

Future harvesting methods and the possible applications of the high-speed computer and associated elements of automatic data processing to the fishing industry were the last subjects discussed. It was reported that at least one United States fishing company is currently using computer techniques, and high-speed digital computers are being used by some shipbuilders.

Future harvesting methods were discussed in a conservative way, which is only natural in an industry internationally famous for its conservative attitude. The engineering technologies of the industrial, military, and space fields were explored and assessed as to their possible application and use for improving existing harvesting methods or developing new concepts for harvesting. These considerations were limited to the next three decades and it was emphasized that science fiction has perhaps already anticipated most of them. Those discussed included: retrievable floats with built-in detection systems that would automatically signal to catcher vessels the presence of fish; artificial logs for attracting fish with built-in detection systems for automatically signalling catcher vessels when concentrations of fish were present; a network of buoys to detect fish and transmit data through satellite telemetry to a shore-based "hydro-central" for computer analysis and transmission of data summarized by facsimile techniques to fishing centers; motorized units which would replace otter boards; and remote-controlled, self-propelled midwater trawls. Also discussed were the possible applications to fishing vessels and gear of lightweight materials developed for space vehicles.

In closing, I wish to emphasize that it was made clear at the Gear Congress that many of the countries that operate extensive fisheries are beginning to take advantage of the advanced technical knowledge existing in many counterpart industries ashore. From the information passed on to us, however, it appears that the advances so far in fisheries technology for which the industry can be justifiably proud, are only a scratch on the surface of the potential we have at our finger tips.

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## **Industry Trends and Indicators of Economic Performance In the Menhaden Fishery**

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### **Abstract**

This paper deals with economic elements underlying the growing relative importance of the Gulf Coast menhaden fishery and the degree to which both the Atlantic and the Gulf fisheries fulfill basic economic objectives of performance.

An extremely high degree of physical output per unit of labor and capital input has characterized the Gulf fishery since 1954 and has been a basic factor in the development of this fishery.

The analysis of available data indicates that both Atlantic and Gulf menhaden

fisheries were probably performing in an economically efficient manner. A thorough analysis of fishery efficiency, however, can be accomplished only when additional cost data are obtainable.

## INTRODUCTION

### **Objectives**

Striking changes occurred in the period 1954 to 1962 in both the primary fishing operations and the reduction aspects of the menhaden industry. The most marked change during this eight-year period has been the increased proportion of total catch, meal, and oil production that the Gulf Coast fishery accounted for when compared to the Atlantic Coast fishery. Although many of these changes may be ascribed to biological factors (for example, available year-classes of fish, different species under exploitation in the two areas, seasonal movements, and the like), economic factors characterize and account for much of this trend.

Industry leaders, biologists, technologists, and economists have been increasingly concerned as to the economic performance and other economic factors involved in the exploitation and management of United States fisheries. Owing to the economic importance of the menhaden industry, it thus is desirable that some indication be obtained as to the degree to which both Atlantic and Gulf menhaden fisheries are fulfilling basic criteria of economic performance.

The objectives of this paper therefore are to describe:

- (1) some of the economic factors behind the growing relative importance of the Gulf menhaden fishery, and
- (2) the degree to which basic economic objectives of performance are being fulfilled in the Atlantic and Gulf fisheries.

### **Methodology**

A major difficulty is encountered when an economic analysis of the menhaden fishery is attempted, as a full comparison of economic efficiency requires data on cost per unit of output. These cost elements are not presently available. The development of normal cost minimization criteria for efficiency evaluation is not possible. Seeking an alternative means of evaluation, one is forced to deal with the data that are available: that is, changes in physical inputs and output. These data have been consistently collected since 1954 by the Branch of Statistics, Bureau of Commercial Fisheries, and provide an indication of the status of the fishery. If the menhaden industry is interested in obtaining an analysis that will completely depict its economic efficiency (or inefficiency), however, it might consider submitting the necessary cost data on a confidential basis to an appropriate research agency. The collection of such data could no doubt be made by the Branch of Statistics.

One limiting assumption in the present analysis must be emphasized. If there is mobility of labor in both the Atlantic and Gulf regions, this factor of production will obtain its opportunity income: that is, if labor has access to other industries as well as to the fishery, the fishery payments to labor must average out to the comparable industry wage payment. This mobility is assumed to be the case in the present analysis.

A thorough analysis of fishery efficiency requires determination of the degree of mobility of labor and the relation of cost elements to the physical input-

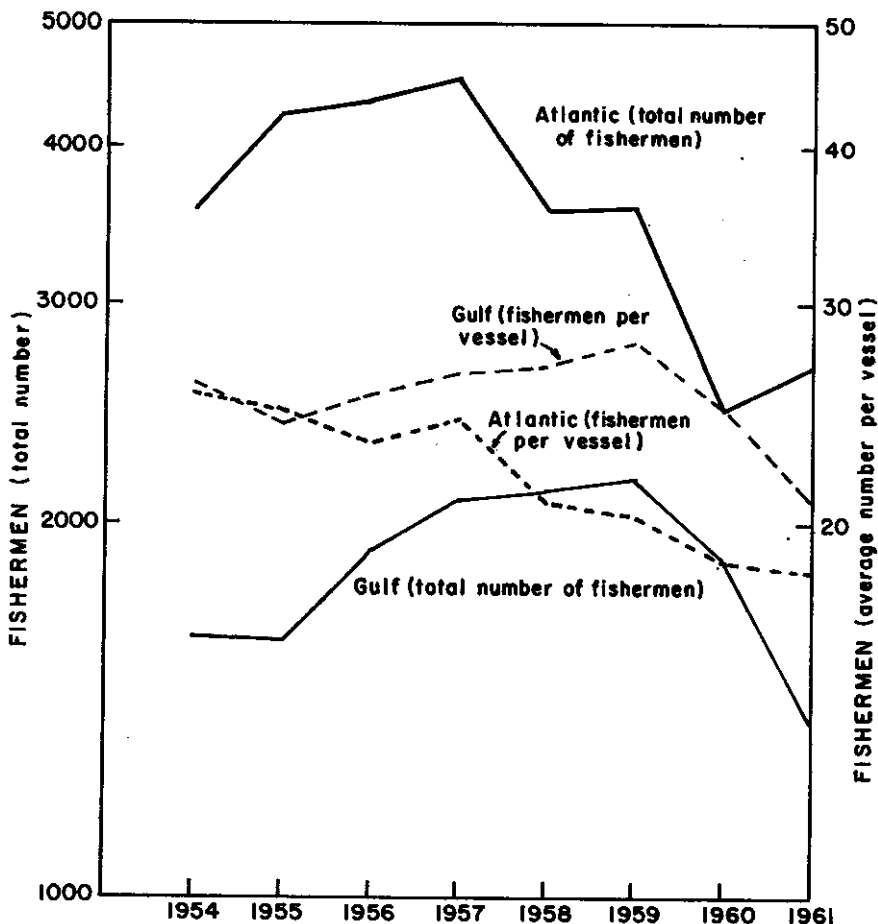


FIG. 1. Number of fishermen and average number of fishermen per vessel, menhaden fleets, Atlantic and Gulf Coasts, 1954-1961.

output data described in this paper. By themselves, the input-output data can only indicate the probable economic state of the fishery over the period studied.

