IV. Long Term Changes in Hydrographic Conditions and Corresponding Changes in the Abundance of Marine Animals

By WILFRED TEMPLEMAN AND A. M. FLEMING
NEWFOUNDLAND FISHERIES RESEARCH STATION

INTRODUCTION

The following account of marine animal abundance and climatic variations has particular reference to Subareas 3 and 2 of ICNAF.

We are grateful to the Meteorological Station at the Torbay Airport for the use of air temperature data. Thanks are also due to Mr. Hubert Squires of the staff of the Newfoundland Station for the use of his squid abundance data and to Mr. R. P. Hunt for assistance in a survey of hydrographic data for Subareas 3 and 2 in an attempt to find valid comparisons.

SEA AND AIR TEMPERATURES

Sea Water Temperatures Subareas 3 and 2.

In Subareas 3 and 2 there are no seawater temperatures for long periods and in the same positions. The hydrographic records of the Newfoundland Fisheries Research Station date only from 1947 but since that date six sections across the Labrador current from southern Labrador to the southern extremity of the Grand Bank have been taken regularly at approximately the same time of the year, the southern ones twice a year in March—April and July—August and the northern in July—August only. Two sections northward as far as Cape Chidley are occupied more irregularly. The former Fisheries Research Station under Dr. Thompson at Bay Bulls, Newfoundland, obtained temperature records between 1931 and 1935 but not at the same time of year nor from the same stations as the more recent records.

The International Ice Patrol has a series of records for the same sections on the eastern edge of the Grand Bank for 8 years from 1934 to 1941 and from 1948 to the present. Further north a section across the Labrador Sea from South Wolf Island, Labrador, in Subarea 2 to Cape Farewell, Greenland, Subarea 1, has been occupied once during each of 15 summers between 1928 and 1952. Within this group of observations the longest unbroken stretch is the series of 5 years from 1948-52. The Ice Patrol has taken many other sections across the Labrador current in addition to the above but none were repeated for so many years.

In addition there are hydrographical observations in Subarea 3 by French research ships in occasional years, particularly since 1924. In recent years the Atlantic Oceanographic group at St. Andrews has made some summer and autumn cruises in Subarea 3. Canadian hydrographic ships have taken temperatures particularly in Subarea 2 and innumerable bathythermograph observations have been taken by U.S. and Canadian naval and other ships especially in Subarea 3.

Iselin in the schooner Chance carried out hydrographic observations in July—August, 1926, taking sections across the Labrador current in Subareas 2 and 3. During the Canadian Fisheries Expedition of 1914-15 under the direction of Dr. Hjort, hydrographic stations were occupied in 1915 in the southwestern part of Subarea 3 on St. Pierre Bank, Green Bank and in neighbouring channels. In 1913 the Scotia expedition under Dr. D. J. Matthews carried out the first systematic hydrographic study of the Grand Bank and Subarea 3 waters and in Subarea 2 at the level of Hamilton Inlet made a section across the Labrador current. In the summer of 1910 the "Michael Sars" Expedition made two sections of the Grand Bank area, one east to west over the northern part of the bank and one from St. John's southward across the bank. A more detailed review of these and other hydrographic observations in Subareas 2 and 3 is to be found in Smith, Soule and Mosby (1937) and Dunbar (1951).

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There are many difficulties in making use of these data for a study of long-term changes in hydrographic conditions. It is noticeable at once that apart from very recent data there is too little agreement in the position of the stations from year to year for ready comparison to be made. Also, comparisons from isolated years are not of great importance in assessing long-term trends since temperatures in individual years may vary greatly during any period. Thus in the recent presumably warmer period, in Subareas 2 and 3 the year 1950 was characterised by a greater abundance of very low temperature water than any other year since 1928 for which good records exist.

From the hydrographic records of the Canadian Fisheries Expedition in the neighbourhood of St. Pierre and Green Banks in 1915 (Bjerkan, 1919) it is indicated that bottom temperatures on the average were lower in 1915 than in 1946-49 and in 1951-53.

Mr. Floyd Soule, Oceanographer with the Ice Patrol, in a private communication says that the part of the eastern branch of the Labrador current measured on the east side of the Grand Bank has been decidedly less since the war than it was during the period 1934-41.

It is indicated by our examination of the available data, in so far as former stations were near present stations, that no long-term temperature data suitable for comparison exist and in general only the recent data are suitable for any rigid comparing of sea temperatures from year to year.

St. Andrews Surface Temperatures.

Probably the best series of sea temperatures near enough to Subarea 3 for a possible temperature relation is the daily series of surface temperatures taken at St. Andrews, N.B. since 1921. (Hachey and McLellan, 1948). The combination of extremely high tides and narrow entrances to Passamaquoddy Bay forms an effective water mixing mechanism, consequently the surface temperatures at St. Andrews are fairly representative of the general temperatures of the ocean water in the area. The annual mean surface temperatures at St Andrews shown in Figures 1 to 4 were above or equal to the 1921-1947 average during the years 1927-33, 1936-38, 1944-47, and 1949-52. Judging by information from the Arctic, most of the years since 1922 may have been in a warmer period. The series is, therefore, not really extensive enough to trace long-term changes but it is useful as showing a trend toward higher temperatures in recent years and for showing any effect of higher and lower temperature short-term periods.

Since there is nothing comparable in Subareas 2 and 3 and since there is a good possibility that the St. Andrews temperatures reflect in some degree Subarea 3 temperatures, the St. Andrews temperatures will be used for comparison.

St. John's Air Temperatures.

