Marine Resource Economics, Volume 7, pp. 229–248 0738-1360/92 $3.00 + .00

Rent Generation During the Transition to a Managed Fishery: The Case of the New Zealand ITQ System

R. K. LINDNER

School of Agriculture,
University of Western Australia
Nedlands, W.A., Australia.

H. F. CAMPBELL

Department of Economics,
University of Tasmania,
Sandy Bay, Tasmania, Australia.

G. F. BEVIN*

Fishery Manager,
Maori Fisheries Commission,
Wellington, New Zealand.

Abstract *This paper examines the generation of resource rent during the transition from an over-exploited to an efficiently managed fishery. A simple theoretical model is used to demonstrate that current industry returns may be low or even negative during this adjustment phase.*

A case in point is the New Zealand commercial fisheries which have recently become subject to a Quota Management System. Three sources of evidence on the level of resource rents generated during the initial years of the Quota Management System are examined and compared. These sources are: annual profitability data; the market price of perpetual quota; and the market price of annual lease quota. The evidence in some cases appears to be contradictory and an attempt is made to resolve or explain such differences. It is concluded that a better understanding of price determination in the quota market is required in order to draw correct inferences about rent generation.

Keywords Rent, Generation, Transition, Individual, Transferable, Quotas, Fishery, Management, New Zealand.

Introduction

This paper examines the generation of resource rent[1] during the transition from an over-exploited to an efficiently managed fishery. If fishery managers want to

The authors are grateful to Lee Anderson and to an anonymous referee for detailed and constructive suggestions about the revision of earlier drafts.
* Gary Bevin was Chief Economist, New Zealand Fishing Industry Board when this paper was first prepared.
[1] We follow Anderson (1988), who defines resource or "management" rent as "the difference between the market price of a unit of catch and the harvesting cost to the marginal producer". We interpret the harvesting cost to the marginal producer to be his long-run

collect resource rent generated in the fishery during this period, it is important that they understand the implications of the fact that it takes time for the fishery to adjust to its new efficient equilibrium. During this adjustment phase current industry returns may be low or even negative, and the imposition of resource rentals may require firms to borrow against expected future returns. Even if capital markets were perfect, this would be an inefficient way of raising public revenue because industry borrowing costs are usually higher than those of government. Moreover, given the apparent inability of governments around the world to solve these capital market imperfections, the capacity of industry to pay resource rentals may be constrained by current resource rents.

A case in point is the New Zealand commercial fisheries which have recently become subject to a Quota Management System which is designed to generate resource or management rent. A possible policy goal is that the government should attempt to collect some of the resource rent generated by the fishery under efficient management. For example, in New Zealand the government has introduced a resource rental which is a specific royalty payable by the holder of the right to harvest the fish. The appropriate level of the resource rental depends upon the amount of rent which is generated. This raises the question of how that rent can be measured over time.

In the second section of the paper a simple model of resource rent generation in a fishery is outlined as a starting point for the analysis. That model is compared with the circumstances surrounding the development of the management regime for the New Zealand commercial fisheries in the third section in order to highlight differences between the simple model and the actual situation of those fisheries. In the fourth section various sources of evidence on the level of resource rents in the initial years of the Quota Management System are examined and compared. The evidence in some cases appears to be contradictory, and an attempt is made to resolve or explain the differences observed. It is essential to be able to do this if managers are to be able to set royalties which are consistent with the industry's current ability to pay. The final section summarizes the discussion.

The Basic Model of Rent Generation

In this basic model it is assumed that the fishery is originally in open access equilibrium and exploited by a large number of identical vessels or firms. When a quota management system is introduced each vessel is allocated a quota which is less than its harvest in the initial equilibrium. The sum of the quotas issued is assumed to be the optimal harvest h^* corresponding to the optimal level of effort E^*. In this analysis the optimal level of effort is assumed to be that which, consistent with a zero rate of interest, maximizes the flow of rent from the fishery. Furthermore the adjustment path from an over-exploited to a managed fishery is

marginal and average total cost in long-run equilibrium. An alternative approach would be to define resource rent earned during a defined time period as the change during that time period in the NPV of all future returns from exploitation of the fishery. Such a definition is consistent with the theoretically impeccable capital theory approach developed, inter alia, by Clark (1976). From a practical point of view, we believe that such a definition is not operational in a world of imperfect foresight. More importantly, it does not provide a reasonable basis for assessing year to year changes to industry's capacity to pay for access rights to the fishery in a world where capital markets are manifestly imperfect.

imposed rather than derived as part of the optimization. Figure 1 reproduces a diagram which is widely used to analyze the generation of rent in a managed fishery (see, for example, Anderson (1986, 1988)).

Figure 1(a) illustrates the short-run average total cost and average fixed costs of a typical firm in long-run equilibrium. The minimum point of the short-run average cost curve is the minimum long-run average cost denoted by C. Figure 1(b) shows the relationship between the value of the average product of fishing effort (VAPE) and total fishing effort defined as the number of vessels times the amount of effort contributed by each vessel. The value of the average product of effort is the price of fish, assumed constant in this model, times the catch per unit effort. The VMPE curve represents the value of the marginal product of effort, measured as the price of fish times the marginal physical product of effort.

In the open access fishery, effort enters the fishery in response to perceived opportunities for earning economic rent. This drives down the average product of effort until all rent has been dissipated. The open access equilibrium is at E_o where the value of the average product just equals the long-run opportunity cost of effort. By contrast, in a fishery managed so as to maximize the flow of rent, effort will be set at level E^* so that the value of the marginal product of effort just equals its opportunity cost.

In Figure 1 comparative static analysis is used to compare the initial pre-management open access equilibrium with the new equilibrium once management is established. No analysis of the process whereby the system moves from the initial to the new equilibrium is attempted. The reason for emphasizing the latter point is that the move from E_o to E^* involves significant changes in the biology and economics of the fishery which take time to occur. This means that analysis based on Figure 1 can be misleading if it is used to make predictions about the short-run during which the adjustment process is still occurring.

