The Demand for Relaying by the Louisiana Oyster Industry

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Abstract. Oyster relaying is one of the means by which oystermen increase the net return from their leases. Using a Poisson regression model, this research evaluates the factors affecting the demand for relaying permits by the oyster industry in Louisiana, the nation's leading oyster producing state. Economic factors and prevailing environmental conditions were found to significantly influence the number of permits demanded.

Keywords: Oysters, Relaying, Poisson regression, Louisiana.

1. INTRODUCTION[1]

Molluscan shellfish are known vectors of infectious and sometimes dangerous diseases. Human consumption of these shellfish products can pose a substantial risk to the consuming public because molluscan shellfish are often eaten raw or partially cooked. In an effort to protect public health, the coastal (estuarine) waters are surveyed according to guidelines established by the National Shellfish Sanitation Program (NSSP).[2] The surveys, which monitor fecal coliform counts, cover 4,230 individual shellfish growing areas in the 21 coastal states.

The purpose of surveying is to classify the waters, again according to the guidelines established by the NSSP, for harvesting purposes. The shellfish growing areas are classified as approved for harvest or as one of four harvest-limited categories: (1) conditionally approved, (2) restricted, (3) conditionally restricted, or (4) prohibited. The approved classification refers to growing waters from which shellfish may be harvested for direct marketing (i.e., fecal coliform levels are below some prescribed amount). The conditionally approved classification refers to growing waters that meet approved classification standards under predictable conditions (e.g., the river stage above some level will trigger the closure of shellfish grounds). The restricted classification refers to shellfish growing waters that may be harvested only if they are relayed or depurated before direct marketing. The conditionally restricted classification refers to growing waters that do not meet the criteria for restricted waters if subjected to intermittent microbiological pollution, but may be harvested if shellfish are subjected to a suitable purification process. The prohibited classification refers to growing waters from which shellfish may not be harvested for marketing under any conditions. Classified U.S. estuarine shellfish growing waters for 1974 and 1995, expressed in thousands of acres, are presented in Table 1.

Table 1:U.S. Shellfish Estuarine Waters Classification Trends, 1974 and 1995 (1,000 acres).[a]

	Year		% Change
Classification	1974	1995	1974 -95
Approved	10,560	14,853	+40.6
Conditionally Approved	387	1,695	+438
Restricted	34	2,106	large
Conditionally Restricted	na	119	---
Prohibited	3,811	2,801	-26.5
Total Harvest Limited	4,232	6,720	+58.8

[a] Does not include classifications of offshore growing areas and/or unclassified waters. Source: U.S.D.O.C. (1997)

1 Much of the Introduction relies heavily on the publications by National Oceanic and Atmospheric Administration (1998) and the United States Department of Commerce (1997) .

2 The National Shellfish Sanitation Program is a cooperative and voluntary alliance between states, the U.S. Food and Drug Administration, and the shellfish industry.

As indicated, shellfish growing waters approved for harvest expanded from about 10.6 million acres in 1974 to 14.9 million acres in 1995; an increase of almost 40%. Harvest limited acreage during the same period increased almost 60%; from 4.2 million acres to 6.7 million acres.
Restricted and conditionally restricted acreage accounted for one-third of the total harvested limited acreage in 1995.[3] Increased relaying activities from conditional and restricted waters is often advocated (and practiced) as a means of enhancing shellfish production in the coastal U.S. states and in many other countries. Relaying activities can be categorized by type of water bottom. First, in the case of publicly owned water bottoms, relaying activities involving the movement of shellfish from restricted public grounds to approved public grounds can be practiced (e.g., Florida has practiced this procedure). Second, in the case of mixed public and private ownership of water bottoms, relaying activities involving the movement of shellfish from restricted public grounds to approved private grounds (i.e., leased grounds) can be practiced. Finally, if private ownership of water bottoms is prevalent, relaying activities can entail movement of shellfish from leases in restricted waters to leases in approved waters.

