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Predicted Trends in Maine Landings by Species

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PREDICTED TRENDS IN MAINE LANDINGS BY SPECIES

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Introduction

Annual commercial production of renewable marine resources has fluctuated widely in Maine during the last century and the number of individual species represented in the catch has fluctuated comparably. Mean annual sea surface temperature measured at Boothbay Harbor since 1905 and up to 30 years before that at other northern Gulf of Maine ports has fluctuated from a low of 4.5° C at Eastport in 1877 to a high of 11.1° at Boothbay Harbor in 1953 (Figure 1). Mean annual Boothbay Harbor temperature has averaged 1.4° C higher than Eastport.

The interrelation of the number of commercial marine species, total catch, relative abundance and availability, and fluctuations of individual species with sea temperature has been under study in Maine since World War II. The results of these studies indicate that sea surface temperature fluctuations have been reliable indicators of future trends in species abundance and availability, in total resource catch, and in the number of species represented in that catch.

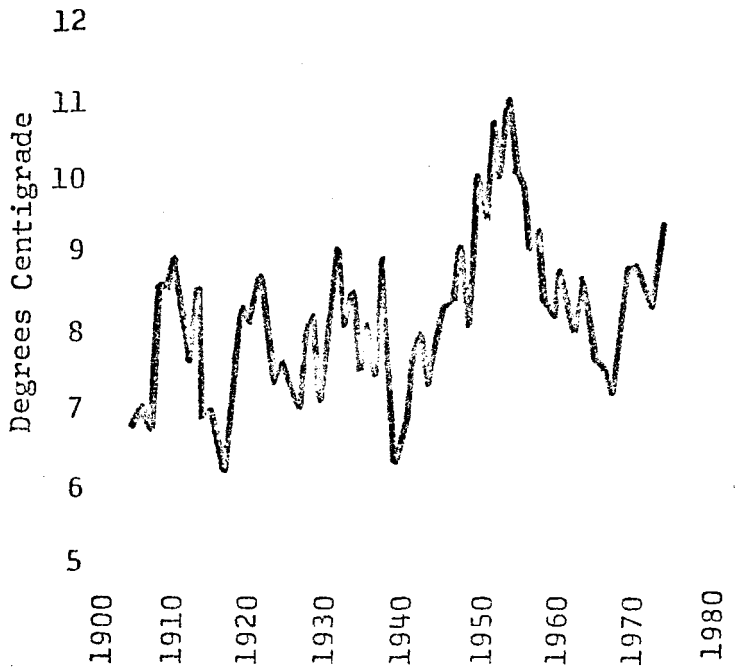
The influence of sea temperature on abundance and availability may be direct or indirect, depending upon the species. The abundance and availability of some species is inversely related to temperature since temperature may influence predation, disease, feeding activity and growth, larval survival, migration and over-wintering success, among other limiting factors.

Based on the temperature subcycles of 1939 to 1967 encompassing an annual Boothbay Harbor temperature mean ranging from 6.5° to 11.1° to

August 18, 1976

Figure 1

Sea Surface Temperature, Boothbay Harbor, Maine
(as measured by the National Marine Fisheries Service)
1905-1974



7.3° C and the annual production records of individual species during and since that period and subsequent temperature records, the following forecasts of abundance and availability are listed by species.

Northern Shrimp

There will be a continued decrease in abundance and landings because of unfavorably high sea temperature during the year of egg hatching. The decline will continue through at least 1979 (Table 1).

Lobster

Although sea temperatures are optimum and the catch should be comparable to that of the 1957-1960 period, overfishing has reduced the available supply of legal lobsters by 30% or more (Figure 2). On a year-to-year basis, catch will increase or decline moderately with sea temperature conditions over the next several years. By the late 1970's and the early 1980's the catch may increase slightly as a result of favorable temperature conditions for survival of larvae and juveniles in 1974 and 1975. If fishing effort is substantially reduced and escape vents are incorporated in all traps to permit sublegals to escape, the recovery of the supply could approach 30%.

