Abstract.– On 1 October 1986, New Zealand introduced Individual Transferrable Quota (ITQ) management for most of its fisheries. ITQ management was implemented to address overfishing, overcapitalization, and excess government regulation. Quotas were based on catch histories, with a quota "buyback" (costing $42.4 million NZ) and prorated cuts to achieve total allowable catch (TAC) levels indicated by preliminary stock assessments. Fixed amounts of quota (defined by weight) were issued in perpetuity. Annual stock assessments are conducted. Government stated that it would buy or sell quota at market-determined prices in order to adjust TACs. On 1 April 1990, ITQs were redefined as proportions of annual TACs (known as "proportional ITQs"). Government extracts resource rent.

To date, there is little evidence of improvement in the condition of the fisheries resources. It is difficult to determine the economic effects of ITQ management; however, economic conditions have worsened due to factors which are unrelated to ITQ management. Revenues to government from the ITQ system have exceeded total costs, but there would have been a deficit if government had purchased quota to reduce TACs to the levels indicated by stock assessments. Government regulation has not been reduced.

Although there is general support for ITQ management in New Zealand, many problems have been encountered: quota overruns resulting from bycatch; inadequate stock assessment capability; disagreement over the level of resource rentals; and failure of government to enter the marketplace to reduce TACs when necessary.

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ITQs in New Zealand: The era of fixed quota in perpetuity

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The idea of managing fisheries by Individual Transferable Quotas (ITQs) is not new. Christy (1973) suggested the method, and Maloney and Pearce (1979) provided the economic rationale for it. Until recently, there were only a few applications of ITQ management (e.g., southern bluefin tuna, Geen and Nayar 1988; Lake Erie freshwater fisheries, Muse and Schelle 1989). One application that has received considerable attention is the ITQ management of fisheries in New Zealand. Two reasons for this attention are that (1) New Zealand is applying ITQ management on a more comprehensive national scale than ever before, and (2) New Zealand officials have done a good job of describing their ITQ system to the rest of the world (e.g., Clark et al. 1988, Crothers 1988). New Zealand's early experience with ITQ management is of interest to the United States because ITQ management is being planned or discussed for several fisheries (e.g., Pacific sablefish and halibut, South Atlantic wreckfish, and East Bering Sea groundfish). It has recently been implemented for Mid-Atlantic surf clams and ocean quahogs. This paper reviews the potential benefits and problems of New Zealand's ITQ management system based on firsthand observations of the authors.[1] The main body of the paper was completed in mid-1990. A postscript has been added to reflect more recent events through 1991.

Before describing the fisheries management situation in New Zealand, the authors want to caution that by pointing out problems, they are not condemning the ITQ system. Despite problems, there seems to be a general acceptance that ITQs are the way New Zealand fisheries will be managed. There is no widespread sentiment, either within government or the industry, to repeal ITQs. A regional poll conducted shortly after implementation of the ITQ system (Dewees 1989) found that the majority of the fishing industry favored it. It would be interesting to repeat the poll nationwide now. The authors are of the opinion that the industry would not want to return to the fisheries management situation (or lack thereof) that preceded ITQs.

New Zealand fisheries setting

Fisheries have always been important to New Zealand. Legend has it that a Maori (the native people of New Zealand) pulled up the North Island of New Zealand from the sea on a hook-and-line while fishing. Fishing was so important that the

[1] The authors of this paper were fortunate to have the opportunity to observe ITQ management in New Zealand firsthand. The first author made six trips to New Zealand during the first three and a half years of ITQ management, including approximately seven months employed by the New Zealand Fisheries Research Centre. The second author was employed by the New Zealand Fisheries Research Centre from August 1986 until May 1989. Both authors maintain contact with the fisheries management situation in New Zealand through their previous affiliations.

Treaty of Waitangi between the Maoris and the British, signed in 1840, deeds the Maoris' rights to their traditional fisheries.[2]

Although New Zealand is a small nation in terms of population and land area, its Exclusive Economic Zone (EEZ) of 1.3 million nm^2 (more than 15 times the land mass) is the fourth largest in the world. Most of the EEZ is deep; 72% of the zone has waters deeper than 1000 m, so it is difficult to judge the total potential yield.

Historically, New Zealand fisheries were restricted to coastal waters (<200 m in depth) and yielded less than 50,000 tons annually (Fig. 1). Deepwater fisheries (to 1500 m) developed during the 1970s, and the yield increased rapidly to a peak of about 500,000 tons in 1977. Most of the increase was due to foreign fishing. In 1978, New Zealand extended its jurisdiction to 200 miles. The yield decreased sharply for a few years, but it has since returned to about 500,000 tons. Since extended jurisdiction, domestic fishing has replaced almost all of the foreign fishing. However, it should be noted that much of the catch recorded as domestic is actually taken by foreign vessels and foreign crews under contract to New Zealand firms. In 1987, the first sale value of the catch was about $350 million NZ.[3] The export value of New Zealand fisheries products increased from $50 million NZ in 1977 to $676 million NZ in 1987. The 1987 figure represented about 6% of New Zealand's total exports (Bevin et al. 1989).

Fisheries management began with the Fisheries Act of 1908 which established authority for input controls, such as limited entry licensing, closed areas and seasons, controls on minimum fish sizes, and requirements for vessels to land at specific ports. The actual basis for the number of licenses allowed in the fisheries is unclear. Restrictive licensing was repealed in 1963.

New Zealand established authority for output controls (i.e., total allowable catches, or TACs) in 1978 when it extended jurisdiction. At the same time, a moratorium was placed on new fishing permits for rock lobsters and scallops. In 1980 the moratorium was extended to finfish permits. In 1983, a Deepwater Enterprise Allocation system was established. Deepwater Enterprise Allocations were a forerunner of ITQs. Quota for each of the species fished in deep water (below about 200 m) was allocated to nine companies which had already invested in deepwater harvesting and shoreside processing capability. The motivation for the Deepwater Enterprise Allocations was not over-

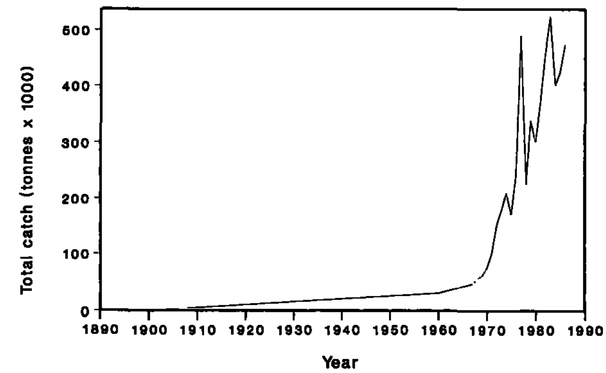

Figure 1
Annual yields from New Zealand EEZ, 1890–1990.

fishing or overcapitalization. It was intended to prevent these ills from occurring (Clark et. al. 1988) Presumably, it also encouraged investment in the deepwater fisheries and hastened the replacement of foreign fishing activity by domestic fishing. The quotas were initially awarded for a period of ten years, but were made permanent in 1985. Although the government had no authority to make quotas transferable, there was considerable de facto trading and leasing of shares among the nine companies.

