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Natural Abundance Fluctuations in the Maine Shrimp Fishery

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NATURAL ABUNDANCE FLUCTUATIONS IN THE MAINE SHRIMP FISHERY

Since the beginning of the Maine northern shrimp (*Pandalus borealis*) fishery in 1938, annual catch has fluctuated cyclically (Table 1). These cycles have a highly significant correlation with corresponding sea surface temperature cycles as measured at Boothbay Harbor.

During the temperature years 1949 to 1968 and the catch years four years later when egg-bearing shrimp enter inshore waters to hatch their eggs, the coefficient of correlation between annual mean sea temperature at Boothbay Harbor, Maine, and total annual landings of the winter fishery at Maine ports has an r value of -0.93 , with a coefficient of determination of 0.865 , accounting for nearly 90% of catch variance (Figure 1). The total catch in this period was nearly 47 thousand metric tons (103 million pounds) and represented 75% of all Maine shrimp landings, which have amounted to 62 thousand metric tons (137 million pounds).

As the Gulf of Maine is the southern terminus of the shrimp's range in the northwest Atlantic, it is evident that sea temperature is a regulating factor in the range of this animal. Further, there is no evidence of other environmental factors correlating significantly with shrimp abundance. The assumption that sea temperature fluctuation historically has directly or indirectly influenced shrimp abundance and availability appears to be well founded. How sea temperature exerts such influence is not understood, but since the relationship has existed for four decades between temperature and shrimp abundance, a continued decline in stock size through at least 1979 can be anticipated as a result of recent high temperature years.

In other species sea temperature influences vary widely from explosive increases in the number of soft clam (*Mya arenaria*) predators which reduce

clam abundance as much as 90% in one April-October growing season to drastically reduced survival of larval and juvenile sea scallops (*Placopecten magellanicus*) to commercial size during spawning periods of higher than optimum sea temperature.

The northern shrimp is an arctic species that is circumpolar in its distribution, extending its range in the Pacific to South Korea and British Columbia and in the Atlantic to the Gulf of Maine and Scandinavia. As with other marine species, its abundance near the end of its range undergoes abrupt and spectacular fluctuations in abundance. In the Gulf of Maine the shrimp has fluctuated in abundance as much as 20,000 or more to one in contrast to the lobster (*Homarus americanus*) whose abundance has fluctuated less than 2 to 1 in the last fifty years.

By the catch year 1960 (Figure 1) it had become evident that the sea temperature decline which had commenced in 1954 was enhancing shrimp abundance. With the long-range climatic forecasts made by Dr. Hurd Willett of MIT, it appeared likely that environmental conditions for shrimp would improve and might continue to be favorable for some years, except for a suppressed warming trend between the mid-1970's and the mid-1980's. More recently (U.P.I. news story), he identified the cold period as the last two decades of this century.

In 1962 and 1963 I served as consultant for some coastal county resource studies. On the basis of evaluating the apparent relationship of sea temperature to shrimp abundance fluctuations between 1938 and 1962, I wrote: "If the current reversal of the 1939-1953 seawater temperature upward trend continues, temperatures favorable for the Northern shrimp should last until the late 1960's." The peak year of shrimp landings was 1969.

Biological research on the shrimp in the Gulf of Maine has been carried on by the Department of Marine Resources under contract with the National Marine Fisheries Service and before that by NMFS and DMR independently. Life history information, developed by DMR and other researchers, provides the following synoptic description.

Pandalus borealis is a sex reversal species as are many shrimp. During initial development, most of the young mature as males. Later they pass through a transitional stage to mature as females. Egg hatching occurs in the winter, with February and March the peak months (Table 2).

Immature animals, including both larval and juvenile stages, remain inshore for the first year to year-and-one-half of their life. At the end of that period they move offshore, and at two years of age are offshore as mature males. They mate with mature females that are already offshore. From mature males to mature females requires approximately one year's time (August to August), although the transitional process itself lasts only about five months.

At the end of the transitional period, newly matured females, three years of age, will mate with the next younger year class which has been maturing as males. Females extrude their eggs and will carry them for approximately 7-8 months before they hatch. At four years of age the females move inshore where they hatch their eggs. It is this year class which constitutes the bulk of the inshore catch (Figure 2).

Since shrimp is the only species of commercial interest which is naturally available in greater concentrations during the winter, the species has attracted a considerable amount of fishing effort in Maine throughout the history of the fishery. Landings have fluctuated widely from year to year and appear to be related primarily to abundance and availability. Increased catches after 1962, especially from 1968 to 1974 when more than 10 million pounds (4500 metric tons

were landed, also reflect more boats, greater effort, more efficient methods, and more reliable information on availability based on forecasts of future abundance.