On pages 25 and 26 of SSRF-683, April 1975 (DOW, BELL and HARRIMAN), the following forecasts were made concerning the immediate future of the Maine lobster resource:

> "Maine lobster abundance declined after 1957. Since the rate of decline has increased during the last 15 yr., it is likely, in view of the demonstrated overfishing of the resource and anticipated less favorable sea temperature conditions until the decade between the mid-1970's and the mid-1980's (H. Willett,

pers. commun.), that decline during the 1973-1976 period may average about 12 percent with an annual average catch of 7,400 metric tons."

The forecast for 1972 was made early that year after 1971 data were available. The accuracy of this and subsequent forecasts is shown below.

Year	Forecast of lobster catch in thousands of metric tons	Actual Catch	% Error
1972	7.4	7.4	0
1973	7.4	7.7	-4.1
1974	7.4	7.5	-1.4
1975	7.4	7.7	-4.1
1976	7.4	7.5*	-1.4

*Based on six months' catch

Clams

Higher sea temperatures in recent years have resulted in proliferation of the principal clam predator, the green crab. Even with protective measures — fences to protect clam growing areas from green crabs — the decline in market size clams will continue for the foreseeable future. In 1976 production will probably be down about 30% from 1975 with an additional 10-20% decline in 1977.

Quahogs (Hard Clams)

Recent improving sea temperature conditions have resulted in limited commercially important progeny survival. Production in 1976 should be approximately five metric tons of edible meats, up about 30% from 1975 (Figure 3).

Sea Scallops

The 1975 catch of 723 metric tons of edible meats was the highest annual catch since 1910 and marked the end of an increasing abundance

Table 1

MAINE SHRIMP CATCH

Year	Sea Surface Temperature (°C)	Shrimp Catch (Log of Metric Tons) 4 Years Later
1939	6.4	2.12
1940	7.0	2.25
1941	7.8	2.40
1942	8.1	1.86
1943	7.4	1.95
1944	8.0	1.08
1945	8.4	.70
1946	8.5	.48
1947	9.2	1.30
1948	8.2	1.67
1949	10.1	1.23
1950	9.6	0
1951	10.8	0
1952	10.1	0
1953	11.1	0
1954	10.2	.30
1955	10.0	.70
1956	9.2	1.61
1957	9.4	1.46
1958	8.5	2.19
1959	8.3	2.38
1960	8.9	2.61
1961	8.5	2.97
1962	8.1	3.22
1963	8.8	3.48
1964	8.3	3.75
1965	7.7	4.05
1966	7.6	3.91
1967	7.3	3.90
1968	8.1	3.88
1969	8.9	3.74
1970	8.9	3.65
1971	8.7	3.50
1972	8.4	2.83*
1973	8.8	2.19*
1974	9.2	1.61*
1975	9.4	1.46*