New Zealand implemented ITQs for most of its fisheries in October 1986. The Government gave several reasons for introducing ITQs. According to Crothers (1988), "Fishery managers were faced with an open access inshore fishery under severe biological and economic pressure... many of the prime species were experiencing growth and probably recruitment overfishing... and the industry was overcapitalized, crippled by excessive government management intervention, and rapidly declining economic performance." A government publication titled "Inshore Finfish Fisheries: Proposed Policy for Future Management" (Anonymous 1984) stated that "... a broad description of the problem of the inshore fishery is that the major fish stocks are too low as a result of overfishing... there has been a moratorium on new entries to the inshore... part-time fisherman were removed administratively... this had a negligible effect on fishing effort or catch... the harvesting sector remains overcapitalized."[4] In summary, the government turned to

[2] The fishing heritage of the Maori people and the Treaty of Waitangi are more than a matter of passing interest. As will be discussed later in the paper, the Treaty of Waitangi has complicated implementation of ITQ management.

[3] Economic values are expressed in New Zealand dollars which equal about $0.58 U.S.

[4] While the removal of part-time fishermen may have had a negligible effect on fishing effort or catch, it did have social ramifications. Many of the part-time fishermen were Maoris. It could be argued that their removal was one of the factors that stimulated them to attempt to regain access to the fisheries through the courts under the Treaty of Waitangi.

ITQs because of perceived overfishing, overcapitalization, and crippling excess regulation.

Undoubtedly, the success of the Deepwater Enterprise Allocation system contributed to the decision to use ITQs to solve the perceived problems in the inshore fisheries. Clark et. al. (1988) labeled it as a model for inshore fisheries management. There was also a belief that problems could be solved only by applying some form of output controls (Sandrey and O'Donnell 1985), and that input controls had already been attempted and had failed (Crothers 1988). In fact, it is unclear how seriously input controls had been attempted, or how severely the fisheries were overfished or overcapitalized.[5] Of course, the failures of input controls or overfishing and overcapitalization are not prerequisites for ITQ management. It is better to put in place a property rights system, such as ITQs, before problems occur.

Implementation of ITQ management in New Zealand

The idea behind ITQ management of fisheries is quite simple. ITQs are intended to conserve the fisheries resource by setting a TAC. They increase economic efficiency by assigning ownership of portions of the TAC, thus eliminating competition between harvesters to obtain the largest possible share of the TAC. By making quota transferable, ownership should eventually rest with the most efficient harvesters, since they should be able to afford to pay the highest price to purchase quota. Excess capital is likely to be removed from the fishery as more efficient operators buy up enough quota to make optimal use of the capital that remains in the fishery.

In New Zealand, implementation of the ITQ management system began with stock assessments of all of the fisheries resources to be managed. Initially, this involved assessments of 153 management units, composed of 26 species-groups in up to 10 management areas per species-group. By April 1990, there were 169 management units, composed of 29 species-groups (45 species) and 10 major management areas. Forty-seven of these management units are of minor importance (in terms of amount of quota) with TACs established for administrative purposes only. There are insufficient data to conduct meaningful assessments for most management units. Initially, most of the TACs were based on one of two methods of estimation: (1) They were equated to landings in the most recent year(s) for which information was available, or (2) they were equated to the product of a trawl-survey biomass estimate and a stock productivity value in the range 0.05–0.15. The first method probably produced overly-optimistic estimates of sustainable yields since recent landings were often the highest on record. On the other hand, the second method may have resulted in overly-conservative estimates, since biomass estimates were conservative (due to conservative assumptions about the vulnerability of fish to trawl gear) and a maximum productivity level of 0.15 is low (although there are notable exceptions such as orange roughy). Other methods used to estimate a few of the initial TACs may have produced reasonable results. These included use of tagging data, yield-per-recruit analysis, and stock reduction analysis.

For the deepwater fisheries, TACs generally matched the sum of quota allocations under the Deepwater Enterprise Allocation system. These Deepwater Enterprise Allocations were converted directly to ITQs. In the inshore, a provisional maximum allocation was determined separately for each fishing permit holder as the average catch of that individual's best two out of the three fishing years of October–September 1981–82, 1982–83, and 1983–84. These catch histories were the basis for the initial allocation of quota defined in fixed amounts by weight. Since the allocations were based on the average of the best two-out-of-three years, it was likely that the "Sum of Catch Histories" (SCH) would exceed the maximum annual catch that had occurred during the base period. In addition, fishermen were given the right to appeal their allocations if they felt it did not represent their true share of the fisheries. Of the 1800 fishermen notified of their catch histories, about 1400 appealed, and many of these have subsequently increased their allocations. The appeals process is still ongoing even though the ITQ system has been fully implemented for more than three years.

If the SCH was equal to or less than the TAC, permit holders were allocated their catch histories as ITQ in perpetuity. TACs in excess of the SCHs were offered for sale. When the SCH exceeded the TAC, there was

[5] It is interesting that there were virtually no input controls on New Zealand fisheries during 1963–78 for rock lobsters and scallops and 1963–80 for finfish. Even after moratoria on new licenses were implemented in 1978 and 1980, there were no additional direct controls on fishing effort (e.g., limits on the number of days that could be fished), although there were some indirect controls (e.g., closed areas).

With regard to overcapitalization, the government estimated that the harvesting sector was overcapitalized by $28 million NZ in 1983, although details of how overcapitalization was defined and how it was estimated are lacking (Anonymous 1984). Investment (book value) in the harvesting sector in 1983 was estimated as $142 million NZ (Bevin et al. 1989). This indicates that the harvesting sector was overcapitalized by about 20%, which is almost certainly less than some North American fisheries (e.g., Mid-Atlantic surf clams, New England groundfish, Pacific halibut).

