The Future of the Gulf Menhaden, the United States' Largest Fishery

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INTRODUCTION

Since 1963 the Gulf menhaden (*Brevoortia patronus*) has supported the largest single fishery in the United States. In 1970, the Gulf purse seine fishery landed 1.2 billion pounds and constituted 25% of all fishery products landed by United States' fishermen. The Gulf purse seine catch in 1971 is expected to be about 1.5 billion pounds and thus only 2 to 4% less than the record catch of Atlantic menhaden in 1956 and of the Pacific sardine in 1936-37. National Marine Fisheries Service personnel have sampled the Gulf menhaden in landings since 1964 for age (from scales), fork length, weight, sex and stage of sexual maturity. Full time samplers were stationed during the 1964-68 seasons at Moss Point, Mississippi; and Empire, Morgan City, and Cameron, Louisiana. Occasionally samples were also collected at Apalachicola, Florida; Dulac, and Intracoastal City, Louisiana and Sabine Pass, Texas, the remaining ports where purse seine catches were landed. During the 1969-71 seasons, samplers were stationed at Moss Point, Mississippi; and Morgan City, and Cameron, Louisiana. Samples of landings at the other listed ports were also obtained as time permitted during these later seasons. In addition to securing fish, samplers maintained daily activity records of each vessel and assisted vessel personnel in the maintenance of a fishing log. Daily catch records of each vessel were also collected during the period 1964-71. Catch records for the seasons 1946-63 were made available by plant managers. A part of these data are reported here.

HISTORY AND STATUS OF FISHERY

Landings of Gulf menhaden by the purse seine fleet during the 25-year period 1946-70 show gradual but not consistent annual increase (Fig. 1). Gulf menhaden were reportedly landed as early as about 1900, but annual catches until after World War II remained small. The present purse seine fishery can be considered as beginning in 1946 when 35,000 metric tons were landed. Decreases in landings occurred in 1952, 1953, 1957, 1963, 1964, 1966 and 1967, but the trend has been toward larger landings each succeeding season. Since 1946, annual landings have increased 15 fold. Landings since 1967, the most recent low, have increased 73% to 546,000 metric tons in 1970. Estimated catches in 1971 are 690,000 tons or 26% greater than the previous record 1970 catch.

The distribution of landings by the various states along the Gulf coast for the past 10 seasons, 1961-1970 (Fig. 2), shows that proportionately, Louisiana's landings have increased most. Landings in Texas, and in Florida west coast and Mississippi have each proportionately decreased. Landings in Florida and Mississippi decreased from 30% of total Gulf landings in 1961 to 17% in 1970. Texas landings decreased from 13% of total landings in 1961 to 4% in 1970. A contributing factor for these changes in landings during this 10 year period is the