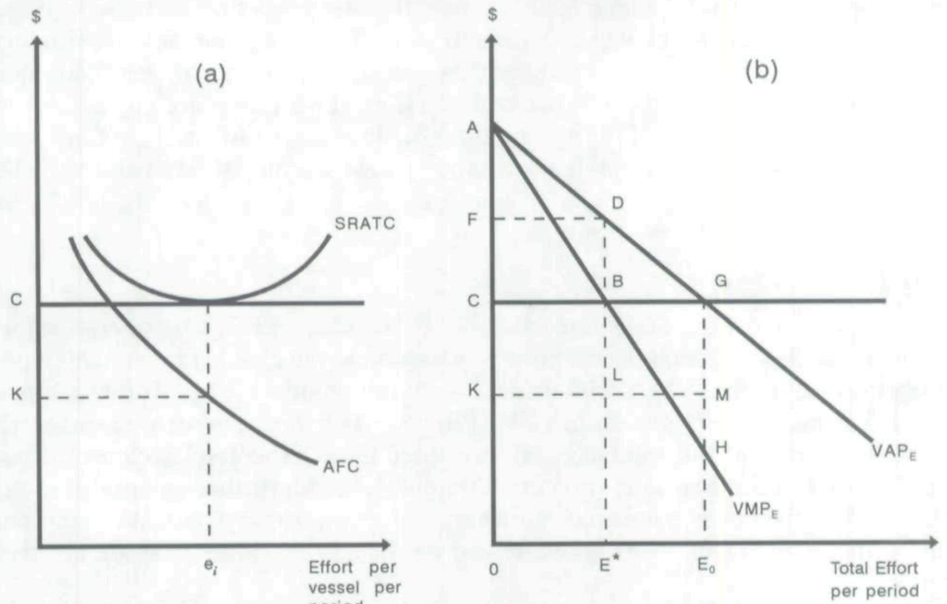

Figure 1. Firm and Industry Equilibrium in a Managed and Unmanaged Fishery.

The reduction in effort from E_o to E^* has two effects which take time to realize: one is a re-allocation to more productive uses elsewhere in the economy; and the other is an increase in the size of the fish stock and consequent productivity of the effort which continues to be devoted to the fishery. In the long-run a resource rent or fishery management rent is predicted to emerge as a result of these changes. It can be measured in a number of ways in Figure 1.

The simplest measure is the area FDBC which is the value of the average product of effort less the opportunity cost per unit of effort, and multiplied by the optimal level of effort. It is also measured by area ABC which is the value of total harvest less total catching costs. A third, and less obvious measure is area BGH, and it is worth examining in detail why this is so. In the initial open access equilibrium there is no economic rent generated by the fishery. This means that the value of total output, measured by area AHE_o0 is equal to total cost, measured by CGE_o0. It follows from this that area BGH must equal ABC which is a measure of resource rent. Thus areas FDBC, ABC, and BGH are equal to one another and equal to the flow of resource rent per period.

An intuitive explanation of why the resource rent can be measured by area BGH lies in the re-allocation of effect to more productive uses elsewhere. The long-run effect of management is to exclude E_oE^* units of effort from the fishery. In the long-run this amount of effort can produce goods valued at BGE_oE^* elsewhere in the competitive economy. Another effect of excluding this amount of effort from the fishery, however, is to reduce the value of harvest by BHE_oE^*. The net gain is BGH which is a measure of resource rent.

It can be seen from the above analysis that the generation of fishery rent depends both upon the re-allocation of effect to other areas of the economy and on the recovery of the fish stock leading to higher catch rates per unit of effort. While these two effects can be expected to occur in the long-run, they will only partially occur in the short-run because the production of fishing effort involves the use of industry specific capital which has no productive use elsewhere in the economy, and because the fish stock will take time to grow. The discussion below considers the generation of resource rent against the background of a growing fish stock giving steadily increasing catch per unit of effort. Two Cases are considered to illustrate the importance of the assumptions made about fixed costs. In Case 1 all costs are assumed to be variable costs; and in Case 2 a mix of fixed and variable costs is considered.

Case 1: All Costs Variable

In this case, when the QMS imposes a TAC less than the initial harvest, effort which is surplus to the taking of this lower harvest at the existing rate of catch per unit effort leaves the fishery with no net loss to the economy. The effort remaining in the fishery, $E > E^*$, initially has a VAPE = C. As fish stocks recover and catch per unit effort rises the amount of effort needed to take the TAC declines further until it reaches the new long-run equilibrium at E^*. This further amount of effort shed by the fishery is employed elsewhere at its opportunity cost. As catch per unit effort rises VAPE rises above C and the fishery starts to generate positive rents.

In summary, as far as costs are concerned, Case 1 is identical to the long-run case illustrated in Figure 1. The only adjustment which takes time is the recovery of the fish stock. Because that does not occur instantaneously it takes time for rents to be generated by the QMS.

At this point it will be helpful to consider the price of annual lease quota immediately after the introduction of the QMS. Since the fish stock has not had time to grow, the catch per unit effort remains equal to the opportunity cost per unit effort. Consequently, enough effort will leave the fishery to ensure that fishing effort continues to earn its opportunity cost because effort is perfectly mobile in this case. The difference between the average return and the opportunity cost of effort measures the resource rent which is initially zero. This is reflected in a zero market price of annual lease quota. The price of perpetual quota may be positive reflecting anticipated rises in the average return per unit of effort, and the price of annual lease quota will rise over time as these changes occur.

