

A Model of the Market for ITQ in Australia's Multi-species South East Fishery

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Abstract. Around 100 commercial fish species are utilized by the trawl sector of the Australian South East Fishery, of which sixteen major species were brought into an ITQ management system in 1992. A revenue function approach is used to analyze catch, price and effort data for the period 1990-96, and to develop a set of individual vessel supply curves for quota species, and demand curves for quota. The latter, together with the quota supply constraints, are used to predict market prices of leased quota for each of the sixteen species. Predicted quota prices are compared with observed values, and the implications of various policy measures, including removing some species from the ITQ system, or removing some vessels from the fishery, are discussed.

Key words: quota market, Australia, multi-species fishery

1. INTRODUCTION

When Individual Transferable Quotas (ITQs) are proposed as a management tool for a fishery there is considerable interest on the part of both government and industry in the price which quota will fetch. This interest is heightened in the case of a multi-species fishery because of the likelihood of interactions among quota markets. For example, establishing a relatively tight quota on a given species will raise the price of quota in that species, thereby increasing (reducing) the demand for quota in substitute (complementary) species. The set of market prices for quota which will emerge consists of a general equilibrium in which each quota price depends on the demand and supply curves for quota in all species. It would be an advantage for industry and management if the results of such a model could be available during the discussion prior to a decision being made about implementing a quota system.

This paper reports on the estimation of a model of the market in quota species in Australia's multi-species South-East Fishery (SEF). The demand for quota in any given species by a representative vessel is estimated from the vessel's system of supply curves of the sixteen quota species. These supply curves are obtained from estimates of the representative vessel's revenue function. A vessel's demand curve for quota in a given species depends on the landed price of the species, on the vessel's planned level of fishing effort, and on the landed and quota prices of all other species in the fishery. The demand curve reflects the various complementary and substitute relationships among species in the vessel's production process. The supply of quota is determined by the management authority.

The intersection of supply and demand determines the predicted market price of quota in each species, which can be compared with the observed value of the market price of quota.

The following Sections of the paper describe the SEF, the data which are used, the supply model and its estimation and results. The quota market model is then outlined, and estimated using the results of the supply model. The predicted quota prices obtained from the quota market model are then compared with various observations of market prices of quota. The paper concludes with a discussion of the results.

2. THE SOUTH-EAST FISHERY

About 100 commercial species are utilized by the trawl sector of the fishery of which 16 species were brought into the quota management system by introducing individual transferable quotas (ITQs) on 1 January 1992, and more than 80% of the landed catch weight belongs to those quota species (Caton et al. 1997). These quota species are Blue-eye trevalla (*Hyperoglyphe antarctica*), Blue grenadier (*Macruronus novaezelandiae*), Blue warehou (*Seriola lalandi*), Gemfish (*Rexea solandri*), School whiting (*Sillago flindersi*), Jackass morwong (*Nemadactylus macropterus*), John dory (*Zeus faber*), Ling (*Genypterus blacodes*), Mirror dory (*Zenopsis nebulosus*), Ocean perch (*Helicolenus sp.*), Orange roughy (*Hoplostethus atlanticus*), Redfish (*Centroberyx affinis*), Royal red prawn (*Haliporoides sibogae*), Silver trevally (*Pseudocaranx dentex*), Spotted warehou (*Seriola punctata*) and Tiger flathead (*Neoplatycephalus richardsoni*). Although

stock assessment is one of the important components of the process of setting the total allowable catch limits, for most of the quota species available scientific information in regard to the stock status is not regarded as adequate. The currently available information regarding the overall status of these 16 species is as follows: Gemfish in the eastern sector is overfished, eight other species are probably fully fished, one is underfished and seven are uncertain (Caton et al. 1997).