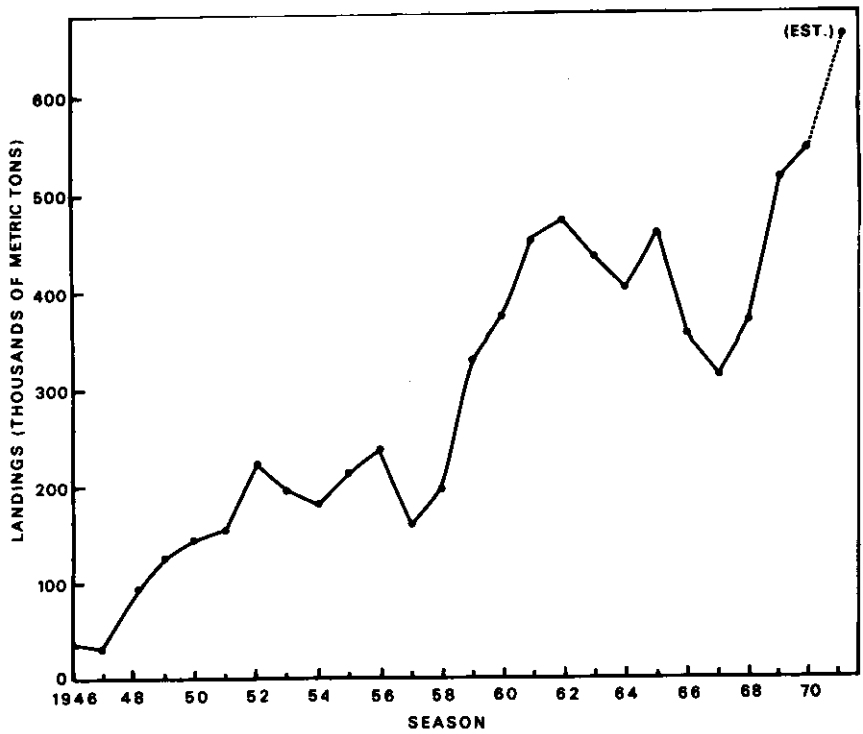

Fig. 1. Purse seine landings in metric tons of Gulf menhaden, 1946-1970.

change in number of carrier vessels and related shore-based facilities which took place during the decade.

The number of operating menhaden reduction plants increased from 2 in 1946 to 14 in 1968. Since then, 12 plants received catches in 1969, and 13 in each of the 1970 and 1971 seasons (Fig. 3).

Spotter aircraft, used to search for schools of Gulf menhaden as well as to aid in the setting of the purse seine, have steadily increased from 1949 when available records show that planes were first used full time in the Gulf fishery. In 1971, 35 airplanes were used (Fig. 3).

Carrier vessels, used to carry the two purse boats and net, as well as the fishermen, to the grounds, and transport the catch back to the reduction plant, generally increased from 4 in 1946 to 86 vessels in 1956. Since then, the number has fluctuated between 68 and 92.

Fish catching ability, although suggested by the number of carrier vessels, is more directly related to size of the vessel and its fish-hold capacity. In 1946, the average size of the carrier vessels, expressed in the vessel's registered net tonnage, was 54 tons. In 1971, the average size of the vessels was 245 tons; a five-fold increase (Fig. 3). The relation of registered net tonnage and fish-hold capacity for the Gulf menhaden fleet has been demonstrated and appears valid.[1] During

[1]A linear surplus-yield model of the Gulf of Mexico's menhaden purse seine fishery, by Robert B. Chapoton. Unpublished manuscript, National Marine Fisheries Service, Mid-Atlantic Coastal Fisheries Research Center, Beaufort, N.C., 28516.

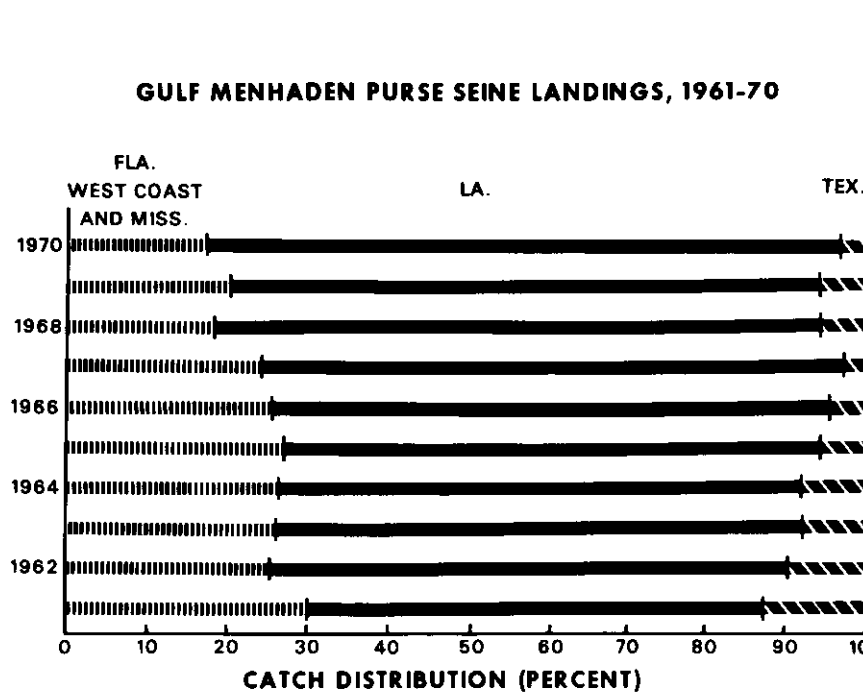

Fig. 2. Distribution of purse seine landings by state, 1961-1970.

the 26-year period shown, the size of the fleet increased at an average annual rate of 14.6%.

