A Synthesis of Cost and Revenue Surveys for Gulf of Mexico Shrimp Vessels

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Introduction

The change in operating costs relative to revenues creates an economic incentive for fishermen to alter their levels of fishing effort. The cumulative effect of individual fishermen responding to fluctuating market conditions is a change in both the number and the fishing power of vessels in the fleet. Monitoring the impacts on fleet size of long-run trends in relative costs has been difficult because comprehensive time series cost data are not routinely collected for vessels operating in any of the U.S. southeast region fisheries.

In the case of the shrimp fishery, a number of cost and revenue survey studies have been conducted under the auspices of the National Marine Fisheries Service (NMFS), Sea Grant, and other public and private institutions and organizations. Since these studies were designed to meet specific short-term objectives, their results are not directly comparable because of differences between the surveys. Information from the individual studies can be incorporated in a generalized least squares regression technique to estimate comparable cost and revenue trends, relative costs, and the financial performance of fishing firms operating in the Gulf of Mexico shrimp fishery during the period 1971 to 1980.

Review of Published Cost and Revenue Data

Differences underlying the cost and revenue surveys prevent direct comparisons of their results. Each report surveyed a particular and, in some cases, distinct subset of vessels in the shrimp fleet, resulting in different sample variances. The magnitude of these differences can be seen in the range of the reported means, variances, standard deviations, and other descriptive statistics. For example, mean total revenue for surveyed vessels was reported as \$60,142 (Warren and Griffin, 1978) and \$9,214 (Duffy and Johnson, 1979). In addition, the sample sizes of the surveys ranged from 1 (Anonymous, 1977) to 115 vessels (Griffin et al., 1976). Vessel characteristics also varied between reports. Vessel length ranged from <24 feet (Duffy and Johnson, 1979) to >70 feet (Griffin et al., 1974). Vessels operated out of Texas (Swartz and Adams, 1979), Louisiana (Roberts and Sass, 1979), and Florida (Blomo and Griffin, 1978). The surveys concentrated on different areas of operation (inshore fisheries vs. offshore fisheries) and were generally restricted to a single year.

Another cause of variation in the reports is the exclusion of information on vessel ownership. The cost structure of a single vessel, owner-operated firm could conceivably be different from the cost structures of vertically integrated, horizontally integrated, or nonowner operated firms. The single vessel, owner-operated fishing firms may maximize the income of a fisherman while the vertically integrated fishing firm may operate at a loss to ensure a continuous supply of fish to the parent company or to maximize profits at some other level within the firm. The reports also did not provide information on the quantity of factor inputs used in the production process such as gallons of fuel or trawl size, and the survey results were reported in current rather than constant or real dollars.

As a result, comparisons of these studies do not provide any information on long-term trends in costs relative to revenues in the shrimp fishery. As an example, consider the comparison of 66-72 foot vessels operating off the coast of Texas (Griffin, et al., 1974) with vessels 24 feet or less in length operating in the bays and rivers of Louisiana (Duffy and Johnson, 1977). Although both studies reported costs and revenues for shrimp vessels, meaningful conclusions cannot be drawn about the long-term trends in the fishery because no common denominator exists between the two reports.

Cost and revenue trends, however, are contained implicitly in the survey data. For example, changes in the cost and revenue structure of the firm from the utlization of a new production technology would have been implicitly represented in the published survey results for that point in time. If these changes are assumed to affect the cost and revenue structures of all firms similarly, then these trends can be used as the common denominator to estimate costs and revenues based on historical data, to interpolate missing values, and extrapolate future values. The differences in the sample variances of each study can be accounted for in a weighted least squares regression analysis (Draper and Smith, 1981:108-109). A set of equations can be estimated from the combined survey results weighted by the sample size of the study. Since weighted least squares corrects for the unequal variances of the observations

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Table 1.—Estimated trend line equations[1].