Since about one-third of the U.S. shellfish harvested limited acreage is classified as restricted, there appears to be considerable potential for enhancing shellfish production and economic returns via increased relaying activities.[4] Despite this potential, economic analysis of the issue is sparse (see Easley, 1982, and Ajuzie and Altobello, 1997 for two exceptions, largely based on theoretical considerations). The goal of this paper is to contribute to the economic body of literature on this subject by empirically estimating whether relaying activities are motivated by economic factors and, if so, to what extent. The analysis is based on the lease-based industry in Louisiana and covers the 1976-98 period. Specifically, economic and environmental factors influencing relaying from leases in restricted waters to leases in approved waters are examined.

To achieve the goal noted above, the next section of the paper provides a brief overview of Louisiana's oyster industry and relaying activities. Then, the model developed for estimation purposes is presented along with the relevant statistics used in the analysis. The empirical results and related discussion are presented in the last section of the paper.

2.LOUISIANA'S OYSTER INDUSTRY AND RELAYING ACTIVITIES

2.1 Louisiana's Oyster Industry

Louisiana is generally the highest oyster producing state in the United States. Its landings tend to fall in the 8-12 million pound range though landings in excess of 13 million pounds are not uncommon (Figure 1).

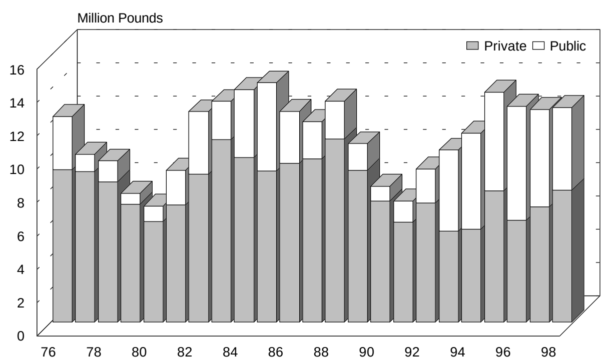

Figure 1: Private and Public Oyster Production in Louisiana

Louisiana's oyster fishery is primarily a lease-based industry. About 400 thousand acres are currently under lease (compared to less than 250 thousand acres during the mid-1970's and early 1980's) and production from these private leases has averaged about eight million pounds annually since the mid-1970's. Overall, the relative long-run stability in production from these leases (see Figure 1) in conjunction with the increasing acreage suggests that the average productivity per acre leased has fallen sharply during the past two decades.[5]

In addition to the private grounds (i.e., leased acreage), Louisiana also maintains considerable acreage devoted to public seed grounds and oyster seed ground reservations.

3 Not all states use all classifications and the use of the restricted classification was used by only a few states in 1974.

4 It is noteworthy that the fractions of acreage approved for harvest varies substantially by region. Along the Atlantic coast, for instance, more than 80% of all shellfish growing areas are approved for harvest. Less than one-half of the acreage in the Gulf of Mexico and West Coast regions, however, are approved for harvest.

5 See Keithly et al. (1992) for a detailed discussion of the legislation which enables leasing activities in Louisiana.

These public seed grounds, which tend to be further offshore than leases, include the most productive natural reef area east of the Mississippi River and encompass some 896 thousand acres in total (Perret et al., 1991). These public seed grounds are open from approximately seven months each year (September through the following March) and serve two purposes to the commercial oyster harvesters. First, they provide a source of seed oyster that can be transplanted by lessees to their individual leases for harvest at a later date.[6] Second, market sized oysters harvested from the public grounds (i.e., three inches or more) can be marketed directly with no intermediate transplanting requirements.

Production of market oysters from the public seed grounds has averaged just over three million pounds annually since 1977, or a little more than a third of the average annual harvest derived from the private leases. Since 1993, however, market oyster production from the public grounds has averaged well over five million pounds annually. The increased production from the public grounds in recent years reflects two factors. First, environmental conditions have been favorable for oyster growth on public grounds in recent years.[7] Second, a major restoration effort, entailing the diversion of fresh water from the Mississippi River to the wetlands east of the Mississippi River (the Caernarvon Diversion Project), was completed in the early 1990's. The operation of this diversion structure has, it is reported, significantly restored the state's most productive seed grounds by reducing salinity conditions on these grounds.

