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# Catch-Effort and Price-Cost Trends in the Gulf of Mexico Shrimp Fishery: Implications on Mexico's Extended Jurisdiction


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## INTRODUCTION

The Gulf of Mexico shrimp fishery is the most valuable fishery in the United States today. In 1976 U.S. fishermen landed over 5.4 billion pounds of fish for a total value of $1,352.7 million. United States shrimp landings were 403.6 million pounds, only 7.5 percent of pounds landed, but accounted for 24.5 percent of the total dollar value. Shrimp landed in Gulf of Mexico ports made up 83.0 percent of the total value of shrimp landed in the United States and 20.3 percent of the total value of all fisheries in the United States (Robinson, 1977).

The future well-being of the Gulf of Mexico shrimp fishery is dependent on economic as well as biological factors. The size of the biomass, environmental conditions, reproductive ability, and other physical factors are only one part of this complex system. Of equal importance are the year-to-year changes in fishing effort, and costs and returns which make up the economic part of the fishery. A complete analysis of the fishery's status should include all of the above factors.

The purpose of this paper is to review trends in the catch-effort and price-cost relationships in the Gulf of Mexico shrimp fishery. In addition, these relationships provide a rudimentary framework for analyzing the effect of Mexico's extended 200-mile jurisdiction. This paper updates the data series presented by Nichols and Griffin (1975) and also provides a more accurate estimate of fishing effort by shrimp vessels (Griffin, 1977).

The information presented is based on data from two sources. The catch-effort data was collected by the National Marine Fisheries Service (NMFS) from all vessels (5 gross tons and larger) landing shrimp at U.S. Gulf ports. This data is summarized in Tables 1 and 2. The price-cost data was collected through personal interviews with vessel owners operating in Florida and Texas by Texas A&M University. This data is summarized in Table 3.

## TRENDS

### Effort

There are several measures of fishing effort available which help explain past changes in landings and may help in predicting future landings. Number of vessels in the fishery is one such measure of the trend in fishing effort. The number of vessels of 5 gross tons and larger landing shrimp at U.S. Gulf ports is presented in Figure 1. In 1962 the number of vessels was 2,542; in 1974 their number had increased 28 percent to 3,247. In 1974 vessels accounted for 70 percent of shrimp landed from U.S. waters. The remainder was landed primarily from inshore by smaller boats not included in this study. Shrimp in Mexican waters is caught exclusively by vessels where most of these vessels have home ports in Texas or Florida.

A second measure of fishing effort is the total number of nominal days fished. This series for U.S. and Mexican waters is indicated in Figure 2. Each nominal day measured represents a full 24 hours fishing on the shrimp grounds. Nominal days fished in U.S. waters by vessels has increased substantially since 1962 while decreasing by over 50 percent in Mexican waters. The total of the two areas shows an increase in nominal days fished by vessels. Subsequent to the recently negotiated agreement with Mexico, fishing in Mexican waters is to be phased out entirely by 1980.

Most observers agree that the total

Table 1.—Gulf of Mexico commercial shrimp landing data from U.S. waters by vessels and total Gulf 1962-75.[1]