The analysis in this paper is divided into two parts. The first part deals with indicative<sup>1</sup> criteria of economic performance in the primary fishing operations of the Atlantic and Gulf fisheries. The second part describes the changes in terms of ratio of catch to meal and ratio of catch to oil that have taken place in menhaden reduction operations.

#### PRIMARY FISHING OPERATIONS

Four basic economic objectives in the exploitation and management of a fishery are as follows: (a) to maximize labor and capital efficiency, (b) to

<sup>1</sup>The term "indicative" is used because cross checks exist in the statistics. That these cross checks are consistent for all data assures that the trends indicated are valid.

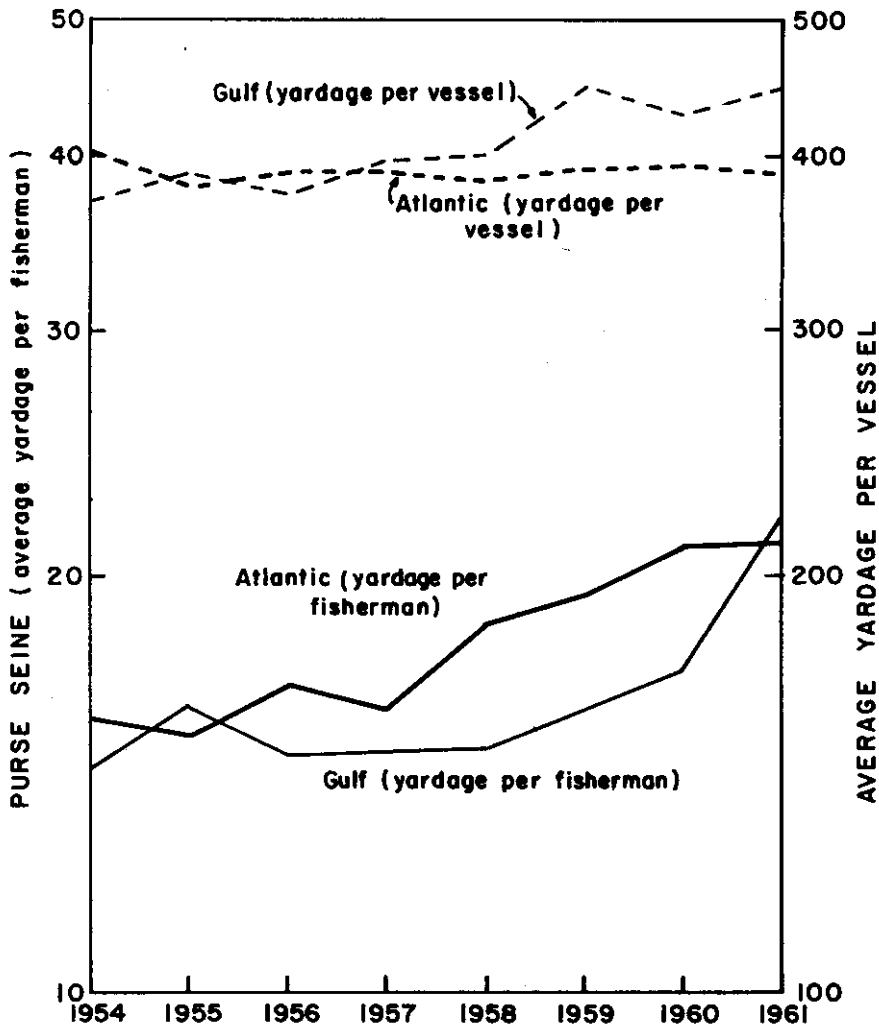


FIG. 2. Average yardage of menhaden purse seine per fisherman and per vessel, Atlantic and Gulf Coasts, 1954-1961.

minimize labor and gear inputs for any given level of catch, (c) to encourage a rapid rate of adaption to technological change, and (d) to ensure that the earnings of the factors of production in a fishery equal or exceed their opportunity incomes<sup>2</sup> (Crutchfield, 1963).

Since data for developing normal cost minimization criteria are not available, changes in physical inputs and output are used in the following analysis to indicate how well the menhaden fishery has fulfilled the above objectives.

<sup>2</sup>The income that the factors of production could earn if otherwise employed.

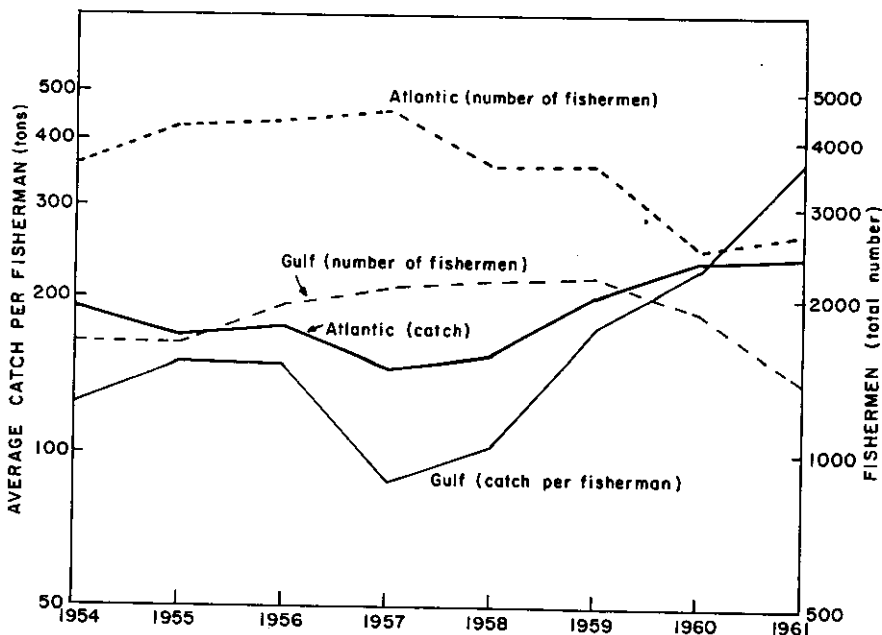


FIG. 3. Average menhaden catch per fisherman and number of fishermen, Atlantic and Gulf Coasts, 1954-1961.

