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Market Power, Industrial Organization and Tradeable Quotas

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Abstract. Individual Transferable Quotas (ITQs) were introduced into the Mid-Atlantic Surf Clam and Ocean Quahog fishery to reduce over-capitalization while conserving clam populations. Because the number of operators in the fishery declined drastically since the introduction of this policy, there is concern about its effect on competitiveness. This paper utilizes Bertrand Pricing Models to show that monopoly power is absent from the surf clam and ocean quahog markets. Concentration ratios, Lorenz curves and Gini Coefficients estimated for the fishery for periods before and after ITQ introduction support the results of the Bertrand model.

Key words: Bertrand pricing model, share concentration, market power, Gini coefficients, fisheries.

I. Introduction

Because of problems associated with open-access fishing, such as depletion of the fish stock and loss of the resource rent, many social and other scientists, fishery managers, fishing firm owners and members of the public alike share the view that fisheries must be regulated to some extent. From the late 1970s through 1989, the Mid-Atlantic Surf Clam and Ocean Quahog (SCOQ) fishery was regulated by a number of different types and combinations of policies, including restrictions on vessel entry, catch quotas and effort and gear restrictions.[1] These policies led to an increasingly over-capitalized fishery (Marvin, 1992; McCay and Creed, 1994; Wang, 1995).

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[1] Surf clams and ocean quahogs are both species of clams harvested in the Mid-Atlantic Surf Clam and Ocean Quahog (SCOQ) fishery which ranges from New England to Virginia. Before 1990, the fisheries were regulated differently in the sense that the ocean quahog fishery only maintained an annual catch quota and no effort or gear restrictions were imposed.

In 1990, an Individual Transferable Quota (ITQ) system was imposed to reduce over-capitalization in the fishery while maintaining a viable clam population. In an ITQ system, firms own or lease shares of the total industry quota called the Total Allowable Catch (TAC). The shares are transferable among individuals. Statistics indicate that since the introduction of ITQs, capital has been reduced in the fishery as the total number of vessels in the SCOQ fishery declined 57 percent from 1988 to 1994. Over the same period, the number of firms in the fishery declined from 56 to 28 in the surf clam fishery and from 24 to 17 in the ocean quahog fishery (Menzo, 1996). Not surprisingly, in most cases, the market shares of those vessel owners remaining in the fishery increased (Menzo, 1996). This has led to concerns that although ITQs have increased efficiency by decreasing over-capitalization, the policy may have also led to the development of another type of inefficiency, that of non-competitiveness resulting from market power over prices by the largest firms.

Statistics on the ratio of actual catch to Total Allowable Catch (TAC) seem to suggest not only that producers have the capacity to control the quantity of fish they catch, but also that they can restrict output. However, this does not necessarily imply that they have the ability to raise prices by restricting output. When industry output is homogeneous, the necessary condition for monopoly power is that output can fall below TAC, and the sufficient condition is evidence that such output restriction implies higher prices. Table I, which shows the percent of the TAC that has been caught from 1979 through 1994 in both the surf clam and the ocean quahog fisheries, suggests that operators have not historically always caught up to the quota in this fishery. Hence, the test of market power is warranted in order to ascertain the industrial organizational effects of ITQs.

This paper investigates the existence of market power in the market for landed clams by utilizing the Bertrand Pricing model. The model involves examining the relationship between owner's share and prices received. The Bertrand model is applied to both the surf clam and ocean quahog fisheries. The model compares the prices among firms and investigates the relationship of surf clam and ocean quahog prices to market share and other demand and cost shift factors. Such factors include price received for the substitute clam species, the number of owners participating and the amount of ITQ share leased, as opposed to owned, by a harvester of clams. In the Bertrand model, if the coefficient of the market share variable is statistically significant and positive, one would conclude that market power exists (Haller and Cotterill, 1996). To get a better idea of the distribution of market shares among firms, Four-Firm Concentrations, and Gini Coefficients and Lorenz curves are also calculated and discussed for both fisheries for post and pre-ITQ periods.