3. THE DATA

The data on daily landings of 16 quota species by individual trawl vessels, along with the size and the engine power of the most of those vessels engaged in fishing activities during the period 1990-1996 in the SEF have been provided by the Australian Fisheries Management Authority (AFMA). The data on number of hours trawled by individual vessels, characterized as 'effort' by, have also been supplied by AFMA for the same period. Hull and engine units have been calculated for each vessel using the arithmetic formula provided by AFMA. A number of missing values for hull depth have been replaced by the estimated values obtained from the Ordinary Least Square (OLS) technique, treating hull depth as a dependent variable and length and breadth as independent variables. For this study, the 'composite input', effort, for the individual vessel is measured by the product of number of hours trawled and the total units (hull and engine units).

To accommodate the possibility of targeting on non-quota species, the monthly vessel effort variable has been further adjusted by the ratio of the weight of its quota species catch to that of its non-quota species catch. This type of measurement may not represent fully the fishing power the vessels bring to bear on stocks of quota species but the lack of necessary information hinders the construction of a better composite index for the individual vessel. Scrutiny of the daily catch data for each species by each vessel revealed a considerable number of zero catch observations for many species. To reduce the number of zero observations the data have been aggregated to form monthly catch figures for each individual vessel. This resulted in a total sample of 7797 monthly observations. Even with the monthly observations there are still considerable numbers of zero catch observations for a particular species or a group of species for a particular vessel.

Data on daily average wholesale auction prices for the quota species are obtained from the Sydney Fish Market Pty Ltd. covering the period March 1990 - December 1996. The weighted average monthly

prices, using quantity sold at each price as weights, are constructed from the daily average prices of unprocessed fish for use in estimating the supply model. As the study mainly considers quota species, and price information on all the non-quota species in the fishery is not readily available, it is preferred not to include these species as an 'aggregate' in the model, but rather to adjust effort as described above. The catch and price data are summarized in Table 1.

4. THE SUPPLY MODEL

In this study the following non-homothetic Generalized Leontief revenue function is used on the assumption that the fishing firm earns some non-zero level of revenue and maximizes that revenue subject to its inputs levels, which are considered to be fixed for the duration of the fishing trip. The reasons for using this flexible functional form are as follows: it imposes only linear homogeneity (in output prices); unlike the translog case, it permits direct estimation of output levels that are useful for the management decision making process; it is linear in parameters; and it deals with the technology that is non-homothetic in nature:

$$R(P; E) = \sum_i \sum_j \alpha_{ij} \left(\frac{P_i P_j}{P_i P_j} \right)^{1/2} E + \sum_i \beta_i P_i E^2 + \sum_s \gamma_s D_s P E + \sum_r \delta_r D_r P E + \sum_k \phi_k D_k P E + \sum_l \varphi_l D_l P E \quad (1)$$

where, $R(E, P)$ is the revenue, P_i is the price of the i^{th} species, E is a composite input which represents fishing effort, D_s represents the quarterly dummies to capture seasonal effects on revenue, D_r stands for a yearly dummy variable to account for annual fluctuations in stock size, the area dummy variables D_k capture spatial variations in fish stocks and their abundance, and D_l represents the structural dummy to account for the effect of quotas introduced in the beginning of the year 1992.

The input compensated vessel-level supply functions for the i^{th} species can be obtained using the derivative property known as Hotelling's Lemma as follows:

$$\frac{\partial R(P; E)}{\partial P_i} = Q_i(P; E) = \alpha_{ii} E + \sum_{j \neq i} \alpha_{ij} \left(\frac{P_j}{P_i} \right)^{1/2} E + \beta_i E^2 + \sum_s \gamma_{is} D_s E + \sum_r \delta_{ir} D_r E + \sum_k \phi_{ik} D_k E + \sum_l \varphi_{il} D_l E \quad (2)$$

