# ECONOMIC AND FINANCIAL ANALYSIS OF INCREASING COSTS IN THE GULF SHRIMP FLEET[1,2]

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## ABSTRACT

The 115 Gulf of Mexico shrimp vessels used in this study were grouped into classes I (larger vessels) through V (smaller vessels) based on their type of construction, length of keel, and index of effort. In 1973, class II vessels were the only vessels able to register a positive return to owner's labor and management, $560; the other four classes registered negative returns. The payback period occurred during the eighth year due to the sale of the vessels in classes II, III, and V, whereas payback did not occur for classes I and IV. A positive rate of return on investment was experienced by the vessels in classes II, III, and V in the amount of 13.21, 2.65, and 2.63%, respectively. The internal rate of return on investment was negative for vessels in classes I and IV.

Input prices increased some 20% from 1973 to 1974 whereas production remained approximately constant and ex-vessel shrimp prices were lower. Thus none of the classes of vessels would have experienced a break-even cash flow for 1974. Increasing input cost another 10% above the 1974 level, and assuming normal production, the average vessel in class II seems to be operating at a better than a break-even level in 1975 assuming ex-vessel shrimp prices remaining constant at 1973 levels. Classes I, III, IV, and V experienced less than break-even cash flows under the same conditions in 1975.

The U.S. economy has faced some strong buffeting in recent years. In spite of temporary wage and price controls and other efforts by the administration, inflation has continued to be a major problem for most sectors. The percentage increases in the wholesale price index (including all commodities) were 4.2% from 1971 to 1972, 13.1% from 1972 to 1973, and approximately 20% from 1973 to 1974 (Board of Governors of the Federal Reserve System 1974). Since inflation can occur at different rates for different products, profit and loss positions in almost every sector or industry in the economy have been affected. Of particular interest to shrimp vessel owners are changes in the price for basic inputs used in the shrimp industry: the price index for fuel, which accounted for approximately 25%of variable costs of shrimp production in 1971 (excluding crew shares) (Hayenga et al. 1974) increased 76% from December 1971 to December 1973; and the price index for lumber, metals, and machinery and equipment (inputs used in the construction of shrimp vessels) jumped 46.5, 19.2, and 7.9%, respectively, during the same period (Board of Governors of the Federal Reserve System 1973).

With regard to prices and production in the Gulf States, in 1973 ex-vessel shrimp prices increased 33% from the 1972 figures, but landings were off from the 1972 levels by 21% (United States Department of Commerce 1974).

Due in part to the economic climate, vessel owners, managers, financial institutions, and marine resource researchers have come to rely heavily upon cost and return data in analyzing investment, financing, and profitability alternatives within the Gulf shrimp industry. But a classification problem exists because of the wide range of combinations of vessel size, construction, power, and fishing capability within the Gulf shrimp fleet and the wide range of variable costs, fixed costs, investment requirements, and profitability associated with the various vessel configurations. It is the purpose of this paper to investigate, for different vessel classes, the profitability of investing in and operating a vessel in the Gulf shrimp fleet based on data collected for the 1973 calendar year, and then with the data adjusted to estimated 1974 and 1975 levels.

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## METHODOLOGY

Standard techniques of cost and return, cash flow, and break-even analysis were used in this study. A budget-generating computer program was established to assimilate and report the data according to each of the desired vessel configurations, in the form of total costs and returns budgets, unit costs and returns budgets, and projected cash-flow budgets.

The vessels were classified in terms of their average costs per pound of shrimp landed. An average cost equation was estimated using regression analysis with construction, keel length (U.S. Coast Guard registry), and effort index[4] as dummy variables. Vessels included in the sample were constructed of either wood or steel. Grouping of vessels according to keel length and effort index for use as dummy variables in the regression analysis was based on a natural frequency distribution of the vessels in the sample.

It must be stressed here that this method of classification is simply a means to group the vessels for the purpose of analysis and is not necessarily a criterion for evaluation of the performance of the different classes. Performance or profit depends not only upon unit cost but also upon unit price. Even though one class of vessels may have a higher average cost curve for a given level and type of shrimp produced, it may not necessarily produce less profit. Therefore, while the product produced may be homogeneous with respect to cost of production, it may be heterogeneous with respect to price.

## DATA DESCRIPTION

### Data Collection and Vessel Description

The cost and return and financial data used in this study were gathered by personal interview with shrimp vessel owners and/or managers operating from ports in Florida, Mississippi, and Texas. Additional financial information was obtained from officials of various lending institutions which engage in shrimp vessel financing. All data were for the period covering the calendar year 1973.

