10-23-1971

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Marine Technology Society Meeting
Fish Expo '71
Boston, Massachusetts
October 23, 1971

CHANGES IN THE ABUNDANCE OF THE MAINE LOBSTER RESOURCE WITH SEA TEMPERATURE FLUCTUATIONS AND INCREASES IN FISHING EFFORT

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The American lobster fishery in Maine has evolved as a classic example of overexploitation of a renewable marine resource. Declining yield associated with less frequent periods of optimum sea temperature conditions has apparently been accelerated by continued increases in fishing effort.

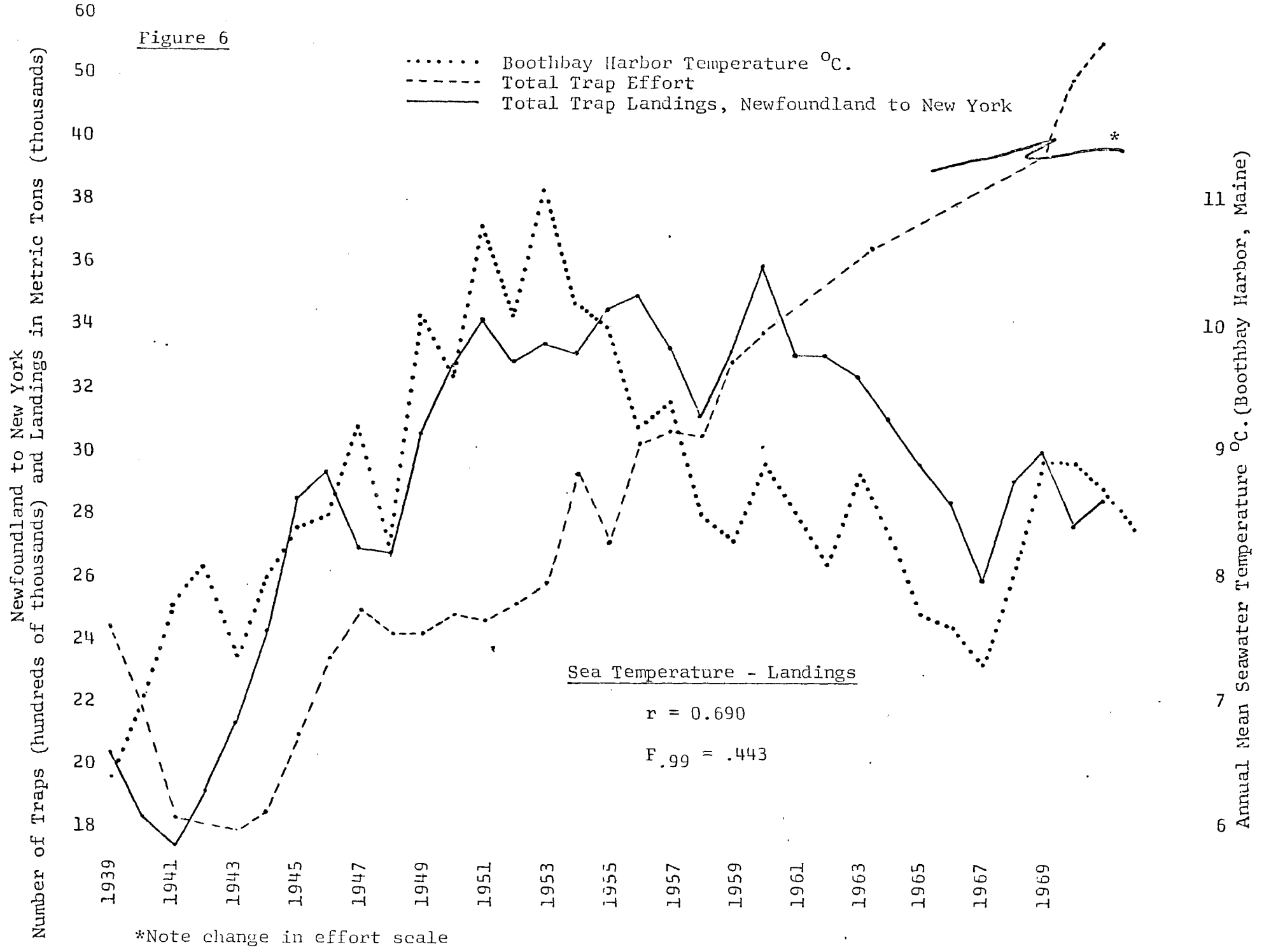
Interacting factors of fluctuating sea temperature influencing recruitment from sublegal stocks and variable fishing effort affecting catch have been evident throughout the history of the Maine lobster fishery. Since 1939 when more correlative data have been collected, less than 10% of unaccounted for variance in supply and yield can be attributed to other factors.