| | Total Gulf of Mexico | | | U.S. waters | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Year | Landings[2] ($10^6$ lb) | Value[3] ($\$10^6$) | No. Vessels | Landings ($10^6$ lb) | Value ($\$10^6$) | Nominal days fished ($10^3$) | Index of days fished (1962 = 100) | Total effort[4] ($10^3$) | Index of effort (1962 = 100) | CPUE (lb) | $/lb |
| 1962 | 89.0 | 60.3 | 2,542 | 45.4 | 33.4 | 88.5 | 100 | 144.0 | 100 | 315 | 0.74 |
| 1963 | 124.7 | 61.3 | 2,653 | 77.0 | 41.5 | 112.9 | 128 | 181.8 | 126 | 423 | 0.54 |
| 1964 | 113.3 | 62.6 | 2,795 | 71.0 | 40.7 | 114.4 | 129 | 186.3 | 129 | 381 | 0.57 |
| 1965 | 123.4 | 71.2 | 2,804 | 80.1 | 49.1 | 113.7 | 129 | 187.6 | 130 | 427 | 0.61 |
| 1966 | 113.6 | 83.6 | 2,924 | 78.3 | 61.9 | 113.7 | 129 | 190.5 | 132 | 411 | 0.79 |
| 1967 | 140.6 | 90.1 | 3,098 | 99.7 | 68.5 | 116.0 | 131 | 201.7 | 140 | 494 | 0.69 |
| 1968 | 128.2 | 95.7 | 3,346 | 83.7 | 68.4 | 121.5 | 137 | 218.1 | 151 | 383 | 0.82 |
| 1969 | 126.6 | 101.2 | 3,362 | 82.4 | 74.3 | 147.8 | 167 | 273.6 | 190 | 301 | 0.90 |
| 1970 | 145.3 | 108.1 | 3,298 | 96.1 | 81.4 | 134.6 | 152 | 249.1 | 173 | 386 | 0.85 |
| 1971 | 143 1 | 136.1 | 3,282 | 91.3 | 100 8 | 137.0 | 155 | 259.0 | 180 | 352 | 1.10 |
| 1972 | 143.8 | 163.7 | 3,496 | 94.3 | 120.1 | 146.8 | 166 | 282.6 | 196 | 333 | 1.27 |
| 1973 | 114.8 | 171.0 | 3,453 | 71.0 | 118.6 | 140.0 | 158 | 269.7 | 187 | 263 | 1.67 |
| 1974 | 117.1 | 137.5 | 3,247 | 73.9 | 99.8 | 132.4 | 150 | 243.6 | 169 | 303 | 1.35 |
| 1975 | 107.0 | 178.2 | | | | | | | | | |

[1]Derived from NMFS data tapes on Gulf of Mexico shrimp landings.
[2]Includes catch by vessels and boats
[3]Includes value by vessels and boats
[4]Effort is real days fished.

Table 2.—Gulf of Mexico commercial shrimp landings. Value and days fished from Mexican waters, 1962-75.[1]

| Year | Pounds ($10^6$) | Value ($\$10^6$) | Days fished ($10^3$) | Nominal days fished (1962=100) | Total effort[2] ($10^3$) | Index of effort (1962=100) | CPUE (lb) | $/lb |
|---|---|---|---|---|---|---|---|---|
| 1962 | 19.1 | 15.7 | 38.0 | 100 | 61.7 | 100 | 309 | 0.82 |
| 1963 | 14.0 | 10.2 | 26.3 | 69 | 43.6 | 71 | 322 | 0.73 |
| 1964 | 17.4 | 11.4 | 31.9 | 81 | 51.6 | 84 | 337 | 0.64 |
| 1965 | 16.3 | 11.7 | 28.0 | 73 | 46.6 | 76 | 350 | 0.71 |
| 1966 | 10.1 | 9.1 | 17.5 | 46 | 29.8 | 48 | 430 | 0.90 |
| 1967 | 10.8 | 9.1 | 14.6 | 38 | 33.2 | 54 | 300 | 0.91 |
| 1968 | 14.4 | 13.9 | 23.0 | 60 | 42.4 | 69 | 338 | 0.97 |
| 1969 | 8.3 | 8.9 | 16.9 | 44 | 31.8 | 51 | 262 | 1.07 |
| 1970 | 9.1 | 9.1 | 15.5 | 41 | 28.3 | 46 | 320 | 1.00 |
| 1971 | 9.1 | 11.5 | 14.8 | 39 | 28.9 | 47 | 313 | 1.26 |
| 1972 | 11.7 | 16.0 | 16.8 | 44 | 32.8 | 53 | 357 | 1.37 |
| 1973 | 10.1 | 18.8 | 17.7 | 47 | 34.7 | 55 | 291 | 1.85 |
| 1974 | 10.2 | 15.0 | 18.7 | 49 | 35.3 | 57 | 289 | 1.47 |
| 1975 | 7.5 | 16.3 | 11.5 | 30 | | | | 2.15 |

[1]Derived from NMFS data tapes on Gulf of Mexico shrimp landings.
[2]Effort is real days fished.