Louisiana, which accounts for almost one-fifth of the nation's total estuarine shellfish growing waters, has a very large percentage of harvest limited acreage. According to the 1995 *National Shellfish Register*, a total of 2.1 million acres of Louisiana estuarine waters (both public and private grounds) were classified as approved. More than one million acres were classified as restricted while more than one-half million acres were classified as prohibited.[8] While statistics pertaining to classified leased acreage are not readily available, there is evidence that approximately 40% of leased acreage is classified as conditional or restricted (see Whitrock, 1999 for details).

2.2 Relaying Activities

In order to relay oysters in Louisiana, one must first apply for and receive a permit from the Louisiana Department of Health and Hospitals. The cost of the permit is nominal, approximately $50, but the applicant is also required to post a security bond of $5,000 which is returned if no violations are detected during the relaying process. In general, the permits are valid for a two week period.

Two types of relaying activities are practiced in the state of Louisiana. The first is generally referred to as an experimental or controlled relay. Relays of this nature are conducted only infrequently. The second type of relaying activity, which serves as the focus of this paper, is referred to as the "regular" relay. This entails the movement of oysters from a leases in conditional or restricted waters to leases in approved waters.[9] As indicated in Figure 2, permits issued for "regular" relaying activities were consistently less than 40 per year from 1976 until the mid-1980's. The number of permits issued then advanced rapidly, peaking at over 100 in 1987. Beginning in 1988, the number fell sharply, though a moderate increase was observed again in 1990.[10]

While considerable more detail is given in the following sections of the paper as to the reasons for the observed

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6 The general 'rule of thumb" is that for every sack of "seed"oyster bedded, the lessee can anticipate the harvest of 1.2 marketable sacks of oysters within the next six to nine months.

7 Oyster growth on the public seed grounds tends to be related to salinity conditions. In "wet" years, when salinity conditions are low, growth of oysters will be high on the public grounds due to less disease (dermo) and less predation. Much of the 1990's can be considered as "wet".

8 The total acreage reported here exceeds, by a large factor, the total amount of public and private acreage reported elsewhere in the paper. This reflects the fact that non-producing water bottoms (i.e., water bottoms that are not natural reefs or leases) are included in the *National Shellfish Register* statistics.

9 Conceivably, this type of relaying could also entail the relaying of oysters from leases in conditional or restricted waters to other leases in conditional or restricted waters. One would expect minimal, if any, activities of this nature because it would then require additional relaying activities before the oysters could be marketed.

10 In some instances, continuations for use of an issued permit were requested and approved. These continuations are not included in the analysis.

annual variation in number of "regular" permits issued, some general observations are presented here. First, the deflated price of the harvested product advanced rapidly during the 1985-90 period but fell sharply in 1991 and has since remained well below that observed during the mid-1980's to 1990 period (see Figure 2). One would hypothesize, *ceteris paribus*, that increases in the deflated price of the harvested product would result in increased relaying activities.

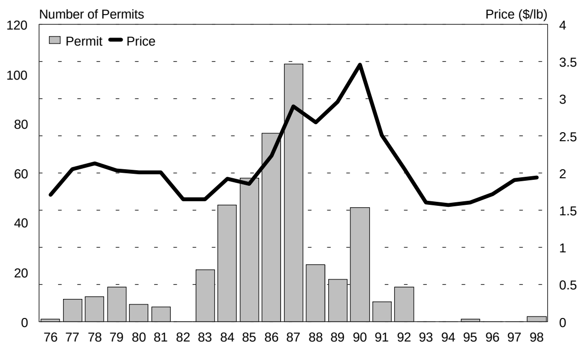

Figure 2. Oyster Relaying Permits and Deflated Price

A second observation regarding the number of permits issued reflects the sharp decline beginning in 1988 even though the deflated price continued to increase through 1990. In 1988, the Louisiana Department of Health and Hospitals initiated a requirement that a security agent be on board any vessel relaying oysters from polluted to approved waters. Given the fact that this requirement would add additional expenses to relaying operations, one would hypothesize that it resulted in the number of permit applications, *ceteris paribus*. A cursory examination of the data suggests this to be the case.