*Forecasts

Figure 2

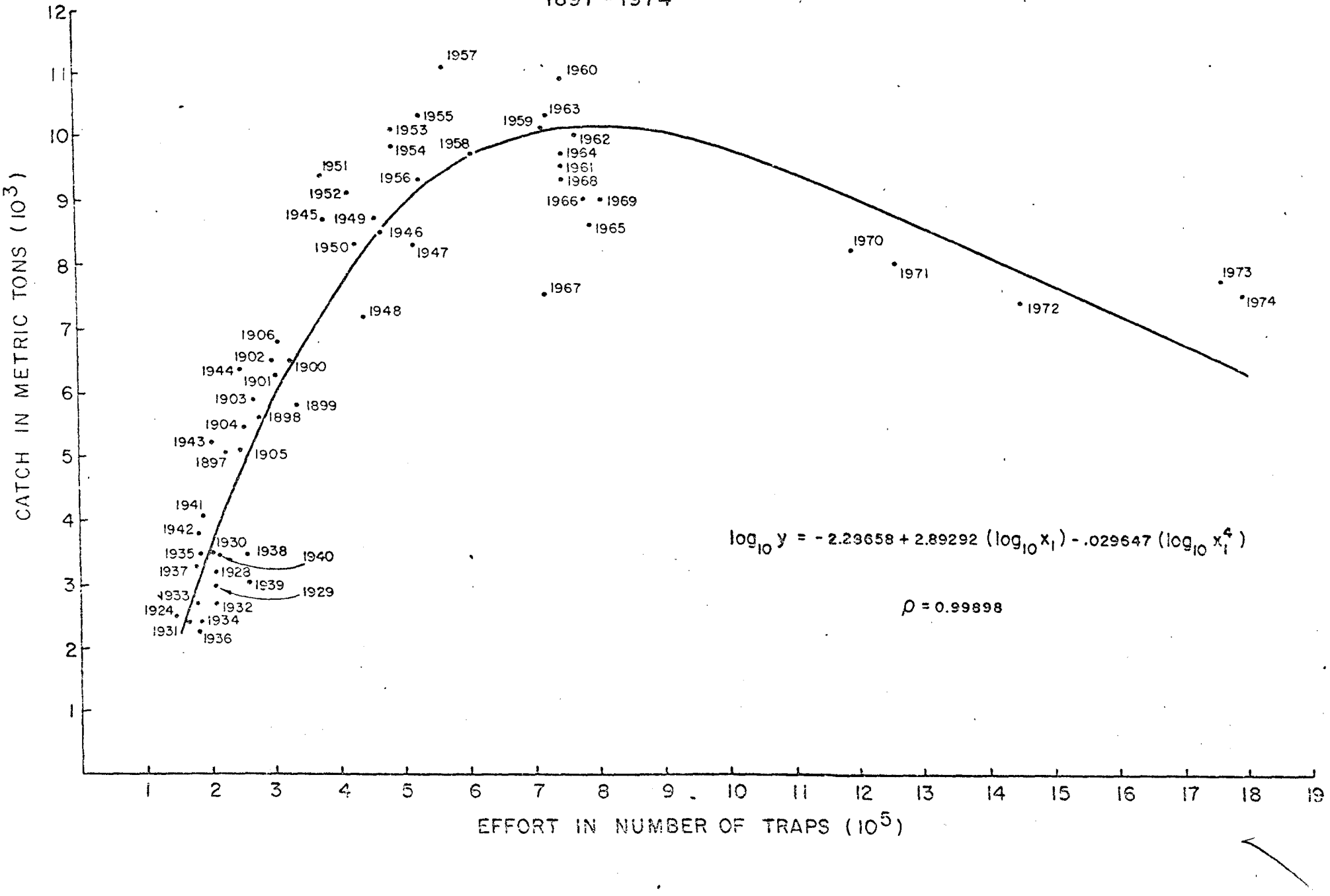
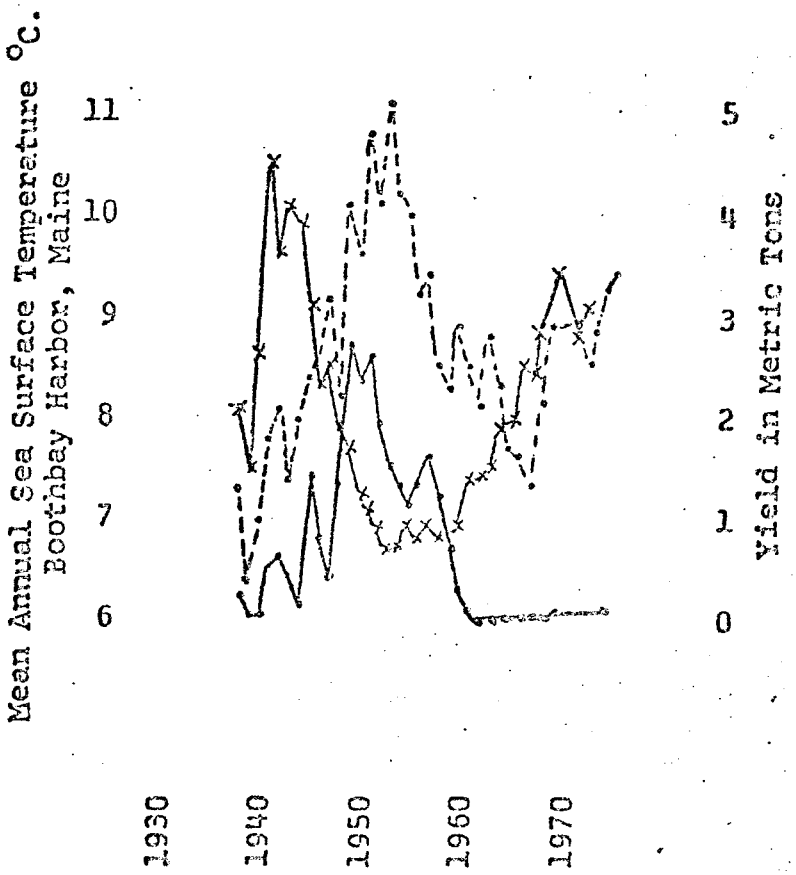