Gross returns to the fishery, the vessels, and the fishermen are used to indicate the earnings position of the two fisheries.

### Inputs

Labor inputs in the Atlantic and Gulf menhaden fisheries are shown in Figs. 1 and 2.<sup>3</sup> The number of fishermen engaged in the two fisheries and the average number of men per vessel<sup>4</sup> showed decreases over 1954-61. In 1961, the number of fishermen on the Atlantic Coast had fallen to approximately 75% of the 1954 level; the average number of fishermen per vessel had declined by about 28%. Gulf Coast figures show a similar decline: the number of fishermen in this area in 1961 had fallen to 86.5% of the 1954 level, and the average number of men per vessel had declined by 19%.

These declines in labor inputs commenced earlier in the Atlantic fishery than they did in the Gulf. This difference may have been due, in part, to a more rapid rate of adoption of labor-saving innovations in the Atlantic fishery, such as the use of power blocks. A second reason for generally rising curves in the Gulf from 1954-59 (as compared to generally declining numbers of men during that period in the Atlantic) can be attributed to the relative newness of the Gulf fishery and the concomitant problems of growth that new fisheries

<sup>3</sup>Data in this paper are plotted on semi-log scales to facilitate comparison. Straight line plots for any series, for example, indicate constant rates of increase, and parallel curves indicate equal rates of change for different series.

<sup>4</sup>It is known that the crews were not actually as large as indicated (June, 1961). The trend, however, seems clear.

typically undergo. Both fisheries, however, are evidently moving in the direction necessary to fulfill the first two economic objectives stated above insofar as labor inputs are concerned.

A further indication of high physical productivity per unit of labor in both the Atlantic and the Gulf fleets is apparent from Fig. 2. With the exception of 1955, when average yardage per fisherman in the Gulf deviated from the trend and was higher than in the Atlantic, the average yardage handled per fisherman in both areas has been rising. In 1961, Gulf fishermen on the average "handled" more of this type of gear (0.8 yards per man more) than did their Atlantic counterparts. In the Atlantic fishery, average yardage per fisherman was 34% above the 1954 level; the comparable Gulf increase was 51%.

Fig. 3 indicates an extremely high marginal physical productivity of labor (that is, average tons per fisherman), with rapid growth being particularly evident after 1957 in both fisheries. Again, gear innovations such as power blocks and airplane spotting undoubtedly accounted for much of this rapid expansion, especially in the Gulf fishery, which was "seeking" its most advantageous level of inputs. This rapid rate of adoption of technological innovation is especially encouraging from an economic viewpoint. The desired element of progressiveness seems apparent. Another factor causing the rapid growth after 1957 relates to the increased skills of the vessel captains and the

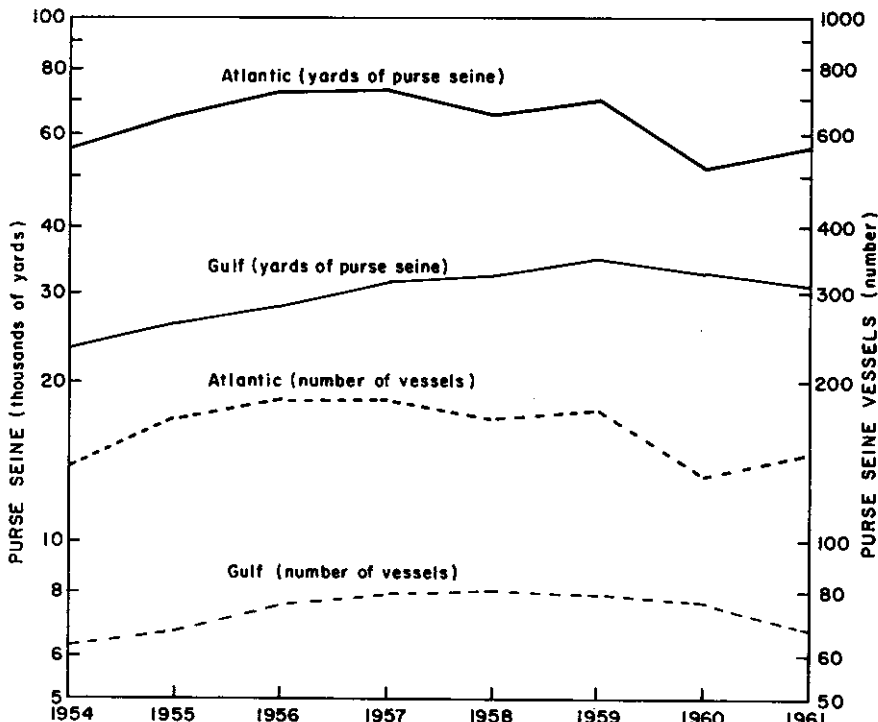


FIG. 4. Menhaden gear operated, Atlantic and Gulf Coasts, 1954-1961.

airplane spotters. These men were probably becoming more familiar with favorable fishing areas and with other factors peculiar to their fishery.

Another reason for these trends relates to changes in the regional economy of the south. A generally rising wage structure has occurred with the shift of many northern manufacturing firms to the region. This upward trend in wages would lend impetus to further capitalization in the fishery.

Major capital inputs in the menhaden fishery are vessels and gear. If vessel age can be used as an indicator of efficiency, the Gulf Coast fleet has forged ahead of the Atlantic fleet with respect to probable vessel efficiency. The