Within several differential levels of effort and supply, fluctuations in catch are measurably related to corresponding fluctuations in temperature or in fishing effort. When fishing effort has expanded catch has increased to the capacity of the legal supply. Subsequent fluctuations in supply occur with corresponding fluctuations in sea temperature.

The increasingly intensive fishery of recent decades has relied heavily on seasonally recruited lobsters from premoult, sublegal stocks to the extent that fluctuations in the population have become more evident. Catch has become less flexibly responsive to changes in fishing effort induced by higher landed value. The lack of flexibility in catch has been caused by the decline in abundance, and the decline in abundance appears to have been the result of sub-optimum temperature and over-fishing.

Fluctuations in lobster catch in other areas of the Northwest Atlantic indicate the probability that sea temperatures have fluctuated correspondingly elsewhere and that in recent years the optimum temperature range for lobsters has been moving from the northern toward the southern limit of their geographical range.

Figure 6



*Note change in effort scale

The decrease in northern abundance is attributable to less frequent moulting and a declining growth rate, which in turn, is associated with decreased feeding activity caused by sub-optimum temperature trends. The apparent lobster abundance limit when it is being intensively fished correlates well with seasonal fluctuations in temperature; winter and spring temperature with summer catch and summer and fall temperature with fall and winter catch. The relationship among catch, sea temperature, landed value, fishing effort and legal and available abundance indicates over-fishing of native lobster populations for either economic or biological efficiency.

Regulations have been designed to hedge the inefficiency and incompetence of participants in the lobster industry. It is extremely doubtful if such laws have accomplished this objective but they have served to confuse and becloud the problem to the extent that many of the deficiencies of the industry are obscured.

The industry has never tolerated regulations which were designed to provide for the welfare of the resource, nor has encouragement been given to biological research which might provide information as a basis for such regulations. The industry has also encouraged inefficiency in order to spread employment as widely as possible. There is no evidence that the industry is concerned with the objective of maximizing the resource either biologically or economically.

During the inter-World War period the fishery was exclusively subsistence. Since World War II less than 25% of licensed fishermen are employed full time in lobster fishing. The largest group of part-time fishermen consists of those under 20 years of age, suggesting that lobster fishing may be used as a means of educational or pre-vocational support. Between 1964 and 1968 full time fishermen between 40 and 54 years of age increased from 33.9 to 34.5%, those 50 years and older increased from 33.5 to 36.0% and those 60 years and over increased from 13.3 to 15.8%. Conversely the number under 40 declined from

43.2 to 41.1% and those under 30 from 22.8 to 22.4%. These data indicate the unattractiveness of the industry in terms of employment recruitment and imply the degree of welfarism resulting from inappropriate regulation of the resource.

For years economists and biologists have recommended for ~~varied~~ and many reasons a reduction in the number of fishermen. Economists argue that spreading employment, ~~a political~~ ploy, is not economically desirable since the policy does not provide an incentive to good management nor to efficient use of the resource. Unrestricted entry dilutes the profitability for those who are competent fishermen and generally results in misuse of the resource and decreases operational efficiency. Biologists have reported the repeated capture and release of sublegal lobsters with consequent physical damage and frequent mortality from predation and mishandling. Regulatory by-products are patch-work restrictions based on ~~whimsical~~ inspiration rather than scientific evidence.

Limited entry undoubtedly has its merits; a license to carry on a selected fishing operation is an economic asset with a measurable value in the market place. A reduction in participation obviously in an incentive for the remaining participants to take a personal interest in the future as well as the present of the resource they are exploiting. But at best limited entry creates artificial barriers which are not particularly meaningful in terms of economic expansion and food production. Responsibility for protection of the renewable marine resource is not assumed by the participants; in fact this responsibility still remains with the powerless paternalistic agency responsible for the resource. Limited entry will not provide maximization of the resource nor will it insure any substantial increase in production.