The original sample for this study consisted of 126 vessels. However, due to incomplete data, only 115 vessels were used in the analysis. Vessels in the sample were constructed of wood and steel, with keel lengths of from 45 to 78 feet, and from 104 to 777 horsepower. The ages of the vessels ranged from 1 to 36 yr.

### Costs and Returns and Cash Flow Data

Variable cost items were separated into variable costs not directly proportional to catch: ice; fuel; nets, supplies, and groceries; repair and maintenance; and variable costs directly proportional to catch: crew shares, payroll taxes, and packing charges. Actual variable cost data reported by the vessel owners were used except for crew shares, payroll taxes, and packing charges, which were determined on the basis of reported pounds landed and gross revenues. Vessel owners paid their captains and/or crew on the basis of a percentage of pounds landed. This percentage ranged from 30% in the eastern Gulf to 40% in the western Gulf. Thirty-five percent was the average share paid and is used in the analysis.

Fixed cost items were separated into: insurance, depreciation, overhead, interest, and opportunity cost (required return to equity capital). Fixed charges for insurance and overhead are reported data. Charges relating directly to investment—depreciation, interest, required return on equity capital for costs and returns, and principal and interest for cash flow budgets—were standardized in terms of 1973 dollars in order to make valid comparisons. Since most of the vessels included in the sample were purchased new, vessel owners (some of which were shipbuilders) were asked to estimate the replacement value of their

[4]The effort index is defined as the amount of fishing power that a vessel can exert in a day fished relative to that of a standard vessel. The value for the effort index for each vessel was calculated using the formula:

$$EI_i = \frac{(HP)_i^{0.1385} \quad (LFR)_i^{0.4064}}{(38)^{0.1385} \quad (14.6)^{0.4064}}$$

where $EI_i$ = effort index for vessel $i$, $(HP)_i$ = horsepower for vessel $i$, $(LFR)_i$ = sum of the lengths of the footropes measured in yards for vessel $i$, (38) = average horsepower of the smallest class of vessels operating in the Gulf from 1962 to 1971, and 14.6 = average net size measured in yards of footrope used by the smallest class of vessels for the same period [Griffin, W. L., M. L. Cross, R. D. Lacewell, and J. P. Nichols. 1973. Effort index for vessels in the Gulf of Mexico shrimp fleet. (Unpubl. rep. to NMFS, contract no. 03-3-042-19 with the Tex. Agric. Exp. Stn., Tex. A&M Univ.].

vessels in 1973 prices. Depreciation charges were calculated using the straight-line method, based on the estimated 1973 replacement value for each vessel, and using an 8-yr depreciable life with 35% book salvage value. For the amortization schedule, the same 1973 equivalent new vessel costs were used, with 67% of the cost financed at a 9% interest rate, for 8 yr, and with 12 equally amortized payments per year. These terms were found to be representative for 1973 through interviews with officers of financial institutions which engage in shrimp vessel financing. The specific amount of interest reported in each costs and returns budget is for the fifth year of the amortization schedule since the majority of the vessels in the sample taken were from 3 to 6 yr old.

Required return to equity capital is economic rather than financial in concept and is an attempt to place a value on the opportunity cost of the equity capital committed to an investment. At the time an owner invests in a shrimp vessel he has several alternative investments available with various rates of return associated with each. Theoretically these different rates of return are representative of the relative risks associated with each—that is, risk and return vary directly. Because the alternative investment opportunities are different for each owner, in the interests of standardization the rate of interest charged by financial institutions for shrimp vessel financing (9%) was assumed to be the highest alternative rate available to the owners for an investment of equivalent risk and can be adjusted by an individual owner to reflect his own investment alternatives.

A note of explanation is necessary concerning the cash flow budgets and cash flow analysis. Terminal vessel value (sale value) and holding period were established by asking each vessel owner to estimate, in 1973 dollars, what that same vessel would be worth as a used vessel if he had held it for the number of years that he customarily fishes a new vessel. Respondents indicated they fished a new vessel from 3 to 15 yr, with 8 yr being the most frequent response, and that even in periods of relative price stability an 8-yr-old shrimp vessel is worth approximately 65% of its original cost. Furthermore, that difference between the 35% book value for depreciation purposes and the 65% terminal value is evidenced by the frequency of income taxes levied on vessel owners for depreciation recapture at the time of replacement. For those reasons, an 8-yr holding period and a 65% terminal value were used in the cash flow budgets.