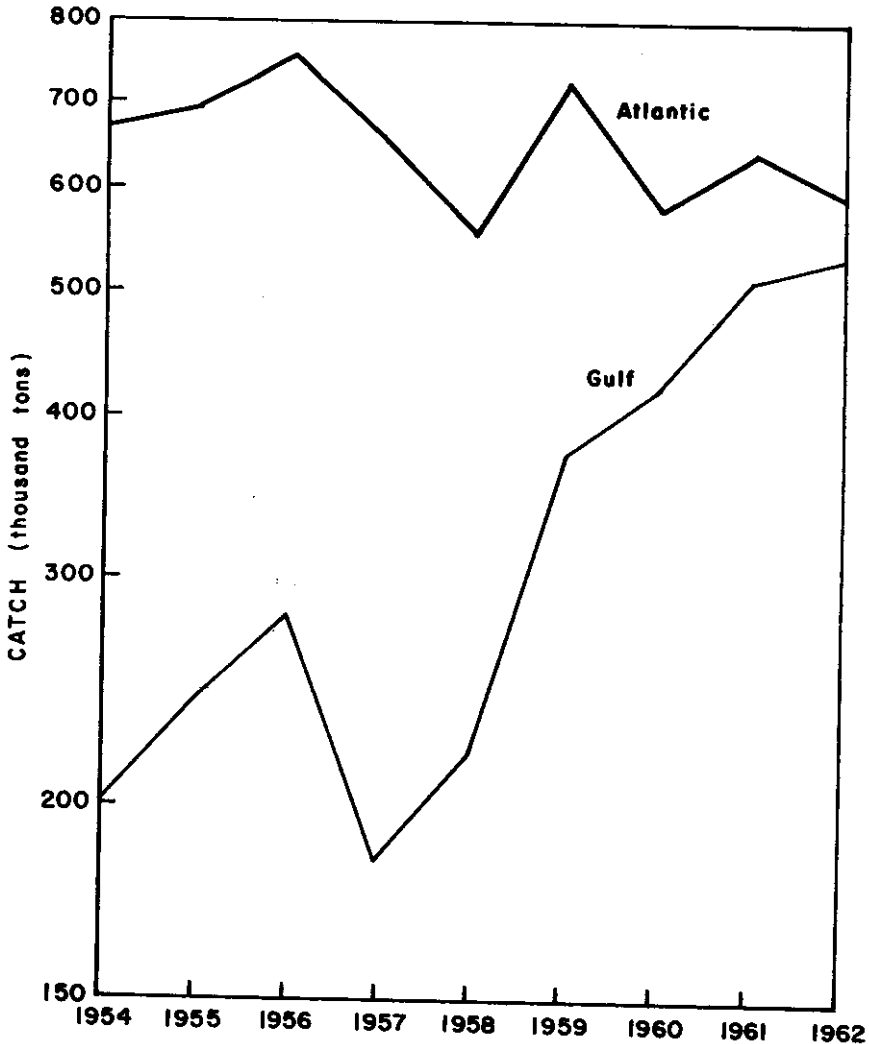


FIG. 5. Menhaden catch, Atlantic and Gulf Coasts, 1954-1962.

average age of the vessels engaged in the Atlantic fishery in 1961 was 23.2 years. The average age of Gulf vessels was 9.7 years (Power, 1961).

Between 1954 and 1960, an estimated 38 new vessels were added to the Gulf fleet. These new vessels accounted for about 57% of the fleet that operated in the Gulf in 1961. The low average age of the Gulf vessels with probable comparatively low costs of operation and maintenance contributed to the high physical product per unit of labor in the Gulf fishery previously described. In addition, the probability of Gulf vessels being larger than those operating in Atlantic waters can be inferred from Fig. 2, which indicates the average amount of purse seine yardage carried per vessel. Average yardage per vessel in the Gulf has been greater than in the Atlantic since 1957.

Average yardage per vessel increased by almost 20% in the Gulf fishery in 1954-61, with the "take-off" point again around 1957. In comparison, average yardage per vessel on the Atlantic Coast vessels had declined about 4% by 1961.

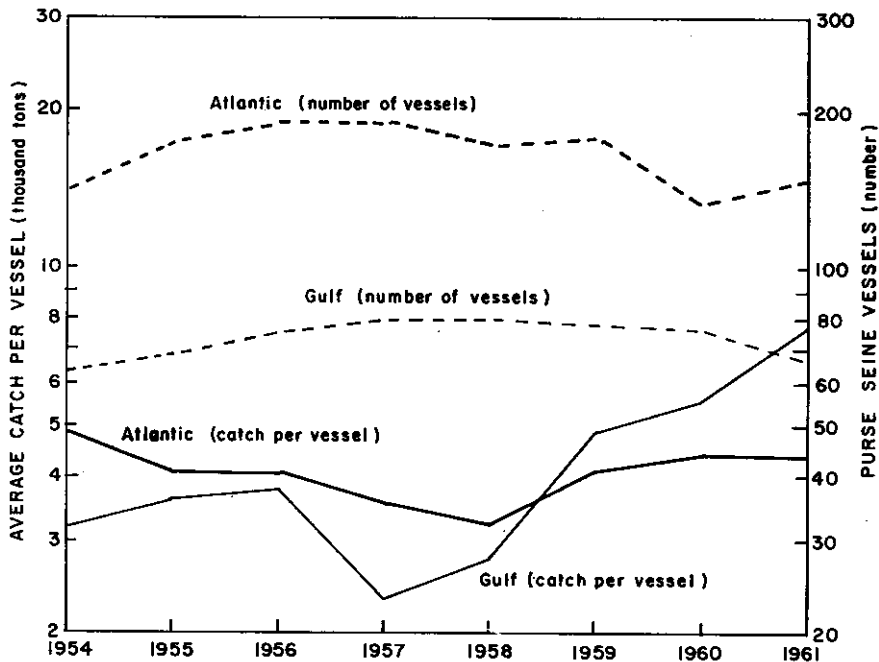


FIG. 6. Average menhaden catch per vessel and number of vessels, Atlantic and Gulf Coasts, 1954-1961.

Aggregate gear inputs are shown in Fig. 4. The trends shown also reflect creditably on the two fisheries in terms of the economic postulate of minimum gear employment. The total Atlantic yardage of purse seine in 1961 was at the precise level of yardage in 1954, but it was carried by a slightly higher number of vessels in 1961. This trend in yardage and vessels moved in much the same pattern as the Atlantic catch curve seen in Fig. 5.

Examination of these curves indicates the dynamic aspects of a developing



fishery on the Gulf Coast. Vessel and purse seine curves (Fig. 4) rose from 1954 through 1958-59 and have since declined. The concomitant catch curve in Fig. 5, however, continued to rise even after the decline in numbers of vessels and seine yardage. This continued rise indicates that the number of vessels and amount of gear obtaining fish in both areas is probably approaching the "minimum" requirement.

### Output

The increased proportion of the total menhaden catch from the Gulf Coast in 1954-62 is shown in Fig. 5. Physical output per unit of vessel input, as seen in Fig. 6, emphasizes the Gulf Coast's tremendous advances. At the same time that a declining trend in vessel numbers began in the Gulf, catch per vessel soared (1958) and was 1.75 times that of the Atlantic in 1961. In this area, performance of the Atlantic fishery lagged. Fig. 6 shows a decrease in catch per vessel in 1954-58, after which the catch per vessel increased. The number of vessels increased throughout 1954-58. Taken together, the two curves indicate a comparatively lower physical output per vessel fishing in the Atlantic.

The reasons for this performance lag in the Atlantic are attributable to several factors. In addition to the greater age (with probably lower efficiency) of the Atlantic vessels, biological factors undoubtedly exercised a great influence. The species being exploited in the Atlantic (*Brevoortia tyrannus*) and in the Gulf (*B. patronus*) are different. Variations in abundance and availability of the two species would directly affect any "per catch" estimates. The future construction of stochastic models for evaluation and prediction, in order to have any meaning, must enlist the aid of the biologist on questions such as availability and abundance.