In 1960, a peak year, the inshore trap catch of lobsters from those areas which normally produce more than 99% of the total North American yield

was 36,000 metric tons only a modest fraction of the potential world market. Using published data on offshore stocks and historical information on population trends of the inshore resource, I have estimated that total annual catch during periods of optimum climatic conditions would probably not exceed 45,000 tons on a sustained yield basis. Suboptimum conditions would likely reduce yield to approximately 25,000 tons annually. The most stringent and biologically sound management might increase yield by 5,000 tons.

By 1970 the American lobster was bringing the highest unit and third highest species total value of any major indigenous North American commercial fisheries resource. Lobsters are caught from Newfoundland to North Carolina, with Canada producing 55 to 65 percent of the annual 30,000 to 35,000 metric ton volume. Maine contributes 25 to 30 percent to the annual catch.

In Canada and the inshore waters of the northeastern United States the catch is made by means of wood, metal, or plastic traps set on the ocean bottom. The trap is not an efficient fishing device; yet, saturation of the bottom with traps effectively reduces the legal lobster population by 90% or more each year.

Varying ratios of yield to effort, ranging from 4.0 to 1.0 in the early 1940's to 0.5 to 1.0 in 1970, have occurred in the Maine fishery. The period 1897 to 1906, transitional from the canned to the live lobster market, was duplicated in expansion of effort and yield in 1943 and 1944, following the post-World War I depression which had induced marked reduction in effort. After World War II demand for lobster further increased as did yield of the fishery.

Continued expansion of fishing effort resulted in greater dependence upon stock newly recruited by moulting from sublegal populations. Only 79% of annual production in 1947 came from recently recruited lobsters, 85% in

1955, and by the middle 1960's more than 90% of the catch consisted of this largely immature stock.

Predation on sublegal lobsters liberated by fishermen is a function of fishing effort which appears to be a significant contributor to the annual mortality of this size group. Unrecovered traps from which lobsters cannot escape, toxic pollutants, a declining growth rate and reduced reproductive capacity may be other important factors.

The major environmental factor influencing changes in lobster abundance throughout its range has been cyclic fluctuations in sea temperature. Optimum or nearly optimum mean annual sea temperatures ranging from 9.0 to 11.0° C., as measured at Boothbay Harbor, Maine, by the National Marine Fisheries Service, occurred regularly in Maine between 1945 and 1957 and less frequently during the period subsequent to 1958.