Dependent variables	Constant	LYR	FA	FB	DG	DL	D	D1	LTP	TD	SD	IOS	F. Stat	r-squared
Total Revenue LTR	−38.8981	11.2953		−0.4728	0.1472	−0.2853	1.1702	−1.7238	0.261	−0.1861	0.3026	−0.272	1178.25	
		(9.609)		(9.67)	(4.85)	(6.89)	(34.90)	(36.90)	(5.40)	(2.64)	(3.79)	(7.01)		0.915
Effort Expense LEE	−0.1354	2.1833		0.1754	0.2218		1.1351	−1.4509		−0.199		0.0996	1156.18	
		(5.34)		(8.17)	(8.31)		(43.90)	(29.28)		(8.25)		(3.67)		0.881
Total Variable Cost LTVC	−19.5297	6.7242		−0.1117	0.1746	−0.3569	1.1657	−1.0893	0.2491	−0.2213		−0.2343	1689.03	
		(7.90)		(3.92)	(6.52)	(9.54)	(38.35)	(25.80)	(5.74)	(3.48)		(6.69)		0.933
Fixed Cost LFC	−51.8255	13.8378	−0.5743		0.2213	−1.4575	1.6983	−2.0518	0.4303	0.2087	−0.5163	0.1869	2142.24	
		(14.42)	(2.95)		(5.65)	(27.80)	(41.06)	(34.22)	(7.56)	(2.60)	(2.58)	(3.82)		0.951

[1]The L prefix to the variable names indicates that it has been transformed to a natural logarithm.
YR: Year the survey was conducted.
FA, FB: Above average (1,0), average (0,0), or below average (0,1) fishing year.
DG, DL: State in which survey was conducted (Texas (1,0), Louisiana (0,1), or West coast Florida (0,0)).
D, D1: Vessel size categories (>50 ft. (1,0), 25-50 ft. (0,0), or <25 ft. (0,1)).
TP: Annual trips by vessel size category.
TD, SD: Source of trip data (NMFS data prior to 1976 (0,1), NMFS data from 1976 to 1980 (0,0), and published survey reports (1,0)).
IOS: Inshore vs. offshore area of vessel operations.

in the pooled data base and the estimated regression equations are based on a common probability distribution, the cost and revenue estimates for vessels operating in the Gulf of Mexico shrimp fishery are comparable.

The Econometric Model

Cost and revenue data from vessels participating in the Gulf of Mexico shrimp fishery were used in a weighted least squares regression analysis. To provide a consistent set of data for estimating cost and revenue trend lines, the survey data were organized into categories reflecting total revenue (TR), the value of the shrimp harvested by the vessel; catch expense (CE), the labor component of variable costs that is directly related to the level of harvest; effort expense (EE), the remaining variable costs that are caused by the fishing activity; total variable cost (TVC), the cost that accrued to the firm due to the level of fishing activity; fixed cost (FC), the overhead expense that accrued to the firm regardless of the level of fishing activity; and total cost (TC), the sum of variable and fixed costs. The total revenue and catch expense categories were adjusted for inflation to a 1977 base year by the producer price index (PPI) for meat, poultry, and fish; effort expense by the intermediate materials and supplies PPI; and fixed costs by the agricultural machinery and equipment PPI. Real variable cost was calculated as the total of adjusted catch and effort expense, and real total cost was the sum of adjusted fixed cost and real variable cost.

These real costs and revenues (dependent variables) were regressed against quantitative and qualitative (dummy) independent variables (Draper and Smith, 1981:3, 71) to explain the variation in the cost and revenue structure of shrimp fishing firms. The independent variables were created from information primarily provided by the published survey results and augmented with data collected by NMFS on the Gulf of Mexico shrimp fisheries. Based on the historic catch and revenue information maintained by NMFS for the shrimp fishery and the economic theory of the firm utilizing a common property resource, a logarithmic functional form (Chiang, 1974:301-303)[1] for the model should provide the best statistical fit to the combined survey data. The historical information indicates that the mean shrimp catch appears to have reached a horizontal asymptote with respect to the factor inputs and technology used in the production process. Since real total revenue received by the firm is determined in part by the quantity produced, the revenue trend lines should conform to the shape of the production function. The cost trend lines should also conform to a logarithmic functional form since the surveys collected cost information from firms that have already reacted to the economic signals in the marketplace and are at or near the theoretical equilibrium where average cost equals average revenue for a common property resource. Even though the actual, underlying cost and revenue functions are not estimated, both the cost and revenue trend lines should conform to the general shape of the production function constraint that appears to be best explained by a logarithmic function. The natural logarithms of the dependent and independent variables[2] were used in a weighted least squares regression analysis, and the results are presented in Table 1. The coefficient of determination adjusted for the

[1]Alternative inherently linear functional forms were also fitted to the data, but the logarithmic function provided the best statistical fit.