The recent warming trend that commenced in 1968 has resulted in an annual temperature increase of more than 2°C between 1967 and 1975 (Figure 3) and a corresponding decline in annual Maine shrimp landings of more than 7,350 metric tons (16.3 million pounds) between 1969 and 1975, with the possibility of the inshore catch declining to less than 100,000 pounds (45 metric tons) by 1979.

If sea temperature declines again during the remaining 1970's, by 1980 conditions should improve and, on the basis of Willett's temperature forecasts, should continue to be favorable for shrimp, but not for lobster, into the next century.

Various management devices have been essayed in recent years, principally closed seasons, mesh regulations, and quotas. In view of the estuarine dependency of the northern shrimp at egg hatch time, the least disruptive and most effective methods to insure maximum yield of the resource will be a seasonal fishery beginning near the end of the egg hatching period but one that would not utilize the small mature males offshore. The taking of mature males reduces the yield of the individual shrimp by approximately 75%.

Several important research investigations should be conducted (1) to identify the percentage of egg hatch by months and (2) an evaluation of spawn stock requirements for maximum yield of the fishery commensurate with the expected fluctuations in abundance associated with climatic cycles.

ROBERT L. DOW

December 14, 1976

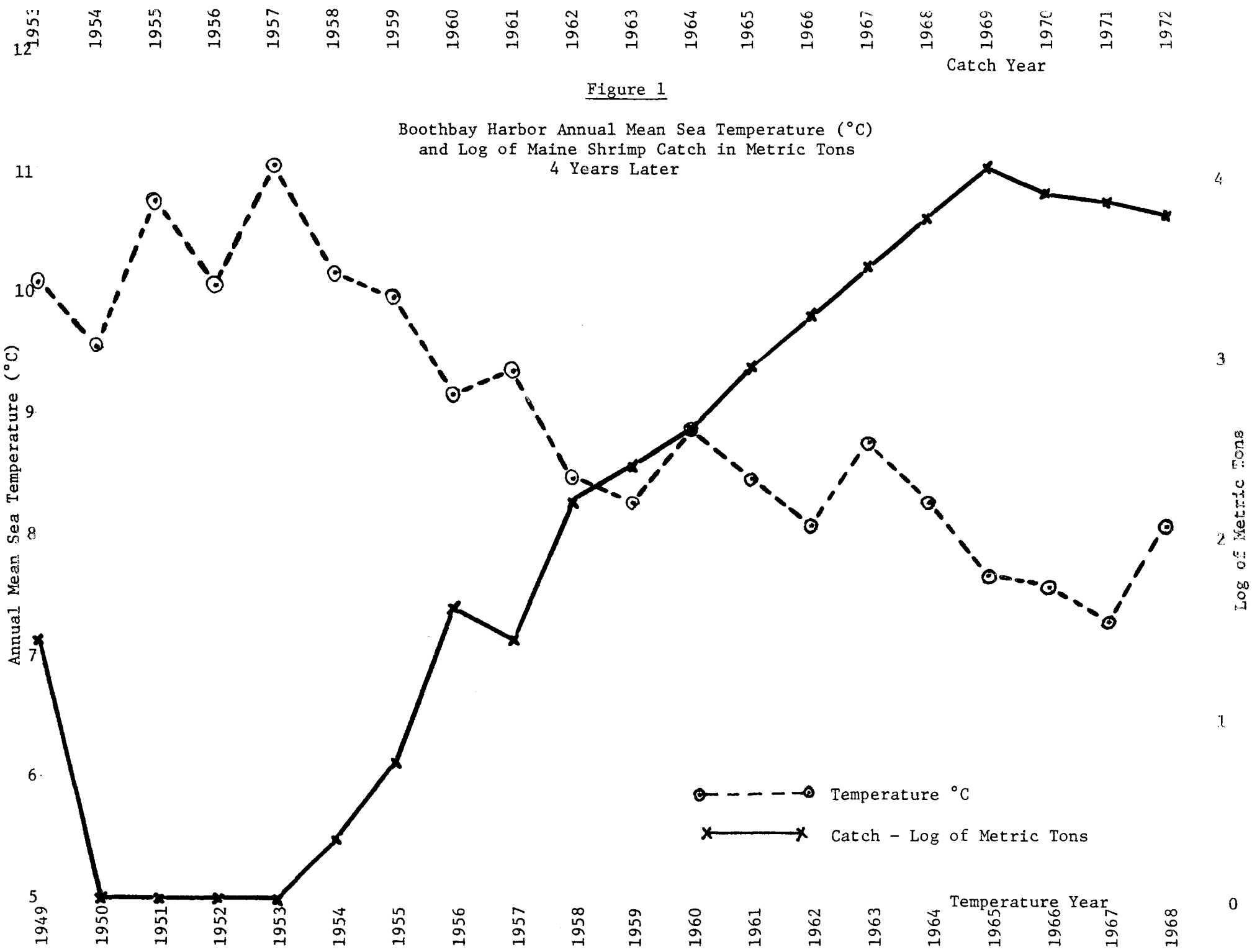
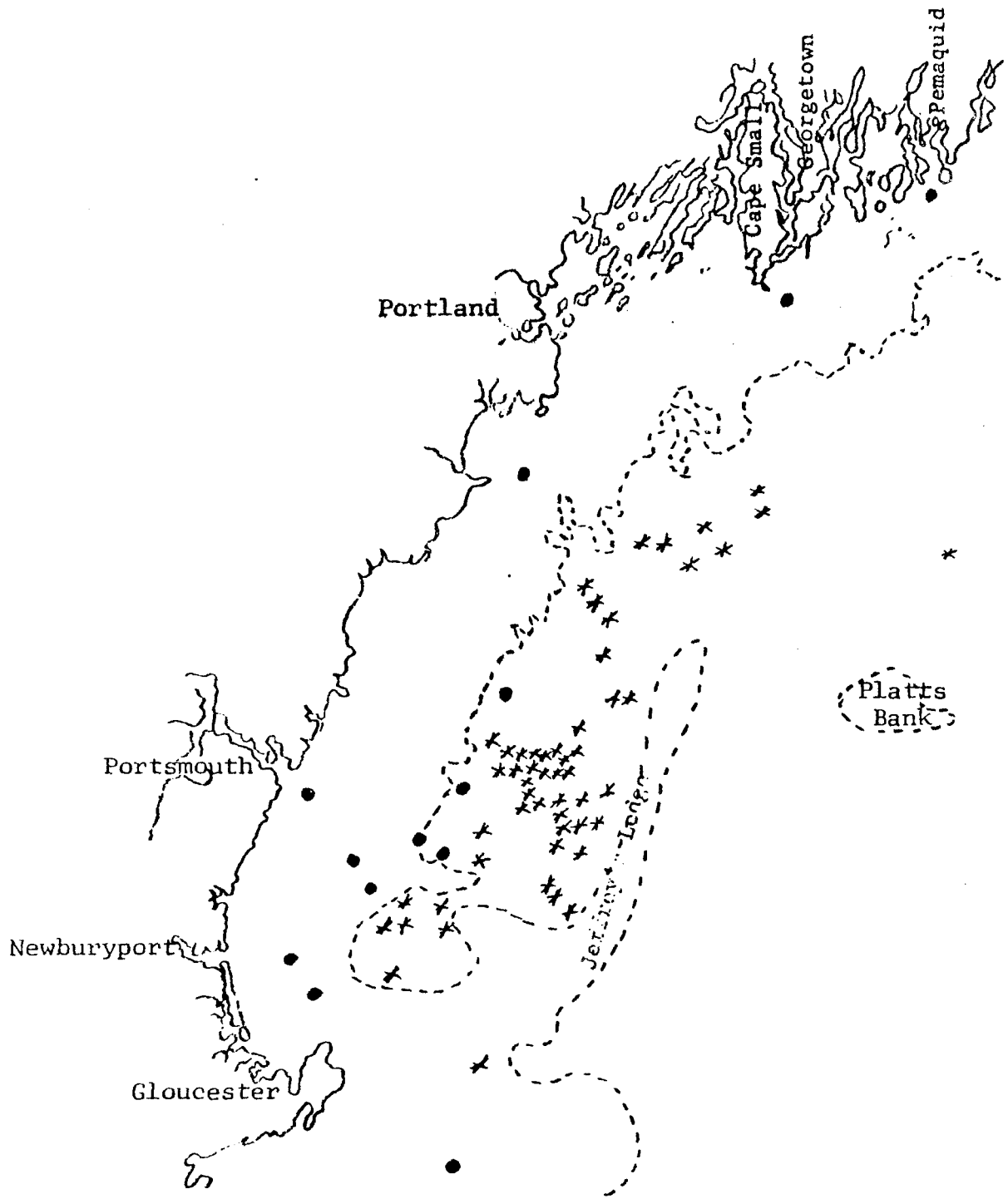