5. ESTIMATION OF THE SUPPLY MODEL

For estimation purposes an error term ε_{it} is added to the input compensated supply function (2) and it is assumed only that the expected value of the error term is zero. The assumption of homoscedasticity has been relaxed as in other studies of supply by individual fishing vessels (Squires and Kirkley (1991)) it has been found that error structures are not homoscedastic in nature. To deal with this problem the procedure suggested by Park (1971) has been followed by assuming that the error variance corresponding to output i is proportional to the square of the composite input (E) level, that is, $\text{Var}(\varepsilon_i) = E_i^2 \sigma^2$, where σ^2 is a constant, and dividing both sides of (2) by the effort variable as follows:

$$\frac{Q_i(P; E)}{E} = \alpha_{ii} + \sum_{j \neq i} \alpha_{ij} \left(\frac{P_j}{P_i} \right)^{1/2} + \beta_i E + \sum_s \gamma_{is} D_s + \sum_r \delta_{ir} D_r + \sum_k \phi_{ik} D_k + \sum_l \varphi_{il} D_l + \vartheta_{it} \quad (3)$$

where, ϑ_{it} is the error term.

To evaluate the performance of the system approach to estimation, the Generalised-R² value was calculated initially for the system of equations (2) using the formula introduced by Baxter and Cragg (1970) and the R² value of 0.7358 suggests a good fit.

The system of individual vessel supply functions represented by Equation (2) is unconstrained by catch quotas. While this was the situation in the South East Fishery prior to 1992, ITQs were in force in the latter part of the sample period. However the ITQs specify annual catch, whereas the catch data used to estimate the supply model are monthly. Individual vessels have an opportunity to acquire quota from other vessels to match their monthly catches. It is an empirical question as to whether any vessels in the sample were actually operating under a monthly catch constraint because of the ITQ system in the latter part of the sample period. This question can be addressed by considering the significance of the structural dummy variable.

The significance of the group of variables which describe the supply relationship is tested under the null hypothesis that all the coefficients (α_{ii} , α_{ij} and β_i) as a group are zero. The model is also tested sequentially for the exclusion of dummy variables under the null hypotheses that the coefficients on the groups of seasonal, annual, area and structural dummy variables are zero, and under the null hypothesis that all dummies are zero as a group. It is found that in all cases except that of the structural dummy the null hypothesis is rejected. The latter result suggests that the unconstrained monthly supply model is an appropriate representation of the behaviour of vessels operating under annual quota constraints.

The overall system of equations (3) is then estimated using the seemingly unrelated regressions technique developed by Zellner (1962) and iterated to convergence. Under the seemingly unrelated regressions framework the symmetry condition (i.e., $\alpha_{ij} = \alpha_{ji} \forall i \neq j$) has to be satisfied to obtain theoretically consistent parameter estimates from the system. A likelihood-ratio test for symmetry is carried out for model (3). The null hypothesis is rejected at the 5% level of significance thereby suggesting that the symmetry condition should be imposed while estimating the system.

Estimation of the supply function where the catch is zero for a particular species creates the so-called limited dependent variable problem in estimation (Kirkley and Strand, 1988). To overcome this estimation problem we follow the procedure adopted by Campbell and Nicholl (1994, 1995) in which zero catch observations are replaced by the arbitrary small value of 0.1 kg. The model is also run with the zero catch observations and it is found that there is virtually no change to the results. It should be noted that the term α_{ii} and the coefficient β_i of this ‘supply per unit of effort’ equation (3) are interpreted as the coefficient of effort (E) and the coefficient of effort squared (E²) respectively of the input-compensated supply function (2).

6. RESULTS OF THE SUPPLY MODEL

At least one area dummy variable (Area 1= the default) is significant at the 5% level for all species except for Blue Warehou (BW) and Gemfish (GF). This is an indication of spatial variations in access to fish stocks. The annual dummy variable for 1991 (1990 = the default) is significant for 7 species at the 5% level. This indicates the inter-annual variability in those species’ stocks.

For Silver Trevally (ST), Gemfish (GF), Blue Grenadier (BG) and Orange Roughy (OR), one Quarter of the seasonal dummies (First Quarter = the default) is significant at the 5% level. This indicates the seasonal character of these species.