[2]Since the natural logarithm of zero is undefined, care must be taken in transforming dummy variables to correspond to a logarithmic function. The data base can be altered so that the dummy variables have values of 1 and 2.718 that are transformed by natural logarithms to 0 to 1, respectively. The resulting regression coefficients, however, provide the same result as that derived when the coefficient and the unaltered dummy variable data (0 and 1) are used in the transformed linear logarithmic model.

degrees of freedom (R^2) range from 88.1 to 95.1 percent and the reported F statistics indicate that each equation is statistically significant.

The coefficients provide empirical estimates of the change in costs and revenues due to a unit change in the independent variables. The (LYR) variable represents the year in which the published survey was conducted and has a statistically significant, positive impact on both the level of operating costs and revenues. The value of the coefficient indicates the increase in the estimated value of revenue or cost for each one year increment in time. Since these data were adjusted for inflation by the PPI, the (LYR) variable was expected to be insignificant. This variable may have acted as a proxy variable, however, being correlated with important omitted descriptive variables in the specification of the model. These omitted variables could be the actual physical quantities of the factor inputs consumed in the fishing operation, changes in the production technology, or changes in the stock of fish being harvested.

The qualitative variables (DG) and (DL) indicate the region within the Gulf of Mexico where the studies were conducted. If the survey was conducted for vessels operating out of Texas, (DG=1) and (DL=0); Louisiana, (DG=0) and (DL=1); and west coast of Florida, (DG=0) and (DL=0). The coefficients of these variables indicate that vessels operating out of Louisiana had lower real revenues and costs than vessels operating out of Florida or Texas. Also, Texas vessels had higher revenues and costs than vessels operating in Louisiana and Florida. These variables could be reflecting differences between regions in vessel characteristics and perhaps in the size or species of shrimp landed. The coefficient of a related variable (IOS), which separates inshore (IOS=1) from offshore (ISO=0) areas of operation, indicates that the variable costs and the total revenue for inshore operations were lower than those offshore. The lower inshore variable costs may be caused by the lower catch expense, which like revenue would be reduced if catch rates or prices were lower for inshore fisheries. Since these variables are highly correlated, suggesting the existence of multicollinearity, care should be taken in interpreting the individual coefficient's effect on the dependent variable (Intriligator, 1978:151-156).

The variables (D) and (D1) separate the survey data into size categories reflecting the reported vessel hull lengths of >50 feet, (D=1) and (D1=0); between 25 and 50 feet, (D=0) and (D1=0); and <25 feet, (D=0) and (D1=1). The estimated coefficients indicate that >50 foot vessels had higher costs and revenues and <25 foot vessels had lower costs and revenues than 25-50 foot vessels. The change in the adjusted coefficient of determination (not reported here) indicated that the vessel length variables explained between one-third and one-half of the variation in the cost and revenue data. Costs and revenue, therefore, appear to vary more by vessel length than by any other independent variable. This may be caused by a high correlation between vessel length and other vessel characteristics, such as horsepower, length of trip, and amount of gear.

The type of fishing year variables (FA) and (FB) represent above average fishing years, (FA=1) and (FB=0), average fishing years, (FA=0) and (FB=0), and below average fishing years, (FA=0) and (FB=1)[3]. The coefficient for (FB) suggests that total revenue falls in below average fishing years probably as a result of declines in catch, price per pound landed, or some combination of both. The increase in effort expense may be the result of attempts by fishermen to maintain their market share of the harvest. The decline in variable costs probably results from a decline in the catch expense that would occur for reasons similar to the decline in total revenue. The (FA) variable was insignificant in all equations except for the fixed cost equation, which is discussed subsequently.

The (LTP) variable indicates the average number of trips made per year by vessels of lengths corresponding to variables (D) and (D1). The average trips per year variable (LTP) had a positive impact in the equations, suggesting that both revenues and variable costs increase as the number of trips increase with revenues increasing slightly faster than costs. Variables (TD) and (SD) indicate the source of this average trip per year data. If the data were provided in the survey reports, (TD=1) and (SD=0); from NMFS census data prior to 1976, (TD=0) and (SD=1); and from NMFS survey data from 1976 to 1980, (TD=0) and (SD=0). The coefficients of these variables indicate that the trip data in the cost and returns surveys are statistically different from the NMFS data. This may have occurred because the NMFS average trips reflects the entire fleet of shrimp vessels in the Gulf of Mexico rather than the annual number of trips in the published surveys collected from only the surveyed vessels.