Clearly some inshore resources were overfished (e.g., snapper), but it is difficult to evaluate how serious the overfishing problem was in general. Stock assessment information is quite limited, as will be discussed later in this paper.

a Government buyback of quota. Crothers (1988) indicates that the buyback was to facilitate an orderly "rationalization" of the industry, and to help create a climate of support for ITQ management. Clark et al. (1988) indicates the buyback was to reduce the mismatch of fleet capacity to available catch. If the Government was not able to buy back as much quota as was necessary, prorated cuts in quota were made. This threat of proration probably encouraged permit holders to be more reasonable in determining the selling price of their provisional allocation of quota.

The buyback cost the Government $42.4 million NZ to purchase 15,700 tons of quota (the annual amount the owners would have been entitled to catch in perpetuity). Prorated cuts were made to reduce quota by an additional 9500 tons. Presumably, the Government felt that the potential increase in value of the fishery when overfished stocks recovered merited the cost of the buyback and the short-term losses that resulted from prorated cuts.

Relatively few stocks accounted for most of the cost of the buyback. Table 1 indicates that more than 85% of funds spent on the buyback were used to buy quota for four species (mostly in one management area where traditional inshore fisheries are prosecuted). Nearly 50% were used for the snapper fisheries. The total reduction from SCHs to TACs for the 1986–87 fishing year (which began 1 October 1986) was 6%. For the 21 species that were involved in the buyback and prorated cuts, the reduction was about 24%. For the four primary species involved, the reduction was 54%.

Table 1
Buybacks and prorated cuts for implementation of New Zealand ITQ management.

Species	Tons reduced (1000s)	Payments ($NZ millions)	% Total $
Snapper	5.7	19.4	45.7
Rig	3.0	7.7	18.1
School shark	3.7	4.3	10.0
Hapuku bass	1.7	5.1	12.0
17 other	11.0	5.9	14.2
Total	25.1	42.4	100.0

Table 2
Relevant information for the four main species included in the buyback and prorated cuts under New Zealand ITQ management. Values in thousands of tons or $millions NZ.

	Hapuku bass	Rig	School shark	Snapper
Tons reduced	1.7	3.0	3.7	5.7
Cost of buyback	5.1	7.7	4.3	19.4
SCH (sum of catch histories)	3.3	4.4	6.0	12.2
TAC 1986–87 (total allowable catch)	1.7	1.4	2.4	6.5
Catch 1985–86	1.7	2.9	3.7	8.6
Catch 1986–87	1.1*	1.1*	1.9*	5.4*

*Provisional

Table 2 gives detailed information for the four primary species affected by the buyback and prorated costs. It is noteworthy that, in all cases, the SCH greatly exceeded the actual catch in the year just prior to ITQs (1985–86). This means that a portion of the quota that was bought back probably would not have been caught. In fact, in all cases the actual catch in the first year of the ITQ system (1986–87) was lower than the TAC. This suggests there may have been a declining trend in the resource condition from the base period when SCHs were established to the point in time when ITQs were implemented. It also seems likely, in the authors opinion, that SCHs were inflated by the industry (i.e., a moral hazard phenomenon) in anticipation of ITQs. As a result, the government may have spent much of the $42.4 million NZ to buy back quota which would not have been caught; therefore, the buyback may have had relatively little effect on fishing mortality rates.

Since ITQ management was implemented in 1986, stock assessments have been conducted annually for each management unit, to the extent that the available data allow. These assessments are conducted in Fisheries Assessment Meetings (FAMs) during the middle of the fishing year (April or May) in order to recommend TAC adjustments for the next fishing year (beginning in October). New Zealand law requires that the TAC be set to produce the maximum sustainable yield (MSY), as qualified by relevant factors including economic and environmental considerations and regional or global standards. Methods for estimating yields have been refined since 1985 when the initial TACs were calculated. New Zealand scientists now interpret MSY in two alternative ways: a static interpretation in which MSY is the maximum constant yield (MCY) that can be taken year after year from a fishery, and a dynamic interpretation in which MSY is the maximum average yield (MAY) that can be attained by varying the current annual yield (CAY) in response to fluctuations in stock size (Annala 1989 and 1990, Mace and Sissenwine 1989). MCY estimates are based on historic estimates of stock biomass from resource surveys, stock production models, or landings statistics. CAY estimates are generally based on recent estimates of stock biomass and a target level of fishing mortality which is expected to produce MAY. Although the dynamic (CAY) strategy leads to higher average yields, the static (MCY) option has received the most attention for two reasons. First, the ITQ system was initially specified in terms of fixed weights of quota, valid in perpetuity. In practice, most TACs were constant. Second, the facilities for fisheries research are inadequate for providing frequent updates of stock status for all but a few of the more important fish stocks.

It should be recognized that FAMs are only part of the process of determining the level of TACs. The actual advice to the Minister of Fisheries on the setting of TACs is given by senior government officials who integrate stock assessment information with other considerations, including an evaluation of the risk to the resource of not adjusting a TAC. But the authors consider FAMs the best source of information on the condition of the fisheries resources, since they are open scientific meetings which formally document their deliberations and conclusions.

When ITQ management was implemented, the government stated that it would adjust the TAC by entering the market to buy or sell quota at market-determined prices. Government also reserved the option to make prorated cuts in quota. During the first three years of ITQ management, government either sold quota in perpetuity or leased annual quota for barracuda, hake, ling, orange roughy, hoki, and stargazer (Table 3). Most transactions were in the first year. A total of $84.2 million NZ was collected in quota sales and lease fees. But since the initial buyback when ITQs were implemented, government has not entered the marketplace to reduce any TACs,[6] despite the fact that the need for reductions has been indicated by several stock assessments (Annala 1989 and 1990; see next section).

Since ITQ management should increase resource rent, government charges an annual royalty (known as a resource rental) on quota holdings. In order to discourage speculation on quota (i.e., owning it without using it), resource rentals are charged on quota holdings rather than landings. This practice is an implied guarantee that fish are abundant enough for all quota to be caught without dissipating rent, which may not be the case due to assessment errors, failure to adjust TACs when assessments indicate TACs are too high, and because of varying economic conditions.