With the symmetry condition imposed, the significance (at the 5% level) and the nature of the relationship between the dependent and independent variables as indicated by the associated t-ratios and the sign of the coefficients of relative price ratios (α_{ij} , $i \neq j$) respectively, for each supply function can be summarized as follows. It should be mentioned that the positive (negative) coefficient estimates of relative price variable indicates that the corresponding two outputs are complements (substitutes) in the production process:

School Whiting (WH): has a significant substitute relationship with Mirror dory (MD);

Silver Trevally (ST): has a significant complementary relationship with Ocean Perch (OP), and substitute relationships with Jackass Mowrong (MR) and Ling (LN);

John Dory (JD): has a significant substitute relationship with Tiger Flathead (TF), and a complementary relationship with Jackass Mowrong (MR);

Tiger Flathead (TF): has a significant complementary association with Mirror dory (MD), and a substitute relationship with Royal Red Prawn (RRP);

Jackass Mowrong (MR): has significant complementary association with Mirror dory (MD).

In the cases of Redfish (RF), Blue Warehou (BW), Gemfish (GF), Blue-eye Trevalla (BE), Spotted Warehou (SW), Blue Grenadier (BG) and Orange Roughy (OR), all coefficients of relative price variables are insignificant at the 5% level. This implies that harvesting decision of the revenue maximising fishing firm in regard to any one of these species does not have any significant economic impact on its harvesting decisions with respect to other quota species.

In all cases except Ocean Perch (OP) and Orange Roughy (OR), the coefficients of the effort variable are negative but insignificant at the 5% level. It will be recalled that the coefficient of 'E' in the input-scaled supply function is the coefficient of 'E²' in the revenue function. The negativity of the coefficients of the effort variable indicates decreasing marginal returns to the composite input, effort. However, the magnitudes of the coefficients indicate that the potential changes in marginal productivity would be very small.

Although the microeconomic theory of supply requires each supply function to be positively sloped, 5 out of the 16 own-price elasticity estimates are negative and significant at the 5% level. These results are due to the effects of the relative price variables involved in the calculation of own-price elasticity. However, Gates (1974) and Kirkley and Strand (1988) suggest that elasticity results should be interpreted with caution as the estimated elasticities may suffer from output aggregation bias and also from the problem of multicollinearity.

7. THE QUOTA MARKET MODEL

One effect of tradeable ITQs is to add an additional input to those already involved in the vessel's supply decision. The cost of the quota input per unit of catch is the cost of the ITQ converted to an annual value per kilogram. The annual cost of owning a kilogram of ITQ is the market price of quota multiplied by the interest rate, to give an annual rental value, and divided by the number of kilograms per unit of quota. This annual cost of quota per kilogram is expected to have the same effect on the vessel's supply decision as would a royalty of the same magnitude payable on each kilogram caught.

The supply model can be modified to include a set of individual species royalties, t_j :

$$\frac{\partial R(P; E)}{\partial P_i} = Q_i(P; E) = \alpha_i E + \sum_{j \neq i} \alpha_{ij} \left(\frac{P_j - t_j}{P_i - t_i} \right)^{1/2} E + \beta_i E^2 \quad (4)$$

Equation (4) can be used to calculate a set of virtual prices for the sixteen quota species (Campbell (1995)). The virtual price is the level of the landed price of fish ($P_j - t_j$) which would be required to induce the vessel to catch the amount of the quota in the absence of the quota regime. This equation can be rearranged to give the expression for t_i , the predicted equilibrium price of quota in a competitive market, as given by Equation (5).

$$t_i = P_i \left[1 - \frac{\left(\frac{\sum_{j \neq i} \alpha_{ij} \left(\frac{P_j - t_j}{P_i - t_i} \right)^{1/2}}{Q_i - \alpha_{ii} E - \beta_i E^2} \right)^2}{1} \right] \quad (5)$$

