferability may lead to another problem. A common social and political purpose of fisheries rationalization for government is to solve a chronic problem of income deficiency that is exhibited by the fishing industry in many localities. After all, economists going back to Gordon (1954) have remarked on the propensity of common property resource exploitation to lead to deficient income levels.

Tullock (1975) demonstrated that where a government applies a measure of long-term assistance to an industrial sector in which it wishes to improve income levels, the gains to the class of people thus favored tend to be transitional. At least this is so where the right to the benefits is transferable. In that case the initial generation of beneficiaries is able to capitalize the stream of future benefits and extract them from those succeeding them, who must purchase these rights at their full value. As a result succeeding generations enjoy no net benefits, as their gross benefits will be offset by the purchase price they were required to pay. If initial circumstances have not changed, the succeeding generations will fall to the lower levels of net income that government action was designed to overcome in the first place.

This scenario may be expected to be acted out in the fishing industry if rationalization produces net benefits, the rights to which are transferable (i.e., saleable). Indeed there is a relevant example in the British Columbia salmon rationalization program, where limited entry licenses were made transferable (Copes 1978; Copes and Cook 1982). The initial reduction in capacity through buy-back (before capital stuffing took off), together with a fortuitous rise in fish prices, produced some rents and expectations of further rents. Their value was capitalized in the price charged for a license on transfer. The consequent precarious financial position of many new fishermen who bought licenses, and the seizure of their boats for nonpayment of loans, is well known.

In the case of some fisheries rationalization schemes (e.g., limited entry licensing), transferability of rights is not an especially crucial ingredient. But as explained above, it is rather important in the case of individual quota management. If, however, it is also important to bring about a long-run improvement in income levels for succeeding generations in a particular fishery, the ITQ approach is likely to prove unsuitable.

### *Industry Acceptance*

To bring about successful reform in fisheries management, it is usually important to secure the approval and cooperation of the fishing industry. Indeed many governments will not attempt any major changes in their system of fisheries management unless such cooperation is assured in advance. Inevitably in any new scheme, participants will be affected. Some participants may expect to benefit more than others, and some may indeed consider it likely that they will lose. It is therefore difficult enough to develop a consensus for change.

The ITQ has some special psychological drawbacks that are likely to diminish its acceptability. The common property condition tends to make fishermen a particularly individualistic and competitive breed. They tend to be relatively risk-prone. Believing in themselves, they are often convinced of their inate ability to outfish their rivals and earn the status of "highliner." Most seem affected by the

"prospector's syndrome," believing that tomorrow's luck will bring the big catch. Having a fixed quota diminishes the opportunity for fishermen to show their mettle and to better themselves by superior performance or to benefit from a lucky big catch they feel they deserve. A large catch becomes a matter of the financial resources to purchase a large quota, rather than a matter of fishing skill or serendipity. There is likely to be a latent fear also that quotas will become concentrated in the hands of a small number of operators with substantial financial resources and that fishing companies, either directly or by proxy, will end up with substantial control over fishing rights. At this stage there is not much evidence that the ITQ will be widely favored by fishermen.

## 5. CONCLUSION

The use of the individual quota (and particularly the ITQ) as a major regulatory device has received much attention and support in recent years from academic fisheries economists,[7] and increasingly also from officials in management agencies. The individual quota, indeed, seems to have replaced limited entry licensing as the new "conventional wisdom." Canada has often taken the lead in fisheries management experimentation and is already applying the individual quota in a number of fisheries—though generally not (or not yet) on a fully transferable basis. The Economic Council of Canada has pronounced itself in favor of the ITQ. With some qualifications, two major fisheries commissions that brought out reports on the Canadian Atlantic and Pacific fisheries, respectively, have also endorsed it (Kirby 1982; Pearse 1982). In New Zealand the individual quota is being used in a few fisheries and being proposed for more. The device is also being advocated strongly for some fisheries in Australia (e.g., Campbell 1984) and the United States (e.g., Stokes 1983). The number of experiments with the individual quota, so far, has been limited and mostly of short duration, so that a general assessment of its effectiveness is not yet available.

From a theoretical perspective, supported by the necessary simplifying assumptions, the ITQ may be presented as an ideal management device, leading to the generation of maximum net economic returns. What should be recognized is that other management schemes theoretically may produce equally ideal results, if the practical problems that are likely to arise with them are assumed away. Not so many years ago limited entry licensing was presented in its simple theoretical purity, with the promise that it would solve the problems of the fishery and generate maximum returns in the form of rent. The real-life experience with limited entry regimes has been sobering. But many of the problems encountered have been so straightforward, that it is difficult to conclude that with a modest application of foresight they could not have been anticipated and contained, circumvented or ameliorated (Copes and Cook 1982).