MAINE LOBSTER CATCH - EFFORT
1897 - 1974
CATCH IN METRIC TONS (10^3)
EFFORT IN NUMBER OF TRAPS (10^5)
$\log_{10} y = -2.23658 + 2.89292 (\log_{10} x_1) - .029647 (\log_{10} x_1^4)$
$\rho = 0.99898$
1897 1898 1899 1900 1901 1902 1903 1904 1905 1906
1924 1928 1929 1930 1931 1932 1933 1934 1935 1936 1937 1938 1939 1940 1941 1942 1943 1944
1945 1946 1947 1948 1949 1950 1951 1952 1953 1954 1955 1956 1957 1958 1959 1960 1961 1962 1963 1964 1965 1966 1967 1968 1969 1970 1971 1972 1973 1974

Figure 3

Hard and Soft Clam Yields
in Relation to Sea Surface Temperature
1938-1975.



Temperature

Hard Clam Yield, Hundreds of Metric Tons, Same Year

Soft Clam Yield, Thousands of Metric Tons, 5 Years Later

cycle that began in 1962. Scallop catch will decline for the next several years. There may be a temporary increase in 1978 as the result of a relatively good year class in 1972, but this will be offset by recent above optimum temperatures which historically are associated with declining abundance. It is unlikely that catches comparable to those of recent years can be repeated until the late 1980's or early 1990's. Long range climatic forecasts indicate that conditions should be optimum for sea scallop after about 1985 for the remainder of the century (Table 2 and Figure 4).

Table 2

Predicted Scallop Landings
(based on pre and postspawning sea temperature)