Two quota market equilibria could be considered: a long-run equilibrium, which is the solution to the sixteen equations (5) determining the t_i , plus an

additional equation, reported in Campbell (1995), determining the optimal level of effort to be supplied by the average vessel; and a short-run equilibrium in which the quantity of effort per vessel is set at the currently observed level, and the sixteen equations are solved for the t_i . Given that the ITQ system was introduced at the beginning of 1992, the third year of the seven year sample period, the effort level in the sample period may not have had time to adjust to the new equilibrium level, and, for this reason, the short-run equilibrium was thought to be the more relevant. The equilibrium quota prices are calculated by setting the level of output of each species in Equation (4) equal to the representative vessel's imputed monthly quota in that species, and setting the effort level equal to the average vessel's monthly level of effort directed at quota species over the sample period. The imputed monthly quota is the total allowable catch divided by the number of vessels and converted to a monthly figure by dividing by 12.

The quota prices generated by the model of the representative vessel's supply and demand for quota are average predicted equilibrium prices for the sample period, given landed prices and catching conditions. They can be compared with lease prices of quota observed in the quota market. If the quota market is competitive we expect the estimated prices to be similar to those observed over the period since 1992.

The main requirements for a competitive market to exist are: a large number of buyers and sellers; no distortions; wide availability of information; and individual property rights. The quota system is a system of individual property rights to the fish catch, and there are no significant distortions in terms of regulations that restrict quota trading. Evidence reported in Hogan et al. (1999) suggests that the distribution of quota ownership is not highly concentrated. Values of the Herfindal-Hirschman Index of market concentration are below 10% for all species in all years since the quota system was introduced (Hogan et al. (1999), Table 2.10), suggesting many possible sellers in the market. Since there are over 100 vessels in the SEF, there are also many possible buyers of quota.

A study of ITQ trading prices (Lindner (1990)) in New Zealand found a substantial degree of price dispersion. Trades were being reported at widely varying prices during a given month, and there was no obvious relationship with the landed prices of the species. This type of outcome is typical of the operation of an ill-informed market, and it has also been observed in markets for other natural resource rights, such as water entitlements (Challen and Petch (1997)). Thus it is unlikely that the informational

requirement for a competitive market will be satisfied in the case of the SEF quota market, and this should be borne in mind in interpreting the results of the model.

8. RESULTS OF THE QUOTA MARKET MODEL

The sixteen-equation short-run quota price model was solved using the NONLIN subroutine in SHAZAM. The solution was obtained by trying various starting values and using three criteria to evaluate the output: non-negative quota prices, zero function values, and gradients close to zero. The results are reported in Column 5 of Table 2. Column 2, Table 2, reports observed average lease prices of quota in 1998, and Column 3 reports observed perpetual quota prices in 1997. The latter can be converted to estimates of annual lease prices by multiplying by the real risk adjusted interest rate. A risk adjusted interest rate for the fishing industry has been estimated at around 10% (Reid and Campbell (1998)). When this rate is used to generate imputed annual lease prices based on the 1997 permanent quota prices, the 1997 lease price estimates reported in Column 4 of Table 2 are obtained.

There are now three sets of estimates of annual lease quota prices reported in Table 2: the estimates obtained from the supply model, reported in Column 5, the observed annual lease prices for 1998, reported in Column 2, and the imputed annual lease prices based on the 1997 quota prices, reported in Column 4. Comparing the quota prices derived from the supply model with the observed prices, it can be seen that the former are generally significantly higher than the latter. However the structure of the estimated set of quota prices is similar to those of the observed sets.

The sixteen-equation model was also solved for a level of effort 1% higher than the average for the sample period, and the consequent percentage changes in estimated quota lease prices were calculated in order to obtain estimates of the elasticity of quota lease price with respect to the level of effort supplied by the average vessel. From the elasticity estimates reported in Column 6 of Table 2, it can be seen that, with one exception, additional effort in the short-run will result in additional demand for quota and an increase in the equilibrium quota price. The exception is the negative quota price elasticity estimate for Blue Grenadier, which is the major quota species imported from New Zealand. In three cases the elasticity is quite high, suggesting that a change in effort level would impact significantly on Redfish, Mirror Dory and Royal Red Prawn quota prices.