Gilbert (1988) estimated that the ITQ system could result in resource rents (referred to as surpluses in his paper) of 15–45% of the first sale value of the catch, depending on the species. His estimates reflect only the benefits of reducing effort relative to the open-access equilibrium (although the validity of an open-access equilibrium baseline is questionable for some of New Zealand's fisheries). They do not include the benefits of eliminating competition for shares of an overall TAC. If the average rent is 25% of the first sale value of the fishing, then there is the potential for government to extract at least $90 million NZ annually (i.e., 25% of the 1987 first sale) as resource rentals. Resource rentals averaged about $20 million NZ annually during the first three years of ITQ management.

On 1 April 1990, ITQs were redefined as portions of annual TACs. This eliminated the need for government to adjust TACs by entering the marketplace to buy and sell quota, and makes it more practical to vary TACs in response to the inherent variability in fisheries resources, and other factors (e.g., new scientific information). The change to proportional ITQs came at a time when government was facing a large liability (discussed further below) to buy quota to adjust TACs. Therefore, government agreed to freeze the rate of resource rentals for five years and redistribute the resource rentals to industry as compensation for TAC reductions.

Table 3

Revenues from sale/lease of quota under New Zealand ITQ management, 1986–89.

Species	Tons (1000s)	$NZ (millions)	% Total $
Barracuda	1.7	1.7	2.0
Hake	1.3	2.2	2.6
Ling	2.1	2.2	2.7
Orange roughy	7.8	23.4	27.8
Hoki	131.0	53.2	63.2
Stargazer	1.8	1.5	1.8
Total	145.7	84.2	100.1

What has happened under ITQ management

It is probably too early to conduct a formal evaluation of ITQ management in New Zealand. A transition period of 3–5 years, or longer, is to be expected. Many of the species in New Zealand are long-lived, and it is likely that adjustments in the condition of the resource, which ultimately affect the economic benefits, will be protracted. However, since some authors have already declared New Zealand's ITQ management a success

[6] The TAC for orange roughy on the Chatham Rise was reduced by exchanging quota in that area for quota on the Challenger Plateau. This was a temporary reduction for 1988–89, although stock assessments indicated that a permanent reduction was necessary.

(Clark et al. 1988), it is worth considering what has happened to date, to the extent this is possible given limitations in available information. As discussed earlier, government authors and government publications indicate that the ITQ system was put in place to address three problems: (1) conservation, (2) economic performance, and (3) government intervention. The initial effects of the ITQ system with respect to these problems are discussed below.

Conservation

There is little evidence of improvement in the condition of fisheries resources; but since stock assessment information is limited, it is difficult to know. The increase in TACs that lead to the revenues reported in Table 3 resulted from a reassessment of the stocks, and not an increase in abundance.[7] There is evidence that some stocks have declined, most notably orange roughy, which has been found to be much less productive than previously believed (Mace et al. 1990). The current TAC for the largest stock of orange roughy exceeds even the most optimistic estimates of long-term sustainable yield by a factor of three. ITQs are not responsible for the problem, but have done little to resolve it.

There are several species in addition to orange roughy in need of TAC reductions. There is accumulating evidence that TACs are too high in the long term for valuable species such as hoki, squid, paua, and rock lobster (Annala 1990). At the 1989 FAM (Annala 1989), MCY was estimated for 110 management units. Twenty-one of the estimates were within 10% of the TACs, 82 were less than 90% of the TAC, and only 7 were greater than 110% of the TAC. CAY was estimated for nine management units. One estimate was within 10% of the TAC, seven were less than 90% of the TAC, and one was greater than 110% of the TAC. In 36 cases, yield estimates were less than 50% of the TAC. Reductions in TACs, either immediate or gradually toward MCY or CAY estimates, were recommended for several species. In other cases, reductions were not recommended because of uncertainty in MCY or CAY estimates, because accumulated biomass was still being fished down (in new or developing fisheries), or because recent catches indicated it was unlikely the TAC would be reached. It should also be noted that "actual" TACs are now almost invariably higher than "official" TACs, mostly as a result of successful appeals to the Quota Appeals Authority. Some of the differences are trivial, but a comparison between actual and official TACs from Annala (1989) indicates that of the 122 scientifically-based TACs (i.e., excluding the 47 administrative TACs), 25% of the actual TACs exceeded the official TACs by more than 10%, and 6% were higher by more than 20%.

There are also many species for which the TAC greatly exceeds the catch. For example, in the 1987–88 fishing year, the TAC was undercaught by more than 10% in 122 (out of 169) management units (including 47 "administrative" management units that have TACs of only 10–30 tons), and by more than 20% in 104 management units (Annala et al. 1991). For the 1988–89 fishing year, the total catch for all management units was 66% of the sum of the actual TACs. In situations in which TACs are nonrestrictive, they have little conservation benefit. In these cases, the stocks are either being overfished (because TACs are too high), or they would not be overfished without the ITQ system. There are other cases in which TACs have been overrun (17 of the 169 management units exceeded the TAC by more than 10% in the 1987–88 fishing year; Annala et al. 1991). There are a number of mechanisms by which fishermen can legally exceed their quota. Most of these mechanisms were established in order to deal with bycatch in multispecies trawl fisheries.

The general conclusion is that TACs are not closely tied to the best available assessments of the fisheries resources, nor are catches strongly controled by the TACs. Some valuable stocks have probably declined in abundance. To date, the track record of ITQ management with respect to conservation is not good.

Economic effects

There is even less information on the economic effects of ITQ management. ITQ management could increase economic benefits through several mechanisms: (1) Conservation could lead to an increase in resource abundance and a decrease in harvesting costs; (2) the initial buyback of quota and prorated cuts might have caused some excess capital and labor to move to segments of the economy where they could add production; (3) transfer of quota might have led to consolidation of ownership by the most efficient operators, and resulted in some excess capital being removed from the fishery; and (4) elimination of competition for TACs might have resulted in a more efficient harvest and an increase in the value of product.

As discussed earlier, it is unlikely that ITQ management has resulted in an increase in population

[7] In the case of hoki, the increase in TAC from 100,000 tons in 1985–86 to 250,000 tons in 1986–87 was controversial. Some components of industry were skeptical of the assessment which was in part based on a single hydroacoustics survey. The hydroacoustics survey results were later found to be gross overestimates. So far, the hoki resource has sustained the increase in TAC, but stock assessment results (Annala 1990) suggest that a catch of 250,000 tons may not be sustainable over the longer term. Government is giving high priority to monitoring the stock.

abundance. On the other hand, the decline in the abundance of orange roughy probably has not increased harvesting costs so far. Although orange roughy abundance has decreased considerably, the catch has been stable. Since orange roughy are fished in dense, spatially and temporally predictable aggregations, the catch rate is probably relatively insensitive to overall population size (see Paloheimo and Dickie 1964, for a general discussion of the phenomenon).