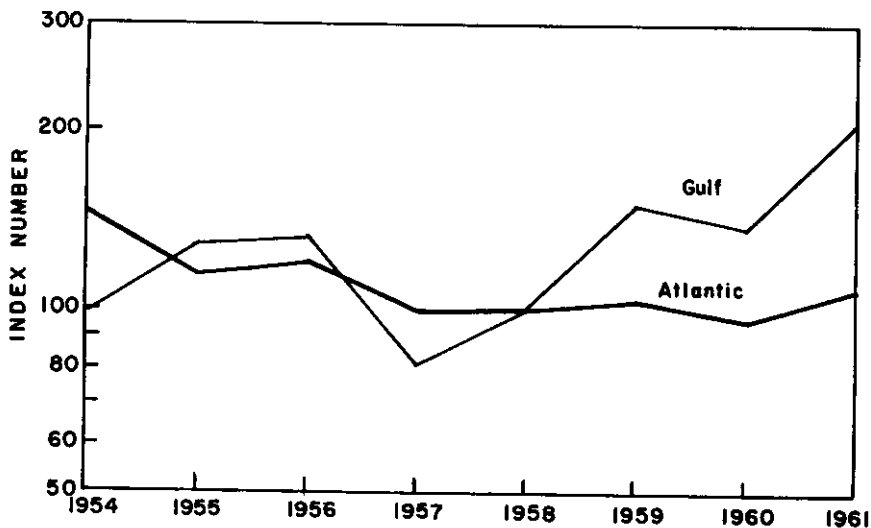


FIG. 7. Aggregative index of Atlantic and Gulf menhaden catch values, 1958 = 100.

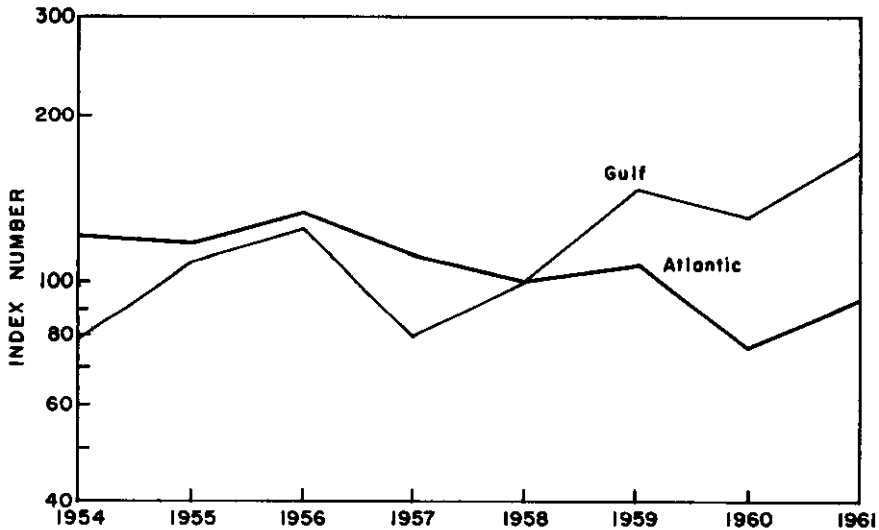


FIG. 8. Aggregate index of gross returns per menhaden purse seine vessel, Atlantic and Gulf Coasts, 1958 = 100.

Reintjes and June (1960) have suggested the possibility of winter exploitation of Gulf Coast menhaden. If such year-round exploitation is found to be biologically and economically feasible, it would reinforce the trend described in this paper: that is, the Gulf's increasing importance as a major area of menhaden production.

**Earnings**

The aggregate index of menhaden catch gross returns for the Atlantic and

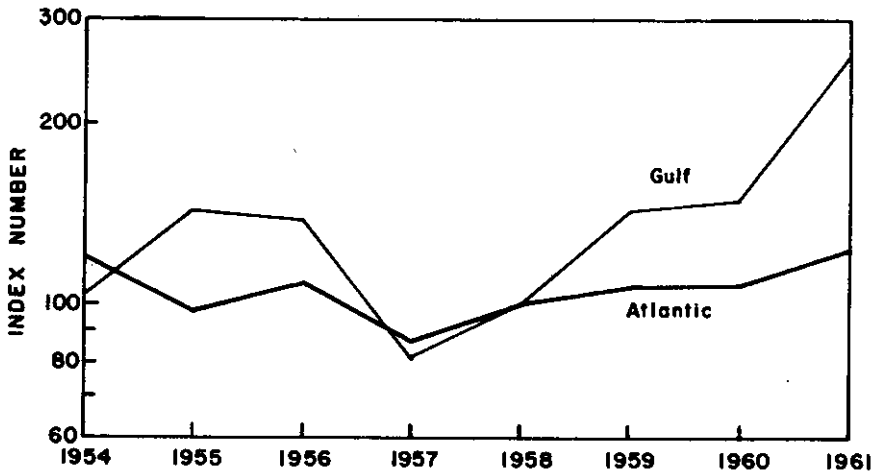


FIG. 9. Aggregate index of gross returns per menhaden fisherman, Atlantic and Gulf Coasts, 1958 = 100.

Gulf Coasts is shown in Fig. 7.

Gulf Coast gross returns reflect the importance of the fishery to the area; after 1958, returns there outstripped the catch values of the Atlantic fishery. Indices of returns on a per-vessel and a per-fisherman basis are shown in Figs. 8 and 9. Every year since 1958, the gross value of the Gulf catch has exceeded that of the Atlantic; in 1955-56, per-fishermen and per-vessel gross returns for the Gulf were above those in the Atlantic.

These data lead to speculation regarding the fulfillment of an important economic objective—the ability of the labor and capital committed in any particular fishery to earn their opportunity costs; that is, the income that the two factors could earn if otherwise employed.

Actual deflated gross returns on a per-fisherman basis are shown in Fig. 10. Although the deck hands employed in menhaden fishing operations on both Atlantic and Gulf Coasts are probably not actually earning \$5200 to \$8200 per year (Fig. 10, 1961), using the data available these "returns per fisherman" (and per vessel) give an indication that a satisfactory return has probably been accruing to the factors of production in the menhaden fisheries—at least, during the period studied. Until more data become available on hourly wage rates and boat-share systems in the two fisheries, however, a more definitive analysis of opportunity cost performance must be deferred.