Case 2: Some Costs Fixed, Some Variable

In Figure 1(a) average fixed cost of producing effort is given by K. Following the introduction of a total catch quota of h* (allocated by ITQ's), effort is reduced to a level in excess of E*, but below E_o, because of the low productivity of the fishery. The value of the catch will be reduced to FDE*O in Figure 1(b). This area is less than the value of the catch under open access because $h^* < h_o$. Because of fixed costs, the reduction in value of harvest will be only partially offset by an increase in output elsewhere in the economy measured by an area less than BGML. The net loss to the economy in the short-run is at least as large as the area LME_oE^*, and this loss will be reflected in a downward revision of capital asset prices in the fishing industry. Implicit in this analysis is the assumption of constant returns to fishing effort in the short-run. If the law of diminishing marginal productivity applies to fishing effort when the size of the fish stock is held constant, then it is possible for resource rents to be positive even during this adjustment period.[2]

In the long-run, as the productivity of the fish stock rises, the required amount of effort will decline to E*. Additional variable inputs will be shifted to other uses and fixed assets will be written off. The decline in value of harvest, as compared with the open-access equilibrium, will be increasingly offset, and eventually outweighed, by increases in output elsewhere in the economy. The pattern of rent generation matches the investment process: an initial period of negative returns is followed by positive rents as the productivity of the fish stock rises and as output rises in other sectors of the economy.

In Case 2, in contrast to Case 1, the price of annual lease quota immediately after the introduction of the QMS will be positive because of the inability of excess fixed assets to exit from the fishery in the short-run to productive uses elsewhere.[3] The positive price of annual lease quota represents a quasi-rent

[2] We are indebted to Lee Anderson for pointing out this possibility to us.

[3] The market price of fixed assets, such as fishing boats, which are made redundant through the introduction of ITQ's will fall below depreciated replacement cost. This fall in asset value is a real social cost measuring the extent of overinvestment in fishing capacity given introduction of a QMS. It also is a real cost to the industry, albeit one which ought to be offset eventually against positive returns once the fish stock has increased in size and investment in catching capacity has been rationalised. The appropriate time to recognise

earned by the quota asset which, other things remaining equal, will disappear in the long-run as capital exits from the industry. It will be replaced by a resource rent the value of which depends upon the difference between the average return per unit of effort and the long-run average cost of effort at the new equilibrium. That the quasi-rent is merely a transfer from the owners of physical assets to the owners of quota is demonstrated by Figure 1(b): area BGH represents the resource rent which only accrues once excess fishing effort has found a productive use elsewhere in the economy. It should be emphasized that this analysis demonstrates that the price of quota in a perfectly competitive market is not a measure of resource rent if that market is in disequilibrium.

In the model described above, which implicitly assumes a zero rate of interest, the total value over some finite time horizon, of the flow of rents generated by the management programme is positive. In the textbook model, quota in the fishery issued in perpetuity would be expected to command a positive price. In a competitive market, this price would be equal to the net present value of the flow of expected rent per unit of quota, assuming risk neutrality. One of the advantages claimed for a tradeable ITQ system is that fishery managers can obtain information about the performance of the system from the quota market.[4] However, as indicated by Case 2, current industry losses are not inconsistent with positive perpetual quota prices or, as argued in the fourth section, with positive annual lease quota prices. Alternatively, information about rent generation can be obtained from traditional sources such as the profit and loss accounts and balance sheets of the firms involved. While the basic model provides a useful context in which to interpret data from these sources, interpretation of data from the quota trading market is not as straightforward as might be suggested by a simple comparative static model for reasons to be discussed below. However, before the data for the New Zealand ITQ system are examined, it is necessary to consider certain respects in which the circumstances of the New Zealand fisheries may vary from those represented by the model.

The New Zealand Quota Management System

The Quota Management System (QMS) is described in detail by Clark and Major (1988) and Clark (1989), as well as being analysed in some detail by Anderson (1988). The system was first developed in 1983 for a limited number of deep-water fish stocks, and then extended in 1986 to almost all remaining significant fish stocks. For most species the TAC was set at a level below current harvest levels, the primary exceptions being some of the deep-water stocks. Most ITQ's were allocated to firms in proportion to past harvests, although some quota was sold to industry by tender. In some fisheries the TAC was reduced by government buying back some of the allocated quota.

There are several respects in which the introduction of the QMS does not fit precisely the textbook model described in the previous section of the paper. In the first place, the QMS applies to a number of fish stocks which varied in terms of the extent and form of previous management, and the intensity of exploitation

these losses is arguable, but in this paper they have effectively been amortised over the working life of the fixed assets by depreciating fixed assets on a replacement cost basis.
[4] See for example Arnason (1988).

prior to the QMS. Not all stocks were in open access equilibrium as depicted by E_o, and not all stocks were subject to the same relative reduction in TAC. In fact, in the case of some previously under-exploited fisheries, additional TAC over current harvest levels was allocated by tender. Secondly, while the TAC's established by the QMS were set with a view to generating resource rent, it is not possible on the basis of the information available to ascertain how close they are to the h* depicted in the textbook model.

A third qualification concerning the applicability of the model relates to the issue of excess capacity. There is evidence of excess capacity following the introduction of the QMS. The Fishing Industry Board conducted a survey of capacity utilization in August 1988. Each of the respondents indicated excess capacity in the order of 25–30 per cent. Anecdotal evidence about depressed prices for boats and fishing gear is consistent with the survey results. On the other hand, at least part of the fishery is exploited by foreign vessels on charter, and it would be expected that these could more readily be switched to other uses.

Clearly the model of the introduction of fishery management described in the second section fits some of New Zealand's fisheries more closely than others. Hence the extent to which current resource rents generated in the initial period of management are negative is an empirical question. Managers seeking to monitor the performance of the QMS in generating resource rent will need to consult various data relating to revenues and costs. Since the industry is largely organized on a multi-species basis with most firms fishing a variety of stocks it is not possible to conduct this kind of analysis on a stock by stock basis even when trading prices of quota on individual species can be observed. The aim of the empirical analysis, therefore, is to provide some evidence on whether, on balance, the New Zealand commercial fisheries are currently earning positive returns, or whether they are still on the adjustment phase of negative returns predicted by the model. The answer to this question has important implications for a public policy of collecting a proportion of current returns by means of a royalty.