It does take considerable time for new management schemes to be planned, accepted and put into place. Therefore it is now still possible to make a careful assessment of the practical feasibility of the individual quota before a wider application is attempted. As this paper has tried to show, caution is warranted as much can go wrong with the individual quota. This is not to say that it is a necessarily inferior device for fisheries management and that its application ought not to be considered. Scrutiny of the record of fisheries management reveals no alternative scheme that is free of significant problems. It should be clear, however, that the individual quota is also prone to quite serious defects and that there should be no rush to embrace it as the new panacea—for which there seems to be a present tendency.

The advocates of the individual quota probably have made too much of the property rights aspects of the scheme. The rights to the fish stock bestowed by the individual quota—even in the form of the ITQ—are still far from fully specified property rights. For that matter, the now maligned limited entry licensing schemes also conferred partial property rights, which didn't save them from serious problems. What really counts in rationalizing

[7] For a notable exception see McConnell and Norton (1980, 193–94).

the fisheries is not what property rights have been installed, but what externalities remain or are newly created by the particular form of partial property rights introduced.

There is a near-infinite variety of biological, economic, social, and political circumstances affecting different fisheries around the world. Each set of circumstances will create its own unique set of actual and potential problems, requiring a particularized management approach for its solution. At the outset it must be realized that what is to be considered a problem depends in part on the objectives of a society's fisheries policy. Almost always this will include a goal to improve net economic returns from the fishery, however, this is qualified by considerations of distributional equity, lifestyle preferences, employment needs and community viability. Therefore the capacity of a management device to generate rents remains a general requisite and a touchstone of success.

It is difficult to be categorical about the merits of the individual quota in relation to those of other fisheries management devices, because so much depends on the vastly different circumstances that pertain to different fisheries. A review of these could fill several volumes. In this paper, a few generalizations will be offered regarding the practical applicability of the individual quota. Given the considerable advantages offered by it under ideal circumstances, it is perhaps best to consider the individual quota a generally attractive management device, except where circumstances leave it vulnerable to serious problems. Drawing on the preceding analysis of this paper, an attempt will be made in the following paragraphs to identify the circumstances under which use of the individual quota should be avoided or approached with particular caution.

There are some fisheries in which individual quota management could not be adapted to biological circumstances or would be in serious conflict with biological management imperatives. Thus the individual quota would be wasteful in a fishery on short-lived species that should be fished up quickly with all available capacity. It would also be irrational in an escapement targeted fishery, where a residual surplus needs to be mopped up with deliberate speed. However, in such a fishery it might be feasible to assign individual quotas for the earlier part of the season, while allowing free fishing on the available surplus at the end of the season. In flash fisheries, also, it will usually be impractical to operate with individual quotas. In general, fisheries with quickly changing, unstable or unpredictable stock levels are ill-suited to an individual quota regime and are better managed by time and area closure in conjunction with limited entry. Fisheries on widely distributed, long-lived species, with stable and slowly changing stock levels, on the other hand, may be better suited to individual quota management. Even where stock levels are not stable, it may prove possible to manage a fishery through individual quotas, if the season is long enough to allow the quotas to be parcelled out piecemeal as the season progresses and knowledge of stock levels is refined.

Because of the strong incentive to engage in quota-busting, enforcement can be a serious problem in individual quota management. The problem is likely to be the more serious, the larger is the number of fishing units involved, the more extensive is the geographical area over which they are dispersed, and the greater is the number of possible marketing channels for the catch. The problem may not be a serious one in an industrial fishery with few landing ports and processing facilities. The problem may be insuperable in a widely distributed small-boat fishery for a luxury species that may be sold over-the-side to a wide range of potential customers. In a small-boat fishery confined to a local community the feasibility of individual quota management may depend on the community's culture and attitude towards self-policing.

In some fisheries the discard problem may be sufficiently serious to rule out individual quota management as being too wasteful. However, in certain other cases it may be feasible to reduce discarding to a tolerable level by fine tuning regulations. Separate quotas might be given for different species or for different fish sizes that have different values per unit weight. If, at the same time, the trading of quotas among fishermen were kept easy and were allowed to take place after the landing of surplus catches, much of the incentive

to discard might be removed. It might also be possible in some situations to devise value quotas, which could be filled by catches of any designated species or fish size according to landed value.

Many fisheries in the developed world, and most in the Third World, produce average incomes that are considered undesirably or unacceptably low from a public policy perspective. In these cases a major objective of improved management is likely to be the permanent raising of average incomes in the fishery. But a higher income level is likely to be undermined in the long run under a management regime that provides for transferable fishing rights, because of the transitional gains trap. Many of the benefits of individual quotas depend on their transferability, which makes their suitability in the case of "social" fisheries doubtful.

The various problems that could arise with individual quotas, and their often serious nature, suggest that great caution should be exercised when considering the introduction of individual quota management in any fishery. But the same warning should be heeded when contemplating any alternative management scheme. One might simply say that every fisheries resource manager should be required to reflect carefully on Murphy's Law before attempting any new move. Experience so far suggests that we should be nondogmatic in our choice of management technique and that we should select from the array of available fisheries management devices, the combination that is most beneficial and least deficient in any particular set of circumstances. Above all, we must reconcile ourselves to the fact that the best *possible* solutions will still be flawed.

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