#### **Summary**

The data available on the primary operations of the menhaden fishery indicate the following trends:

(1) A high physical productivity per unit of labor input exists in both the Atlantic and the Gulf Coast menhaden fisheries, as is seen by examining the number of fishermen and fishermen-per-vessel in both areas in 1954-61. Further support for this conclusion is provided by the trends in yardage of purse seine handled on a per-fisherman basis. A high marginal physical productivity of labor also seems apparent from catch per fisherman and the trend in the total numbers of fishermen employed during these eight years. A rapid rate of technological progress and a high level of managerial ability appears to exist in the Gulf fishery.

(2) It is likely that the efficiency of Gulf Coast vessels is greater than that of Atlantic Coast vessels, based on the data available on vessel ages. The average yardage of purse seine carried per Gulf vessel is greater than is the average yardage carried per Atlantic vessel.

(3) Gear inputs in the Atlantic fishery, in terms of yards of purse seine, have trended downward after peaks in 1956-57. This declining trend commenced in the Gulf fishery after 1959.

(4) Trends in labor inputs and productivity in both fisheries reflect probable fulfillment of the economic objectives of maximum labor efficiency and minimum labor inputs for given catch levels. With respect to vessel efficiency, the Gulf has apparently gained ascendancy over the Atlantic fleet, owing to the relatively recent introduction of new vessels and increased use of aircraft for spotting schools of fish. Minimum gear employment for given catch levels appears to be the trend in the Atlantic fishery, with gear and vessel curves approximating the catch curve in that fishery in 1954-61. Comparable gear and vessel input curves in the Gulf fishery rose from 1954 through 1958-59, and then declined; the catch curve in the Gulf continued to rise after 1959,

which indicates a trend toward an optimum level of gear and vessel inputs for a minimum level of catch in this fishery.

(5) Whereas the Gulf catch accounted for only 23.1% of the menhaden catch in 1954, it accounted for 47.4% in 1962. This was the highest peak attained over a nine-year increasing trend. The output (catch) per vessel in

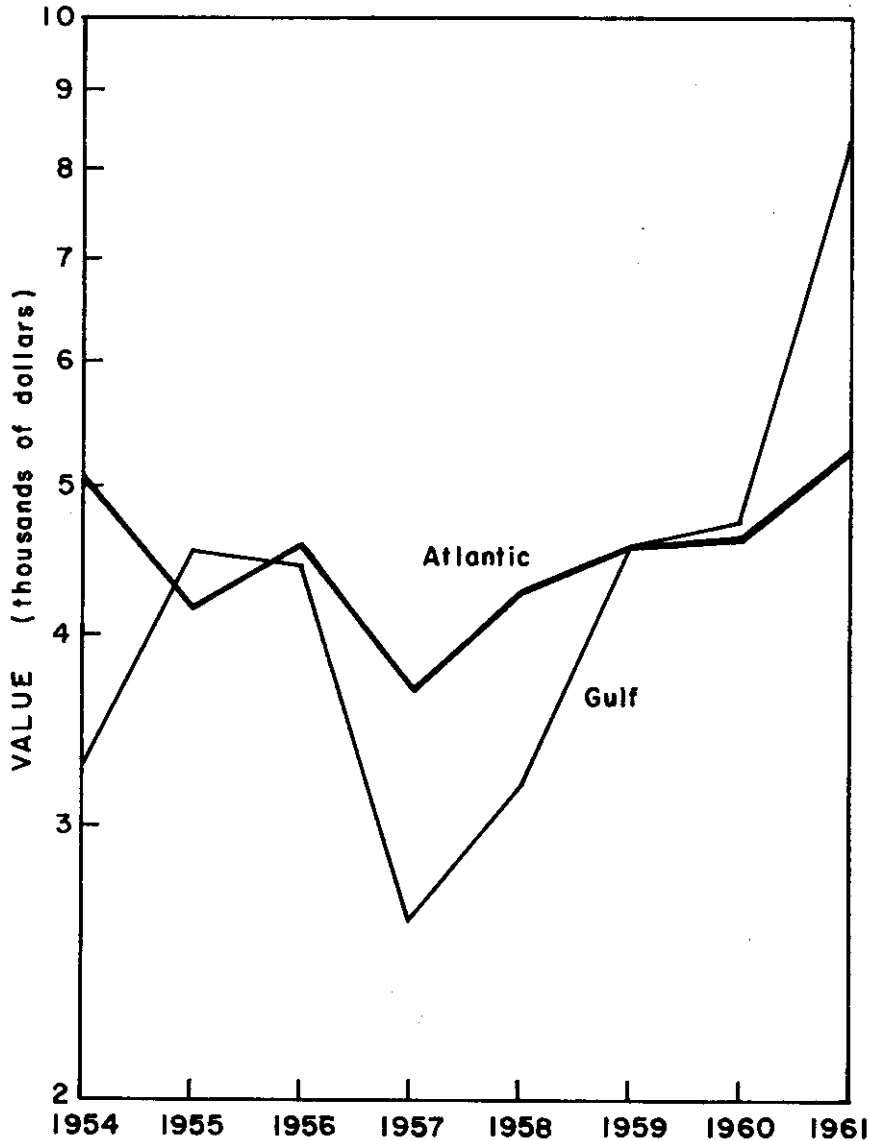


FIG. 10. Average gross returns per menhaden fisherman, Atlantic and Gulf Coasts, 1954-1961.

the Gulf fishery increased rapidly beginning in 1958. In 1961, the Gulf catch per vessel was 1.75 times that of the Atlantic catch per vessel. A comparatively low physical output per Atlantic vessel is noted; several possible reasons for this include biological factors of the fishery itself and higher average vessel age.

(6) If increased exploitation of Gulf menhaden during winter months, as suggested by Reintjes and June (1960), is found to be feasible and is initiated, even greater catches and greater production of meal and oil from the Gulf will occur. Based on the apparent vessel and gear efficiency now existent in the region, the Gulf Coast may well become our principal menhaden fishing area in the future.

(7) A generally declining aggregative index of menhaden catch values has occurred in the Atlantic fishery since 1954. The Gulf index, however, soared above that of the Atlantic after 1958. Indices of gross returns on a per-fisherman and per-vessel basis also exceeded those on the Atlantic for most years. It is noted that labor and capital in both fisheries are probably earning their opportunity costs. A thorough analysis of the opportunity costs, however, necessitates data on actual wage rates and boat shares in the two fisheries and the alternative incomes available to these factors in the regions.

### REDUCTION INDUSTRY

#### *Number of Operating Units*

The number of reduction plants producing menhaden products in 1954-62 is shown in Fig. 11.