Sampling of the purse seine landings for age composition since 1964 shows that the fishery is dependent on principally two age groups of menhaden. The number of fish of each age in landings during the 1967-1969 fishing seasons shows that annually, the number of fish recruited is not consistent (Fig. 4). In 1967, age group I comprised 59% of the sampled fish and contributed about 2.8 billion fish to landings that year. In 1968, age group 1 decreased in abundance and comprised only 28% of the sampled fish which represented an estimated 1.4 billion fish, only one-half as many fish as the previous season. In 1969, age group 1 were more abundant, and comprised 68% of samples and contributed about 4.1 billion fish. Also of significance is that a year class will sometimes contribute more fish to landings as age group 2 than age group 1. In 1968, an estimated 1.4 billion fish were landed, but the following year 2.1 billion or 50% more fish of this same year class were landed by the purse seine fleet. Thus, it is evident that Gulf menhaden are not fully recruited until reaching age group 2.

Gulf menhaden of age groups 3 to 5 are present in landings but contribute only a small amount to annual landings, usually less than 15% (Fig. 4). Thus, the current purse seine fishery is dependent on a fish population whose size and age composition can and does change from one fishing season to the next. The comparatively small numbers of older fish, ages 3-5, do not provide for a "cushion" in landings should fish of either age groups 1 or 2, or both, fail to appear on the grounds. Thus, reduced spawning success or survival of young, one year, is immediately evident the next fishing season by the reduced number of 1-year-old fish in landings. While the numbers of age group 1 fish in the landings

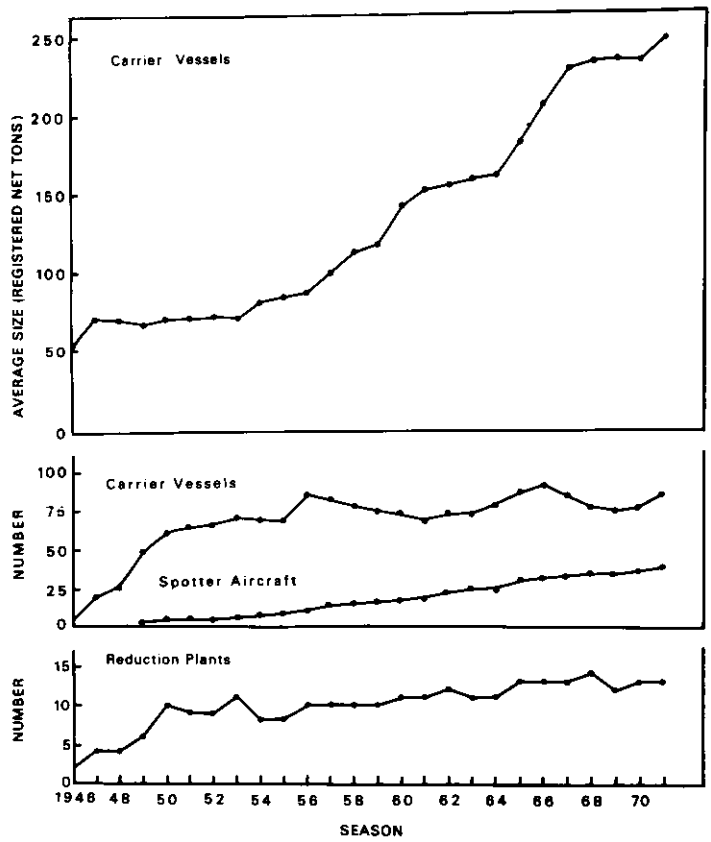

Fig. 3. Number of reduction plants, spotter aircraft and number and average size of carrier vessels in Gulf menhaden purse seine fishery, 1946-1970.

prove that no year class, since 1964 at least, has had a spawning failure, the number of fish recruited as age 1 fish has fluctuated greatly (Fig. 4).