Estimating Current Returns to the Fish Resource

In the second section of the paper it was concluded that implementation of a QMS might initially impose costs rather than yield benefits. The three sources of evidence that are available in New Zealand to estimate resource rents are now examined: industry profitability data, prices paid for perpetual quota, and prices paid for annual lease of quota.

Industry Profitability Data

An estimate of the size of the current resource rent for the 1987/88 fishing year can be derived from data provided by two recent studies. Each year the New Zealand Department of Statistics carries out a profitability survey of firms in the fishing industry as part of its Annual Enterprise Survey (AES). In 1988, industry and the government also jointly commissioned an independent study to estimate the required rate of return on assets for the fishing industry.

While the AES provides comprehensive coverage of all sectors of the New Zealand fishing industry, and is expertly collected and collated by independent professionals, it was not designed nor intended to answer the type of questions posed here. Hence the raw data from the AES have to be adjusted in various ways in order to derive an estimate of the current level of resource rent derived from catching fish in New Zealand. A detailed description of the adjustments made is provided in Lindner and Campbell (1989)[5] and only the main aspects are summarised here.

Firms surveyed in the Annual Enterprise Survey used a variety of different year end balance dates ranging from March 1988 to November 1988. Hence simply summing financial flows and capital values across all firms can provide a distorted picture of the results if one or more of the key determinants of profitability altered appreciably during the 1987/88 fishing season. There is no easy and completely satisfactory solution to this problem, but at least it was possible to correct for significant price movements by use of price indices to "roll forward" accounting data to a common balance date. Details of the procedure used to adjust these data so as to apply to the 1987/88 fishing year ending 30 September 1988 are explained in Lindner and Campbell (1989).

Adjustment also had to be made to the treatment of capital costs used by the Department of Statistics to calculate profit from AES data, because the estimate of resource rent should be based on economic profit rather than accounting profit. In particular, the opportunity cost of capital calculated by applying an estimate of the required return on capital to the entire capital base was substituted for actual interest payments made.

Of the four measures of asset value enumerated in the Annual Enterprise Survey, historical book value under-estimates true value because it does not allow for inflation subsequent to acquisition of the asset. Conversely, gross replacement cost over-estimates true value because no allowance is made for physical depreciation. Arguments could be mounted in support of either subjectively estimated market value or indemnity value, but as there turned out to be little difference between them, indemnity value was used in this paper as the more objective measure.[6] The required real rate of return on fishing industry assets as at March 1988 was estimated to be 9 per cent after tax.[7]

The treatment of depreciation also was modified to correct for distortions arising from typical accounting practices such as under-valuing assets at historical cost, and for biasing up depreciation rates used in books of account because of taxation considerations. To calculate real depreciation, an assumption needs to be made about the working life of the assets. Industry sources advised that a reasonable life expectation for well maintained modern fishing vessels would be 30 years. This assumption translates into a "declining balance" depreciation rate of about 5 per cent, so that rate was applied to the indemnity value of physical assets to arrive at an estimate of real depreciation.

Certain firm expenses such as resource rental payments to government are merely transfer payments from a broader social perspective, and need to be excluded when estimating resource rents. For similar reasons, all "profits" (or losses) associated with trading in, or leasing of ITQ's, as well as dividend pay-

[5] Available on request from the authors.
[6] Because there are financial penalties to the firm from under or over-insurance.
[7] Based on a "risk free" rate of 5 per cent, a company tax rate of 28 per cent, an estimated market risk premium of 8 per cent and an estimated beta value of 0.7, the required real rate of return is 8.97%, and the corresponding nominal rate is 16.7% after tax. Lindner and Campbell (1989) provide further details.

ments to shareholders, were netted out from revenues and expenses. Likewise, the value of assets used to calculate the opportunity cost of capital were exclusive of all quota holdings, and of possible cross share-holdings between member companies of the same corporate group.

Interpretation of these data is further complicated by the fact that some 15 large vertically-integrated firms own about 90 per cent of all quota, while the remainder of the quota is held by about 500 small fishing operations who, almost without exception, do not process their catch in any significant way. Because there are different types of problems associated with each of these two industry sectors, they are treated separately.

Data for the so-called Major Quota Holders (MQH) are based on audited accounting records of company activities, which include but are not necessarily limited to fishing. Within the limitations of the data supplied to it, the Department of Statistics attempts to the best of its ability to separate profitability estimates for each of these activities, but the need to make various subjective assumptions inevitably influences these estimates. For example, most of the major quota holders both catch and process fish, so there are no "arm's length" market transactions which can be used to value fish caught and processed by the same firm. Some firms put their own value on these fish transfers which are based on ruling market prices, but for other firms it was necessary to make some assumption about the port price that would have been received on a "wetfish" basis in order to separate combined revenue into components attributable to the catching operation, and to processing. On the basis of information from industry sources, realised port prices in markets for "wetfish" during this period averaged about 15 per cent above catching costs, so this markup was assumed for those firms that did not value the catch separately.

Aggregate industry revenues, expenses, and asset values derived from the Annual Enterprise Survey using the procedures outlined above are set out in Table 1.

Estimated resource rents for major quota holders in 1987/88 was -NZ$22 million, and close to zero for non-major quota holders. Given the relative magnitude of quota holdings by these two sectors, the two estimates are broadly consistent, and indicate that resource rent for the industry in *toto* was at best zero, and may well have been negative and in excess of NZ$20 million.