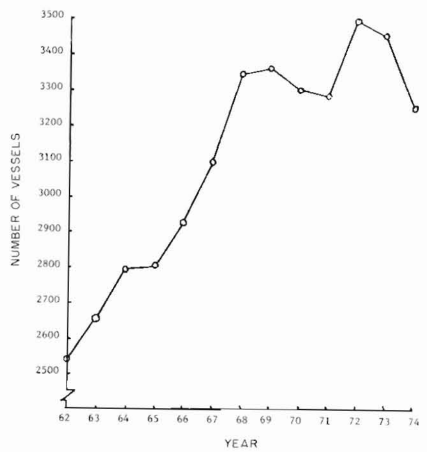


Figure 1.—Number of vessels 5 gross tons and larger that landed shrimp in the Gulf of Mexico shrimp fishery, 1962-74.

Table 3.—Annual costs and returns for Gulf of Mexico vessels of steel and wood construction, 51 to 80 feet in length, and 104 to 425 horsepower.[1]

| | 1971 | 1973 | 1974 | 1975 |
|---|---|---|---|---|
| Returns | | | | |
| Gross receipts from shrimp sales | $60,742 | $74,135 | $78,864 | $101,324 |
| Lb. landed | 50,656 | 39,907 | 46,270 | 44,070 |
| Price/lb. | $ 1.20 | $ 1.86 | $ 1.70 | $ 2.30 |
| Costs | | | | |
| Variable: | | | | |
| Ice | $ 1,387 | $ 1,579 | $ 1,541 | $ 1,766 |
| Fuel | 6,561 | 9,539 | 18,976 | 19,114 |
| Nets, supplies, groc. | 2,358 | 6,747 | 9,885 | 11,211 |
| Repair & maintenance | 11,708 | 9,593 | 9,337 | 11,643 |
| Subtotal variable costs not proportional to catch | 22,014 | 27,458 | 39,739 | 43,734 |
| Crew shares | 19,437 | 23,723 | 26,593 | 32,422 |
| Payroll raxes | 388 | 474 | 1,547 | 1,815 |
| Packing | 2,411 | 1,899 | 2,428 | 2,905 |
| Total variable costs | 44,250 | 53,554 | 70,307 | 80,876 |
| Returns above variable costs | 16,492 | 20,581 | 8,557 | 20,448 |
| Fixed costs | | | | |
| Insurance | 3,632 | 4,291 | 4,306 | 4,840 |
| Depreciation | 6,333 | 8,177 | 11,228 | 12,607 |
| Overhead | 0 | 2,415 | 3,201 | 3,073 |
| Interest | 2,256 | 2,611 | 5,604 | 6,984 |
| Total fixed costs | 12,221 | 17,494 | 24,339 | 27,504 |
| Total costs of operation | 56,471 | 71,048 | 94,646 | 108,380 |
| Total profit/loss from operations | 4,271 | 3,087 | −15,782 | −7,056 |
| No. of vessels in class | 25 | 103 | 109 | 101 |

[1]Derived from unpublished cost and returns data collected by Department of Agricultural Economics, Texas A&M University.

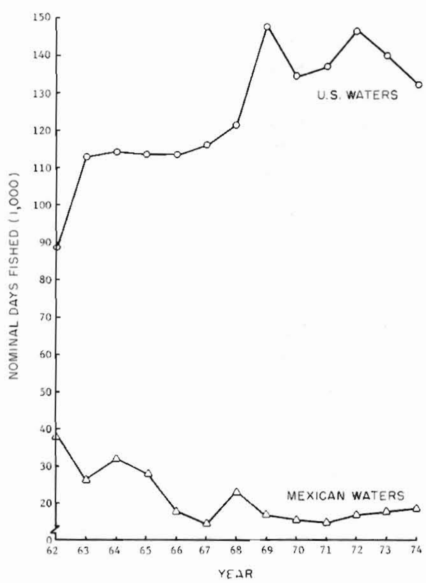


Figure 2.—Nominal days fished (24-hour equivalent) by U.S. shrimp vessels in United States and Mexican waters of the Gulf of Mexico, 1962-74.