FIGURE 2



* Summer and Fall Population

• Winter Population

Figure 3

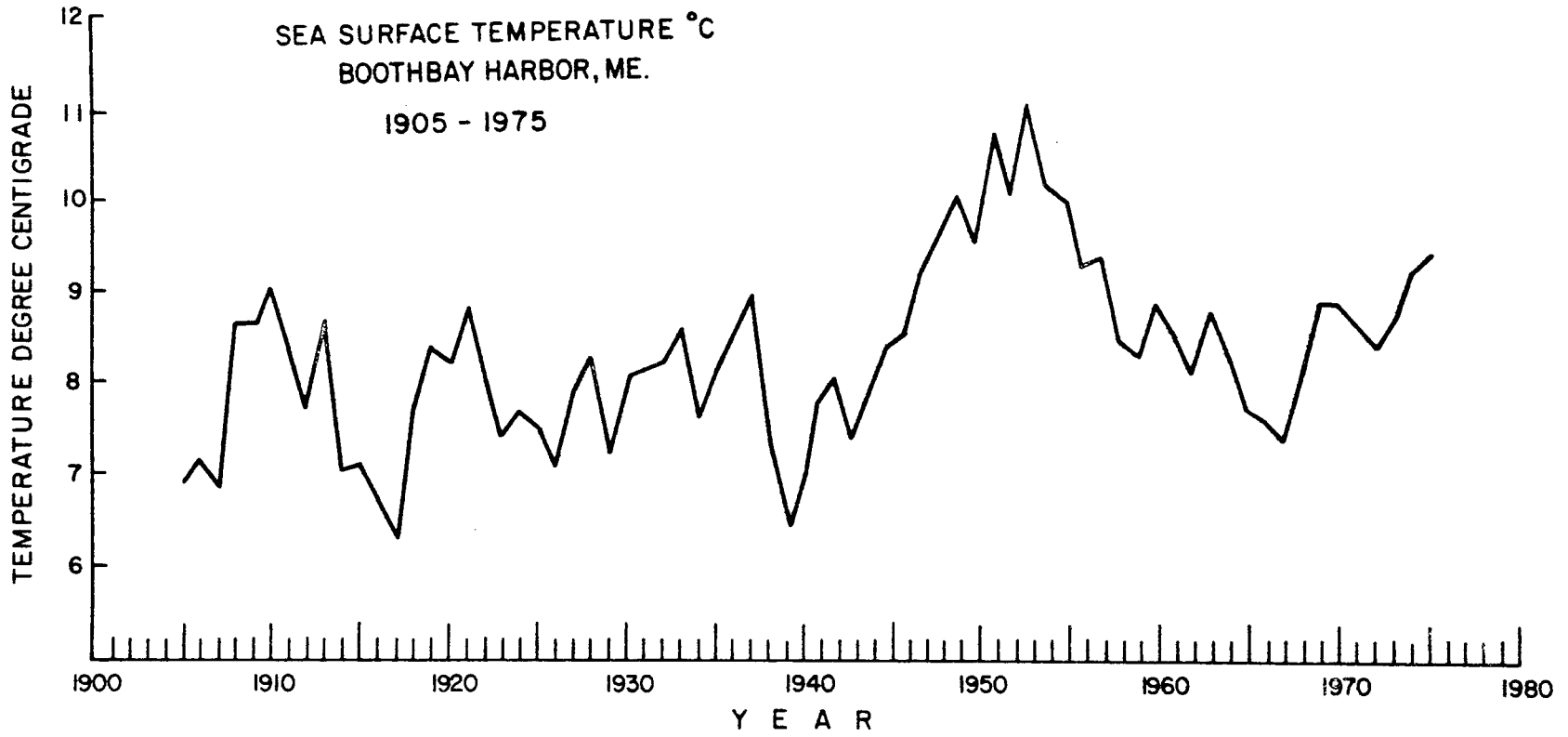


Table 1

MAINE SHRIMP FISHERY

<u>Temp. Year</u>	<u>Mean Annual Temp. (°C) Boothbay Hbr.</u>	<u>Fishing Season</u>	<u>Duration</u>	<u>Peak Month</u>	<u>Total Landings in Pounds</u>	<u>Catch (Log of Metric Tons)</u>	<u>Average Landed Value per Poun</u>
1934	7.6	1938	February-April	March	82,500	1.57	\$.07
1935	8.2	1938-39	---	---	18,300	.92	.04
1936	7.5	1940	January-June	March	8,315	.58	.05
1937	9.0	1940-41	December-May	February	54,207	1.39	.04
1938	7.3	1941-42	December-March	February	79,032	1.55	.04
1939	6.4	1942-43	December-April	March	291,628	2.12	.05
1940	7.0	1943-44	November-April	March	389,313	2.25	.04
1941	7.8	1945	January-April	March	554,299	2.40	.05
1942	8.1	1946	January-March	March	161,515	1.86	.05
1943	7.4	1947	February-April	March	193,699	1.95	.05
1944	8.0	1948	February-April	March	27,325	1.08	.11
1945	8.4	1949	February-June	February	9,853	.70	.18
1946	8.5	1950	March-May	April	7,359	.48	.19
1947	9.2	1951	February-April	March	44,843	1.30	.20
1948	8.2	1952	February-April	March	103,926	1.67	.18
1949	10.1	1953	February-April	February	38,130	1.23	.19
1950	9.6	1953-54	---	---	0	--	--
1951	10.8	1954-55	---	---	0	--	--
1952	10.1	1955-56	---	---	0	--	--
1953	11.1	1956-57	---	---	0	--	--
1954	10.2	1958	March	March	4,899	.30	.32
1955	10.0	1959	February-March	February	11,201	.70	.32
1956	9.2	1959-60	November-April	February	89,899	1.61	.23
1957	9.4	1961	January-April	March	64,184	1.46	.20
1958	8.5	1961-62	December-May	February	339,996	2.19	.15
1959	8.3	1962-63	October-March	February	529,126	2.38	.12
1960	8.9	1963-64	October-April	February	897,740	2.61	.12
1961	8.5	1964-65	October-May	March	2,068,180	2.97	.12
1962	8.1	1965-66	November-April	March	3,695,345	3.22	.14
1963	8.8	1966-67	November-April	March	6,580,454	3.48	.13
1964	8.3	1967-68	November-May	March	12,364,576	3.75	.11
1965	7.7	1968-69	August-April	March	23,552,977	4.05	.13
1966	7.6	1969-70	August-July	March	18,093,726	3.91	.20
1967	7.3	1970-71	August-July	March	17,515,851	3.90	.20