It is possible that even this large loss might understate the true economic return for 1987/88, because conventional accounting procedures commonly underestimate the marginal value product of some inputs. For instance, owner/operators of fishing firms often have highly developed catching skills which are not fully recompensed by their salary payments. Anderson (1988) dubs these unrewarded expenses "high-liner rents". In addition, note that any super-normal profits earned from fish processing or other related activities might also be incorporated into the accounting data collected in the AES. By the same token, there are obvious incentives for firms to minimise accounting profit, and it is quite possible that the figures in Table 1 over-estimate the magnitude of the losses incurred by the fishing industry in 1987/88. Although no obvious sources of distortion were discovered by the authors in a critical review of the AES data, the aggregated nature of the data preclude detection of possible understatement of profits by some firms. On balance, the AES survey data suggests that the industry sustained an economic loss which may have been substantial in the 1987/88 fishing year.

Table 1
Estimated Catching Accounts for Fishing Year to 30/9/88

Asset Values (Indemnity)	15 Major Quota Holders	Non-Major Quota Holders
	NZ$ million	NZ$ million
Boat Value	161.181	46.047
Land Value	1.305	3.639
Buildings Value	10.954	5.071
Other Construction	1.581	0.212
Vehicle Value	1.693	7.128
Plant Value	14.411	6.359
Other Capital	8.513	3.232
Total Fixed Assets	199.638	71.688
Financial Assets	128.301	16.330
Total Assets	327.939	88.018
Total Debt	129.055	25.784
Owner's Equity	198.884	62.234
Revenue	NZ$ Million	NZ$ Million
Closing Stocks	16.826	0.164
Fish Sales	338.346	52.420
Interest	0.976	0.996
Dividends, etc.	0.102	0.090
Govt. Subsidies	0.583	0.012
Other Income	3.792	0.706
Extraordinary Gains	0.856	0.691
Total Revenue	361.481	55.080
Expenses	NZ$ Million	NZ$ Million
Opening Stocks	14.869	0.295
Fuel, Fish, etc. Purchases	116.756	9.557
Charter, Port & FIB fees	121.499	1.379
Employment Payments	35.707	17.067
Overheads + Misc. Expenses	54.297	15.215
Bad Debts, etc.	0.990	0.008
Real Depreciation	9.982	3.584
Opportunity Cost Capital	29.416	7.895
Total Expenses	383.517	54.999
Net Returns	−22.036	0.080

Prices Paid for Perpetual Quota

Some idea of the characteristics of the market for quota can be gained from Table 2 in which trades of ITQ of selected fish stocks are summarized. For each species, this Table contains the average price paid for perpetual quota, the median price, and the highest and lowest decile price in the 1986/87 and 1987/88 seasons. Aggregate quota value for the fishery as a whole can be estimated by multiplying median price by the respective TAC for each species, and then summing across species. Unfortunately, available data were incomplete, and so only provided

Table 2
Summary of Trading Data for Perpetual Quota for Selected Fish Stocks

Species & Zone	TAC (tonnes)	86/87 Season Prices				Est. Aggreg. Rent (NZ$m)	87/88 Season Prices				Est. Aggreg. Rent (NZ$m)
		Low	Weighted Av (NZ$/tonne)	Median	High		Low	Weighted Av (NZ$/tonne)	Median	High	
Barracouta											
1	8589	30	1313	756	5900	6.493	50	1018	1000	1375	8.589
5	9010	1100	1348	1210	2200	10.902	370	370	370	370	3.334
7	10539	50	310	350	2000	3.689	10	562	350	2000	3.689
Flatfish											
1	1101	400	2489	2018	6600	2.222	3	3486	3850	5500	4.239
2	674	300	1172	2100	3850	1.415	884	2175	1700	3000	1.146
3	2430	400	2268	3300	21373	8.019	99	3256	3630	5000	8.821
7	1840	100	2084	1730	5000	3.183	50	2226	2000	3685	3.680
Gurnard											
1	2010	100	2941	2000	8000	4.020	5	3200	3000	5618	6.030
2	645	180	1175	1000	3300	0.645	750	1834	1600	2599	1.032
3	480	750	2069	1650	4424	0.792	1334	2143	2000	3300	0.960
7	610	15	1029	800	3005	0.488	15	1095	1050	3000	0.641
8	511	200	903	762	3850	0.389	750	860	750	1600	0.383
Hoki											
1	250028	25	253	550	4167	137.515	300	616	650	2000	162.518

Orange Roughy											
2A	5600	3400	4161	3833	6600	21.465	6600	7066	6600	7425	36.960
3B	38000	90	3836	3882	6235	147.516	2000	3500	5000	5000	190.000
7A	10000	na	na	na	na	na	5000	5000	5000	5000	50.000
Paua											
5	445	na	na	na	na	na	6000	9348	15000	38500	6.675
7	250	na	na	na	na	na	841	9776	19800	27500	4.950
Red Cod											
1	30	100	1699	1060	3960	0.032					0.000
2	353	100	665	600	1500	0.212	450	965	900	1000	0.318
3	11972	68	631	800	1970	9.578	99	983	1000	3300	11.972
7	2945	25	745	500	4167	1.473	5	948	600	2000	1.767
Snapper											
1	4714	12	13401	13401	20900	63.172	13	13630	14000	17600	65.996
2	131	800	2706	2706	8250	0.354	800	4096	5000	14300	0.655
7	330	25	3223	3223	8250	1.064	2	3741	2200	11550	0.726
8	1331	200	4616	4616	11000	6.144	100	2889	1900	9900	2.529
Squid											
1J	57705	na	na	na	na	na	500	500	500	500	28.853
1T	30962	na	na	na	na	na	1600	1600	1600	1600	49.539
6T	32333	na	na	na	na	na	na	na	na	na	na

na = not available because either ITQ's not in place or no trades observed.

lower bound estimates of aggregate value. The estimated capitalized value of the fishery derived from 1986/87 data was NZ$550 million while the 1987/88 data suggest a value of NZ$765 million.