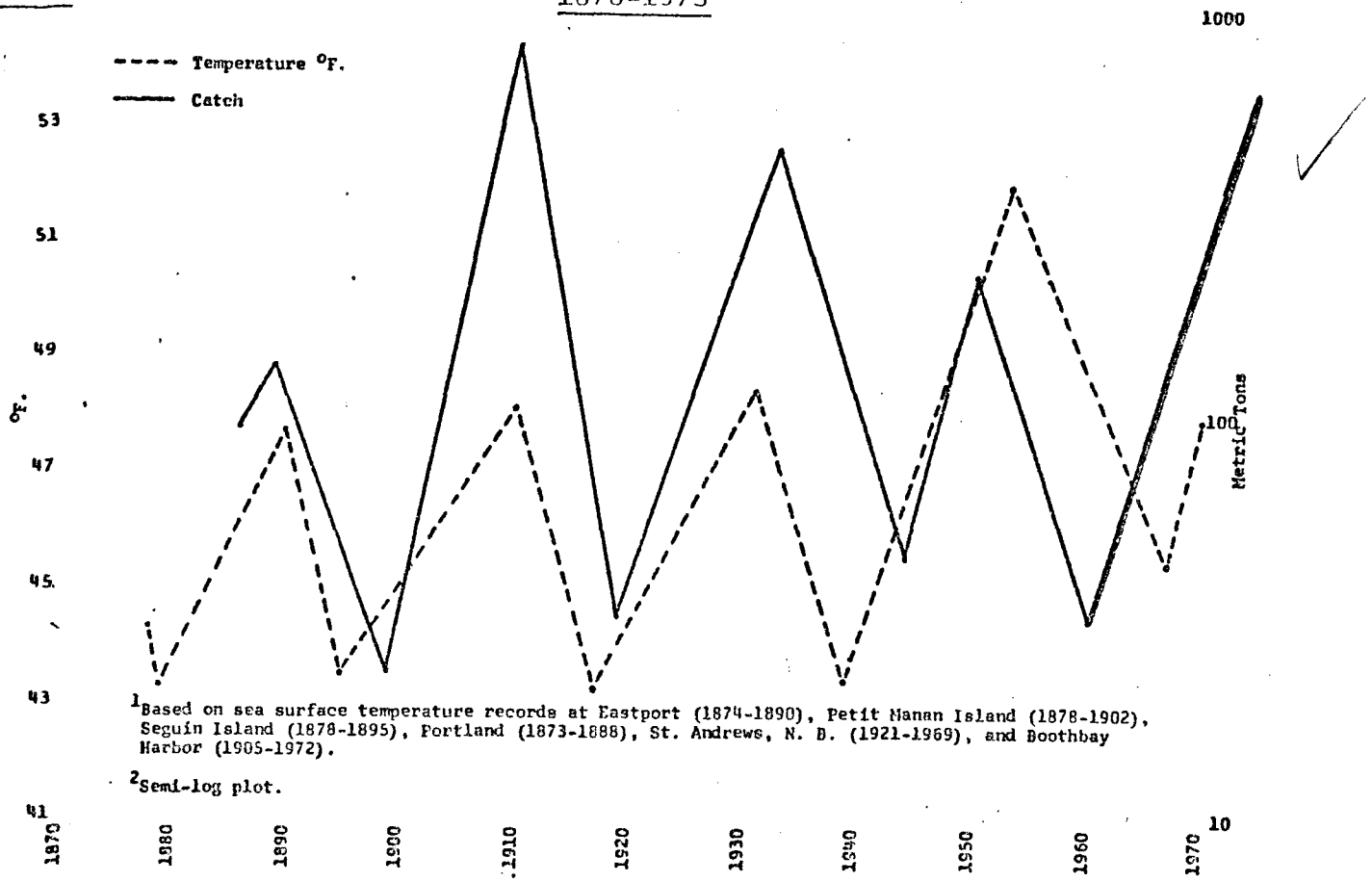
Temperature Year	March-April Oct.-Nov. °C	Predicted Catch Metric Tons	Catch Year
1970	7.4	135	1976
1971	7.2	135	1977
1972	6.2	350	1978
1973	6.8	180	1979
1974	6.9	160	1980

Herring

In 1976 the availability of sardine-size herring increased markedly over recent years. Although environmental conditions have been good since 1969, intensive fishing of offshore mature herring by foreign vessels appears to have adversely influenced the abundance and availability of inshore immature herring suitable for sardine canning. It is unlikely that extended jurisdiction will improve abundance conditions for at least four years.

Figure 4

Maximum and Minimum Annual Sea Temperature[1] and Sea Scallop Catch[2] Trends in Maine
1878-1975



[1]Based on sea surface temperature records at Eastport (1874-1890), Petit Manan Island (1878-1902), Seguin Island (1878-1895), Portland (1873-1888), St. Andrews, N. B. (1921-1969), and Boothbay Harbor (1905-1972).

[2]Semi-log plot.

This graph shows the trends of maximum and minimum annual sea temperature averages from 1878 through 1975 and inshore sea scallop catches from 1884 through 1975.

Sea temperature cycles for the past 100 years have alternated between good and poor scallop spawning and survival conditions at about decade intervals.

According to Department of Marine Resources biennial reports, the average scallop shell diameter before 1920 was 5.5 inches (140 mm) indicating an average age of 10 growing seasons and an edible meat yield of 46.5 grams.

Since World War II the average diameter has declined to 4.6 inches (117 mm) indicating an average age of 6.5 years and an edible meat yield of 26.5 grams.