It is difficult to determine whether the initial buyback of quota and prorated cuts reduced excess capital, but it seems unlikely. As noted earlier, it probably did not reduce fishing mortality in most cases because the quota that was bought back would probably not have been caught. Fishing mortality is a function of capital investment in the harvesting sector (e.g., number of vessels), labor inputs (e.g., number of days the vessels are operated), and technology. It seems unlikely that capital would have been removed from the fishery unless fishing mortality were reduced.

There is evidence that quota holdings have been consolidated, presumably to more efficient owners.[8] During the period October 1986–April 1988, there were 15,580 quota sales involving 453,000 tons, and 3417 leases of quota involving 253,000 tons, the sum of which exceeds the total amount of quotas (494,000 tons owned privately and 64,000 owned by government); therefore, some quota was involved in multiple transactions (Muse and Schelle 1988). According to Bevin et al. (1989), the total number of quota holders decreased by 5.7% during the first two years of ITQ management. The amount of quota held by the top ten quota owners increased from 57% to 80% of the total. The number of quota holders with more than 50 tons decreased by 37%. This consolidation in ownership of quota does not necessarily mean that vessel ownership has also been consolidated. Apparently, a number of vessel owners who have sold their ITQ allotments to fishing companies have also entered contracts to fish that quota for periods of several years.

Unfortunately, the authors have not been able to obtain reliable data on the number of vessels in the fishery prior to and since ITQ management. There are some data available (e.g., Anonymous 1987, Bevin et al. 1989), but the information is inconsistent. There are data that indicate a slight decrease in investment in the harvesting sector in 1987, after several years of steady growth (Bevin et al. 1989). On the other hand, the data indicate that employment and investment in the fisheries increased steadily through 1987 (Table 4).[9]

Table 4

Investment and employment (in harvesting sector and total; processing-sector values can be obtained by difference) in New Zealand fisheries, 1983-87 (from Bevin et al. 1989). Values are in $millions NZ (book-value) and numbers of employees.

	1983	1984	1985	1986	1987
Investment					
Harvesting	142	170	182	223	213
Total	353	405	437	510	550
Employment					
Harvesting	3700	4000	4450	3800	4240
Total	7500	8000	8650	9200	10240

It is also difficult to evaluate the effects of eliminating competition for TACs, but there are some positive signs. In informal discussions with members of the fishing industry, the authors have been told that harvesters have modified their fishing practices to reduce costs and/or increase the market value of their catches.

At this stage, it is unclear what economic effects ITQ management has had. But, all other things being equal, it seems reasonable that ITQ management should have increased economic benefits. Unfortunately, all other things are not equal.

Two events unrelated to ITQ management have adversely affected the economic condition of the New Zealand fishing industry. They are a weakening of the price of product in export markets (particularly orange roughy in the USA) and unfavorable exchange rates. As a result, the industry had only a 4.3% return on investment (before income taxes) during the one-year period beginning 1 April 1987 (Bevin et al. 1989).[10]

While the overall economic benefit of ITQ management to New Zealand is unclear so far, it was profitable for the government. As noted earlier, the government's revenues from sale or lease of quota was $84.2 million NZ. It also collected about $60 million dollars in

[8] There is a legal limit to how much consolidation can occur. It is illegal for a company to own more than 35% of the quota for a species in any management area, or more than 20% of the quota for a species overall. It is interesting that some segments of the fishing industry have viewed the potential of consolidation of ownership of quota negatively, while government fisheries managers have generally viewed it as part of the process of increasing economic efficiency (i.e., efficient harvesters can afford to buy quota from less efficient harvesters). New Zealand government officials also note that consolidation should reduce the cost of managing the ITQ system.

[9] Note that there was a high rate of inflation during this period (3.6, 9.4, 15.3, 18.2, and 9.6% in 1983–87, respectively, or 69% overall) which approximately offsets the increase in nominal value of capital investment.

[10] It should be recognized that the economic condition of the New Zealand industry is a controversial matter because of resource rentals and fuel excise taxes. Bevin et al. (1989) indicate that in 1987 the industry paid $55 million NZ in resource rentals and fuel excise taxes which reduced the rate of return on investment from 16.2% to 4.3% (before income taxes).

resource rentals during the first three years of ITQ management. This income exceeds the cost of the buyback ($42.4 million NZ) and the entire cost of the government's fisheries research, management, and enforcement programs (about $30 million NZ per year). And there is the potential for resource rentals to increase substantially (see previous discussion). On the other hand, the authors are of the opinion that government should increase fisheries research considerably if it is to produce adequate stock assessments to support ITQ management (i.e., to conserve without being too restrictive). Furthermore, if government had entered the marketplace and purchased quota to implement the reductions suggested by yield calculations performed at the 1989 Fisheries Assessment Meetings (Annala 1989), the cost would have far exceeded the revenue from the ITQ system (e.g., the reductions for orange roughy alone would have cost in the range of $60–150 million NZ).

Government intervention

The third problem that ITQ management was intended to solve was excess government intervention. To date, it has not reduced government intervention except by removing the moratorium on new licenses. The moratorium was replaced by the requirement to own quota. In addition, there are new recordkeeping/reporting requirements and complicated rules that are intended to cope with bycatch (Annala et al. 1991).

One form of government intervention that probably hampered the fishing industry was restrictions on the port at which harvesters were allowed to land their catch. However, this restriction was removed prior to ITQ management. Other forms of input controls, such as minimum fish size restrictions and closed areas or seasons, have usually not been removed. Some of these restrictions are necessary, in addition to a quota, in order to conserve the fisheries resources and to prevent potential yield from being wasted.[11] In other cases, regulations were put in place to aid one segment of the fishing industry relative to another. For example, large factory trawlers are restricted from fishing within 25 miles of the coast, which reduces direct competition with smaller vessels.