The data reported in Table 2 are most unlikely to provide fishing managers with an indication of the current size of resource rent for a variety of reasons. First, some reservations about their reliability should be noted. According to industry sources, statistics on trading prices for ITQ cannot be taken at face value because the prices recorded on the registration forms are often fictitious. Some trades take place at purely nominal prices between different legal entities which are under common managerial control. Other trades are really barter transactions with no money changing hands, and an arbitrarily chosen price is registered simply to satisfy the recording requirements of the QMS. Preliminary analysis of quota trading data has revealed numerous anomalies which support this point of view.

Secondly, the trading price of ITQ in perpetuity will be determined by the capitalised value of the expected stream of annual willingness to pay for quota. There are several reasons why annual fishery management rent might be expected to grow over time, so it is conceivable that positive prices will be paid for ITQ held in perpetuity even when the current level of rent is negative. Two principal reasons for expecting resource rent to increase over time are technical change leading to a decline in costs, and increases in the relative price of fish.

Once the ITQ system becomes effective, rents generated by technological change should not be dissipated by over-fishing. Hence firms will have a greater incentive to invest in new technology, which in turn improves the productivity of catching activities. Agriculture is probably the industry which provides the best indication of the empirical magnitude of this effect. Results from studies of the rate of return on capital investment in agriculture consistently show very low rates of return (*i.e.* typically around 3 per cent per annum on total invested capital, including the value of land). The other way of viewing this evidence is that land prices are over-capitalised relative to the current returns earned from farming.

Two explanations for this low rate of return are often put forward. One is that farmers value farming as a way of life and are prepared to accept lower returns in order to continue to enjoy the lifestyle. There is an obvious correspondence here to the situation for small, owner/operator fishermen. The other reason for the depressed returns in agriculture is that productivity keeps improving as a result of research and development, so that farmers expect the returns of farming to keep rising over time. It seems reasonable to assume that a similar situation will henceforth exist in the New Zealand fishing industry, with capitalised prices for ITQ's playing a similar role to capitalised land prices in agriculture.

However, there are grounds for believing that the real price of fish might increase over time. One is that the supply of fish from the ocean is highly inelastic because there is limited environmental carrying capacity available to sustain a fish stock.[8] The other reason is that the demand is likely to shift outwards over time due to the high income elasticity of demand, and due to the expected shift in tastes toward fish because of alleged health benefits.

Consequently, without detailed knowledge of industry expectations about fu-

[8] As a caveat, note that this supply constraint will be modified to the extent that supplies from mariculture and aquaculture are developed.

ture changes in fishery rent, it is impossible to draw any reliable inferences about levels of resource rent in any given year from trading prices for perpetual quota.

Prices Paid for Annual Lease of Quota

A summary of trading prices for annual lease of quota for selected fish stocks is reported in Table 3. As with the prices for perpetual quota report in Table 2, high, low, median, and average prices are reported. A lower bound estimate of aggregate willingness to pay for annual lease quota of NZ$59 million for the 1986/87 season, and of NZ$75 million for the 1987/88 season was obtained by multiplying the median price by the corresponding TAC for each species for which data were available.

As suggested in the second section above, in a deterministic and certain world the price of quota in the annual lease market will measure current resource rent provided that the market is competitive and in long-run steady state equilibrium, and provided that quota trades are not conditional on trades of other assets such as vessels, or otherwise distorted by tax or regulatory considerations.

However, the current annual lease markets in the New Zealand fishing industry do not conform to the sort of ideal and stylized market described above. In the first place, the industry is operating under a set of cost conditions which are not conducive to a competitive equilibrium. Secondly, changes brought about by the implementation of the QMS guarantee that the industry will be going through a period of adjustment for a few years. Thirdly, price, cost and catching conditions facing the industry are, and will continue to be stochastic even after industry has adjusted to the QMS. Hence the market operates in a climate of highly imperfect information. Finally, trade in quotas is likely to be distorted by tax or other considerations.

For these reasons, annual lease prices for quota are unlikely to provide reliable and accurate estimates of current fishery resource rents. The basic problem is that the decision to lease quota on an annual basis is, and always will be dictated by short-run rather than by long-run considerations. Hence willingness to pay for a quota lease will be determined primarily by the margin between incremental revenue and variable costs associated with utilization of the leased quota. This margin, by definition, exceeds resource rents.

As explained by Anderson (1988), the requirement of the act to balance catch with quota at the end of each month creates what is undoubtedly the most extreme example of a situation where willingness to pay for quota can exceed resource rents. Vessels which exceed their quota for a species are required to purchase additional quota to cover the excess catch before the proceeds from the sale of the catch are released to them. When such a need to acquire quota arises, willingness to pay for quota on a short-term basis can exceed resource rents by a sum which includes all otherwise variable costs as well as all fixed and overhead costs involved in catching fish. Indeed, because resource rentals themselves are payable quarterly in advance, even these costs are fixed and cannot be saved during the course of the year. Furthermore, once the fish have been caught, literally none of the costs involved in catching them are variable any more. In other words, since all costs are sunk it is rational for fishermen to be willing to pay any price for quota up to the port price for delivering the fish.

No doubt many trades for annual lease of individual transferable quotas are

Table 3
Summary of Trading Data for Annual Lease of Quota for Selected Fish Stocks

Species & Zone	TAC (tonnes)	86/87 Season Prices: Low	Weighted Av (NZ$/tonne)	Median	High	Est. Aggreg. Rent (NZ$m)	87/88 Season Prices: Low	Weighted Av (NZ$/tonne)	Median	High	Est. Aggreg. Rent (NZ$m)
Barracouta											
1	8589	41	146	110	330	0.945	6	83	120	500	1.031
5	9010	20	115	120	200	1.081	11	136	150	165	1.352
7	10539	16	86	50	350	0.527	6	46	36	350	0.379
Flatfish											
1	1101	165	538	500	880	0.551	225	517	500	800	0.551
2	674	173	331	303	500	0.204	87	353	303	2020	0.204
3	2430	320	462	500	540	1.215	10	276	300	727	0.729
7	1840	75	601	110	1900	0.202	11	212	99	500	0.182
Gurnard											
1	2010	55	427	400	1250	0.804	10	323	275	900	0.533
2	645	218	292	218	600	0.141	125	272	218	1450	0.141
3	480	55	190	125	220	0.060	5	223	200	400	0.096
7	610	38	532	55	850	0.034	24	91	52	247	0.032
8	511	55	86	75	110	0.038	12	52	65	247	0.033
Hoki											
1	250028	16	64	24	1000	6.001	10	105	60	1000	15.002