II. Conceptual Framework

The Bertrand Pricing model has been used extensively to model and test for monopoly power. The approach is used in this paper to model the price-market share relationship in the Mid-Atlantic SCOQ fishery. The model developed is

Table I. Surf clams and ocean quahogs harvested as a percent of the total allowable catch, 1979 through 1994

Year	Surf clams	Ocean quahogs
1979	93%	101%
1980	105%	85%
1981	108%	72%
1982	83%	81%
1983	98%	80%
1984	108%	99%
1985	92%	93%
1986	99%	69%
1987	90%	79%
1988	90%	74%
1989	87%	95%
1990	109%	87%
1991	94%	91%
1992	99%	93%
1993	99%	89%
1994	100%	85%

based on similar work by Cotterill (1994), Haller (1994) and Wen and Haller (1994). The model has also been used to examine prices received by different brands of differentiated products such as catsup (Haller and Cotterill, 1996) and spring water (Wen and Haller, 1994). Although the clams landed by individual firms are not thought of as different brands which are unique to a particular vessel owner, brand characteristics are manifested in different marketing behaviors and contractual arrangements among vessel operators (Menzo, 1996). In addition, the behavior of vessel owners seems to be consistent with oligopoly behavior.

To illustrate the Bertrand model, consider the following profit function for the ith firm:

$$\Pi_i = p_i * q_i - TC_i. \tag{1}$$

The firm's own perceived demand curve can be specified as follows:

$$q_i = q[Q(p_i, \ldots), q_R(p_i, \ldots), p_R(p_i, \ldots)], \tag{2}$$

where p_i is the price received by firm i, $Q = q_i + q_R$ is total industry output, q_R is the sum of all competitors' output quantities, and p_R is the competitors' price function.

The first order conditions for profit maximization are obtained in terms of the ith firm's price, marginal cost and own price elasticity of demand, η_i:

$$\delta\pi_i/\delta p_i = -(p_i - MC_i)\eta_i + p_i = 0. \tag{3}$$

According to Harris (1988),

$$\eta_i = -(\delta q_i/\delta p_i * p_i/q_i) = (\eta^M + \theta(1 - s_i) - \eta^C \eta^R s_i)/s_i. \tag{4}$$

The price elasticity of market demand is

$$\eta^M = -(\delta Q/\delta p_i * p_i/Q) > 0. \tag{5}$$

The conjectural own-price elasticity of competitors' supply is

$$\theta = (\delta q_R/\delta p_i * p_i/q_R) > = < 0. \tag{6}$$

The cross-price elasticity of own firm demand is

$$\eta^C = (\delta q_i/\delta p_R * p_R/q_i) >= 0. \tag{7}$$

The conjectural competitor price response elasticity is

$$\eta^R = (\delta p_R/\delta p_i * p_i/p_R) > = < 0. \tag{8}$$

The notation s_i represents market share (Wen and Haller, 1994). These elasticities can be substituted in Equation (3) and p_i can be solved for as follows:

$$\begin{aligned} p_i &= MC_i * \eta_i/(\eta_i - 1) = MC_i(\eta^M + \theta(1 - s_i) - \eta^C \eta^R s_i)/(\eta^M \\ &\quad + \theta(1 - s_i) - \eta^C \eta^R s_i - s_i). \end{aligned} \tag{9}$$

Equation (9) suggests that the price received by the ith firm is a function of marginal cost, total industry supply, the amount supplied by the ith firm, the amount supplied by competitors, firm i's own market share and the prices received by competitors. Industry structural and demographic variables may also be included in a regression on price. It is also possible to obtain the derivative of price received by the ith firm (p_i) with respect to market share (s_i) as shown:

$$\delta p_i/\delta s_i = MC_i(\eta^M + \theta)/[\eta^M + \theta(1 - s_i) - \eta^C \eta^R s_i - s_i]^2. \tag{10}$$

As can be seen from Equation (10), if marginal cost is constant and share increases, price will increase. When marginal cost is decreasing the result is ambiguous in that the relationship between price and market share cannot be determined. However, in the relevant economic range of production, stage two of production, marginal cost is always rising for producers to produce any output at all, and marginal cost must be above average variable cost. This occurs in the rising portion of the marginal cost curve. When marginal cost is rising, the price and share must be positively related for monopoly power to exist. According to Harris (1988), if price and marginal cost are not directly related, the conclusion is that there is no monopoly power because the conjectural price elasticity (θ) is negative, and its absolute value is greater than the own-price elasticity (η^M).