Because fixed costs accrue regardless of the level of output, none of the independent variables in the fixed cost equation should have been significant. Fixed cost should be a function of vessel age, interest rate on the construction loan, insurance, depreciation, and overhead. The statistical significance of these misspecified variables may be caused by a high correlation with the omitted variables in the model specification. For example, the (LYR) variable would be highly correlated with the entry of new shrimp vessels into the fishery. These new vessels would have higher fixed costs of operation caused by higher construction loan interest rates and construction costs. Unfortunately, the survey results do not provide sufficient information on these omitted variables to include them in the model.

Discussion

A model with a good statistical fit is

[3]The type of fishing year was based on the total value of the shrimp landed. An above average fishing year was determined to be a shrimp harvest valued in excess of $250 million, an average fishing year had a value between $100 and $250 million, and a below average year was valued at less than $100 million in constant dollars with a 1977 base year. These categories were chosen after considering both the biological and economic conditions existing during years that industry analysts indicated were above average, average, and below average. A year when pounds landed were low, for example, could still be above average if prices were exceptionally high.

Table 2.—Estimated cost and return values[1].

Item	Texas >50′	Texas 50′ - 25′	Texas <25′	Louisiana >50′	Louisiana 50′ - 25′	Louisiana <25′	Florida >50′	Florida 50′ - 25′	Florida <25′
				Offshore vessels for 1971					
Total revenue	$96,817.00	$31,194.90	$5,564.90	$62,826.60	$20,243.00	$3,611.20	$83,565.50	$26,925.10	$4,803.20
Catch expense	$36,008.80	$11,698.40	$5,161.70	$13,190.20	$4,313.00	$2,433.00	$31,683.80	$10,288.40	$4,443.40
Effort Expense	$37,355.10	$12,005.80	$2,813.70	$29,925.50	$9,617.90	$2,254.10	$29,925.50	$9,617.90	$2,254.10
Total variable cost	$73,363.90	$23,704.20	$7,975.40	$43,115.70	$13,930.90	$4,687.10	$61,609.30	$19,906.30	$6,697.50
Fixed cost	$18,468.50	$3,595.80	$462.10	$3,445.90	$670.90	$86.20	$14,801.40	$2,881.80	$370.30
Total cost	$91,832.40	$27,300.00	$8,437.50	$46,561.60	$14,601.80	$4,773.30	$76,410.70	$22,788.10	$7,067.80
Profit	$4,984.60	$3,894.90	($2,872.60)	$16,265.00	$5,641.20	($1,162.10)	$7,154.80	$4,137.00	($2,264.60)
Relative cost index	0.95	0.88	1.52	0.74	0.72	1.32	0.91	0.85	1.47
				Offshore vessels for 1972					
Total revenue	$113,644.30	$36,991.30	$6,598.90	$73,746.20	$24,004.40	$4,282.20	$98,089.50	$31,928.20	$5,695.70
Catch expense	$42,298.80	$13,987.80	$5,969.90	$16,639.70	$5,579.00	$2,889.40	$37,010.90	$12,225.30	$5,125.60