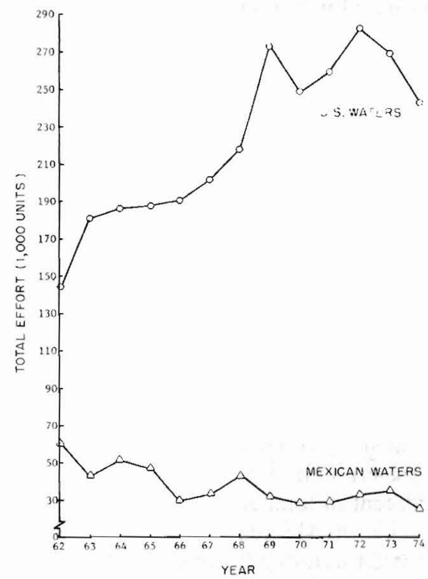


Figure 3.—Total effort units (real days fished) expended by U.S. shrimp vessels in United States and Mexican waters of the Gulf of Mexico, 1962-74.

number of nominal days fished is a rather crude measure of effort in that it fails to account for changes in the nature of the vessels in the fleet over time. Intensity of shrimp fishing effort is increasing as vessels upgrade their potential productivity with larger horsepower engines and net size. A precise mathematical formulation for expressing relative fishing power of vessels based on horsepower and net size is presented in Griffin et al. (1977). Adjusting nominal days fished by relative fishing power of vessels, Figure 3 shows that in U.S. waters effort (now defined as total real days fished) increased perceptibly from 1966, reached a peak in 1972, and has declined somewhat in later years. The impact of adjusting for this change in relative fishing power over time is illustrated by the index of nominal days fished and index of effort series where the base year for both series is 1962 equal to 100 (Fig. 4). Fishing effort in U.S. waters is increasing faster than nominal days fished. While nominal days fished increased by 55 to 65 percent from 1962 to a peak in 1972, total effort increased by 80 to 90 percent during the same time. The difference is due to the gradual increase in vessel horsepower

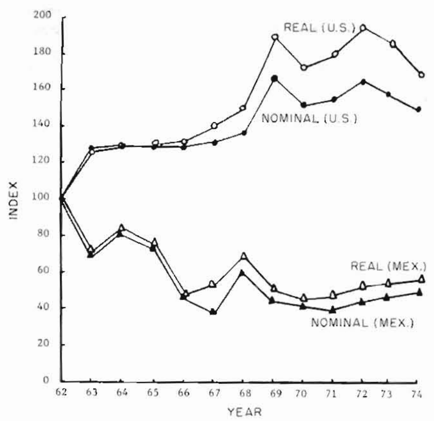


Figure 4.—Index of nominal and real days fished by U.S. shrimp vessels in U.S. waters of the Gulf of Mexico, 1962-74.

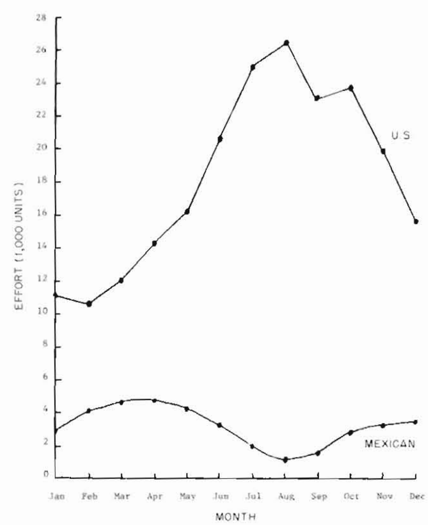


Figure 5.—Seasonality of total effort units (real days fished) by U.S. shrimp vessels in United States and Mexican waters of the Gulf of Mexico, 1963-71.

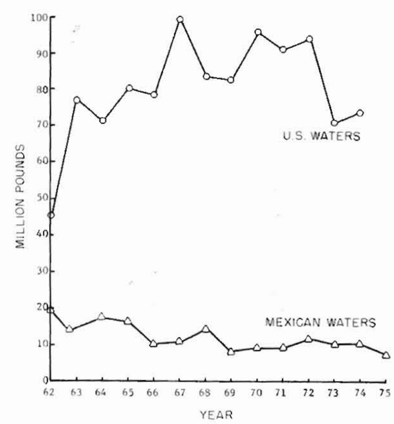


Figure 6.—Landings of shrimp by U.S. vessels from United States and Mexican waters of the Gulf of Mexico, 1962-74 (heads-off weight).

and net sizes used in the industry (Griffin et al., 1977).

Effort in Mexican waters (Fig. 3) has trended downward as observed above in the nominal days fished series (Fig. 2). The decline in total effort appears slower than the decline in days fished (Fig. 4), again reflecting an increase in fishing power of the average vessel.