3. MODELING CONSIDERATIONS AND DATA

3.1 Theoretical Considerations

Oyster leases are an asset which are acquired for the purpose of producing market oysters. As such, an oyster lease is no different than, say, agricultural property where the land is an asset used in the production of a crop. The implied goal therefore is the maximization of the discounted stream of returns generated from employment of his property (owned or leased) over an infinite time horizon, or:

$$\max\ (NPV) = \sum_{t=1}^{\infty} \frac{(P_t * Q_t(q) - C_t(Q))}{(1+r)^t} \qquad (1)$$

where:

NPV = net present value of returns from oyster leasing activities;

P_t = the output price of the harvested lease-based oyster product in time period t;

Q_t = the quantity of oyster output from lease-based activities in time period t which in turn is a function of the quality (q) of the asset;

C_t = cost of production in time period t which is a function of output $Q_t(q)$;

r = discount factor;

The net present value of returns, i.e., the discounted profits, are, as indicated, related to the output price (P_t), the output quantity (Q_t) which in turn is related to the quality of the asset (q), costs of production (C_t) and the discount factor (r). As specified, an increase in the output price or quantity will result in an increase in the net present value of returns. Conversely, an increase in costs for a given level of production (due to, say, an increase in input costs) or an increase in the discount factor will result in a decrease in the net present value of returns.[11]

In general, demand for relaying activities can be considered as a derived demand for a factor of production (see Layard and Walters, 1978 for details). As such, demand for relaying activities will be directly related to the ability of these relaying activities to enhance the net present value of returns from oyster farming activities. The implications of this are multifaceted. First, it implies that the demand for relaying activities will increase (decrease) in relation to an increase (decrease) in the output price (P_t), *ceteris paribus*. Second, it implies that the demand for relaying will be positive only to the extent that it will achieve a short-run or possibly long-run increase in the output from lease-based activities (Q_t). A short-run increase in output may be achieved if the relayed oysters are removed shortly after being placed on the approved lease(s). To the extent,

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[11] An infinite time horizon is assumed for discussion purposes. The analysis could be changed, without loss of generality, to allow for the sale of property after a fixed number of time periods.

however, that relaying activities provide attachment material (i.e., the oyster shell and the living community of oysters and the associated fauna of an oyster reef environment), these activities can enhance the long-run productivity of a given lease.

The quantity of oyster output from lease-based activities (Q_t), as specified in equation 1, is a function of quality. Environmental factors, such as the salinity regime, can affect annual, or even long-run quality of a lease. The derived demand for relaying activities as a function of lease quality is, to a large extent, unknown. For example, low potential production on approved acreage in a given year due to, say, an unsuitable salinity regime, may also indicate that potential productivity of leased acreage in conditional or restricted waters is also low. Under this scenario, there would be little benefits from relaying since there would be little product to relay.

A third implication, based on the calculation of net present values as presented in equation 1, is that an increase in relaying costs will result in a reduction in the derived demand for relaying activities, *ceteris paribus*. Specifically, an increase in relaying costs result in an increase in overall harvesting cost, denoted as $C_t(Q)$. This is intuitive in that as relaying costs increase, it becomes less likely that the lease holder will achieve a positive return on his investment from relaying activities. While one generally thinks of costs in terms of inputs to the production process (e.g., fuel, crew, repairs, etc.), there are other costs that should also be considered. One of the most relevant of these other costs is that of opportunity costs. One alternative to relaying is that of transplanting from the public seed grounds. As such, if the availability of oysters (seed and market) on the public grounds is high, the need to relay from polluted to approved leases is diminished. As such, the demand for relaying should, in theory, be inversely related to availability on the public seed grounds, *ceteris paribus*.