Effort expense	$38,513.40	$12,378.10	$2,901.00	$30,853.40	$9,916.20	$2,324.00	$30,853.40	$9,916.20	$2,324.00
Total variable cost	$80,812.20	$26,365.90	$8,870.90	$47,493.10	$15,495.20	$5,213.40	$67,864.30	$22,141.50	$7,449.60
Fixed cost	$22,515.00	$4,457.90	$572.90	$4,201.00	$831.80	$106.90	$18,044.50	$3,572.70	$459.10
Total cost	$103,327.20	$30,823.80	$9,443.80	$51,694.10	$16,327.00	$5,320.30	$85,908.80	$25,714.20	$7,908.70
Profit	$10,317.10	$6,167.50	($2,844.90)	$22,052.10	$7,677.40	($1,038.10)	$12,180.70	$6,214.00	($2,213.00)
Relative cost index	0.91	0.83	1.43	0.70	0.68	1.24	0.88	0.81	1.39
				Offshore vessels for 1973					
Total revenue	$81,553.70	$25,982.00	$4,634.90	$52,921.90	$16,860.20	$3,007.70	$70,391.30	$22,425.80	$4,000.50
Catch expense	$28,930.30	$9,803.30	$4,850.30	$8,083.60	$2,517.20	$2,090.20	$27,803.50	$8,820.50	$4,211.00
Effort expense	$47,298.50	$15,201.60	$3,562.70	$37,891.20	$12,178.10	$2,854.10	$37,891.20	$12,178.10	$2,854.10
Total variable cost	$76,228.80	$25,004.90	$8,413.00	$45,974.80	$14,695.30	$4,944.30	$65,694.70	$20,998.60	$7,065.10
Fixed cost	$26,619.90	$5,087.20	$653.70	$4,966.90	$949.20	$122.00	$21,334.40	$4,077.10	$523.90
Total cost	$102,848.70	$30,092.10	$9,066.70	$50,941.70	$15,644.50	$5,066.30	$87,029.10	$25,075.70	$7,589.00
Profit	($21,295.00)	($4,110.10)	($4,431.80)	$1,980.20	$1,215.70	($2,058.60)	($16,637.80)	($2,649.90)	($3,588.50)
Relative cost index	1.26	1.16	1.96	0.96	0.93	1.68	1.24	1.12	1.90
				Offshore vessels for 1974					
Total revenue	$92,463.40	$30,000.30	$5,351.80	$60,001.50	$19,467.80	$3,472.90	$79,807.70	$25,894.10	$4,619.20
Catch expense	$34,765.00	$11,496.00	$5,466.60	$10,032.90	$3,414.10	$2,429.50	$31,079.00	$10,259.60	$4,732.70
Effort expense	$48,724.60	$15,659.90	$3,670.10	$39,033.70	$12,545.30	$2,940.10	$39,033.70	$12,545.30	$2,940.10
Total variable cost	$83,489.60	$27,155.90	$9,136.70	$49,066.60	$15,959.40	$5,369.60	$70,112.70	$22,804.90	$7,672.80
Fixed cost	$30,702.10	$6,046.70	$777.00	$5,728.60	$1,128.20	$145.00	$24,606.00	$4,846.10	$622.70
Total cost	$114,191.70	$33,202.60	$9,913.70	$54,795.20	$17,087.60	$5,514.60	$94,718.70	$27,651.00	$8,295.50
Profit	($21,728.30)	($3,202.30)	($4,561.90)	$5,206.30	$2,380.20	($2,041.70)	($14,911.00)	($1,756.90)	($3,676.30)
Relative cost index	1.23	1.11	1.85	0.91	0.88	1.59	1.19	1.07	1.80
				Offshore vessels for 1975					
Total revenue	$95,479.40	$31,500.00	$5,619.30	$61,958.60	$20,441.00	$3,646.50	$82,410.90	$27,188.50	$4,850.20
Catch expense	$31,381.20	$10,827.10	$5,289.10	$7,734.90	$2,921.60	$2,301.80	$28,293.30	$9,715.90	$4,587.80
Effort expense	$50,173.70	$16,125.60	$3,779.20	$40,194.60	$12,918.40	$3,027.60	$40,194.60	$12,918.40	$3,027.60
Total variable cost	$81,554.90	$26,952.70	$9,068.30	$47,929.50	$15,840.00	$5,329.40	$68,487.90	$22,634.30	$7,615.40
Fixed cost	$30,377.10	$6,149.70	$790.30	$5,667.90	$1,147.40	$147.40	$24,345.50	$4,928.60	$633.30