The short life span of Gulf menhaden is in contrast to other clupeid fishes, occuring in more northern latitudes, which have shown not only long life, but have produced dominate year classes which greatly influenced catches in succeeding years. Hjort (1926) reported that the 1904 year class of herring (*Clupea harengus)* annually dominated catches from 1907 to 1919, a span of 13 years. Nicholson and Higham (1965) showed that the 1958 Atlantic menhaden (*Brevoortia tyrannus*) dominated purse seine landings for at least 4 consecutive years. The Atlantic menhaden, a closely related allopatric form of the Gulf menhaden, commonly occurs in catches to age 5, and 8- to 10-year-old members were once not rare. The Atlantic species grows to a fork length of 420 mm and a weight of 1,674 grams (Reintjes 1969). The largest Gulf menhaden sampled thus far was 247 mm in fork length and weighed 296 grams.

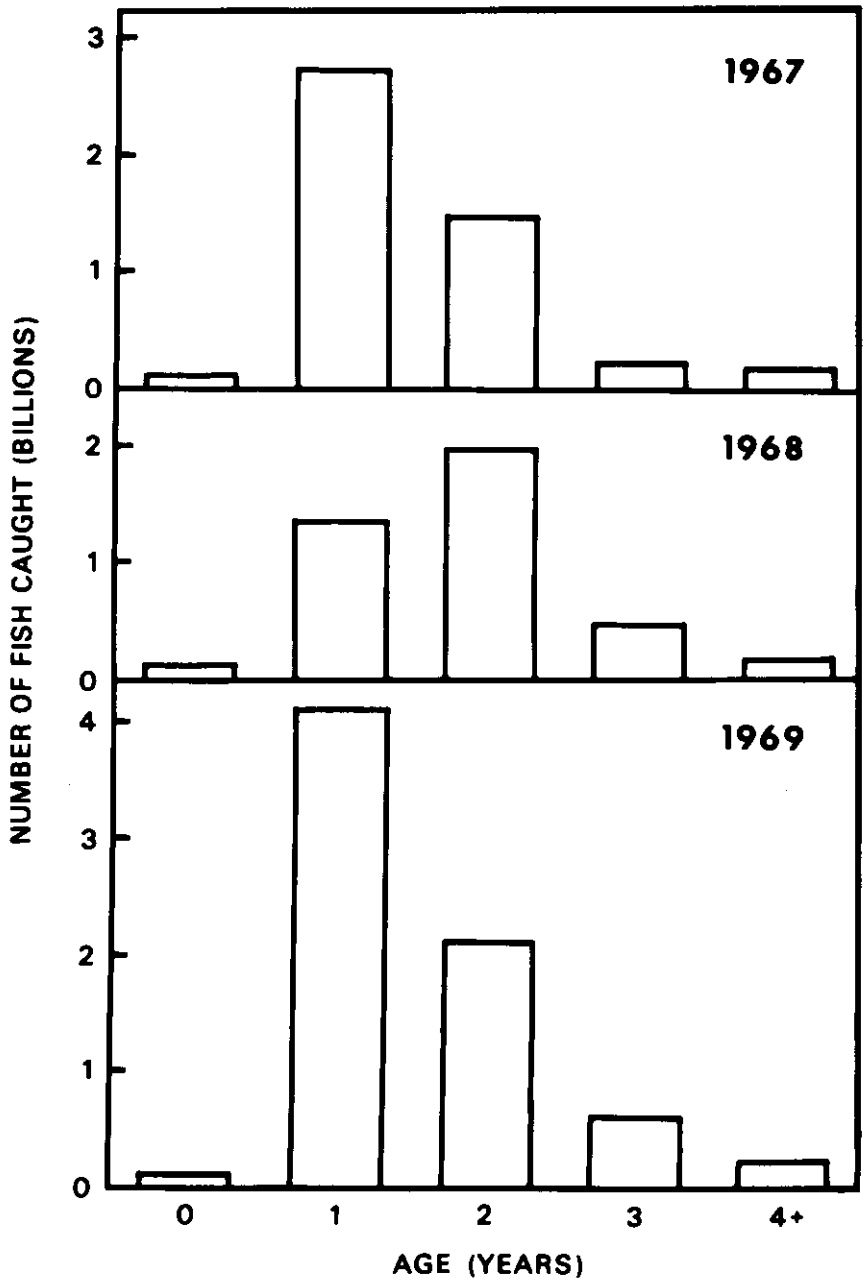

Fig. 4. Estimated number of Gulf menhaden by age landed, 1967-1969.

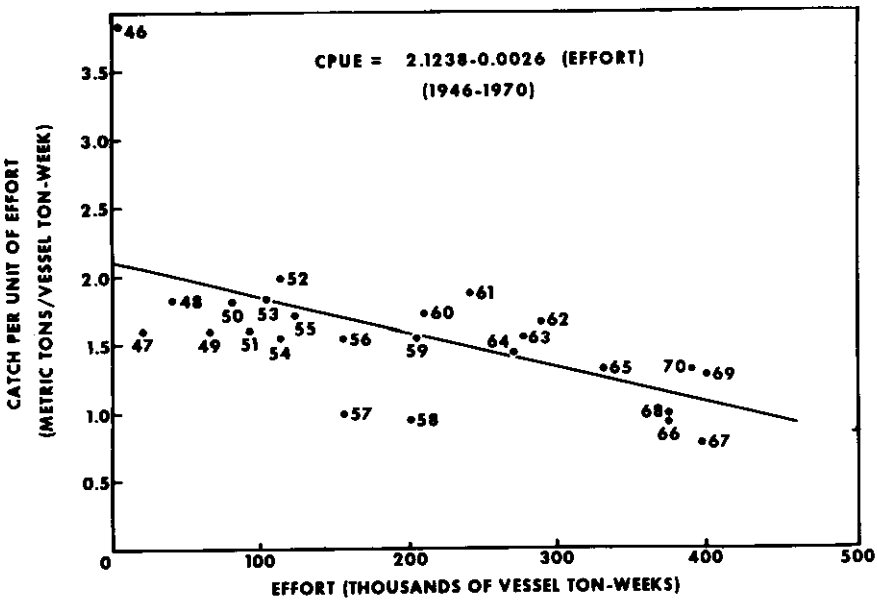

Fig. 5. Equilibrium relation (solid line) between catch per unit of effort and effort in Gulf menhaden fishery, 1946-1970 (numbers refer to years).

ESTIMATES OF MAXIMUM SUSTAINABLE YIELD

The linear surplus-yield model, sometimes called the Schaefer type, assumes logistic population growth. This assumption results in (1) a linear relation between fishing effort and population size and (2) a parabolic curve when yield is plotted against population size or fishing effort (Schaefer, 1954).

A summary of landings and corresponding catch per unit of efforts (CPUE) for the 24-year period (1946-1969) of this fishery has been made, as well as estimates of the maximum sustainable yield.[1] The catch and effort statistics from the 1970 season provide an opportunity for updating. Purse seine landings in 1970 were 546,000 metric tons and fishing effort, calculated as before, amounted to 397,156 vessel ton-weeks of effort. The CPUE for 1970 is thus 1.37 tons of catch per vessel ton-week of effort (Fig. 5). This CPUE is slightly higher than the 1.27 value observed in 1969, but appreciably greater than those of 0.94, .78 and .97 observed for the three previous seasons 1966-1968. By linear regression, the trend of CPUE on effort for 1946-1970 can be summarized by the expression

$$CPUE = 2.1238 - 0.0026 \text{ (Effort)}$$

and is shown as the solid line (Fig. 5). The trend indicated appears downward and is only slightly changed from the value previously calculated for the period 1946-69.[1]