## RESULTS

### Classification of Vessels

Vessels were grouped according to construction, keel length, and effort index (Table 1). All vessels in the sample were either wood or steel. Vessels were divided into three keel length intervals: 45-62 feet, 63-69 feet, and 78-80 feet. The range of effort indices was divided into three intervals: 1.64-1.89 units, 1.90-2.19 units, and 2.20-2.51 units. Using these groupings for classification, 12 combinations were possible and the vessels in the sample fell into 9 of those possible combinations (See Appendix).

Predicted average cost values for the 115 vessels were plotted and vessels were classed into five general categories as shown in Table 1, where class I is the highest cost curve and class V is the lowest. Classes I and II, the two highest cost curves, consist entirely of steel vessels whereas classes III, IV, and V consist entirely of wooden vessels. The position of the average cost curves seem to be related to vessel length for each type construction except for class IV which includes two length intervals.

These results are not surprising. Previous research by Nichols and Griffin (1974) indicated that smaller, less powerful wooden vessels can produce a given quantity of shrimp at a lower cost than can a larger, more powerful steel vessel. As a matter of fact, their research showed that a 50% reduction in total effort exerted by the shrimp fleet would only reduce total catch by about 10%.

For the 4-yr period, 1962-65, the average vessel exerted about 1.16 units of effort in a day fished

TABLE 1.—Classification of Gulf of Mexico shrimp vessels, based on construction, keel length, and effort index from a sample of 115 vessels, 1973.

| Vessel class | Construction | Keel length (feet) | Effort index (units) |
|---|---|---|---|
| I | Steel | 70-78 | 1.90-2.19 |
| | | | 2.20-2.51 |
| II | Steel | 63-69 | 1.90-2.19 |
| | | | 2.20-2.51 |
| III | Wood | 63-69 | 1.90-2.19 |
| | | | 2.20-2.51 |
| IV | Wood | 45-62 | 1.90-2.19 |
| | | 63-69 | 1.64-1.89 |
| V | Wood | 45-62 | 1.64-1.89 |

and the annual landings per vessel were 31,700 pounds of shrimp (heads-off). However, in the 4-yr period, 1970-73, the average vessel exerted about 1.68 units of effort in a day fished and the annual landings were only 28,900 pounds (heads-off). The average length of the vessel operating in the Gulf also increased over time (Nichols and Griffin 1975). Thus, as additional effort has been added to the Gulf of Mexico shrimp fishery—by increasing the number of vessels and/or the average size of the vessel—the total pounds landed have been divided between more and more units of effort.

From these figures it is apparent that the average Gulf of Mexico shrimp vessel has been increasing in size and relative fishing power and the annual landings per vessel have declined. Due to the lower investment levels and lower operating costs of smaller, less powerful vessels it follows that those smaller vessels could produce a pound of shrimp at a lower unit cost than could a larger, more powerful vessel if both were fishing the same or equally abundant fishing grounds. However, two distinctions and/or disadvantages of the smaller vessels compared to larger vessels must be noted here. First, as discussed earlier, shrimp is not a homogeneous product, and larger shrimp command higher ex-vessel prices than do smaller shrimp. Because the larger shrimp are usually associated with deeper waters, farther out in the Gulf, a smaller vessel with less capacity both for deepwater trawling and for holding fuel and shrimp is at a disadvantage compared with a larger vessel because of that depth and distance from shore.

The second distinction, and associated with the first, is the fact that larger vessels are better able to operate in and cope with rougher seas and the frequent storms in the Gulf than are smaller vessels. Therefore, the smaller vessels would either be forced to trawl closer to shore for smaller, less valuable shrimp, or for a given period of time in the deeper fishing grounds with typical weather conditions, the smaller vessels would not be able to realize as many actual fishing hours as a larger vessel operating in the same waters during the same period of time.

## Comparison of Classes

Table 2 shows a summary of the costs and returns, equity requirements, payback period, and internal rate of return for the five classes of shrimp vessels operating in the Gulf of Mexico in 1973 (a more detailed break down of cost is available from the authors). Class I vessels received the highest price per pound, \$2.03, for the shrimp landed but produced 5,500 pounds less shrimp than the smaller class II vessels. Class I vessels also had the highest levels of variable costs not proportional to catch, \$45,152, the highest fixed costs, \$31,906, and the highest total costs, \$108,291, of any of the general classes. These cost relationships were to be expected since the larger steel vessels should have the highest initial investment requirements and operating costs. Due to low production and high cost, these vessels averaged the greatest loss for the year, \$20,704, and payback did not occur. The internal rate of return on investment was negative.