Total cost	$111,932.00	$33,102.40	$9,858.60	$53,597.40	$16,987.40	$5,476.80	$92,833.40	$27,562.90	$8,248.70
Profit	($16,452.60)	($1,602.40)	($4,239.30)	$8,361.20	$3,453.60	($1,830.30)	($10,422.50)	($374.40)	($3,398.50)
Relative cost index	1.17	1.05	1.75	0.87	0.83	1.50	1.13	1.01	1.70
				Offshore vessels for 1976					
Total revenue	$109,683.00	$38,276.50	$6,828.20	$71,175.60	$24,838.50	$4,430.90	$94,960.50	$33,037.60	$5,893.60
Catch expense	$40,539.00	$15,319.20	$6,576.30	$14,575.50	$6,030.50	$3,168.10	$35,715.60	$13,403.40	$5,648.80
Effort expense	$43,338.90	$13,929.00	$3,264.40	$34,719.20	$11,158.60	$2,615.20	$34,719.20	$11,158.60	$2,615.20
Total variable cost	$83,877.90	$29,248.20	$9,840.70	$49,294.70	$17,189.10	$5,783.30	$70,434.80	$24,562.00	$8,264.00
Fixed cost	$25,552.30	$5,675.20	$729.30	$4,767.70	$1,058.90	$136.10	$20,478.70	$4,548.30	$584.50
Total cost	$109,430.20	$34,923.40	$10,570.00	$54,062.40	$18,248.00	$5,919.40	$90,913.50	$29,110.30	$8,848.50
Profit	$252.80	$3,353.10	($3,741.80)	$17,113.20	$6,590.50	($1,488.50)	$4,047.00	$3,927.30	($2,954.90)
Relative cost index	1.00	0.91	1.55	0.76	0.73	1.34	0.96	0.88	1.50
				Offshore vessels for 1977					
Total revenue	$121,544.30	$42,008.30	$7,493.90	$78,872.70	$27,260.10	$4,862.90	$104,908.30	$36,258.60	$6,468.20
Catch expense	$43,179.40	$15,993.40	$6,844.30	$15,859.50	$6,340.50	$3,305.50	$37,985.40	$13,985.00	$5,877.50
Effort expense	$44,593.70	$14,332.20	$3,358.90	$35,724.40	$11,481.70	$2,690.90	$35,724.40	$11,481.70	$2,690.90
Total variable cost	$87,773.10	$30,325.60	$10,203.20	$51,583.90	$17,822.20	$5,996.40	$73,709.80	$25,466.70	$8,568.40
Fixed cost	$28,451.50	$6,219.20	$799.20	$5,308.60	$1,160.40	$149.10	$22,802.30	$4,984.40	$640.50
Total cost	$116,224.60	$36,544.80	$11,002.40	$56,892.50	$18,982.60	$6,145.50	$96,512.10	$30,451.10	$9,208.90
Profit	$5,319.70	$5,463.50	($3,508.50)	$21,980.20	$8,277.50	($1,282.60)	$8,396.20	$5,807.50	($2,740.70)
Relative cost index	0.96	0.87	1.47	0.72	0.70	1.26	0.92	0.84	1.42
				Offshore vessels for 1978					
Total revenue	$140,549.90	$45,830.80	$8,175.80	$91,205.80	$29,740.60	$5,305.40	$121,312.50	$39,557.80	$7,056.70
Catch expense	$49,861.00	$16,544.10	$7,071.40	$19,514.30	$6,576.80	$3,418.50	$43,645.70	$14,463.40	$6,071.90
Effort expense	$45,867.80	$14,741.80	$3,454.90	$36,745.20	$11,809.80	$2,767.80	$36,745.20	$11,809.80	$2,767.80
Total variable cost	$95,728.80	$31,285.90	$10,526.30	$56,259.50	$18,386.60	$6,186.30	$80,390.90	$26,273.20	$8,839.70
Fixed cost	$34,013.40	$6,754.40	$868.00	$6,346.40	$1,260.30	$161.90	$27,259.90	$5,413.30	$695.60
Total cost	$129,742.20	$38,040.30	$11,394.30	$62,605.90	$19,646.90	$6,348.20	$107,650.80	$31,686.50	$9,535.30
Profit	$10,807.70	$7,790.50	($3,218.50)	$28,599.90	$10,093.70	($1,042.80)	$13,661.70	$7,871.30	($2,478.60)
Relative cost index	0.92	0.83	1.39	0.69	0.66	1.20	0.89	0.80	1.35