The maximum sustainable yield for the Gulf fishery was calculated through use of the constants, a and b obtained above. This, plus a series of equilibrium yields, is indicated by the curved line (Fig. 6). The model indicates that the average annual maximum sustainable yield (catch) for this fishery is 434,000

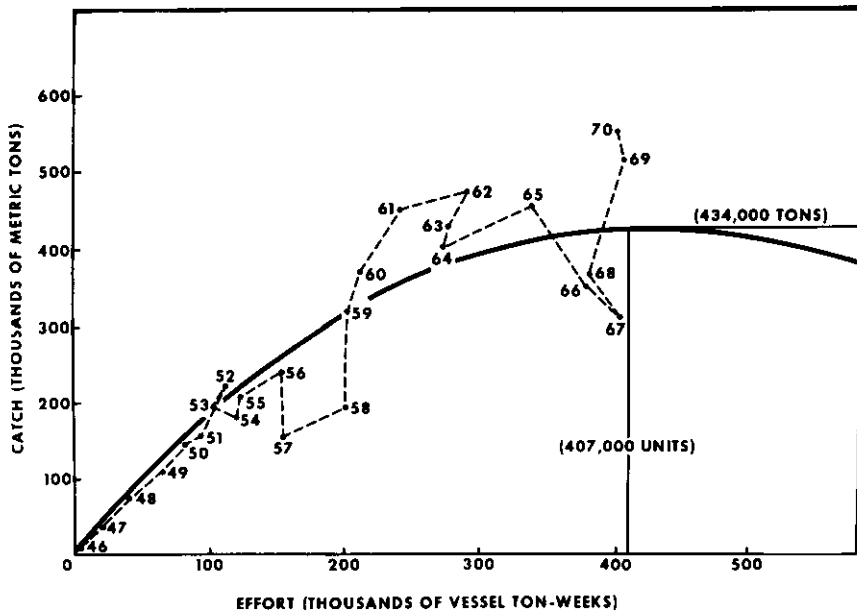

Fig. 6. Equilibrium yield predicted (solid line) and observed catch and effort (dashed line) in Gulf menhaden fishery, 1946-1970. Point of maximum catch (horizontal line) and corresponding effort (vertical line) indicated (numbers refer to years).

metric tons. It is also indicated that 407,000 vessel ton-weeks of effort would produce this yield. As Schaefer (1957) pointed out, additional units of fishing effort greater than that suggested in the model do not produce proportionally more yield. Additional effort will have a negative effect on the population and will tend to reduce future yields. In the Gulf menhaden fishery, as with other major fisheries studied to date, a precise estimate of the amount constituting "too much" is not known. In the Pacific sardine fishery, Murphy (1966) reported that catches exceeded maximum sustainable yield estimates by 20% prior to its collapse. Additional factors, including other fish competition, are believed to have played a part in the rapid decline in the sardine population (Marr, 1960). Cushing (1968) gives examples of other fisheries that show marked changes in apparent abundance, as indicated by landings, and indicates that herring-like, pelagic fishes tend to fluctuate more than do demersal fishes.

An examination of recent annual catches with the model suggests that the Gulf menhaden fishery is reaching or has already reached predicted maximum yields. The average catch during the previous 5 years, 1966-1970, is 423,000 metric tons, or 3% less than the model estimate of 434,000 tons. Landings in 1971 are estimated at 690,000 tons, and while comparisons of landings in a single year are difficult or possibly misleading in a fishery showing wide annual fluctuations, this catch is a significant 59% greater than the level identified as being sustainable.