III. Empirical Model, Data and Estimation

To empirically estimate the hypothesis of market power in the SCOQ fishery under the ITQ regime, Ordinary Least Squares (OLS) is used to regress price received by the ith firm on proxies for the variables suggested by theory above and on additional characteristics of the Mid-Atlantic SCOQ fishery that may also impact prices. The regressions utilized data from 1993 and 1994.[2] Independent variables include the price received for the alternative resource, the number of vessel owners participating, the percent of a vessel owner's boats that have greater than 400 horsepower, owner's share of landings, and the proportion of a vessel owner's landings for which ITQ share is leased.

The analysis was conducted using data from the National Marine Fisheries Service. The data available for this fishery are unique in that very detailed information regarding ownership, vessel characteristics and trip level information is available.[3] Logbook data are collected for every trip made by each vessel. This logbook information provides the date of the fishing trip, vessel name and permit number, species of clam landed, number of bushels landed, and vessel owner. From the logbook data, it was possible to construct a number of important variables, including owner's share of clam landings, number of vessels owned by a single owner, the total bushels harvested in a given time period, the amount of ITQ share that was leased by an owner in a given year and the inflation adjusted price per bushel received by a vessel owner. No cost data are available therefore marginal cost is not included in the model. However, horsepower is used as a proxy for economies of scale. These vessel characteristic data are also available from the National Marine Fisheries Service. A description of the data can be found in Table II.

The dependent variable (OWNPR) is the price per bushel received for a harvesting trip by a vessel owner. The price is adjusted for inflation using 1982 prices. Separate harvesting trips are made for surf clams and ocean quahogs. Therefore, the price recorded in the logbook data from the NMFS is for a homogeneous bushel of either surf clams or ocean quahogs. Market share is incorporated by using the vessel owner's landings share variable, OWNSHR. Although the observations are trip level, the vessel owner's share of landings used in the analysis is the vessel owner's share of landings for an entire year for a given species. The hypothesized relationship between price and owner's share is positive.

[2] Although data are available for 1990 and 1992 as well, price data reporting methods varied for those years. Therefore, only the 1993 and 1994 data are used in the final model.

[3] All variables except ownership are based on government-collected data, with protections of their confidentiality. Because the category of ownership often reflects accounting practices rather than actual firm behavior, our ownership data are based on attempts to determine "true ownership" of clam vessels, with the help of Carolyn Creed and other knowledgeable persons.

Table II. Descriptive statistics on the surf clam and ocean quahog data sets

	Surf clam		Ocean quahog	
Variable	Mean	Standard deviation	Mean	Standard deviation
(OWNPR) Price per bushel received by the vessel owner, trip level observation.	8.28	2.73	3.44	0.48
(OWNSHR) Vessel owner's share of landings, yearly observation.	0.09	0.08	0.11	0.08
(SUBSTPR) The quarterly average price received in the alternate fishery.	3.45	0.10	7.92	0.91
(NUMOWN) The number of vessel owners harvesting the observation's species, monthly observation.	19.95	2.51	14.90	1.12
(HP) The percent of a vessel owner's boats that are greater than 400 horsepower, yearly observation.	62.16	40.96	78.40	34.85
(LEASEAMT) The proportion of a vessel owner's landings for which ITQ share is leased, yearly observation.	0.44	0.30	0.41	0.36
(OWNAMT) Cross-term variable between OWNSHR and LEASEAMT.	0.035	0.030	0.05	0.06

The price of the alternative resource (surf clam if the observation is for an ocean quahog trip and vice versa) is the quarterly average price received for that particular species, adjusted for inflation using 1982 prices. The variable is denoted as SUBSTPR. The number of owners, NUMOWN, is included in the analysis as a structural variable that measures concentration in the industry. Economic theory suggests that as an industry becomes more concentrated in the hands of fewer firms, the potential for the development of some type of market power increases. The NUMOWN variable represents the number of vessel owners harvesting the recorded species during the month of the observation.