General reaction

It is not surprising that implementation of ITQs in New Zealand has been accompanied by controversy. The newspapers report numerous charges by the industry against the government. The industry is upset about the level of resource rentals. There are complaints about the fairness of the Quota Appeals Authority. There were complaints that government had overestimated the productivity of the hoki resource when it sold quota, and there are complaints that it has overestimated the severity of the problem with orange roughy now that it is attempting to reduce the quota. Although there is strong support from industry and government for ITQ management, many specific aspects of implementation are unpopular. This is probably unavoidable for a system that is relatively complex and so radically different from previous management.

Potential problems

From a theoretical perspective, ITQ management is an ideal method which generates maximum net economic returns, under some simplifying assumptions; but as Copes (1986) points out, there are many potential problems. Instead of reviewing Copes' list of potential problems that apply to ITQ management in general, this paper reviews actual and potential problems that apply specifically to New Zealand. They are (1) problems arising from redefinition of quota ownership, (2) implications of the Treaty of Waitangi, (3) inadequacy of the scientific basis of TACs, (4) bycatch, (5) highgrading, (6) enforcement, and (7) an adequate basis for setting resource rentals.

Redefinition of quota ownership

The need to redefine ITQs from fixed quantities in weight to proportions of the TAC resulted from government's failure to enter the marketplace to reduce TACs when necessary. Early versions of the proposed ITQ system included a "revolving fund" that would be administered by the New Zealand Treasury. Resource rentals and revenues from the sale of quota would have gone into the fund which could then be used to buy back quota as necessary. In fact, Crothers (1988) actually reported that the revolving fund existed. However, the fund never materialized and revenues paid to government by the fishing industry were used for other government functions. When faced with the overwhelming cost of buying back quota to reduce the TAC for orange roughy, the government announced its intention to change the ITQ system from fixed to proportional ITQ. The authors were surprised at how rapidly government was able to obtain the legal authority from Parliament to make such a fundamental, and economically significant, change in the system. It took approximately one year from the time that

[11] Fisheries management needs to consider two control variables: the fishing mortality rate which can be regulated by a quota, and the age- or size-at-first-capture which can be regulated by gear restrictions, area/season closures, or minimum fish size (Sissenwine and Shepherd 1987).

government announced its intentions to convert the system to proportional ITQs until the change became effective on 1 April 1990.

The actual details of how the conversion will be implemented had not been determined at the time this paper was written, but some difficulties are almost certain to be encountered. In order to gain industry acceptance of the change, government agreed to freeze resource rental rates for five years, and redistribute these funds to compensate industry for quota reductions. Industry may have misjudged the amount of compensation it will receive, since several of the species that are most likely to have large quota reductions are also the species that generate most of the resource rentals (e.g., orange roughy, hoki, squid). Therefore, the greater the reductions, the smaller the pool of funds available for compensation.

One implication of converting from ITQ in fixed amounts to proportional ITQ is that there will be pressure to change the method of yield estimation from an MCY strategy to a CAY strategy, with consequent increases in the amount and variety of assessment information required. With quota as a fixed amount, there was little change in TACs from year to year. With ITQs as a proportion of the TAC, there will be greater pressure from the industry to change TACs (particularly to increase them when stock size is perceived to be high).

Treaty of Waitangi

The Maori people have sued for rights to the fisheries under the terms of the Treaty of Waitangi. There are several related cases which had not been settled at the time this paper was written, but it appears that the Maori people are entitled to a significant amount of quota. Prior to the ITQ system, when there was no ownership of the fisheries, there was less incentive for the Maoris to exercise provisions of the Treaty of Waitangi. But when property rights were established, and many Maoris were excluded from the system because they were part-time fish harvesters who had already been removed from the fishery, it was inevitable that a controversy would follow. Bevin et al. (1989) reported that industry has delayed major investments in the fisheries because of uncertainty about Maori fishing rights. Industry is concerned that the eventual settlement with the Maoris will be at their expense (i.e., they will not be compensated for quota that is transferred to Maori ownership). The dispute over the Treaty of Waitangi has also caused government to delay adding important species into the ITQ system.

Stock assessments

The scientific basis for assessing fish stocks, setting TACs, and evaluating the overall performance of the ITQ system is generally inadequate. New Zealand had relatively little need for stock assessment capability prior to ITQs. For the most part, their fisheries management was laissez-faire. In the case of data for assessing deepwater species, New Zealand relied heavily on foreign research vessels. When ITQs were implemented, they were ill-prepared, in the opinion of the authors, to conduct stock assessments for all of the management units included in the system. The situation has improved since the implementation of ITQ management as New Zealand scientists have developed and refined the scientific basis for stock assessments, but they have had inadequate support (e.g., research vessels, data collection systems, and personnel). Inadequate assessment databases mean that the ITQ system is operating under high levels of uncertainty. The price of uncertainty is either conservative quotas or a high risk of stock collapses.

Bycatch

Some bycatch is inevitable in multispecies fisheries. This means harvesters will catch some fish for which they do not own quota. New Zealand planned to manage bycatch with a taxation scheme (referred to as surrendering catch to the government or "Crown"), which was intended to produce a neutral incentive for bycatch. The tax was supposed to be high enough so that harvesters would have no incentive to catch species for which they did not hold quota, but if they caught them as bycatch, it would be worth their while to land them for sale. The problem is knowing what the proper tax level is in order to result in a neutral incentive. In some cases, even taxing 100% of the ex-vessel value does not discourage fishing for species for which harvesters do not hold quota. This is because of vertical integration in the fishing industry and a very high value added during processing.

There are several other provisions for dealing with bycatch. Quota holders may overcatch by up to 10% in exchange for next year's quota. They may trade retrospectively for quota to cover catch they have already taken. They may trade quota of certain species to cover bycatch of certain other species (for specified combinations of species, often involving one-way trades only).

Another aspect of the bycatch problem is that it is difficult to distinguish between bycatch problems that are a conservation threat to the bycatch species and those that result from setting the wrong TAC, as a result of imprecise assessments. Regardless of whether it is a conservation problem or not, bycatch constitutes a management problem. It also constitutes a problem for members of the fishing industry when they try to adjust their portfolios of quota holdings to match their landings. In theory, this can be done by buying and selling quota, assuming that the overall TACs match the relative catch rates experienced by the fishing industry in aggregate; but this may not be so.

Annala et al. (1991) reviewed the bycatch situation in detail. In the 1987–88 fishing year, the quota was overcaught for 33 (out of 169) management units, by up to 74%. Nine management units were overcaught by more than 20%. The frequency and magnitude of overcatching increased from 1986–87 to 1987–88.