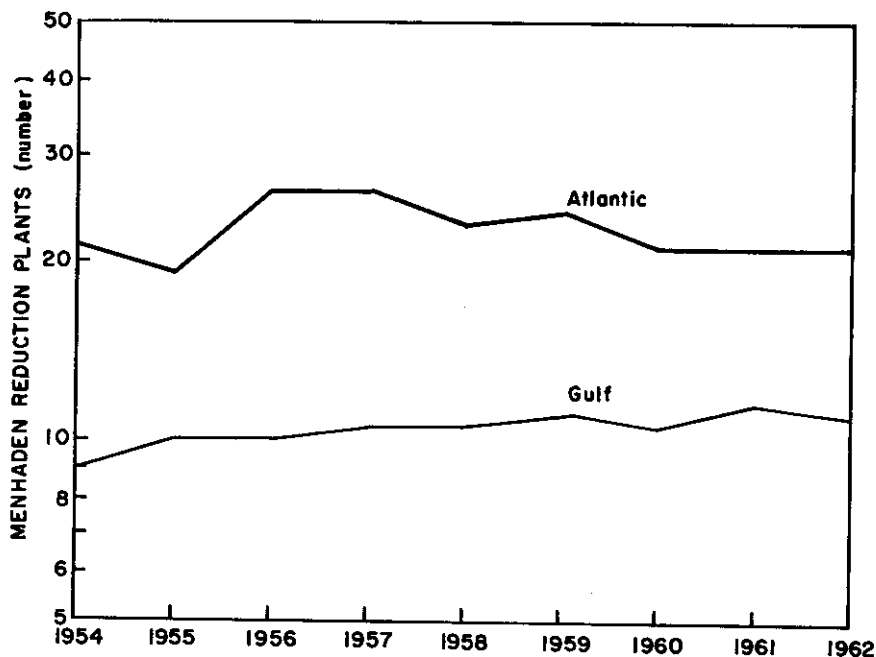


FIG. 11. Number of menhaden reduction plants operated, Atlantic and Gulf Coasts, 1954-1962.

The number of Atlantic Coast plants in 1962 had returned to the 1954 level—that is, 21—after declining from a peak of 26 plants in 1956-57. The upward trend in the number of plants on the Gulf Coast, however, reflects the large increase in catch that has occurred in the region and the concomitant increased meal production. The number of plants gradually rose from 9 in 1954 to 12 in 1962.

### **Menhaden Meal Production**

The production of menhaden meal in 1954-62 is shown in Fig. 12. Gulf

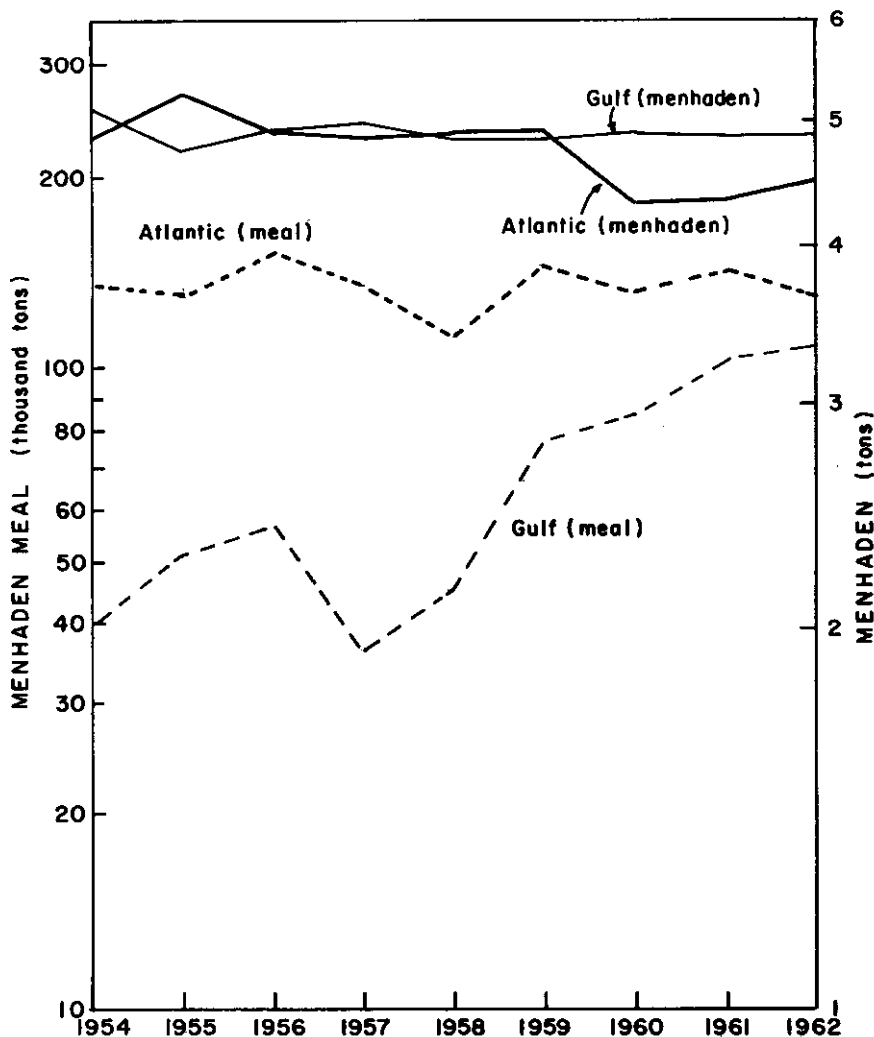


FIG. 12. Menhaden meal production and tons of menhaden necessary for the production of 1 ton of menhaden meal, Atlantic and Gulf Coasts, 1954-1962.

Coast meal production in 1962 was almost three times the production from that region in 1954. In contrast, meal production on the Atlantic Coast at the end of 1962 was slightly below that in 1954.

In order that the amount of fish necessary for the production of 1 ton of meal in the two regions could be estimated, meal production from each given region was divided into the catch from that region in 1954-62. The results are shown in Fig. 12. They indicate that a slightly higher amount of fish is generally necessary to produce 1 ton of meal in the Gulf region. This result, however, would not appear valid when the catch (Fig. 5) and meal (Fig. 12) curves for the two regions are compared. In this comparison, Atlantic and Gulf catch and meal curves follow each other closely. Further investigation is necessary before any definite conclusion can be reached. There is need for technologists