Optimum sea temperature during the year of spawning has ranged from 45.4° F (7.4° C) to 46.5° F (8.1° C) or an average of 46.2° F (7.9° C) as measured at Boothbay Harbor by the National Marine Fisheries Service and DMR. Before 1920 the spawning year was associated with the catch 9 years later; since World War II, with the catch 6 years later.

On the basis of this evidence, an increase in average shell diameter to the former 5.5 inch average would increase the catch more than 75% in weight.

Groundfish

Although substantial increases in 1975 landings of cod, haddock, hake, cusk, and pollock over 1974 occurred with all five species (cod landings increased 40%, cusk 27%, haddock 239%, hake 21%, and pollock 64%), it is unlikely that comparable increases will occur in 1976 and 1977. It is likely that landings of cod, hake, and pollock will average 2,300 to 2,700 metric tons each in 1976 and 1977, and haddock and cusk 350 to 450 tons annually.

Marine Worms

Bloodworm production should remain relatively high for the next several years as the result of optimum or near optimum environmental conditions during the year of spawning. Recent high levels of landings can be attributed in large part to the taking of younger and smaller worms.

Sandworms have not traditionally been as intensively dug as have bloodworms; therefore, recent practices of taking smaller worms indicate that the same trend as in the bloodworm fishery is developing. Conditions for continued high production appear to be good.

Flounder group

Increasing catches of dab, graysole, blackback, and yellowtail during the recent upward trend (since 1967) in sea temperature indicate that catches should continue at the same or somewhat higher levels for the next several years.

Ocean Perch

Overfishing of the slow-growing ocean perch is unlikely to be reduced in the immediate future. From 1972 to 1975, annual landings declined 50% from 19,389 to 9,759 metric tons. This trend probably will continue for the next several years.

Menhaden and Squid

Table 3 illustrates how sensitive both menhaden and squid are to sea temperature. Only during high temperature years does either species appear in large numbers along the Maine coast.

If the present temperature trend continues until the mid-1980's, as it very well may, we may expect that large but variable quantities of both species will appear in Maine waters. The amount will vary from year to year depending in part upon commercial activity further south.

Wolffish

The wolffish catch which averaged nearly 100 metric tons annually during the decade after 1943 has declined steadily ever since and now averages about 10% of that figure. Little change is anticipated in the immediate future.

Table 3

MENHADEN AND SQUID CATCH

Year	Sea Surface Temperature (°C)	Menhaden Catch Same Year (Metric Tons)	Squid Catch Same Year (Metric Tons)
1939	6.4	0	0
1940	7.0	0	0
1941	7.8	0	0
1942	8.1	0	0
1943	7.4	0	0
1944	8.0	0	0
1945	8.4	38	0
1946	8.5	0	0.3
1947	9.2	6	0.2
1948	8.2	11	0
1949	10.1	2280	9.0
1950	9.6	222	10.0
1951	10.8	687	2.0
1952	10.1	274	0.5
1953	11.1	991	2.0
1954	10.2	2665	0.8
1955	10.0	1822	3.0
1956	9.2	552	0.7
1957	9.4	124	1.0
1958	8.5	0	3.0
1959	8.3	0	0
1960	8.9	16	0
1961	8.5	0	0
1962	8.1	0	0.2
1963	8.8	0	3.0
1964	8.3	0	0
1965	7.7	0	0
1966	7.6	0	0
1967	7.3	0	0

Mackerel

The mackerel has varied widely in its relative abundance and availability in Maine waters. Recent declines may have been influenced by heavy fishing of this species before it appears on the Maine coast. Catches are likely to remain low for the next several years.

Whiting

Commercialization of the whiting resource increased rapidly after World War II and with higher and more favorable temperatures reached a peak of production between the early 1950's and the middle 1960's. Since then the catch has declined drastically and the decline has been attributed in large part to the intensive offshore fishery by foreign vessels. In 1975 landings were slightly more than 500 metric tons. During the peak years the catch was well over 13,000 metric tons. Catches appear likely to remain low for the next several years.