TABLE 2.—Summary of costs and returns information, net present value analysis, and pay back period for five classes of shrimp vessels operating in the Gulf of Mexico in 1973.

| Item | Vessel class I | II | III | IV | V |
|---|---|---|---|---|---|
| Number of vessels | 14 | 28 | 48 | 15 | 10 |
| Catch (pounds) | 43,146 | 48,602 | 39,170 | 30,716 | 30,950 |
| Gross revenue: | | | | | |
| Per pound ($) | 2.03 | 1.89 | 1.93 | 1.65 | 1.55 |
| Total ($) | 87,587 | 91,802 | 75,764 | 50,770 | 48,044 |
| Cost: | | | | | |
| Variable | | | | | |
| Not proportional to catch ($) | 42,152 | 31,694 | 28,134 | 22,835 | 16,784 |
| Total ($) | 77,195 | 68,600 | 58,543 | 43,444 | 36,385 |
| Fixed ($) | 31,096 | 22,642 | 22,231 | 18,550 | 15,296 |
| Total ($) | 108,291 | 91,242 | 80,774 | 61,994 | 51,681 |
| Returns above variable cost ($) | 10,392 | 23,202 | 17,221 | 7,326 | 11,659 |
| Net revenue ($) | -20,704 | 560 | --5,010 | -11,224 | -3,637 |
| Equity requirement ($) | 47,407 | 38,921 | 30,630 | 24,200 | 22,176 |
| Payback period (yr) | (1) | (2) | (2) | (1) | (2) |
| Internal rate of return (%) | (3) | 13.21 | 2.65 | (3) | 2.63 |

[1]Does not occur.
[2]Does not occur through operations—payback in the eighth year is due to sale of the vessel.
[3]Less than 0%.

Class II vessels had the highest landings, 48,602 pounds, of the five classes of vessels. They also had the highest gross revenues even though the average price per pound received was $0.14 less than class I vessels. They did experience relatively high total costs, yet the variable costs not proportional to catch, the "manageable" variable costs, were $10,500 less than class I. Class II vessels were able to register a positive return to owner's labor and management of $560—the only one of the classes to achieve that. Payback occurred only with the sale of the vessel in the eighth year. The internal rate of return on investment was 13.21%, which was the highest of the five classes.

Class III was the most populous class. Gross revenue was approximately $15,000 below and total costs were about $10,500 below those of class II vessels. The difference in the total costs was due to costs directly proportional to catch—a reflection of the fact that class III vessels caught roughly 9,000 pounds less shrimp than did the class II vessels. Class III vessels had a negative net return of $5,010. The internal rate of return on investment was 2.65% and payback occurred during the eighth year only with the sale of the vessel.

Class IV vessel production was about 9,000 pounds less than class III vessels and the price per pound was about $0.30 less, so that gross revenue was $25,000 lower for the class IV vessels. Variable costs not directly proportional to catch were roughly $5,000 lower, and total cost was $19,000 less for class IV vessels than for class III vessels. Because of the low level of production and gross revenues, class IV vessels had the second greatest net loss, $11,224, of any of the five classes, and payback did not occur. The internal rate of return on investment was negative.

Class V vessels reached roughly the same level of production as did class IV vessels, but at $6,000 lower variable costs not directly proportional to catch. Comparison of the returns above variable costs shows class V vessels contributed over $4,000 more towards fixed costs than did class IV, while receiving some $2,000 less in gross revenues. Net revenue was a negative $3,637, but was still the second highest with respect to the other four classes. Payback occurred in year 8 only with the sale of the vessel and the internal rate of return on investment was 2.63%.