Finally, the issue of overall market supply needs to be considered. High volume sales, after controlling for price and environmental factors, may suggest readily available markets as opposed to limited markets whereby quotas may be imposed by individual dealers on the fishermen. The high volume sales associated with available markets may necessitate the need for alternative supply sources by the lease holders. If the leaseholders are not able to secure the needed supply from their leases in approved waters or from the public seed grounds, they may turn to relaying as one method to secure the additional supply. This is of particular relevance when environmental conditions limit availability on leases in approved waters or on the public seed grounds.

3.2 Conceptual Model

Based on the above discussion, demand for oyster relaying activities in Louisiana is specified as follows:

$$Perm_t = \beta_0 + \beta_1{*}Price_t + \beta_2{*}Acres_t + \beta_3{*}Cost_t + \beta_4{*}Avail_{t-1} + \beta_5{*}Salinity_t + \beta_6{*}Public_t + \beta_7{*}Private_t + u_t \quad (2)$$

where:

$Perm_t$ = number of permits issued in year t;

$Price_t$ = deflated Louisiana dockside oyster price in year t (in $/lb. of meat);

$Cost_t$ = discrete variable indicating whether security agent is required (zero before 1988; one thereafter);

$Acres_t$ = acres of water bottoms leased for the cultivation of oysters in year t (in thousand acres);

$Avail_{t-1}$ = indicator of market oyster availability on public oyster grounds in year t-1 (in million sacks);

$Salinity_t$ = wetlands acreage with salinity >10 ppt (in million acres);

$Public_t$ = production of oyster meats from public grounds in year t (million pounds of meat);

$Private_t$ = production of oyster meats from private grounds in year t (million pounds of meat);

$\beta_0, \beta_1, ..\beta_7$ = parameters to be estimated;

u_t = error term.

The model, as given in equation 2, includes seven exogenous variables. The rationale for including the deflated price ($price_t$) has been established. Given that the demand for relaying activities is hypothesized to be positively (negatively) related to an increase (decrease) in price, the sign associated with β_1 is anticipated to be positive.

Costs, as discussed above, are also considered to influence the demand for relaying activities. While a time-series database pertaining to harvesting and relaying costs does not exist, one cost factor, in particular, is hypothesized to influence the demand for relaying permits. Specifically, beginning in 1988, a requirement that a security agent be onboard the vessel when relaying activities are occurring was enacted. This requirement is thought to significantly increase overall relaying costs. To account for this increased cost, a discrete variable ($Cost_t$), equal to zero before 1988 and one thereafter, was included in the model. Given that the demand for relaying is hypothesized to be negatively related to increased costs, the sign associated with β_2 is anticipated to be negative.

Acreage under lease ($Acres_t$) is included in the model to account for the long-run change in quality of the "average" oyster lease. As previously noted, while the amount of water-bottoms being leased has increased substantially during the period of analysis, the long-run oyster production on private leases has remained stable, indicating a substantial decline in the "average" production per acre. This reduction in per acre productivity is hypothesized to be due, in part, to less desirable water-bottoms being leased over time. Specifically, one would expect the more suitable oyster growing areas to be leased initially. Remaining water-bottoms subsequently leased are, therefore, of lower quality on average.[12] Thus, the greater the number of acres leased, the higher the proportion of less desirable or marginal leases. Relaying, which constitutes one of the means of improving the productivity of these marginal leases, is hence hypothesized to be positively related to the number of acres leased. It follows that one would anticipate that β_3 is positive.