Anadromous Species

The following anadromous species, those that spend most of their life in the sea but return to rivers and lakes for spawning purposes, are of some commercial importance in Maine: the rainbow smelt, the American shad, the alewife or river herring, the blueback (which spawn in estuaries), and the Atlantic salmon.

Spawning areas for alewives have been improved in the last decade by the construction of fishways in dams and other man-made obstructions. With greater need for fish protein, it can be expected that landings of alewives for the foreseeable future will average between 1500 to 2000 metric tons per year. With the removal of unused and uneconomical dams

and construction of adequate fishways in those dams which are considered to be essential, the production of alewives could reach 23,000 metric tons annually in Maine.

From the 1920's to the mid-1940's annual landings of the rainbow smelt in Maine ranged from 100 to nearly 400 metric tons annually. Since that time, the recorded catch has declined appreciably, in part caused by an increase in the sports fishery and a decline in the commercial catch. This species appears to be one of several in Maine whose commercial use, with scientific management, could be greatly increased.

Halibut

The catch of halibut increased from a low during World War II of less than ten metric tons to a peak in the middle and late 1950's of more than 60 metric tons annually. Since that time, the catch has declined and in recent years has been only about 20 metric tons. There is no evidence to indicate any substantial change in the size of the catch for the foreseeable future.

Atlantic Eel

Approximately one-half the annual landings of the eel comes from Washington County. Increases in the market for eels in recent years have stimulated greater fishing effort, and the catch has increased approximately threefold in the last decade. Since this level is only about 50% of what landings were in the 1920's, further increases in production could be made, since many areas which support eel populations are no longer being fished.

Rock Crabs

There are two species of rock crabs taken commercially in Maine, Cancer irroratus and Cancer borealis. The catch has declined approximately 50% since the early and middle 1960's. Reasons for the decline are not fully understood, but there is evidence that sea temperature is highly important, as maximum catches were made during years of relatively low sea temperature, both in the early 1940's and again from 1964 to 1967. Since there is a highly significant inverse relationship between sea temperature and crab landings, it does not appear likely that the commercial catch will increase until the current high temperature period has ended, unless extensive stocks presently unfished are used.

Mussels, Whelks, Surf Clams, and Mahogany Quahogs

The population size of these presently underutilized species is, with the exception of the blue mussel, largely unknown. Although several of them are subject to high accumulation levels of paralytic shellfish poisoning, they do offer a potential for greater food production during periods when they are free of toxin.

Periwinkle

The periwinkle is one of the most consistent of any commercial species in its catch response to sea temperature. Landings are inversely related to the level of Boothbay Harbor sea temperature. In recent years catch has declined about 40% from the two peak periods in the cold water years of the 1939-1945 period and in the period from 1964 to 1967. Landings are not likely to increase greatly until after the mid-1980's.

Atlantic Sturgeon

Since 1939, catches of the Atlantic sturgeon in Maine have ranged from 0 to nearly 3 metric tons. There have been only five years in that period where no landings were reported. The greatest catch occurred in 1970 and 0 catches occurred in both 1939 and 1953, the coldest and warmest sea temperature years of the period. Landings of this species will likely remain low for the foreseeable future.