No cost information is available in the data set. However, other variables for which data are available can be used as proxies for production costs. For example, information on fleet size, horsepower of vessels, and age of vessel are possible proxies for production costs since they are indicators of economies of scale. In this case, the horsepower variable (HP) was included as an independent variable to capture the effects of larger, more powerful vessels. The data on the fishery suggest that the larger and more powerful boats had greater longevity in the business and that smaller boats had a greater tendency to exit the fishery. The horsepower variable, which measures the proportion of vessels owned with between 400 and

1,640 horsepower, should reflect not only economies of scale but also production costs in the industry. The vessels in the data set range from 115 to 1,640 horsepower.

Industry representatives believe that one of the most influential determinants of ex-vessel price received per bushel is a vessel owner's ratio of owned ITQ share to leased ITQ share. Owned ITQ allocation can lead to higher prices received for the clams because the owner is likely paid both the value of the clam and the value associated with ownership of the ITQ allocation. Those firms for which a large proportion of their ITQ shares are leased are, in some instances, able to charge a lower price for the clams because those firms do not own the tag itself and therefore may have lower costs. The variable LEASEAMT measures the proportion of a vessel owner's landings for which ITQ share is leased in a particular year. It is hypothesized that a negative relationship exists between LEASEAMT and OWNPR. A cross-term variable between OWNSHR and LEASEAMT (OWNAMT) is also included in the study to incorporate any relationship that may exist between a vessel owner's share of landings and the proportion that he/she leases. The empirical model to test for market power is specified as follows:

$$\begin{aligned}\mathbf{OWNPR}_i = {} & \alpha_0 + \alpha_1\,\mathbf{OWNSHR}_i + \alpha_2\,\mathbf{SUBSTPR}_i + \alpha_3\,\mathbf{NUMOWN}_i \\ & + \alpha_4\,\mathbf{HP} + \alpha_5\,\mathbf{LEASEAMT}_i + \alpha_6\,\mathbf{OWNAMT}_i + u_i \qquad (11)\end{aligned}$$

where u_i is assumed to be normally and independently distributed with a mean of zero and a constant variance.

IV. Descriptive Statistics and Model Parameter Estimates

Descriptive statistics from the data set provide preliminary insight into industrial organization in the fishery. These are presented in Table III. With respect to market power, industries are generally considered to fit into four broad categories; pure monopoly, dominant firms, tight oligopoly, and effective competition. To explore the issue of which category the Mid-Atlantic SCOQ fishery fits, industry concentration of landings and distribution of landed clams were calculated. These suggest the absence of either a pure monopoly or the existence of dominant firms (Market share must be near 100 percent for the firm to be considered a pure monopoly). Market share must be between 50 and 100 percent and the firm must have no close rival to be considered a dominant firm (Shepherd, 1985). Between 1988 and 1994, no one firm in either fishery held more than 28 percent of total landings share.

The diminishing number of firms in the fishery since the inception of the ITQ system suggests the need to be concerned about oligopoly power. An oligopoly typically exists when only a few firms participate in an industry. In an oligopoly, a firm's business decisions are often based on anticipated reactions of rival firms because each firm's output decisions may affect prices for the entire industry. A key requirement to be considered a tight oligopoly is to have a four-firm concentration

Table III. Calculated Gini coefficients and four-firm concentrations for the surf clam and ocean quahog fishery, 1988, 1990 and 1994

		1988	1990	1994
Surf clam fishery	Gini coefficient	0.6239	0.6094	0.5663
	Four firm concentration	51.7%	50.37%	51.20%
Ocean quahog fishery	Gini coefficient	0.6329	0.5820	0.2996
	Four firm concentration	62.50%	53.04%	49.50%

(combined market share) above 60 percent (Shepherd, 1985). Stable market shares of the top firms may also be a sign of tight oligopoly (Shepherd, 1985).