9. DISCUSSION

The supply model reveals some significant substitution and complementarity relationships which should be taken into account if proposals to remove some species from the quota system were to be considered. It was found that Gemfish (considered the most over-fished species) are complementary to Tiger Flathead, Jackass Morwong and Blue-eye Trevalla, and substitutes for Royal Red Prawn. A decision to remove one or more of these three complementary species from the quota system would place additional pressure on the Gemfish stock. A decision to reduce the Royal Red Prawn quota would have a similar effect.

While all the estimated quota prices are positive, the solution algorithm was designed to exclude negative values, and the estimation process does not make it possible to compute standard errors. Consequently it cannot be concluded that all quota prices are significantly different from zero. The latter condition is a requirement for the quotas to be binding on the fishing vessels, thereby performing the management function for which they are intended.

If all quotas were binding it would be expected that total annual catch of each species would equal the TAC (the sum of the individual quotas) in that species. However commentators on the fishery have pointed out that total catches generally fall considerably short of the TACs. For example, Tilzey (1998, p.52) comments that "with the exception of Eastern Zone Orange Roughy, Ling and Spotted Warehou, the 1996 recorded catch totals of quota species were no more than 75% of their TACs. For 9 species, less than 50% of the TAC was landed. For several species, catches have never exceeded 50% of the TAC since ITQ management was introduced".

Various reasons have been suggested for these shortfalls. The most obvious explanation is that the set of species TAC limits imposed by the ITQ system is inconsistent with the production technology of the fishery. If there were a serious discrepancy between the TACs and the production technology, the only way total landings equal to the TACs could be achieved would be by discarding catches in excess of quotas. While some observers have suggested this is a problem (Tilzey (1999) p.30), the fact that very few species TACs have been even approximately filled suggests that, while discarding may occur, it is not a result of a major discrepancy between TACs and technology.

It has been suggested that the failure to achieve the TACs is a result of a lack of flexibility at the vessel level. The supply model described above is

deterministic and fails to take account of the substantial variability of the species composition of the catch experienced by the individual vessel. It has been argued that vessels tend to carry a "reserve" of quota to cover these eventualities. On the other hand, vessels are allowed to carry catch overages/underages forward and to match them by buying/selling quota leases in a subsequent period, and the quota market seems to be reasonably active in most species.

The structure of lease quota prices predicted by the model is similar to the structure observed in 1997 and 1998. When the rankings of the predicted quota prices are compared with those of the observed 1998 quota prices, as reported in Table 2, a Spearman Rank Correlation Coefficient of 0.6022 is obtained, which is significantly different from zero at the 2% level; a similar result is obtained from a comparison of predicted quota prices with the imputed quota prices reported in Table 2.

While the structure of the predicted quota prices is similar to that of observed prices, the levels of predicted prices of leased quota tend to be significantly lower than the observed market prices of quota. This result may indicate that the market is ill-informed, or that factors not dealt with in the model, such as management fees based on quota holdings, are coming into play.

An annual management fee is levied per unit of quota in each species. The levy is calculated by first allocating the estimated annual management cost of the fishery among the quota species in proportion to the quota species shares in the value of the total catch of the fishery. Each species' share of the management cost is then divided by the number of quota units in that species to calculate the levy per unit of quota in that species. The size of the levies varies from year to year: in 1999 levies ranged from zero for eastern sector Gemfish to \$0.21 per kg for Blue-eye Trevalla; the unweighted average across species and sectors was \$0.07 per kg. It can be seen from Table 2 that levies of this order of magnitude are not sufficient to explain the differences between the observed and predicted quota prices.