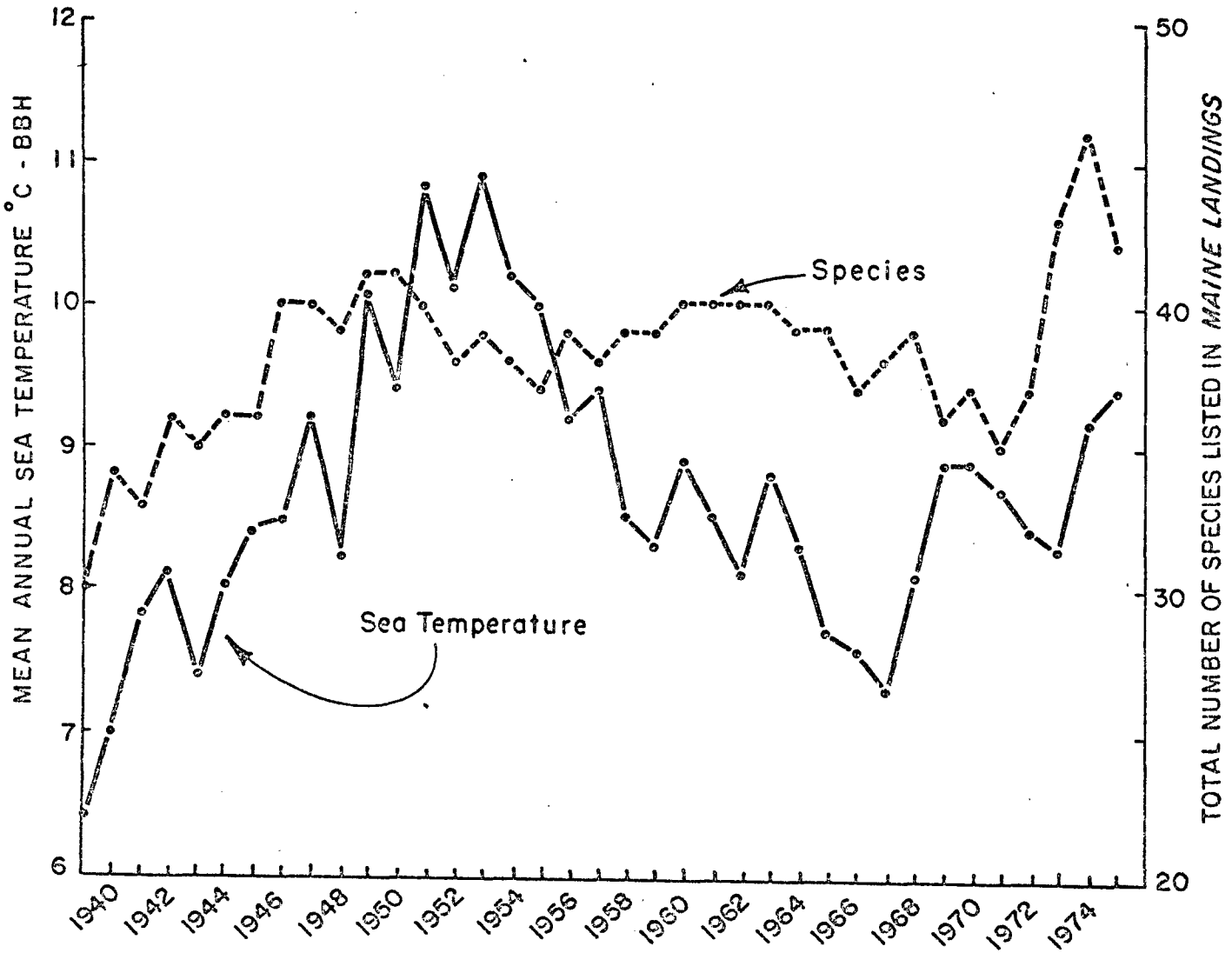
Miscellaneous Species

Other erratically and seasonally abundant species include bluefish, fluke, tilefish and butterfish. These species appear during higher temperature years in the commercial catch but are variable in their abundance. We can anticipate that this variable availability will occur as long as temperatures are near or just below the maximum levels recorded at Boothbay Harbor.

Number of Species

The number of species in the commercial catch and the total volume of the commercial catch has fluctuated widely in the last 35 years. During low temperature years many of the migratory species from south of Cape Cod do not reach the Gulf of Maine and the Maine coast. During high temperature years the situation is reversed and some localized relict populations of warm water species, for example the American oyster, flourish and become commercially significant. Figure 5 illustrates this relationship of number of species and sea temperature cycles.

Figure 5. Sea surface temperature and number of species


MEAN ANNUAL SEA TEMPERATURE °C - BBH
TOTAL NUMBER OF SPECIES LISTED IN MAINE LANDINGS
Species
Sea Temperature
12
11
10
9
8
7
6
50
40
30
20
1940
1942
1944
1946
1948
1950
1952
1954
1956
1958
1960
1962
1964
1966
1968
1970
1972
1974