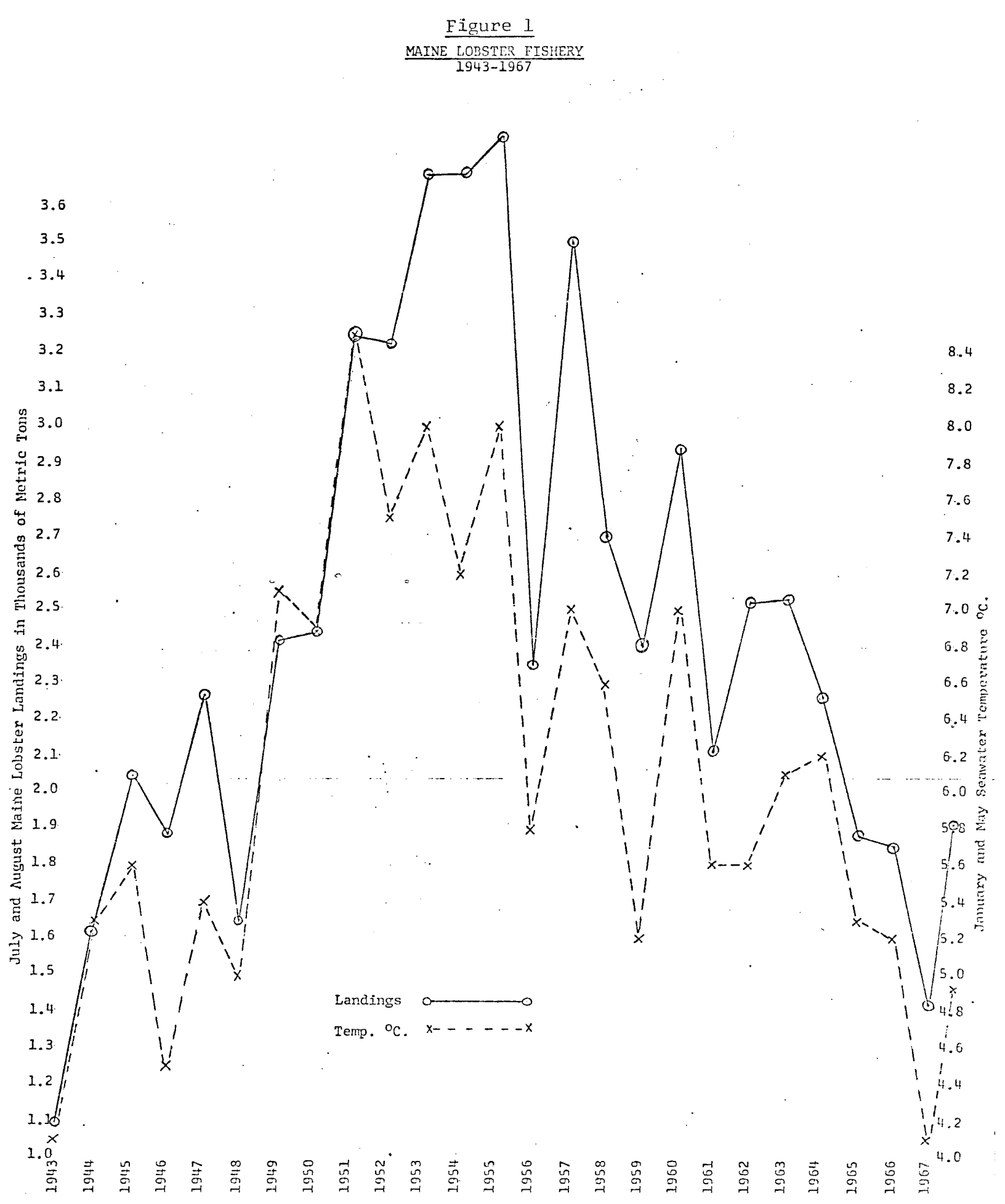
Fluctuations in sea temperature influence lobster availability and abundance. The level, rate and amount of increase in the January-May period appears to determine both the magnitude of the catch in the early part of the lobster year as well as the peak month of production. There is a coefficient of correlation of 0.91 between January and May temperature as measured at Boothbay Harbor and the total July and August lobster catch each year for the 25-year period 1943-1967, which coincides with the termination of a climatic subcycle (Fig. 2).

Catch and temperature were virtually the same at both ends of the period; averaging 1.6 thousand metric tons and 4.93° C. for the first three years and 1.7 thousand tons and 4.87° C. for the last three years, although fishing effort increased nearly threefold during the period.

Increases in effort, as indicated by the total number of traps being fished, reflect response to market conditions. Historically yield has

Figure 1

MAINE LOBSTER FISHERY
1943-1967



fluctuated with effort within the abundance limitations imposed by climatic cycles. Based on 42 observations from 1897 at the beginning of consecutive year records, to 1958 immediately preceding the point of inflection on the yield curve, the coefficient of correlation between effort and yield is 0.93 (Fig. 2). Following the record 1957 catch, sea temperature declined below the optimum range in all years except 1960, 1963, 1969, and 1970. Although sea temperature declines have reduced the rate of legal size lobster recruitment, little recovery of supply has occurred during recent optimum temperature years.