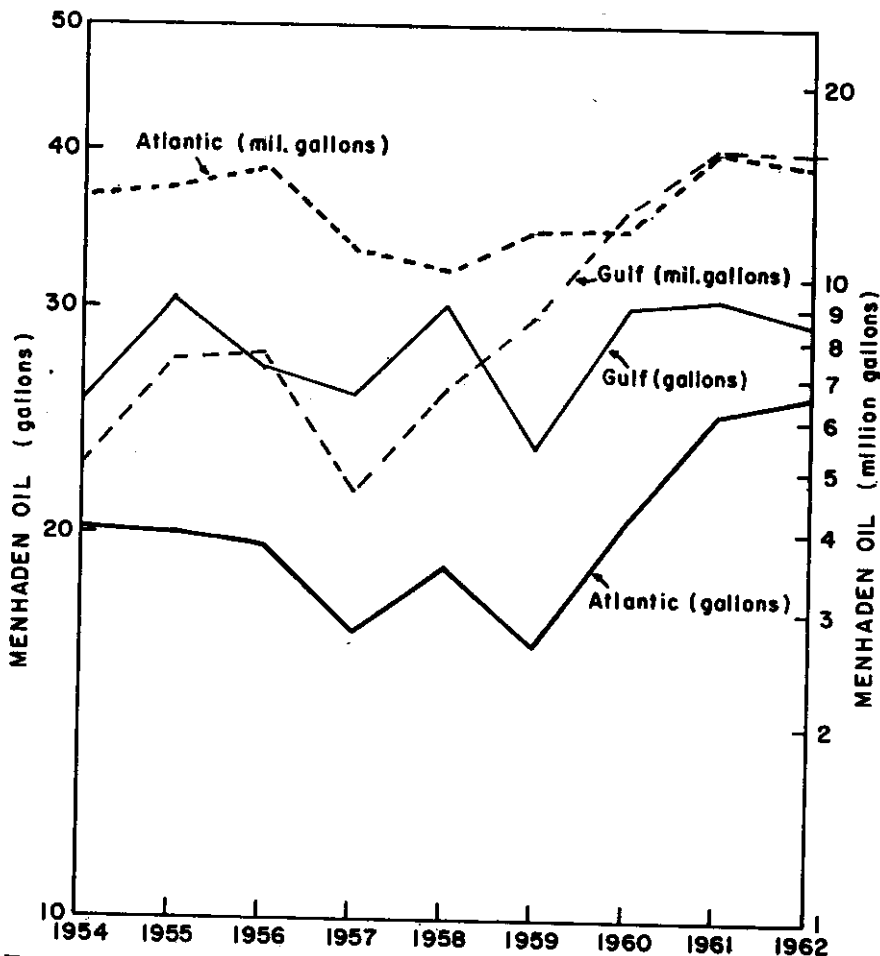


FIG. 13. Menhaden oil production and gallons of oil produced per ton of menhaden, Atlantic and Gulf Coasts, 1954-1962.

to cooperate with economists in determining such factors as plant efficiency in the reduction of fish for meal and oil.

### **Menhaden Oil Production**

In the production of menhaden oil, the Gulf Coast has overtaken the Atlantic Coast in recent years. The production of oil from Gulf plants in 1962 was 15.5 million gallons, or three times the 1954 production. Atlantic Coast oil production in 1962 was about 12% greater than that in 1954. These data are shown in Fig. 13.

Since 1954, the Gulf Coast has consistently produced more oil per ton of fish than has the Atlantic Coast. For 1954-62, the average number of gallons of menhaden oil produced per ton of fish was as follows: 28.1 gallons on the Gulf Coast and 20.3 gallons on the Atlantic Coast. Yearly averages are shown in Fig. 13.

When Figs. 5 and 13 are compared, it is evident that the curve of Gulf oil production follows the Gulf catch curve. Gulf fish are consistently fatter and uniformly of one or two age groups. In the Atlantic, oil yield follows the passage of dominant year classes through the fishery.<sup>5</sup> This is further evident from data shown in Fig. 13, where the variation of the average yield in the Gulf is roughly half that in the Atlantic.

### **Summary**

The data available on the menhaden reduction industry indicate the following trends:

(1) The number of reduction plants on the Atlantic Coast rose from 21 in 1954 and 19 in 1955 to a high of 26 in 1956-57. The number subsequently declined, and in 1962 again was 21. The number of Gulf Coast plants rose from 9 in 1954 to 12 in 1962.

(2) The production of menhaden meal on the Gulf Coast rose from about 39 thousand tons in 1954 to over 108 thousand tons in 1962. With the exception of 1957, the region, when viewed yearly, accounted for an increasing percentage of total meal produced. In comparison, Atlantic Coast 1962 meal production, with slight fluctuations over the intervening years, was near the 1954 level (almost 137 thousand tons in 1954 and 130 thousand tons in 1962).

The percentage of the total meal produced by the Atlantic Coast subsequently shows a general decline from almost 78% of the total in 1954 to about 55% in 1962.

(3) The amount of fish generally required to produce 1 ton of menhaden meal in 1954-62 averaged 4.9 tons in Gulf plants and 4.8 tons in Atlantic plants. These figures appear to be in conflict, however, with catch and meal curves for the two regions.

(4) Except for slight declines in 1957-58, Gulf Coast production of menhaden oil rose from about 5 million gallons in 1954 to 15.6 million gallons in 1962. The production of oil on the Atlantic Coast was 13.5 million gallons in 1954. It fluctuated (generally downward) in subsequent years until 1961-62, when over 15 million gallons per year were produced.

The Gulf Coast accounted for over 50% of the total oil produced in 1962. In 1954, only 27.5% of total oil production came from the Gulf. Although

<sup>5</sup>Personal communication with F. C. June, Acting Laboratory Director, Biological Laboratory, U.S. Department of the Interior, Bureau of Commercial Fisheries, Pivers Island, Beaufort, North Carolina.



Atlantic Coast production in 1962 was above that in 1954, the percentage share of total production from this region declined over those years from about 72% to 50%.

(5) The average number of gallons of menhaden oil produced per ton of fish in the Gulf region was 28.1 for 1954-62. The comparable average for the Atlantic Coast was 20.3 gallons per ton of fish.

### CONCLUSIONS

(1) High physical productivity per unit of capital and labor in the Gulf menhaden fishery since 1954 has been a basic factor in the rapid growth of this fishery and in the currently significant role of that region in the United States production of menhaden meal and oil. High vessel efficiency due to low average age of vessels operating in the Gulf Coast waters and to a rapid rate of adoption of technological innovations is also apparently a causal element.

(2) Four economic criteria for evaluating fishery performance were postulated. The analysis indicates that both the Atlantic and the Gulf fisheries were probably approximating these economic criteria in the period studied. A more definitive analysis, especially with regard to opportunity costs, however, must be undertaken when cost data from the two fisheries become available.

### ACKNOWLEDGMENTS

The review and comments of James A. Crutchfield, Charles F. Lee, John B. Glude, and Fred C. June were extremely helpful. Some recent statistics were supplied by Ralph Russell and Edward A. Power.

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## **Fishing Vessel Construction Differential Subsidies**

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### **Abstract**

This paper includes a history of fishing vessel construction differential subsidies paid in the United States as well as examples of some foreign subsidies. The