1968	8.1	1971-72	August-July	March	16,998,327	3.88	.19
1969	8.9	1972-73	August-July	March	12,689,104	3.75	.28
1970	8.9	1973-74	August-July	February	10,076,543	3.65	.36
1971	8.7	1974-75	August-July	February	7,306,433	3.50	.28
1972	8.4	1975-76	September-April	February	1,812,475	2.91	.33

Table 2

SHRIMP DATA FROM WARDENS' NOTES

<u>Season</u>	<u>Date of First Shrimp Catch</u>	<u>50% or More of Egg Hatch by</u>	<u>Reported Ending Date of Shrimp Fishing</u>	<u>Eastern Limit</u>
1963-64	12/14/63	2/29/64	4/11/64	New Harbor
1964-65	12/5/64	3/27/65	4/3/65	New Harbor
1965-66	11/30/65	3/26/66	4/2/66	New Harbor
1966-67	12/3/66	3/11/67	4/15/67	Grand Manan
1967-68	11/18/67	3/9/68	4/15/68	Campobello
1968-69	10/19/68	3/8/69	5/3/69	Campobello
1969-70	11/22/69	3/14/70	4/4/70	Jonesport
1970-71	11/28/70	3/10/71	4/24/71	Winter Harbor
1971-72	11/6/71	3/11/72	4/8/72	Mt. Desert

First catches inshore are usually reported to be small shrimp.

Shrimp landings and egg hatch progress from west to east with a several week difference between the two extremities.

Insert in "Natural Abundance Fluctuations in the Maine Shrimp Fishery," page 4, before first paragraph, after paragraph ending "...forecasts of future abundance."

In the late 1940's and early 1950's, no more than a handful of small draggers and lobster boats (5 to 12) were fishing for shrimp, down from a 1944 high of 31 small and medium draggers. Fishing effort increased slowly after the catch disaster years of 1953-54 to 1956-57 when no shrimp were landed.

With improving catches, more boats entered the fishery, influenced in large part by the promise of several more years of good fishing associated with temperature declines. By the 1969-1970 fishing season, the number of Maine boats had increased to 287 and in 1970-1971 reached a total of 284 draggers and 17 small boats engaged in trap fishing. Thereafter, effort in terms of vessels in operation declined rapidly with the decrease in shrimp abundance. Even during the maximum fishing effort years, there is no indication that overfishing accounted for more than a possible 40% in the decline of the available stock.