Highgrading

Highgrading is the discarding or dumping of a lower valued size or species of fish, in favor of keeping more valuable fish. Although highgrading is illegal under the New Zealand ITQ system, it is known to occur (Annala et al. 1991). For example, it probably occurs in the snapper fishery where there is a premium paid for high quality fish for the Japanese "iki jime" (killed by spiking the brain) market, and in the oreo dory fishery where three species (spiky, and black and smooth oreo dory) with significantly different values are managed by a combined TAC. The amount of highgrading in New Zealand fisheries has not been quantified.

Clark and Duncan (1986) felt that highgrading would be "...a short term, transitional problem and should disappear once the fishery recovers and product value differential within the same stock diminish..." There is little evidence that the fishery has recovered. Nor should recovery of the fishery eliminate the incentive for highgrading, unless the ITQ system is administered such that TACs do not limit catch. If so, then other advantages of ITQ management would be undetermined. Nor are the authors aware of reasons why ITQ management should reduce value differences between species or levels of quality.

Enforcement

ITQ management is potentially difficult to enforce. New Zealand has some advantages over the United States when it comes to enforcement. First, the population is small, and therefore there is less scope for the development of a domestic black market, although black markets may be significant for some inshore species consumed domestically. Second, the country is remote, so that it is difficult to smuggle fish elsewhere. Third, most fish are exported, which involves recordkeeping that helps to check the accuracy of quota reports. Finally, fisheries enforcement is carried out entirely by a single, coordinated agency.

New Zealand placed a high priority on establishing enforcement capability when it implemented ITQs. It reoriented enforcement from at-sea operations to shoreside investigations. The emphasis moved from conservation officers to accountants and investigators and "electronic surveillance" (computerized data recording). The industry is required to maintain and submit several different types of records that are necessary for monitoring catch and product flow. Penalties for quota violations are heavy. They may involve forfeiture of catch, vessel, and quota holdings, in addition to fines of up to $10,000 NZ. A second offense within seven years may result in prohibition from participation in any aspect of the fishing industry for up to three years. In addition, the fisheries enforcement agency passes information on to the tax department, which may then be used in income tax prosecutions. It is difficult to assess how well this enforcement approach is working.

Resource rentals

The New Zealand fishing industry is concerned about the basis of setting resource rentals, although it does not seem to dispute them in principle. The government planned to gradually increase resource rentals[12] until the fair market value of quota was reduced to approximately zero. In theory, government is extracting all of the resource rent from the fisheries at the point in time that there is no longer incentive to enter the fisheries. The industry argued that not all of the resource rent should be extracted, since investment in fishing is inherently risky.

It is arguable whether the market value of quota reflects resource rent in the fisheries. The price paid for quota should reflect the buyer's estimate of its net present value. However, the buyer's estimate may be incorrect (i.e., a bad investment). Even if the price paid for quota is correct, it may not reflect rent in a particular year. In practice, the price paid for quota has been extremely variable (e.g., from $13 per ton to $16,500 per ton for snapper; Bevin et al. 1989) for a variety of reasons (e.g., imperfect knowledge, inclusion of other assets in the price of quota, different discount rates, noncompetitive price setting). This makes it difficult to use the sales price of quota as a criterion for setting resource rentals.

[12] The law limits increases in resource rental rates to 20% per year.

Table 5

Problems and benefits of fisheries management by input controls, quotas (Q), and ITQs. The symbol "0" is used as the standard. The symbol "+" means a more difficult problem or greater benefit than "0." The symbol "++" means even greater problems or more benefit than "+."

	Type of management		
	Input	TACs	ITQs
Problems			
Stock assessments	0	+	+
Catch statistics	0	+	++
Enforcement	0	+	++
Bycatch	0	+	++
Benefits			
Conservation	0	0	0(+)
Economics	0	0	+

General Issues

Many potential problems of ITQ management are problems associated with TAC management in general. In some cases they are exacerbated by individual quotas. Table 5 compares the problems and benefits associated with input controls (e.g., effort limits, closed areas or seasons), TACs, and ITQs. TAC management requires more frequent and timely stock assessments than management by most input controls (Sissenwine and Kirkley 1982). The problem is particularly severe for short-lived species (Copes 1986). The problem of providing stock assessments for ITQ management is about the same as that for TAC management. Catch statistics are one component of stock assessments. The need for catch statistics is generally greater for TAC management than for management by input controls. The need is even greater for ITQs because statistics on individual quota holders are the basis of management. Both TAC and ITQ management encourages "data fouling" or misreporting (Copes 1986), although the incentive is greater for ITQs. Similarly, enforcement is generally more of a problem for TAC management (although this is not universally true) because the catch has to be accurately enumerated. For ITQs, it must be accurately enumerated for individual quota owners, some of whom may have developed successful methods for circumventing the system. The bycatch problem is more difficult for TAC management than for input controls. For ITQs, the bycatch problem is even more difficult because individual quota owners must adjust their portfolios to match their multispecies catch rates.

In terms of the conservation benefits, input controls, TACs, and ITQs are all potentially effective (Sissenwine and Kirkley 1982). ITQs may have a potential advantage over TAC management because, with ownership, there should be greater incentive for the industry to cooperate. But limited-entry licensing (a form of input control) also conveys privileges that may encourage industry cooperation. In terms of economic benefits, ITQs are superior in theory. Both input controls and TAC management eventually allow dissipation of resource rent. For both forms of management, there is an incentive for fishermen to increase their cost of fishing, in order to gain a larger share of the resource, until the rent is dissipated. In practice, the actual economic benefits of input controls, TACs, and ITQs are probably fishery-specific.

Learning from New Zealand's experience

There is much to be learned from New Zealand's experience with ITQ management. New Zealand took a systems approach. Comprehensive new legislation was introduced. Enforcement needs, penalty schedules, reporting and recordkeeping requirements (including wholesalers and retailers), a quota trading system, a process for appealing initial allocations, a buyback scheme for "rationalization" of some fisheries, mechanisms for controling bycatch, the principle of resource rentals, and public and fishery industry education were all considered. New Zealand made some mistakes, but it would have probably made more if its approach had been piecemeal.

The authors are of the opinion that one mistake made by New Zealand fisheries managers was to establish ITQs in fixed amounts, valid in perpetuity. This method was used because it was thought that ITQs in fixed amounts would create a more certain environment for industry; they would provide a mechanism for government revenue-raising, since government believed TACs were conservative and future quota sales were likely; and the trading price for fixed amounts of quota would be the most effective method to obtain information to set resource rentals (Clark et. al. 1988).