## Financial Analysis with Cost Adjusted to 1974 and 1975

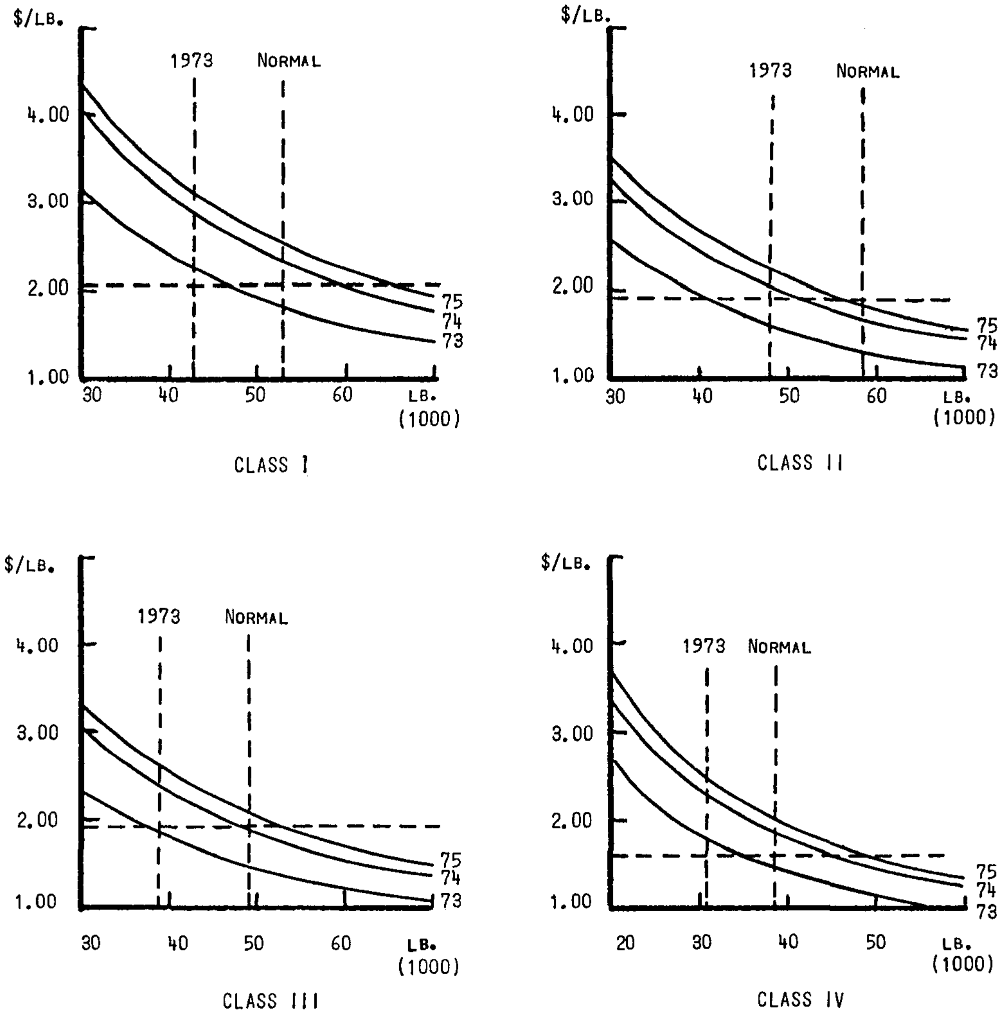
Fishing for shrimp in the Gulf of Mexico in 1973 was definitely not an enterprise in which profits could be achieved across the board. Figure 1 shows the break-even undiscounted cash flow analysis for each of the five vessel classes, based on 1973 costs and for costs updated to 1974 and 1975. Costs for 1974 were calculated by increasing all cost items (fixed and variable) by 20%[5] except fuel and new vessel cost. Because fuel represents such a large portion of a vessel's operating costs, it was treated separately and increased from 18 to 32 cents per gallon. New vessel cost was held constant at 1973 levels since there has not been a significant number of vessels entering the industry since 1973. Inflation is expected to continue to increase at a rate between 5 and 15%; therefore, 1975 costs were increased by 10% over 1974 levels with the exception of new vessel prices. For comparison purposes the vertical dashed lines, labeled 1973, indicate the 1973 average landings and the horizontal dashed lines indicate the 1973 average ex-vessel price received for each vessel class.

### 1974 Analysis

Input prices continued their upward trends in 1974. At the same time landings showed approximately a 2% improvement over the 1973 levels, but shrimp prices fell by approximately 20%; the combined effect was a 15% drop in the value of shrimp produced in the Gulf of Mexico in 1974.[6] Figure 1 explains graphically the ramifications of such conditions on the undiscounted break-even cash flows for each of the five vessel classes. As the graphs show, none of the classes would have experienced a break-even cash flow for 1974 given the 20% decrease in shrimp prices and minimal increase in landings over the 1973 levels. This of course means that none would

[5]Based on the July 1974 wholesale price index including all commodities (Board of Governors of the Federal Reserve System 1974).