Another area of interest with respect to total fishing effort in U.S. and in Mexican waters is the seasonality of effort. This is depicted in Figure 5. Total effort in U.S. waters is of magnitudes 3 to over 20 times that of total effort in Mexican waters over a year; however, the oscillations in each are completely opposite—the highest effort in U.S. waters corresponds with the lowest in Mexican waters. During the first 4 months of the year, from 20 to 28 percent of total effort in the Gulf takes place in Mexican waters. This has caused serious adjustment problems for those vessels no longer able to fish in Mexican waters.

## Catch

Little change is noted in the composition of shrimp landings in the past decade. Brown, *Penaeus aztecus*, white, *Penaeus setiferus*, and pink, *Penaeus duorarum*, shrimp compose nearly all of these landings. The most noticeable shift among these has been a relative decline in landings of pink shrimp from 22 percent in 1965 to 15 percent in 1975. Brown shrimp landings have increased in share from 51 percent in 1965 to 57 percent in 1975.

Shrimp landings from the Gulf are presented in Table 1. With the exception of years 1962, 1973, 1974, and 1975, shrimp landings by vessels in U.S. ports show only an approximate 25 percent increase in landings from U.S. waters, despite the large increase in total effort. Year-to-year variations in total catch are significant and are influenced by poor environmental conditions in some years which prevent either adequate growth in the shrimp biomass or the shrimp fleet from fishing (Fig. 6). The catches in 1962, 1973, and 1974 serve as examples of large variations in yearly catch when the Mississippi River discharge was high (Barrett and Gillespie, 1973; Griffin et al., 1976).

The decline in shrimp landings from Mexican waters, however, is entirely consistent with the decrease in total fishing effort in Mexican waters over time (Table 2). Evaluating U.S. shrimp landings from the Gulf of Mexico as a whole shows no clear increasing or decreasing trend over the 1962-74 period, as others have pointed out before (Nichols and Griffin, 1975). In fact, landings have been stabilized at roughly 195 million pounds, heads-on weight, since 1950.

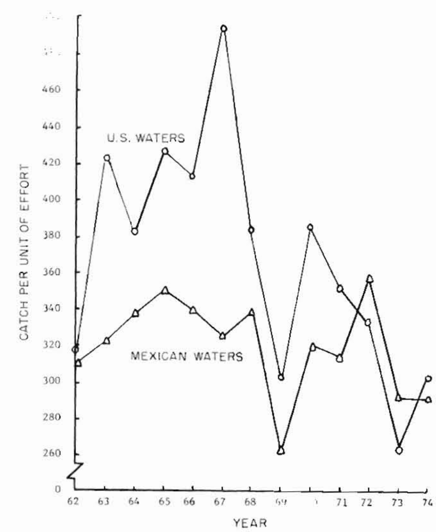


Figure 7.—Catch per unit effort for U.S. vessels 5 gross tons and larger, United States and Mexican waters of the Gulf of Mexico, 1962-74 (heads-off weight).

## Catch/Unit

Catch per unit effort (CPUE) is calculated by simply dividing the appropriate catch statistic by its accompanying total effort statistic, as developed earlier. The result is illustrated in Figure 7, which shows catch per unit effort for vessels landing shrimp from U.S. and from Mexican waters. Of interest is that while U.S. CPUE has declined over time from approximately 400 pounds to approximately 300 pounds, CPUE in Mexican waters has stayed relatively constant at approximately 300 pounds.

In addition to calculating CPUE, a relationship was established between shrimp landings and total effort from U.S. waters by vessels. In this way, holding all other factors constant, landings can be predicted at various levels of total fishing effort. One other factor considered in this relationship was river discharge during the months that shrimp are in their nursery grounds. A high discharge reduces temperature and salinity, causing population and, in turn, landings to be reduced (Griffin et al., 1976). The yield relationship used was of the form

$$Y=b_0\, D^{b2\,(1.0-(b_1)^E)} \qquad (1)$$

where $b_0D^{b2}$ is the maximum yield the function approaches for a given level of river discharge, $D^1$. Here, the Mississippi River discharge, reported by the U.S. Army Corps of Engineers (1961-74), is used for $D$. $E$ is the total effort in U.S. waters. The term $b_1$ indicates the ratio by which incremental products of $E$ decline. The above equation was estimated using regression analysis and time-series data for the period 1962-74 as follows:

$$Y=6{,}593\, D^{-0.60134\,(1.0-0.995701^E)} \qquad (2)$$

where $Y$ is in million pounds and $E$ is in thousand units.[2]