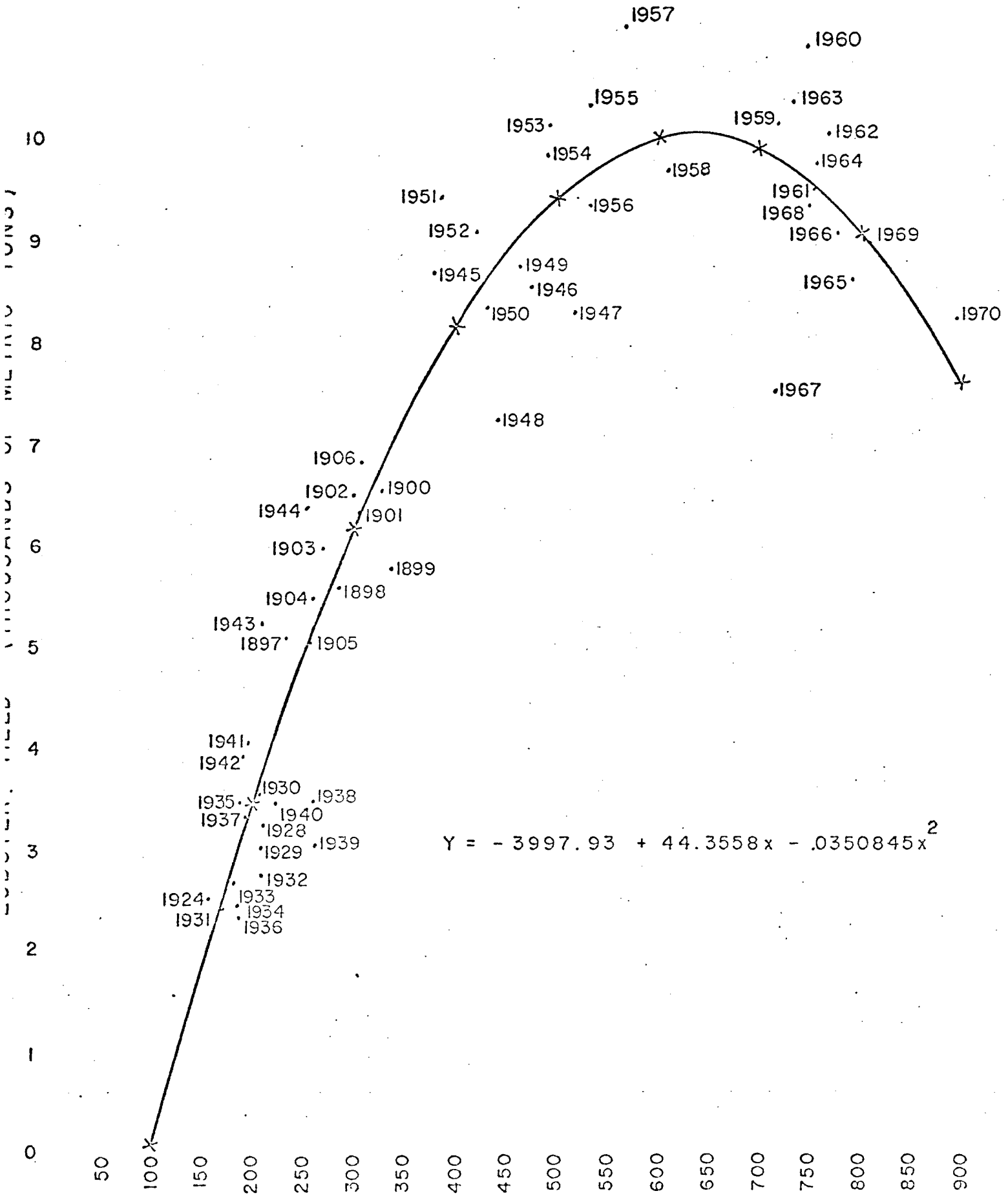
With an increase in fishing effort from 565,000 units in 1957 to nearly 900,000 in 1970 and a decrease of nearly 35 percent in yield by 1967 and a recovery of only 10 percent during the optimum temperature years of 1969 and 1970, it is evident that the resource is being overexploited and will continue to decline in supply unless substantial reductions in effort are effected.

Meteorological studies by Willett (personal communication) indicate that following a suppressed warming cycle in the middle and late 1970's summer sea surface temperatures will likely decline to the lowest levels yet recorded and "probably as low as they are likely to get for most of the next century."

These forecasts suggest that the major lobster producing areas of Canada and the United States will be naturally less productive than they have been in the recent past.

Continued use of the native lobster population for recreational and subsistence fishing without any great expenditure of time, effort and money on management would permit concentration on the development of large scale, economically feasible, commercial culture of improved quality stock.

Figure 2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FISHING EFFORT (THOUSANDS OF TRAPS)

REFERENCES

Cyclic and Geographic Trends in Seawater Temperature and Abundance of American Lobster. Robert L. Dow. Science, Vol. 164, 30 May 1969, pp. 1060-1063.

Monthly and Annual Means of Surface Seawater Temperature, Boothbay Harbor, Maine, 1905 through 1966. Walter R. Welch. U. S. Bureau of Commercial Fisheries, Boothbay Harbor, Maine, 1967.

Long-Term Solar-Climatic Relationships. H. C. Willett and J. T. Prohaska. Final Scientific Report, NSF Grant 14077 (Cambridge, Mass., 1 Oct. 1963).