[6]Total Gulf of Mexico shrimp landings (heads-off) in 1973 were 114.8 million pounds, average ex-vessel price per pound received was $1.50 and the value was $171.7 million (United States Department of Commerce 1974). Landings for the same period in 1974 were 116.9 million pounds, the average ex-vessel price per pound was $1.18, and the value of the landings was $137.4 million (United States Department of Commerce 1974-75).



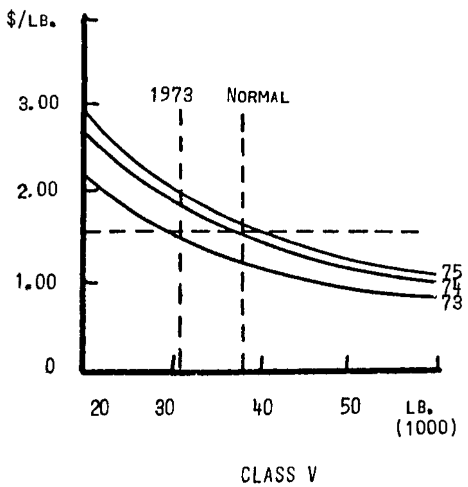




FIGURE 1.—Break-even undiscounted cash flow analysis (0% rate of return on investment) based on 1973 costs and returns data, and with costs inflated to 1974 and 1975 levels, for five classes of shrimp vessels operating in the Gulf of Mexico.

have registered a positive return on investment. As a matter of fact, the class II vessels, which had the highest rate of return in 1973, would have had to receive approximately $2.20 per pound of shrimp landed to achieve a break-even investment (0% internal return on investment) if annual production of shrimp is held constant at the 1973 level of 48,602 pounds. Since they only received $1.89 per pound in 1973 and prices declined in 1974, investment in a class II vessel in 1974 would have yielded a negative rate of return on investment.

**1975 Analysis**

If inflation continues at a 10% rate in 1975, and production remains at approximately the 1973 level, Figure 1 indicates that ex-vessel prices would have to increase to approximately $3.10, $2.25, $2.65, $2.50, and $2.00 per pound of shrimp landed for vessel classes I, II, III, IV, and V, respectively, to achieve even a zero internal rate of return on investment. Or, on the other hand, with prices remaining constant at the 1973 level, production would have to increase to approximately 66,000, 57,000, 52,000, 49,000, and 40,000 pounds of shrimp landed per vessel, respectively.

However, based on production functions estimated by Nichols and Griffin (1974) for the Gulf of Mexico shrimp fleet where catch is a function of effort, 1973 production of shrimp from the Gulf was below normal. Average annual landings for the vessels in the sample were estimated in a normal year to be approximately 53,000, 59,000, 49,000, 37,000, and 38,000 pounds of shrimp landed per vessel for classes I, II, III, IV, and V, in that order. The vertical dashed lines in Figure 1 labeled "normal" indicate the average landings for each class of vessel for the normal production year.

The average vessel in class II seems to be operating at better than a break-even level in 1975 assuming normal production and 1973 ex-vessel prices for shrimp. That is, given normal production, class II vessels would have to receive $1.85 per pound for shrimp landed in 1975 while the 1973 average price for the class was $1.89 per pound. But, a new vessel cost of $130,000 would be just enough to set this cash flow at the break-even level and the replacement of a class II type vessel is estimated to be in excess of $150,000 in 1975.

From the graphs in Figure 1 it is obvious that none of the other classes (I, III, IV, V) are operating at the break-even level assuming a normal production year and 1973 average shrimp prices and new vessel costs. In order to bring the cash outflows down to the levels necessary to achieve break even, class III-type vessel owners could only invest approximately $30,000 in a new vessel in 1975, and class V owners could invest no more than $40,000. To reiterate, these break-even levels represent a zero internal rate of return on investment. Significantly, class I and class IV-type vessel owners could not achieve the breakeven level even with a zero investment requirement.

## DISCUSSION AND IMPLICATIONS

The resolution of problems facing the Gulf shrimp industry may come about as a result of changing economic conditions and/or changes in specific policies which may or may not be initiated or suggested by the industry. A number of possible changes have been suggested which bear consideration.