The four-firm concentration of landings shares is examined between 1988 and 1994. For landings in the surf clam fishery, the four-firm concentration ranged from a high of 55.8 percent in 1993 to 46.6 percent in 1991. In 1988, the four-firm concentration level was 51.7 percent and in 1994, the level was 51.2 percent. The level never exceeded 60 percent. Over the period, there was no steady increase in concentration ratio associated with the ITQ in the surf clam fishery. The players with the highest market shares did remain fairly constant over the period as there are three that are consistently a part of the top four firms. However, the average prices these three particular firms receive are among the lowest.

On the ocean quahog side, there were fewer operators. The 1988 four-firm concentration level of landed ocean quahogs was 62.5 percent (above the 60 percent criterion for an oligopoly), suggesting tight oligopoly. However, after 1988, the level has not exceeded 57.5 percent which was obtained in 1993. This suggests no increase and perhaps a decrease in oligopoly power after ITQ introduction. It should be noted that while at least three of the same operators have consistently been included in the top five holders of ocean quahog share of landings, the average prices these three particular firms receive are in the lowest 60 percent.

Lorenz Curves and Gini Coefficients calculated for the distribution of landings in both the surf clam and ocean quahog fisheries also reveal industry market structure. Both measure the degree of inequality in output distribution in an industry (Adelaja, 1991). To construct the Lorenz Curve, the cumulative percent of owners is plotted against the percent of landings. A straight diagonal line from the lower left corner of the diagram to the upper right corner represents perfect equality. Usually, however, the curve falls below the line of equality. The greater the distance between the perfect equality line and the actual Lorenz Curve, the more unequal the distribution of landings. The Gini Coefficient measures the proportion of total area that lies between the Lorenz Curve and the line of equality (Adelaja, 1991). The higher the Gini Coefficient, the more unequal the distribution of landings.[4]

[4] Gini Coefficient is calculated as $1/(0 - \Sigma_{i=1}^{n} b_i(z_i + z_{i-1}))$, where b_i is the proportion of vessel owners in the firm size interval i, and z_i is the proportion of total landings received by vessel owners of size interval i and all lower intervals (Fichtenbaum and Shahidi, 1988).

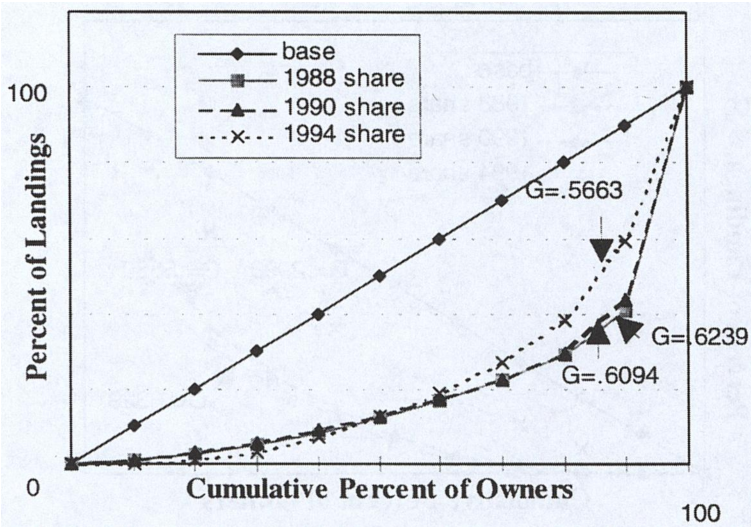

Figure 1. Surf clam fishery: Lorenz curves for landings, 1988, 1990, 1994.