Apparently, the government did not recognize how uncertain TACs might be (due, for example, to errors in stock assessments) or how often TACs might need to be adjusted (due, for example, to the inherent variability in the size of fish stocks) by entering the market to buy and sell quota, since the revolving fund (or some other method) was not established. It is also possible government did not expect the price of quota to be so high as to make it prohibitively expensive for the government to buy it to reduce quotas. In fact, the sales price of quota may not have been economically rational, in which case government would not want to overpay to adjust TACs downward. But it should be noted that the Government did sell quota for similarly high prices. In any case, it seems more practical to define quota as a portion of the TAC, in an uncertain and dynamic environment.

In the authors' opinion, New Zealand fisheries managers underestimated the complexity of the bycatch problem. In a multispecies setting, the apparent independent fluctuations of each species complicate the bycatch problem. In general, insufficient information, variability between harvesters, and the complex organization of fisheries mean that it will be difficult to solve the bycatch problem by adjusting a tax on bycatch. Many fisheries are essentially single-species (e.g., surf clams, herring, scallops, lobsters). These are the best candidates for ITQ management with respect to bycatch. If ITQ management is to be applied to multispecies fisheries (e.g., New England groundfish), it might be better to exclude some of the minor species from the scheme, or to recognize that they may need to be "sacrificed" in order to optimize fishing on the more valuable species.

New Zealand lacked adequate stock assessment data for a quota-based management system such as ITQs. And, unfortunately, it will take time to develop appropriate time-series of data. In addition, there is much that needs to be learned about the basic biology of the deepwater species, many of which have only recently been discovered in commercially viable quantities. The basis for stock assessments is better in some other places (e.g., throughout North America and Europe), but the expectations for a high degree of precision may still make stock assessment capability problematic.

ITQ management requires adequate monitoring and enforcement capability to track individual catches. New Zealand's enforcement of ITQs is geared towards investigations by accountants and auditors, instead of traditional fisheries officers. In order for these investigators to be effective, the New Zealand fishing industry is required to maintain detailed "paper trails" for products. Penalties for violations are severe. It is too early to say whether this scheme is working, but it is obvious that it will be necessary to impose additional recordkeeping to enforce ITQs in most cases in the United States.

It is unclear how serious the overcapitalization problem was in New Zealand, but there are U.S. fisheries that are severely overcapitalized (e.g., New England groundfish). The buyback scheme in New Zealand probably did little to reduce overcapitalization. If a buyback scheme is intended to reduce overcapitalization, funds should be used to reduce capital, and not hypothetical catches that might not have been taken anyway.

A positive lesson that should be learned from New Zealand is the need to be clear about objectives when applying an ITQ system. Clearly, one of the intentions of New Zealand's fisheries managers was to increase resource rent in the fisheries and to extract the rent (through annual royalty payments[13]) for the general benefit of the country. What will be the objective for applying ITQ management elsewhere? If the objective is conservation, then quota management (or other forms of management) is sufficient in theory, although pressure from an overcapitalized fishing industry may prevent TACs from being set conservatively enough. If the objective is economic efficiency, then it is important to address distributional issues (resource rents, producer surplus, and consumer surplus).

There is a great potential for ITQ management, but it is not a panacea. When ITQ management is applied, it is important that it be approached with realism and based on adequate experience and data.

Postscript

Approximately 20 months have passed since New Zealand converted its ITQ program from one of fixed quota valid in perpetuity to one based on quota specified as a proportion of an annual TAC (also referred to as a percentage ITQ system in New Zealand or a percentage quota share system in the United States). As predicted in this paper, the transition has been controversial, in part because compensation available to the industry in the form of resource rentals has not been as large as anticipated. As a result, the fishing industry filed a $150 million NZ court action against the government. The lawsuit has since been settled out of court.

In spite of the change from fixed to variable quota, most TACs have remained unchanged from one year to the next. This is partly a result of inadequate information for stock assessments. However, there have been three notable reductions in TACs. The total hoki TAC has been reduced from 250,000 to 200,000 tons, Challenger orange roughy from 12,000 to 1900 tons, and Chatham Rise orange roughy from 32,800 to 23,800 tons. The reduction in hoki quota was a reflection of new stock assessment results suggesting that then-current TACs were unlikely to be sustainable; the reductions in orange roughy TACs resulted from assessment results suggesting that stock collapse was imminent.

The anticipated need for large reductions in the Chatham Rise orange roughy TAC was one of the

[13] At present, a legal basis for resource rentals in an ITQ system is lacking in the Unites States.

major factors that precipitated the change from fixed to variable ITQs, since it could have cost the government more than $100 million NZ to buy back sufficient quota to reduce the TAC to the estimated long-term sustainable level. After the change, it was agreed that the quota would be reduced at the rate of 5000 tons per year to the sustainable level, the latter being recalculated periodically as new data became available. Recent assessments (Francis and Robertson 1991) indicate a sustainable level of 7000–9000 tons and show that the risks of stock collapse under the proposed reduction schedule have increased due to the accumulation of new data which has resulted in a decrease in the point estimates of stock size and a decrease in uncertainty of the estimates. The results clearly indicate the need for a faster rate of reduction. However, the fishing industry continues to oppose quota reductions, and at this point in time the government has postponed the 5000-ton reduction schedule. The discovery of new orange roughy aggregations in the southern portion of the management area may alleviate the problem in the short term, but the low productivity of orange roughy stocks means that any accumulated biomass can be quickly fished down. Long-term sustainable yields from orange roughy stocks are estimated to be only about 1.5–2.5% of the recruited virgin biomass.

The problem of not reducing quotas when reductions are indicated by assessments is exacerbated by widespread rumors of quota busting, in spite of New Zealand's efforts to tailor enforcement to ITQ management. Some of these rumors have been confirmed by government sources.

New Zealand is now considering further evolution in its fisheries management system towards a form of comanagement. Topics being debated include the need to incorporate recreational fisheries into the management system, the need to include all remaining exploited species-stocks, and the pros and cons of eliminating the current limits on aggregation of quota (Pearse 1991). One objective is to transfer the costs of management and responsibility for the resource to the users of the resource, under the assumption that with ownership comes motivation for conservation. Stay tuned.

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