Using an average daily river discharge of 696 cubic feet per second, the maximum yield for vessels in the shrimp fishery is estimated to be 128.7 million pounds annually. This relationship is such that the maximum yield is approached asymptotically by increased effort. An increase in effort in U.S. waters by 50 percent from 180,000 units to 270,000 units would cause an increase in expected catch from 69.4 million to 88.5 million pounds, respectively, which is an increase of 27.5 percent. The estimated equation indicates that CPUE was 15 percent less in the early 1970's than in the early 1960's.

## Prices-Costs

Attention is now turned to the individual vessel's costs and returns for operating in the Gulf of Mexico. While the number of vessels interviewed make up a very small sample of all vessels, the data presented in Table 3 generally reflect changes felt by all vessels. Average gross receipts ranged from a low of $60,742 in 1971 to a high of $101,324 in 1975. Average landings per vessel was highest in 1971 at 50,656 pounds; lower landings in 1973-75 reflect a high level of river discharge experienced in those years. The price per pound received by these vessels almost doubled from $1.20 in 1971 to $2.30 by 1975.

Costs are broken into three categories: Fixed costs, variable costs proportional to catch, and variable costs not proportional to catch. Variable cost items not proportional to catch include ice; fuel; nets, supplies, and groceries; and repair and maintenance. These costs almost doubled during 1971-75, with fuel tripling in cost and nets, supplies, and groceries increasing by five times. Costs proportional to catch include crew shares, payroll taxes, and packing charges.

Total variable costs for these vessels almost doubled from $44,250 in 1971 to $80,876 in 1975. Returns above variable costs remained relatively constant from 1971 to 1975 at approximately $20,200, except for 1974 when it dropped to only $8,557. Thus, in 1974, after paying for variable costs, very little was left over to pay for fixed costs.

Fixed cost includes insurance, depreciation, overhead, and interest. Of these four items the significant increases are in depreciation and interest since these two items reflect the cost of a new vessel[3]. Thus, based on new vessel prices, depreciation and interest more than doubled. This caused fixed costs to more than double from $12,221 in 1971 to $27,504 in 1975.

Total costs (variable plus fixed) almost doubled during this 5-year period, from $56,471 to $108,380. Since revenues increased at a slower rate than costs, this caused negative returns in 1974 and 1975 of $15,782 and $7,056, respectively.

Rates of increase in the cost components and in total revenue are illustrated in Figure 8. Costs and revenues are in the form of indices (1971 = 100) which are calculated so that they reflect the nominal percentage increase in each item. All items showed the first significant increase in 1973. Fixed cost shows the most increase of 125 percent while revenue shows the least increase of 66 percent.

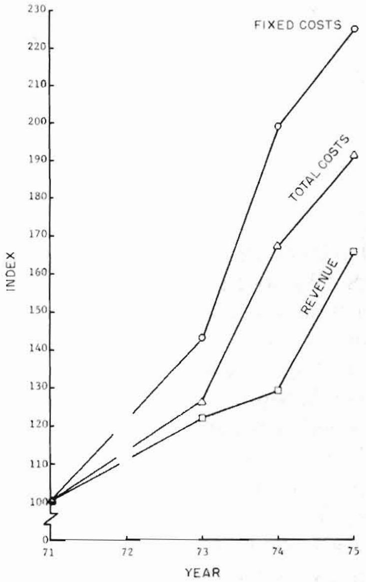


Figure 8.—Indices of costs and revenues for U.S. shrimp vessels operating in the Gulf of Mexico, 1971 and 1973-75 (1971 = 100).

[1]Because of the regression technique used, the actual equation estimated was $Y = b_0D^{b2(1.0-b_1{}^E)a}$. Theoretically, $a = 1$; therefore, $b_1$ was solved for through an iterative procedure such that $a$ approaches 1.

[2]Coefficients were significant at the 99 percent level. $R^2$ was 78.5; Durbin-Watson was 2.25. The simple correlation coefficient between landings and effort is 0.64 and between landings and discharge is −0.63.