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Table 2.—Estimated cost and return values[1]—Continued.

Item	Texas			Louisiana			Florida		
	>50′	50′ - 25′	<25′	>50′	50′ - 25′	<25′	>50′	50′ - 25′	<25′
Offshore vessels for 1979									
Total revenue	$260,157.90	$65,064.70	$11,606.90	$168,822.00	$42,221.80	$7,532.00	$224,549.50	$56,159.10	$10,018.20
Catch expense	$116,585.00	$26,378.00	$10,422.40	$58,451.80	$12,267.50	$5,367.10	$99,729.10	$22,737.80	$8,889.90
Effort expense	$47,161.50	$15,157.50	$3,552.40	$37,781.50	$12,142.80	$2,845.80	$37,781.50	$12,142.80	$2,845.80
Total variable cost	$163,746.50	$41,535.50	$13,974.80	$96,233.30	$24,410.30	$8,212.90	$137,510.60	$34,880.60	$11,735.70
Fixed cost	$88,431.50	$11,335.80	$1,456.70	$16,500.00	$2,115.10	$271.80	$70,872.80	$9,085.00	$1,167.50
Total cost	$252,178.00	$52,871.30	$15,431.50	$112,733.30	$26,525.40	$8,484.70	$208,383.40	$43,965.60	$12,903.20
Profit	$7,979.90	$12,193.40	($3,824.60)	$56,088.70	$15,696.40	($952.70)	$16,166.10	$12,193.50	($2,885.00)
Relative cost index	0.97	0.81	1.33	0.67	0.63	1.13	0.93	0.78	1.29
Offshore vessels for 1980									
Total revenue	$204,755.80	$62,708.50	$11,186.60	$132,870.40	$40,692.90	$7,259.20	$176,730.50	$54,125.50	$9,655.50
Catch expense	$75,350.50	$22,535.60	$9,172.70	$33,878.10	$9,919.30	$4,611.50	$65,152.10	$19,527.40	$7,844.20
Effort expense	$48,474.70	$15,579.60	$3,651.30	$38,833.50	$12,480.90	$2,925.10	$38,833.50	$12,480.90	$2,925.10
Total variable cost	$123,825.20	$38,115.20	$12,824.00	$72,711.60	$22,400.20	$7,536.60	$103,985.60	$32,008.30	$10,769.30
Fixed cost	$99,673.20	$17,847.50	$2,293.50	$18,597.50	$3,330.10	$427.90	$79,882.50	$14,303.80	$1,838.10
Total cost	$223,498.40	$55,962.70	$15,117.50	$91,309.10	$25,730.30	$7,964.50	$183,868.10	$46,312.10	$12,607.40
Profit	($18,742.60)	$6,745.80	($3,930.90)	$41,561.30	$14,962.60	($705.30)	($7,137.60)	$7,813.40	($2,951.90)
Relative cost index	1.09	0.89	1.35	0.69	0.63	1.10	1.04	0.86	1.31

[1]These estimated values are calculated from the regression equations in Table 1 using NMFS trips data rather than the trips reported in the published surveys. This table provides interpolative information not found in the published reports and the real cost and revenue estimates for different years, regions, vessel sizes, and areas of operation are comparable. Catch expense is calculated by subtracting the estimated effort expense value from the estimated total variable cost value for a given state and size category. Total cost is calculated by adding the estimated values for total variable cost and fixed cost. Profit is the difference between estimated total revenue and total cost. The relative cost index is calculated by dividing estimated values of total cost by total revenue. It provides a measure of the direction and magnitude of the change in operating costs relative to revenue. An increase in relative costs can occur from either an absolute increase in costs with revenues held constant or an absolute decrease in revenue with costs held constant. When the relative cost index is >1.00, relative costs have increased; when it is = 1.00 there is no change in relative costs; and when it is <1.00, relative costs have declined. Although a relative revenue index (*TR/TC*) would provide the same type of information, a relative cost index (*TC/TR*) is conceptually easier to convert to a profit rate

$$= (TR - TC)/TR = [(1 - TC/TR) \times 100]$$

than is a relative revenue index

$$= (1 - 1/[TR/TC]) \times 100).$$

further enhanced when it conforms to what is known about the economics of the industry in both applied and theoretical terms. The independent variables in this model specification account for the known trends in cost and revenue and can be relied upon to provide fairly accurate aggregate estimates for the financial performance of firms in the Gulf of Mexico shrimp fishery.

The unexplained variance in the regression equations may be due to some violation of the implicit assumptions used in developing the model. The vessels surveyed were assumed to be independent, owner-operated, single species fishing firms operating competitively. Some of the surveyed vessels, however, may actually be multiple species, vertically or horizontally integrated, nonowner-operated fishing firms that do not conform to these assumptions. These fishing firm ownership types could each have a different cost-revenue structure associated with it. For example, a vertically integrated firm could operate its fishing vessels at a loss to maximize profits at some other level within the firm. Without information from the surveys on the organization of the firm, the remaining variation could not be accounted for in the model specification.

The estimated real costs for fishing firms operating in the Gulf of Mexico shrimp fishery have increased from 1971 to 1980 (Table 2). Real revenues have also increased over this time period resulting in only 3 years (1973, 1974, and 1975) when the weighted average relative cost index for regions, vessel sizes, and areas of operation indicates that losses have occurred (Table 3). The relative cost index number of 0.921, weighted for all vessel sizes, years, regions, and areas of operation, indicates that the fishery has been profitable (7.9 percent rate of return over total costs; see footnotes to Table 2) for firms during the 1971-80 time period.