Indicators of oyster availability on public grounds in year t-1 ($Avail_{t-1}$) and on private leases ($Salinity_t$) in year t were also included as explanatory variables in the analysis. The indicator of availability on the public seed grounds included both seed oyster and market oyster and was based on square meter samples conducted by the Louisiana Department of Wildlife and Fisheries in August of each year. It is stated in terms of total estimated sacks (i.e., combined seed and market oyster sacks) available on the public seed grounds (in millions).[13] As estimated availability of seed and market oyster on public seed grounds increases, there should, in theory, be less of a need to relay from conditional or restricted water-bottoms to leases in approved waters.[14] Hence, it is hypothesized that the sign associated with the coefficient β_4 is less than zero. The indicator of oyster availability on leased grounds was the estimated amount of wetland acreage throughout coastal Louisiana that had a salinity regime of ten parts per thousand or more in April of each year; expressed in millions of acres.[15]

Finally, variables representing annual production from public grounds ($Public_t$) and private leases ($Private_t$) were included in the analysis. As previously discussed, high levels of sales, after controlling for price and environmental factors, may suggest increased marketing opportunities. High volume sales, in turn, may indicate a need to secure additional sources of product from nontraditional sources. One of these sources is that of relaying oysters from polluted to approved waters. Hence, the expected signs associated with both β_6 and β_7 are hypothesized to be positive.

3.3 Data

Data relative to the number of permits issued annually were obtained from the Louisiana Department of Health and Hospitals. All additional data were provided by the Louisiana Department of Wildlife and Fisheries. Summary statistics for the variables used in this study are provided in Table 2.

Overall the number of relaying permits issued per year ($Perm_t$) averaged 21 and ranged from zero in several years (primarily after 1992) to 104 1987. The standard deviation associated with issued permits equaled 28.

The deflated price per pound of the harvested product ($Price_t$) averaged \$2.11 for the 22-year period ending in 1998 with a range from \$1.57 to \$3.46. Overall, a sharp decline in the deflated price, which can be attributed to *Vibrio vulnificus* based mandatory warning labels and associated negative publicity, was observed after 1990 (see Keithly and Diop for discussion of the impacts of *Vibrio vulnificus* on the Gulf of Mexico dockside oyster price).

12 While this is the case, on average, there are certainly exceptions. Due to wetlands erosion and subsidence, for example, many historically productive areas are now likely to be of little value in terms of their ability to produce significant quantities of oysters.

13 Only the data for the public seed grounds east of the Mississippi River (i.e., Breton Sound seed grounds) was used in the analysis.

14 As indicated, the indicator of availability on public seed grounds was lagged by one period in the analysis. This reflects the fact that the survey taken to estimate availability is conducted in August of each year and harvesting activities for either seed or sack production is permitted from about September through the following March. Hence, it is the estimate of availability from time period t-1 that will largely influence relaying activities in time period t.

15 It is generally believed that an extended salinity regime of less than five ppt. results in high mortality rates. The data required to construct a variable using the five ppt. criteria, however, was not available for the current study.

Table 2: Summary Statistics

Variable	Mean	Std Dev
Permit	21.00	28.05
Price	2.11	0.49
Acres	309.95	62.51
Avail	1.33	1.66
Salinity	1.46	0.51
Public	3.13	1.98
Private	7.99	1.67

Annual oyster production from leased acreage ($Private_t$), which averaged eight million pounds annually during 1977-98, exhibited a range from about five million pounds to almost 11 million pounds. Annual production from the public seed grounds ($Public_t$), by comparison, averaged only 3.1 million ponds and ranged from less than one million pounds to almost seven million pounds.

Acres leased for the purpose of growing oysters averaged about 300 thousand annually during the period of analysis and ranged from 213 thousand to almost 400 thousand. In general, leased acreage increased monotonically during the period of study.

Finally, acres of wetlands with a salinity level in excess of 10 parts per thousand (i.e., an indicator of oyster availability on private leased grounds) ranged from one-half million to 2.8 million and averaged about 1.5 million. By comparison, the indicator of oyster availability on the public seed grounds (i.e., estimated number of seed and market sacks based on square meter samples) ranged from almost no sacks (primarily in the early 1990's) to almost five million sacks (occurring in the mid-1990's).