[3]Detailed discussion of the methodology to calculate depreciation and interest will not be presented here as they are available elsewhere; see Robinson (1977).

## IMPLICATIONS OF MEXICO'S EXTENDED 200-MILE JURISDICTION

Mexico's 200-mile offshore fishing zone officially went into effect on 27 July 1976. At present, U.S. vessels must secure temporary permits until 1980 to continue shrimping in Mexican waters. Without any future reciprocal or bilateral agreements, vessels which do some or all of their fishing off the coast of Mexico will be forced to do all of their shrimping off the Gulf coast of the United States after 1980. The effect of this will be to shift vessels and total effort geographically by the Gulf shrimp fleet. This in turn implies serious consequences for the individual vessel owner and the industry as well.

The landings-effort relationship derived in Equation (2) was used to help trace through the effect of shifting effort from Mexican to U.S. waters. Using average effort expended for 1970-74 as a base, if all effort in Mexican waters were shifted to U.S. waters, effort increases 12 percent (260,800 to 291,400 units) and expected catch increases by 6 percent (87 million to 97 million pounds); CPUE would decrease from 325 pounds per unit to 310 pounds per unit (Griffin and Beattie, 1977).

Assuming that part of the industry operating in U.S. waters was in a state of equilibrium, i.e., total receipts equal total costs, increasing effort over the equilibrium effort will result in financial losses for the industry. In fact, until the industry moves back to an equilibrium the real cost to the industry is the annual stream of net losses over time. Depending on the ex-vessel price, the numbers of years to adjust to an equilibrium, and the discount rate for evaluating net losses over time, real costs to industry could vary between $4.2 million and $27.0 million (see footnote 3).

To gauge the effect of Mexico's extended 200-mile jurisdiction on individual vessel owners, use is made of the survey data presented in Table 3. The landings-effort relationship indicates CPUE would decline from 325 pounds per unit to 310 pounds per unit. For the average vessel depicted in Table 3 this would mean 4.6 percent less landings. Holding prices and costs constant over the survey years, the average vessel's gross receipts would be reduced by approximately $2,800, $3,400, $3,600, and $4,700 for 1971, 1973, 1974, and 1975, respectively. It is only in 1971 that the representative vessels would have earned a profit.

## SUMMARY AND CONCLUSIONS

A review of trends in catch-effort and price-cost relationships reveals the necessity for monitoring year-to-year changes in the fishery. Knowledge of these trends will indicate the status of the fishery in physical and economic terms and may pinpoint causes for its condition. The catch-effort and price-cost relationships can also be a basis for drawing up management plans by the newly created U.S. Fishery Management Councils.

Several points stand out in this review of the Gulf of Mexico shrimp fishery. First, changes in total effort were shown to affect landings. Expressed in a precise mathematical relationship, increases in the industry's total effort causes landings of shrimp to increase but at progressively lower rates. This has serious implications for policy makers and for private firms. For one, a vessel must expend greater efforts for marginal increases in catch; assuming fixed prices and per unit costs, increases in effort become less and less profitable. For the industry, this relationship has a compounding effect as the existing fleet increases total effort and/or new vessels enter the fishery.

An on-going survey of individual vessel costs also indicates items of major importance to the firm's operation. These items determine the ultimate profitability of the vessel and, in turn, its activity in the fishery. In the period 1971-75, total costs increased at a faster rate than revenue for the interviewed vessels, causing net losses in 1974 and 1975. Items showing the greatest increase included fuel, nets, interest, and depreciation.

The extension of Mexico's offshore fishing zone was analyzed using the effort-landings relationship derived earlier and the survey of costs and revenues. The extension would have adverse effects on the U.S. Gulf fleet, particularly the same type of vessels interviewed. Although the largest calculated loss from Mexico's policy amounts to 8 percent of the value of all shrimp landed, it would seem that the effects will largely be felt in Florida- and Texas-based vessels which do nearly all the fishing by U.S. Gulf vessels in Mexican waters. Finally, the estimates made of revenues reduced for fishing vessels by Mexico's policy is based on the assumption that the effort diverted from Mexican to U.S. water will be distributed uniformly through the year. However, as Figure 5 shows, that effort is very seasonal which will cause cash flow problems for vessel owners during the winter and early spring.

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