COMPARISON WITH OTHER UNITED STATES FISHERIES

In a comparison of the Pacific sardine and the Atlantic menhaden fisheries, McHugh (1969) points out some remarkable, though not fully explained, similarities. In like fashion, the Gulf menhaden fishery appears similar to that of the sardine as well as the Atlantic menhaden fisheries, and in some regards, perhaps more striking. The estimated parameters for the three fisheries, each representing, at one time or another, the predominate fishery along the three large coastal areas of the United States; namely, the Pacific sardine on the Pacific coast, the Atlantic menhaden on the Atlantic coast and the Gulf menhaden on the Gulf coast, are listed (Table 1). Reported maximum landings of sardine were made in 1936-37, those of Atlantic menhaden in 1956. Peak landings of the three species are within 4% of one another. Estimates of maximum sustainable yield, each obtained via a different method or modification, are also similar. In each case, landings exceeded the maximum sustainable amount suggested by the models. Because of the arbitrary selection of years and dates when the estimates were made, the three values vary, but they still tend to be approximately comparable. McHugh (1969) asks, "does the history of the sardine fishery offer any lessons that might help. . . .other fishing industries anywhere in the world to avoid the fate of the sardine industry?" It would be reasonable to conclude that even without definitive scientific evidence, the answer is yes. Gulland (1971) points out that in a rapidly expanding fishery, acquisition of irrefutable evidence may not be possible before over-development occurs. Landings of Gulf menhaden increased at an average rate of 59% per year between 1946 and 1970.

TABLE 1
Comparison of Certain Parameters of the Pacific Sardine, Atlantic Menhaden, and Gulf Menhaden Fisheries. Pacific Sardine Data from Murphy, 1966. Atlantic Menhaden Data from Schaaf and Huntsman.[1]

Item	Fishery		
	Pacific sardine	Atlantic menhaden	Gulf menhaden
	Thousand Metric Tons		
Maximum landings	718	712	690[2]
Maximum sustainable yield	427	380-500	434
Landings in excess of max. sustainable yield	91	100	55[3]

[1]Effects of Fishing on the Atlantic Menhaden Stock; 1955-1969. Unpublished Manuscript, William E. Schaaf and Gene R. Huntsman, National Marine Fisheries Service, Mid-Atlantic Coastal Fisheries Research Center, Beaufort, N.C. 28516.

[2]Estimated 1971 purse seine landings.

[3]Based on average of landings 1967-1971.

FUTURE PROSPECTS

History shows that industry tends to increase its capacity to catch and process greater amounts of fish when the resource is near or at its maximum size and supporting near record catches. With a time lag of about 1 year in the Gulf fishery, any increased capacity comes on line the following season. In 1969, the fleet numbered 75 vessels and this was increased slightly to 76 in 1970. Record landings in 1969 and 1970 undoubtedly contributed to optimism, overshadowing the caution that poor landings in 1966 and 1967 had caused, and the 1971 fleet was enlarged. The 1971 fleet numbered 85 vessels, 12% more than the previous year but due to the size of the added vessels, the potential fishing effort was increased 15 to 20% over 1970 levels.

The Gulf menhaden has a high reproductive potential, as evidenced by the successively rapid increase in catches in 1968, 1969, 1970 and 1971, following the recent lows in 1966 and 1967. Conversely, the population evidently underwent a considerable reduction in size in 1966 and 1967 following the near record landings in 1965. Thus, the population and the number of fish recruited has undergone marked changes and will likely continue to fluctuate. At present, the purse seine fleet is totally dependent on the dense schooling Gulf menhaden as no suitable alternate resource has yet been found that would provide a supply of fish to this highly specialized fishery. If for any reason, spawning should decrease and/or recruitment fail appreciably, the fishery will find itself with excess capacity. Use of this excess will tend to reduce the population and will further complicate its recovery and perhaps cause a major decline. The recent history of the fishery suggests that fluctuations in the population and landings should be expected. The Gulf menhaden fishery, as presently outlined, is probably sufficiently understood to permit a reasonable, though possibly conservative estimate of what the resource can be expected to sustain. The correctness of the maximum sustainable yield estimate of 434,000 metric tons will be proven in possibly 5 years.

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