One suggestion has been a fuel subsidy for the fishing industry. This would be a direct saving to vessel owners on the largest single input cost item. Assuming a normal production year, it would take a subsidy of 35, 13, 48, and 15 cents per gallon for classes I, III, IV, and V, respectively, to break even with a zero return on investment assuming prices stayed constant at the 1973 level. Chances of obtaining any relief in this area are very slim. At best, the extent of such relief would likely be limited to future increases related to oil import taxes. Current fuel expenses would probably not be reduced.

Efforts to improve the efficiency of fishing operations are also a priority consideration. The operation of fishing vessels during periods of marginal profitability required improved management and closer consideration of the effects of the day-to-day decisions in running the vessel.

Import quotas and tariffs are one suggested alternative to the current cost-price squeeze in the industry. By controlling imports it is anticipated that supplies on the market can be reduced thus preventing prices from being depressed below the domestic producer's costs. The goals of free trade and stabilized or lower consumer prices may make approval of the necessary controls through the political process difficult to realize.

Market expansion and development programs have also been suggested as a means of shifting demand and increasing prices. Market development is a long term process and the industry should commit itself to such a program. This suggests a greater continuity of programs than the occasional reaction to crisis situations which are evident in the recent history of the industry.

A much larger question has been introduced in this discussion of economic efficiency. Industry sources have indicated a concern that the industry has become overcapitalized in shrimp trawling vessels. One classic solution to this is a total fisheries management scheme which includes a limited entry concept. Other conditions assumed equal, this would increase catch per unit of effort and would result in lower costs per unit of shrimp landed. This is not a short-run solution, however. It is only now being experimented with in U.S. fisheries. A great deal of planning and information would be needed to design and implement such a program.

Long-run problems of limited entry include the possibility of creating a stagnant, protected industry which loses touch with both the consumer market and the market for resources. In the long-run this may be more detrimental than going through periodic readjustments such as that which the industry currently faces.

If it can be assumed that the relative positions of the unit cost and revenue curves remain constant in the future and assume normal production years, then based on the sample size of each vessel class, the percentage reduction in vessels needed for break even can be calculated. Using class I as an example, in a normal year, the 14 vessels in class I would have landed a total of 742,000 pounds of shrimp. To experience a break-even rate of return, each vessel would have to land 66,000 pounds of shrimp. Dividing 66,000 pounds per vessel into 742,000 pounds implies that class I's total production of 742,000 pounds could only support approximately 11 vessels or 79% of the vessels sampled.[7]

## CONCLUSIONS

The major conclusion from the analysis presented here is that investment in a shrimp trawler is unprofitable assuming the environment existing in 1973 when these data were collected and for which the average relationships were estimated. The analysis permits tracing the effects of altered assumptions regarding average prices and vessel landings on profitability. Only class II vessels showed profits under the 1973 conditions.

The shrimp industry is undergoing considerable economic stress. The underlying causes relate to factors in the general economy beyond industry control and the rapid expansion in potential fishing effort which occurred during the period since the late 1960's. Means of coping with this stress include both improved management to reduce costs and various forms of government programs will be necessary to permit the implementation of some of these ideas.

Perhaps some would prefer to allow a period of significant readjustment forcing the marginal firms to leave the industry. The costs of this readjustment, both economic and social, must be considered by those who propose this solution. Several things could happen which would prevent a significant readjustment: landings could increase dramatically, the economy could recover quickly thus improving demand and prices, or input costs could decline. However, these things may not happen soon enough to avoid the difficult readjustment problems.

[7]It is obvious that if the total Gulf shrimp fleet were reduced to 79% of its current size, total production would also decrease. That is, the estimated reduction in the fleet should be adjusted with respect to the production function. However, calculations using the production function made less than a 1% difference.

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# APPENDIX

Average cost equations were estimated using ordinary least squares regression analysis for each of the nine groups of vessels by the use of linear, quadratic, and log linear functions. In general, considering all nine equations, the log linear model gave the best statistical results whereas the quadratic gave the worse. This implies that the average cost curves were ever decreasing over the range of the data available. Predicted values from the log linear model for the nine equations were plotted by the computer on one graph and compared. Because all nine plots were relatively parallel, economies of scale did not exist over the range of the sampled data.

Since the plotted predicted values were relatively parallel, one average cost equation was estimated using construction, length, and effort as dummy variables. All three were statistically significant variables at least at the 95% level of confidence in explaining the average costs of producing shrimp. For a more detailed discussion see Wardlaw and Griffin (1974).