Lorenz Curves for the surf clam fishery were constructed for 1988, 1990 and 1994. As shown in Table III and Figure 1, the Gini Coefficient (G) for 1988 for the surf clam fishery is 0.6239. In 1990, G equals 0.6094, and in 1994, G equals 0.5663. Figure 1 shows that the distribution of landings in the surf clam fishery became more equal over time. Similar results are obtained in the ocean quahog fishery (Figure 2). Gini Coefficients suggest that landings distribution became much more equal in the ocean quahog fishery since the implementation of the ITQ system. In 1988, $G = 0.6329$, in 1990, $G = 0.5820$, and in 1994, $G = 0.2996$. The gain in equality in the ocean quahog fishery has been more pronounced than in the surf clam fishery. The results from the four-firm concentration level analysis are consistent with those of the Lorenz Curve/Gini Coefficient analysis. They suggest that oligopoly or monopoly power does not exist in the market for landings of either surf clams or ocean quahogs. However, these statistics do not involve a structured test of the existence of monopoly power and do not provide conclusive evidence of such power. The Bertrand model on the other hand, is a structural statistical test for monopoly power. The results are presented next.

OLS estimates of the Bertrand model in Equation (11) for the surf clam and ocean quahog fisheries are presented in Table IV. The R-Square for the surf clam model is 0.5530 and there are 4,631 observations in the data set. In contrast, the R-Square for the ocean quahog model is 0.0173 and there are 5,924 observations in the data set. The low R-Square for the ocean quahog regression casts doubts on the reliability of the estimates and suggests that there are many other factors that may influence price.

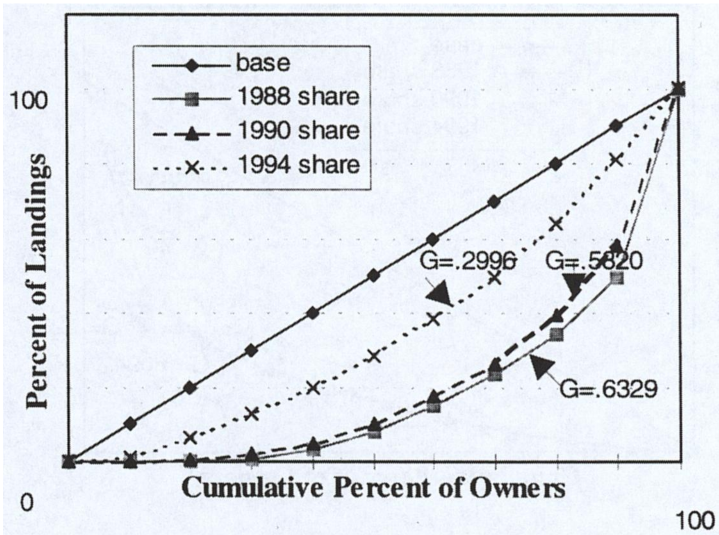

Figure 2. Ocean quahog fishery: Lorenz curves for landings, 1988, 1990, 1994.

Table IV. Estimated coefficients of factors that determine price per bushel received in the 1993–1994 surf clam and ocean quahog fisheries

Variable name	Surf clam regression: Parameter estimate (standard error)	Ocean quahog regression: Parameter estimate (standard error)
Intercept	*1.958 (1.110)	*3.727 (0.098)
OWNSHR	*−34.975 (0.937)	−0.143 (0.177)
SUBSTPR	*3.400 (0.297)	*0.058 (0.008)
NUMOWN	*−0.068 (0.011)	*−0.047 (0.006)
HP	*−0.019 (0.001)	*−0.001 (0.000)
LEASEAMT	*−2.948 (0.146)	0.045 (0.031)
OWNAMT	*42.444 (2.600)	−0.197 (0.282)

* Statistically significant at the 0.10 level.