The firms with the best financial performance, lowest relative cost index in Table 2, were the 25-50 foot vessels. The financial performance of this size vessel may have resulted from economies of scale in the fishing operation and from increased operating flexibility that allows these vessels to operate both inshore and offshore as conditions in the fishery dictate. Larger and smaller vessels may be less efficient in utilizing the factor inputs in the fishing process and also may not be able to take advantage of better fishing conditions outside their fishing areas. The vessels <25 feet in length operating

Table 3.—Comparison of the Relative Cost Index to the size of the offshore fishing fleet.

Year	Relative Cost Index	Number of vessels reported in the Gulf of Mexico shrimp fishery
1971	0.8934	3,487
1972	0.8519	3,683
1973	1.1830	4,091
1974	1.1379	3,785
1975	1.0796	3,690
1976	0.9304	4,177
1977	0.8890	4,335
1978	0.8525	4,607
1979	0.8669	5,051
1980	0.9463	5,107
1981		5,205

out of Texas, Louisiana, and Florida ports take a higher proportion of their total revenue in terms of catch expense (wages, salaries, packing fees, etc.) than the larger vessels. This may have resulted from the smaller vessels being one-man, part-time operations with fishermen wishing to make a higher relative income in the short run. Large vessels had their best financial performance operating out of Louisiana. Only in Louisiana did large vessels make a profit in inshore operations; Louisiana large vessels had a relative cost advantage in offshore operations.

When the weighted relative cost index for the offshore fleet was compared to the number of vessels operating in the Gulf of Mexico shrimp fishery (Table 3) as a measure of fishing effort, declines in the relative costs of fishing were usually accompanied in the next year by an increase in the number of vessels operating in the fishery. Increases in the relative cost index were followed in the next year by declines in the number of vessels. For example, the 1973 relative cost index of 1.1830 indicates operating costs were 18 percent higher than revenues, and fishing firms experienced a financial loss (profits $= (1 - TC/TR) \times 100 = (-0.1830) \times 100 = -18.30$ percent) that was followed in 1974 by a decline in the number of operating vessels. The real costs and revenues, therefore, appear to be acceptable estimates of the financial condition of fishing firms operating in the Gulf of Mexico fishery.

The close relationship between the fishing firms relative cost index and the number of vessels in the Gulf of Mexico shrimp fishery ($r = -0.46$) suggests that the financial condition of the firm rather than the fisherman's personal income determines whether fishing effort increases or declines. The profit maximizing objective of the firm would, therefore, be of secondary importance relative to the objectives of minimizing the entrance of new fishing firms or of maintaining or improving its relative market share of the shrimp resource. The firm's failure to maximize profit, however, could result in a nonoptimal allocation of resources for the industry.

Conclusions

Since detailed cost data are not routinely collected and the published survey data from various sources are not easily compared, trends in costs and revenues for the Gulf of Mexico shrimp fishing fleet cannot be readily determined. A consistent data set for comparing vessel operating costs and revenues between states, vessel sizes, and years was estimated using weighted least squares regression analysis. Differences in the sample variance between the published cost and revenue data caused by time, type of survey, region surveyed, vessel size, sample size, or area of operation are accounted for in the econometric model. The coefficient of determination adjusted for the degrees of freedom (r^2) and the F statistic (Table 1) indicate that the model specification provides a good statistical fit to the survey data.

The cost and revenue estimates suggest that fishing firms in the Gulf of Mexico shrimp fishery have generally been profitable over the time period of the analysis, exclusive of opportunity costs. Medium sized vessels (25-50 feet) exhibited the best financial performance. Smaller vessels (<25 feet) took a larger proportion of total revenue as catch expense. Of the states included in the analysis, vessels in Louisiana for all size classes seemed to have a relative cost advantage. Comparisons of the relative cost index and the number of vessels reported operating in the Gulf of Mexico shrimp fishery suggest that these cost and revenue trends are indicative of changes in fishing effort levels.

Acknowlegments

Without the considerable expertise of Lourdes Corvo and Brett Schavey in the use of computers to organize and analyze data, this paper could not have been written. I also extend my appreciation to Richard Raulerson for his support of this project and to Wade Griffin, Vito Blomo, and Fred Prochaska for their review of an earlier draft of this paper. As always, all errors or mistakes in the article are the sole responsibility of the author.

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