Orange Roughy											
2A	5600	180	881	500	1540	2.800	300	490	1100	1100	6.160
3B	38000	330	509	440	2000	16.720	220	245	220	300	8.360
7A	10000	na	na	na	na	na	20	186	240	500	2.400
Paua											
5	445	na	na	na	na	na	7150	7641	7150	9100	3.182
7	250	na	na	na	na	na	3000	3047	3000	3800	0.750
Red Cod											
1	30	na	na	na	na	na	50	97	50	143	0.002
2	353	87	184	143	300	0.050	18	126	143	143	0.050
3	11972	11	142	100	180	1.197	7	154	55	200	0.658
7	2945	22	175	28	675	0.082	10	148	23	3000	0.068
Snapper											
1	4714	100	2178	2000	3300	9.428	3	1458	1100	2750	5.185
2	131	293	547	293	700	0.038	41	973	293	1950	0.038
7	330	19	354	95	1900	0.031	55	403	100	1900	0.033
8	1331	110	1116	1000	1650	1.331	2	951	1000	2000	1.331
Squid											
1J	57705	na	na	na	na	na	125	125	125	125	7.213
1T	30962	na	na	na	na	na	10	134	114	200	3.530
6T	32333	na	na	na	na	na	63	10	63	10	2.037

na = not available because either ITQ's not in place or no trades observed.

not made in such dire circumstances as those described above. For such cases, costs of labour, fuel and other operating costs will most likely be variable, but other costs such as administration, the opportunity cost of capital invested in shipping and office space etc, depreciation of plant and equipment, plus any contractual obligations of a long term nature which cannot be avoided simply by electing not to put out to sea to try to catch fish, will be fixed. The firm's willingness to pay for quota in the short-run will not take these fixed costs into account with the result that willingness to pay for quota will exceed current resource rents by a margin up to the level of costs that are already fixed at the time when the quota is leased.

The degree of market concentration in much of the New Zealand fishing industry is not consistent with the assumption of a competitive market. The percentages of total quota held in 1986/87 by the six largest quota holders for three major species were:

Hoki—76 per cent; Orange Roughy—75 per cent; squid—59 per cent (New Zealand Fishing Industry Board, 1989). Presumably this degree of concentration reflects economies of size in catching these deep-water species. As a result, the marginal willingness to pay for quota (approximated by port price less the marginal cost of catching) will exceed resource rent (approximated by port price less long-run average catching costs).

The concentration in ownership of quota reflects similar concentration in the processing sector, again as a result of the existence of scale economies. Because the ability to catch fish can generate extra returns in other sectors of the industry, such as processing and/or marketing, vertically integrated firms may be willing to acquire extra quota because they have excess capacity in their processing and/or marketing arms which can generate positive gross margins if extra fish are caught. Gross margins from these post harvest operations also can get incorporated into the willingness to pay for annual lease of quota.

For the above reasons, catch quotas are highly complementary to other inputs in the industry such as vessels and processing capacity. Sales of vessels together with quota are reasonably common, particularly in a market in which there is excess catching capacity, and where the possession of quota is the critical limiting factor. In these circumstances the important consideration to the trading parties is the overall price of the transaction—the price of vessel *and* the quota, so the recorded price of quota is a notional price which may bear no relationship to resource rent, or to willingness to pay for quota *per se*.

In addition to the above considerations, Anderson (1988) has carefully explained how what he calls 'high-liner rents' and what otherwise can be regarded as under payment of fishing skills, are also likely to be incorporated into the price paid for annual lease of ITQ's.

The extent to which it might be necessary to discount trading prices for annual lease of quota to adjust for fixed costs built into lease prices can be very large. Without detailed information about the structure of fishing industry costs, it is not possible to identify precisely the magnitude of fixed costs under various circumstances. Data on the costs of deep-water trawling for four representative vessels are provided in New Zealand Fishing Industry Board (1988, Table 6.5). For these vessels, the average cost of crew, fuel and repairs was equal to 48 per cent of catch value, which can be treated as a proxy for total cost. On the same basis, all non-capital costs averaged 77 per cent of total costs. Aggregate data on costs of catching fish also are available from surveys conducted by the Board, and these data are summarized in Table 4. Even in the very long-run, it could be judged that at least 19 per cent of these fishing costs are sunk. For short term decisions of less than one year's duration, all costs except fuel, fish, providoring, repairs and others could be fixed. Such costs account for about 60 per cent of total costs. Similar conclusions could be deduced from the data in Table 1.

To illustrate how excluding those sunk costs likely to be built into annual lease quota prices can affect measures of current resource rents, sunk cost and other appropriate deductions can be assumed to be a percentage of the price received for fish. To cover all likely circumstances, the percentage of port price treated as an estimate of fixed costs was varied from 10% to 50%. This amount was deducted from the median price paid for annual lease of quota for each species, and then multiplied by the TAC and summed over species to obtain an estimate of aggregate resource rent. Based on the above data, annual quota lease prices could exceed resource rents by a margin equal to 20 to 30 per cent of port price, which corresponds to estimates of resource rents ranging from −NZ$17.5 million to −NZ$65 million. If 50 per cent of total catching costs are built into annual lease prices, then actual resource rents could be as low as −NZ$159 million. On the other hand, they would equal nearly NZ$30 million if only 10 per cent of total costs are sunk into quota lease prices.