The signs and magnitudes of the estimated coefficients are similar for the two fisheries. Perhaps the most striking result is the fact that the total effect of vessel owner's share of landings on price is negative for both fisheries. For the surf clam fishery, $\delta p_i/\delta s_i = -42.4$ (LEASEAMT) and for the ocean quahog fishery, $\delta p_i/\delta s_i$ is not statistically significant.[5] The LEASEAMT variable always lies between zero

[5] The calculated t value for the sum of the coefficients of OWNSHR and OWNAMT (for the surf clam regression) is −1.29; the critical t value for a 0.10 level of significance is −1.282, suggesting that the summed parameter estimate is statistically significant.

and one. Hence, the total effect of owner's share on price will always be negative. Also, as LEASEAMT increases, the relationship between owner's share of landings and price received for those clams becomes less negative. The hypothesis of market power is therefore rejected in the cases of surf clam and ocean quahog.

The coefficient for LEASEAMT in the surf clam regression is negative as hypothesized, suggesting that the greater the proportion of landings for which ITQ is leased, the lower the price received. The positive parameter estimate for OWNAMT (the cross-term between OWNSHR and LEASEAMT) in the surf clam regression also indicates that although monopoly power is absent, as the ratio of leased to owned quotas increases, monopoly power may eventually develop. The vessel owners who received large ITQ shares at the initial distribution over the years found it beneficial to build up their operations by leasing (not buying) more quota share from those who found it in their best interest to leave the harvesting sector of the fishery. One should be concerned about eventual monopoly power among this group.

In both the surf clam and ocean quahog fisheries, a positive relationship exists between substitute price (SUBSTPR) and own price. Because supply is determined by the overall quota set by the Mid-Atlantic Fisheries Management Council, it is assumed that the upper limit of supply is fixed. Therefore, changes in price largely would occur through shifts in demand. The positive sign observed confirms the fact that surf clams and ocean quahogs were substitutes in 1993 and 1994, the years of this analysis, even though historically they have had distinct although overlapping market niches and levels of demand.

In both fisheries, the horsepower coefficient (HP) is statistically significant and negative. As the percentage of vessels owned with horsepower greater than 400 increases, the price received for the landed clams declines. This is consistent with the notion that larger, more efficient firms generate cost savings which can be transferred to the buyers. However, it refutes the notion that price advantages accrue to owners of larger, more powerful vessels.

The coefficients for NUMOWN (number of owners in the fishery) are negative for both fisheries, suggesting that when fewer participants are in the fishery, vessel owners will generally be able to command higher prices. Although smaller numbers of firms may be able to charge higher prices, this does not necessarily imply that monopoly power exists in this fishery. When looking at the partial derivative of price with respect to owner's share, and the descriptive statistics presented above, one concludes that, at present, market power does not exist in the landings market.

V. Conclusion

The results show that with reduced numbers of vessel owners in the SCOQ fisheries, vessel owners generally are able to command higher prices (NUMOWN coefficient). However, there is no significant positive relationship between owner's share of landings (OWNSHR), which is here taken to indicate firm size, and ex-vessel price, which would be expected if some type of monopoly power were being exercised by the large firms. Moreover, descriptive statistics show that the firms with the highest market shares were strongly inclined to receive relatively low prices for both surf clams and ocean quahogs.

It would appear that market power is generally absent from the SCOQ fishery of the U.S. However, the results of the Bertrand model suggest that if the large operators continue to expand their control of quota shares (as distinct from landings shares) by leasing, the competitive climate in the surf clam fishery may be compromised. Moreover, the lack of price responsiveness to vessel owner's share of landings may be due to factors that are not included in this analysis, including the possibility that vertically integrated firms are likely to offer lower ex-vessel prices to their own vessels than to independent vessels. It should also be noted that the Bertrand model was employed only for the years 1993–1994 because of inconsistencies in available price data. A longer period of analysis as well as one that incorporates data on buyers and their market positions may have different results.

Finally, the analysis conducted in this study is of market power on the seller side (vessel owners). The analysis is silent about the possibility of monopsony power that may result from the fact that there is a limited number of buyers in the market. As of 1990, 22 distinct buyers existed in the fishery and this number fell to 17 by 1994. There is also the possibility of monopsony power resulting from vertical integration. These issues have not been pressing issues for policy makers and researchers because what has been dramatic is the decrease in the number of sellers. An investigation of the absence of presence of monopsony power will eventually be useful in understanding the SCOQ fishery.

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