3.4 Statistical Considerations

In the model specified in equation 2, the dependent variable, i.e., the number of relaying permits issued annually, takes only non-negative integer values. Under these conditions, the Poisson regression model, in lieu of ordinary least squares, is the appropriate modeling approach. Detailed presentations of the Poisson regression model can be found in Greene (1993;1998) and Long (1997). The brief presentation of the Poisson regression model provided below draws from Greene (1993).The Poisson regression model can be written as:

$$\Pr ob(Y_i = y_i) = \frac{e^{-\lambda_i} \lambda_i^{y_i}}{y_i!} \;; \ln \lambda_i = x_i \beta \qquad (3)$$

with y_i= 0,1,2,3...; y_i and x_i are the dependent variable and the explanatory factors used, respectively. Marginal effects are given by:

$$\frac{\partial E[y_i | x_i]}{\partial x_i} = \lambda_i \beta \qquad (4)$$

The corresponding log likelihood function to maximize is:

$$\ln L = \sum_i \left[-\lambda_i + y_i x_i \beta - \ln y_i! \right] \qquad (5)$$

Goodness of fit statistics such as the Pearson χ^2 can be used to derive R^2 measures. The Pearson χ^2 and the Pearson-based $R_p^{\ 2}$ are given in equations (6) and (7), respectively.

$$\chi^2 = \sum \frac{(y_i - \lambda_i)^2}{\lambda_i} \qquad (6)$$

$$R_P^2 = 1 - \left[\frac{\chi^2}{\sum_i (y_i - y^*)^2 / y^*} \right] \qquad (7)$$

where y* is the maximum likelihood estimator for λ_i.

4. RESULTS AND DISCUSSION

4.1 Results

The model was estimated by maximum likelihood using Limdep version 7.0. (Greene, 1998). The Cameron-Trivedi (1990) test performed did not indicate the presence of overdispersion[16]. Poisson estimation results are presented in Table 3. Results include parameter estimates, marginal effects ,corresponding standard errors and goodness of fit measures.

Table 3: Poisson Estimation Results

Variable	Estimate (Std Error)	Marginal Effect (Std Error)
Constant	-2.597* (0.749)	-----
Price	1.1069* (0.187)	23.3* (6.5)
Acres	0.0067** (0.003)	0.14 (0.10)
Cost	-1.559* (0.207)	-32.8* (7.2)
Avail	-1.039* (0.156)	-21.8* (5.4)
Salinity	0.396* (0.115)	8.3** (4.01)
Public	0.292* (0.058)	6.1* (2.0)
Private	0.110** (0.048)	2.3 (1.6)

Log Likelihood = -66.9; $R_p^{\,2}$ = 94.1%
*statistically significant at the 0.01 level;
**statistically significant at the 0.05 level.

As suggested by the likelihood ratio test performed (calculated $LR\chi^2$=618.7 with 7 degrees of freedom), the Poisson model is significant at the 0.01 level. The Pearson-based $R_p^{\,2}$ indicates that 94.1 percent of the variation observed in the number of relaying permits issued annually is explained by the regression model proposed. All parameter estimates are statistically significant and conform to theoretical expectations with respect to parameter sign. Given the fact that no previous research has been conducted in this area, the magnitude of the current parameter estimates cannot be compared with results from previous research exercises to ascertain conformity across research studies.

A one dollar increase (decrease) in the deflated dockside price of the harvested product in year t was found to result in an increase (decrease) in 23 permits demanded. The results also indicate that the requirement of a security agent onboard the vessel when relaying activities are occurring ($Cost_t$) significantly influences the overall level of relaying activities. Specifically, the security agent requirement resulted in a reduction in the number of permits demanded by 33, *ceteris paribus*.

Acres of water bottoms leased by the state for the cultivation of oysters ($Acres_t$) was also found to influence the demand for relaying activities. Overall, the results suggest that each additional thousand acres taken for the purpose of cultivating oysters results in an increase in 0.141 permits demanded. Leased acreage during the period of analysis, as previously noted, advanced from 213 thousand to 398 thousand, or by 185 thousand. Holding all other factors constant (and at their mean value), this implies a total increase in demand equivalent to 26 permits.