The estimates of quota price elasticities reported in Column 6 of Table 2 suggest that a reduction in fishing effort could cause significant declines in the quota prices of some species: Redfish, Mirror Dory and Royal Red Prawn quota prices appear to be particularly vulnerable. This means that a structural adjustment program involving a reduction in fishing effort, such as that introduced in 1997, may impose capital losses on quota holders generally, and on holders of quota in these three species in particular. Under the 1997 \$6.9 million adjustment plan, \$1.7

million was used in 1998 to buy out 27 permit holders from the fishery.

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Species	Catch (tonnes)		Price (\$ per Kg)	
	Average	Standard Deviation	Average	Standard Deviation
School Whiting (WH)	1036.60	3052.50	2.06	0.42
Silver Trevally (ST)	326.41	1171.00	1.79	0.45
John Dory (JD)	163.70	337.64	6.14	1.29
Tiger Flathead (TF)	1646.10	2524.00	2.33	0.42
Redfish (RF)	1275.30	4024.20	1.71	0.52
Jackass Morwong (MR)	751.83	2033.10	2.78	0.44
Blue Warehou (BW)	814.81	3360.90	2.16	0.59
Ling (LN)	779.90	1586.20	3.89	0.52
Gemfish (GF)	415.62	2366.50	4.06	0.76
Mirror Dory (MD)	239.31	707.45	2.31	0.50
Blue Eye (BE)	62.11	503.38	4.98	1.49
Spotted Warehou (SW)	1510.30	5567.80	1.89	0.47
Ocean Perch (OP)	199.78	513.27	2.95	0.54
Royal Red Prawn (RRP)	273.40	1171.70	3.57	0.70
Blue Grenadier (BG)	2199.60	11403.00	2.42	0.57
Orange Roughy(OR)	12957.00	42097.00	2.92	0.69
Overall Mean Effort	6696.2			
Overall St. Dev. Of Effort	52107			
No. of Observations (monthly)	7797			

Sources: Australian Fisheries Management Authority and Sydney Fish Market Pty. Ltd.

Table 1: SEF Average Catches and Prices, 1990-1996

Quota Species	Landed Price (\$A/kg)	Observed Quota Lease Price (\$A/kg), 1998	Observed Perpetual Quota Price (\$A/kg), 1997	Imputed Quota Lease Price (\$A/kg), 1997	Estimated Quota Lease Price (\$A/kg), 1990-96 Average	Elasticity of Quota Lease Price with respect to Effort
	(1)	(2)	(3)	(4)	(5)	(6)
School Whiting (WH)	2.06	0.10	1.25	0.13	1.954	1.06
Silver Trevally (ST)	1.79	0.10	2.75	0.28	1.747	2.14
John Dory (JD)	6.14	1.20	6.25	0.63	5.503	1.14
Tiger Flathead (TF)	2.33	0.20	3.75	0.38	2.222	1.13
Redfish (RF)	1.71	0.30	4.25	0.43	1.167	16.03
Jackass Morwong (MR)	2.78	0.40	3.75	0.38	2.620	2.61
Blue Warehou (BW)	2.16	0.50	4.25	0.43	2.160	0.62
Ling(LN)	3.89	1.30	7.50	0.75	3.289	2.77
Gemfish (GF)	4.06	1.00	5.50	0.55	2.222	3.92
Mirror Dory (MD)	2.31	0.40	3.75	0.38	0.186	28.78
Blue Eye (BE)	4.98	1.80	7.00	0.70	4.915	0.8
Spotted Warehou (SW)	1.89	0.30	3.75	0.38	1.775	0.71
Ocean Perch (OP)	2.95	0.40	4.25	0.43	2.739	0.89
Royal Red Prawn (RRP)	3.57	0.30	3.50	0.35	2.076	11.13
Blue Grenadier (BG)	2.42	0.10	1.75	0.18	2.404	-6.18
Orange Roughy(OR)	2.92	1.40	7.50	0.75	2.869	1.63

Table 2: Landed Prices and Observed and Estimated Quota Prices for Sixteen Species