Now consider a world in which prices, costs and catching conditions are subject to changes which can be treated as occurring at random from the point of view of the industry. In this stochastic world, quota holders can be assumed to have expectations about the likely values of economic and environmental variables, and hence about the value of quota. Detailed analysis of the functioning of

Table 4
Aggregate Accounts for the Catching Activities of Eleven Major Quota Holders for the Year to 31/3/88

Assets	NZ$ million	
Replacement value	371.0	
Indemnity value	247.0	
Expenditure	NZ$ million	%
Fuel	66.5	17.1
Fish	54.1	13.8
Providoring	1.7	0.4
FIB levies	1.2	0.3
Employment payments	30.9	7.8
Rentals, hire, & charter	130.1	33.3
Repairs	20.1	5.2
Others	12.3	3.2
ITQ lease	4.5	1.2
Rates & harbour duties	2.4	0.6
Insurance	5.0	1.3
Extraordinaries	4.6	1.2
Depreciation	10.0	2.6
Required return on assets	46.9	12.0
Total costs	390.3	100.0

a market operating under imperfect knowledge can be very complex, and is beyond the scope of this paper. However, a simple search model would predict that individual willingness to pay for quota will take on more extreme values, the lower are the opportunity costs of not making a trade, and the lower is the quality of information about the market clearing price of quota. As the fishing season progresses, more and better information about the value of annual lease quota becomes available. If the information is favourable (e.g. better than expected price) asking price for quota will be raised. Likewise, depending on whether catch is worse or better than expected, the opportunity cost of holding quota may rise or fall over the season. If it is worse, the quota holder may find that there is no market for the quota late in the season because the TAC cannot be taken; but if it is better, he may find strong demand for quota by vessels which need extra quota at the end of the season to cover higher than expected catches.

When quota leasing decisions have to be made in an uncertain environment, annual willingness to pay for quota will exceed annual resource rent because the act of holding the quota *per se* does not create any obligation to attempt to catch fish irrespective of the short-run profitability from doing so.[9] Holding quota is analogous to holding an option in the financial market to purchase shares at some future date. It is generally accepted that capital markets are efficient in processing available information, so the expected value of future price movements will be zero. Notwithstanding these expectations, it is well documented that a positive price is paid in the market for such options to purchase shares, and it is rational to do so because there is no obligation to take up the option if future price movements prove to be unfavourable.

Likewise, given that holding quota only provides the option to fish, annual willingness to pay for quota can be predicted to exceed expected resource rents by a margin which is equivalent to an option premium in the share market.[10] The size of such an option premium will be equal to the expected value of the avoided losses by not fishing if and when future returns do not cover variable costs. In the short-run,[11] holding quota surplus to expected level of catch provides the option to continue fishing should realised catch rates be higher than expected. The expected value of such an option will depend, *inter alia,* on the likelihood of needing extra quota for this purpose, as well as on the potential returns that would be realized if the quota can be used. Without further research it is difficult to gauge the possible size of such an option premium.

Summary

It has been argued in this paper that one might reasonably expect there to be initial losses associated with the introduction of an ITQ system. In the New Zealand fisheries three sources of data are available to the fishery manager who wishes to

[9] This "distortion" between willingness-to-pay for quota and management rent also applied to trades in the market for perpetual quota.
[10] Similar but analytically distinct arguments have been made by Anderson (1987) with respect to an option premium component in prices for import quotas, and by Karpoff (1988) with respect to an option premium in the price of limited entry fishery licenses.
[11] In the long-run, if unfavourable scenarios such as a collapse in fish prices and/or stocks materialise and force quota holders to mothball some or all of their quota, it may be possible to avoid certain semi-fixed cost as well as variable catching costs.

monitor the current performance of the system, or to collect resource rentals. These sources are: annual profitability data; the market price of perpetual quota; and the market price of annual lease quota. It was suggested that some of the information provided by these sources is irrelevant, misleading, or contradictory. The relevant data have to be identified, interpreted correctly, and the contradictions resolved if the information is to provide an accurate picture of performance. In particular, a better understanding of the market in annual lease quota is required. A detailed analysis of quota markets to estimate the extent to which annual lease prices are inflated by short-run considerations is suggested as a worthwhile topic for further research.

References

Anderson, J. E. 1987. "Quotas as Options: Optimality and Quota License Pricing under Uncertainty" (*Journal of International Economics*, 23(1/2):21–39.

Anderson, L. G. 1986. *The Economics of Fisheries Management* (Baltimore: Johns Hopkins).

Anderson, L. G. 1988. "Resource Rentals and Other Issues in the New Zealand ITQ Program", pp. 76, (unpublished).

Arnason, R. June, 1988. "Minimum Information Management in Fisheries", Workshop on the Scientific Foundations for Rights-Based Fishing, Reykjavik, Iceland.

Clark, C. W. 1976. *Mathematical Bioeconomics: the Optimal Management of Renewable Resources,* John Wiley & Sons, New York.

Clark, I. N. 1989. "New Zealand's ITQ Fisheries Management System", *Marine Policy,* (forthcoming).

Clark, I. N., and P. J. Major 1988. "The Development and Implementation of New Zealand's ITQ Management System" *Advanced Research Workshop on the Scientific Foundations for Rights Based Fishing,* pp. 66, Reykjavik.

Karpoff, J. M. 1988. "Characteristics of limited entry fisheries and the option component of entry licenses", mimeo.

Lindner, R. K., and H. F. Campbell 1989. "The New Zealand Fishing Industry: Estimated Profitability for the 1987/88 Fishing Year", unpublished report prepared for the New Zealand Fishing Industry Board.

New Zealand Fishing Industry Board 1987. *Economic Review of the New Zealand Fishing Industry,* 1986–87 NZFIB, Wellington.

New Zealand Fishing Industry Board 1989. *Economic Review of the New Zealand Fishing Industry,* 1987–188 NZFIB, Wellington.