An increase (decrease) in estimated availability of seed and sack oysters on the public grounds ($Avail_{t-1}$) was found to significantly reduce (increase) the demand for relaying activities in the current year. Overall, each additional million sacks of seed or market oysters was found to result in a reduction in relaying demand equivalent to almost 22 permits, *ceteris paribus*. The indicator of oyster availability on private grounds ($Salinity_t$) was also found to be statistically significant and increased availability on the private grounds was found to negatively influence the demand for relaying activities, *ceteris paribus*.

The results suggest that a one million pound increase in market oyster production from public seed grounds ($Public_t$) results in an increase in demand of 6 permits while an equivalent increase in production from private leases ($Private_t$) results in an increase in demand for only 2 permits. The large difference between these two estimates may reflect the fact that when market production from public grounds is large, time allocated for transplanting seed oyster from the public beds to the private leases is diminished. As a result, the need to relay from restricted leases to approved leases during that portion of the year that the public seed grounds are closed is enhanced.

4.2 Discussion

Overall, the results support the hypothesis that economic and environmental factors largely determine the demand for relaying activities. Specifically, the analysis helps to explain the observed trend in Louisiana's relaying activities

[16]For detailed presentations of dispersion tests for Poisson regression models, see Dean and Lawless (1989) and Cameron and Trivedi (1990).

over the past two decades. Increased relay activities during the early-to-mid 1980's reflects two primary factors. First, the deflated dockside price of the harvested product increased substantially during the time frame. Second, abundance on the public seed grounds was extremely low due to the drought conditions in the state at the time. Conversely, the decline in relaying activities during much of the 1990's reflect reflects several factors. First, the required security agent aboard the vessel negatively impacted the demand for permits. Second, the sharp fall in the deflated price of the harvested product further reduced the demand for permits. Finally, estimated abundance of oysters on the public grounds was abnormally high which dampened the demand for permits by and even greater extent.

While controlling environmental factors that influence relaying activities is, by and large, outside the control of management agencies, development of options to control economic factors, particularly costs, may be feasible. Controlling costs will, under optimal conditions, encourage increased relaying activities.

Finally, Louisiana's shellfish situation relative to that in some of the other states warrants discussion. Relaying is not commonly practiced in Louisiana, as noted, likely due, at least in part, to the extremely large amount of growing waters available in the state. In other states, suitable growing waters are less abundant and, hence, dependence on relaying and other shellfish-production enhancement activities are of higher relevance. As noted in a recent report (NOAA, 1998) "[t]he presence of shellfish growing waters suitable for harvest does not necessarily correlate with the quantity of shellfish landings. For example, in 1995, the state of Louisiana had almost 14 times as much classified acreage as did the state of Washington. Yet, through intensive aquaculture, shellfishermen in Washington landed 32 pounds of oysters per acre, while compared to four pounds per acre in Louisiana." Hence, while relaying activities in Louisiana may not contribute significantly to production due to favorable shellfish-growing conditions in the state, relaying may be of considerably greater importance in other, less environmentally conducive, states.[17]

[17]Ajuzie and Altobello (1997) suggest that about 80% of Connecticut's marketed oysters are derived from relaying activities. In this situation, however, relaying involves the movement of oysters from public to private grounds.

5. SUMMARY AND CONCLUSIONS

Through relaying, oystermen can increase the revenues drawn from their private leases. This study evaluated the main factors influencing the demand for relaying permits in Louisiana. The Poisson regression model proposed suggested that economic and environmental factors significantly affect the number of relaying permits demanded. Significant economic factors included oyster prices, public and private production levels. Salinity conditions and oyster availability on public water bottoms were identified as significant environmental factors. While the demand for permits is currently very limited in Louisiana, future price increases and changes in the favorable oyster growing conditions prevailing in the state may result in increased demand for relaying permits.

6. ACKNOWLEDGMENTS

The research reported herein resulted from the Coastal Economy Strategy Development Project, conducted by Louisiana Sea Grant and partially funded by the U.S. Economic Development Administration, May 1998.

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