From the Dominion Meteorological Station at Torbay Airport a series of mean monthly air temperatures has been obtained for St. John's Nfld. from 1872, with some breaks, until 1941. There is also a similar series for Torbay Airport, 5 miles from St. John's, from 1942 to 1952. From these the mean yearly temperatures have been calculated. For 46 months when records were taken from both St. John's and Torbay Stations in 1944-45 and 1948-51, the Torbay temperatures have been adjusted to represent St. John's temperatures and these adjusted temperatures have been used for 1942-52. (In the overlapping period Torbay temperatures were on the average 0.6°C. lower than St. John's temperatures).

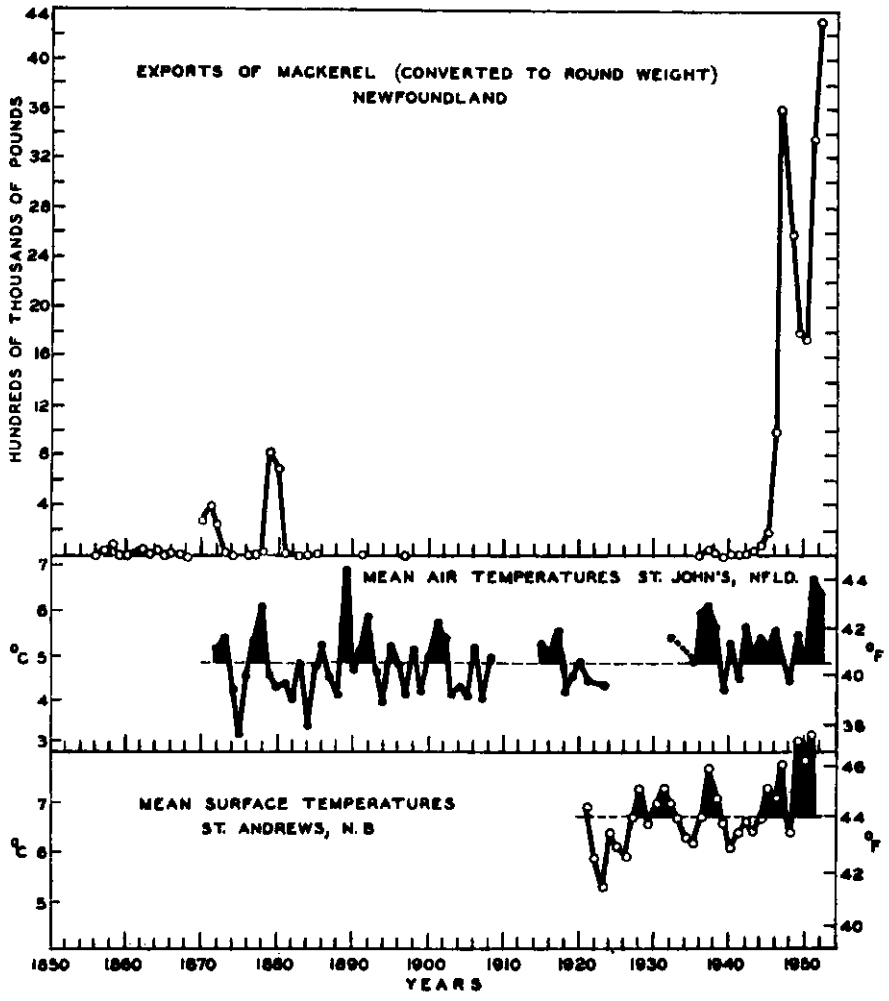
On each figure is shown the mean yearly air temperatures at St. John's for the available years between 1872 and 1952 and the mean yearly surface sea temperatures at St. Andrews, N. B. from 1921 to 1951. Extending through each temperature graph is an average line representing the average yearly temperature for the whole period at St. John's and at St. Andrews for most of the years for which temperatures are available. It will be noted that although mean air temperatures from year to year vary a number of degrees there is a gradually increasing temperature curve since the 1870's and 1880's with the past twenty years almost all above the average mean temperature for the whole period.

It is obvious also that there is a fairly good relation between high and low air temperatures at St. John's and corresponding periods of high and low temperatures of the sea water at St. Andrews. The average line at St. Andrews was calculated from the recent presumably warmer period 1921-47 whereas the average airtemperature at St. John's was derived by including the earlier colder period as well. Thus the St. Andrews average is possibly a half degree Centigrade or a degree Fahrenheit higher than it should be to compare with the St. John's average. There is probably a difference of not much more than 1½ degrees Centigrade between the mean sea temperature at St. Andrews and the mean air temperature at St. John's. It is certain that because of the location of St. John's its air temperatures will be strongly affected by the surface temperatures of the nearby Atlantic.

CHANGES IN ABUNDANCE OF MARINE ANIMALS IN SUBAREAS 3 AND 2.

In Subarea 3 there have been only two brief periods of research activity from the Newfoundland Fisheries Research Station, 1931 to 1935, and from 1946 to the present time. The long-term records of marine animal abundance, therefore, are those of marine animals taken commercially and from newspaper records of unusual species. In the following account all the old newspapers have not been thoroughly searched but the fisheries catch and export records have been investigated.

FIGURE 1



Mackerel.

While they were doubtless present on the west coast of Newfoundland, mackerel were apparently absent or extremely scarce from the east coast of the island for many years prior to their recent appearance in numbers. In the senior author's early years at Bonavista in the middle of the east coast, although numerous cod traps were used with mesh small enough to catch mackerel, he can remember seeing only one mackerel.

A statement by Mr. L. G. Hodder from Ireland's Eye in Trinity Bay, one of the present large centers of the fishery, runs as follows— "Mackerel were almost unknown in Trinity Bay prior to the mid 1940's but since then have made their appearance in considerable quantities and a significant mackerel fishery has developed especially during the months of September and October each year."

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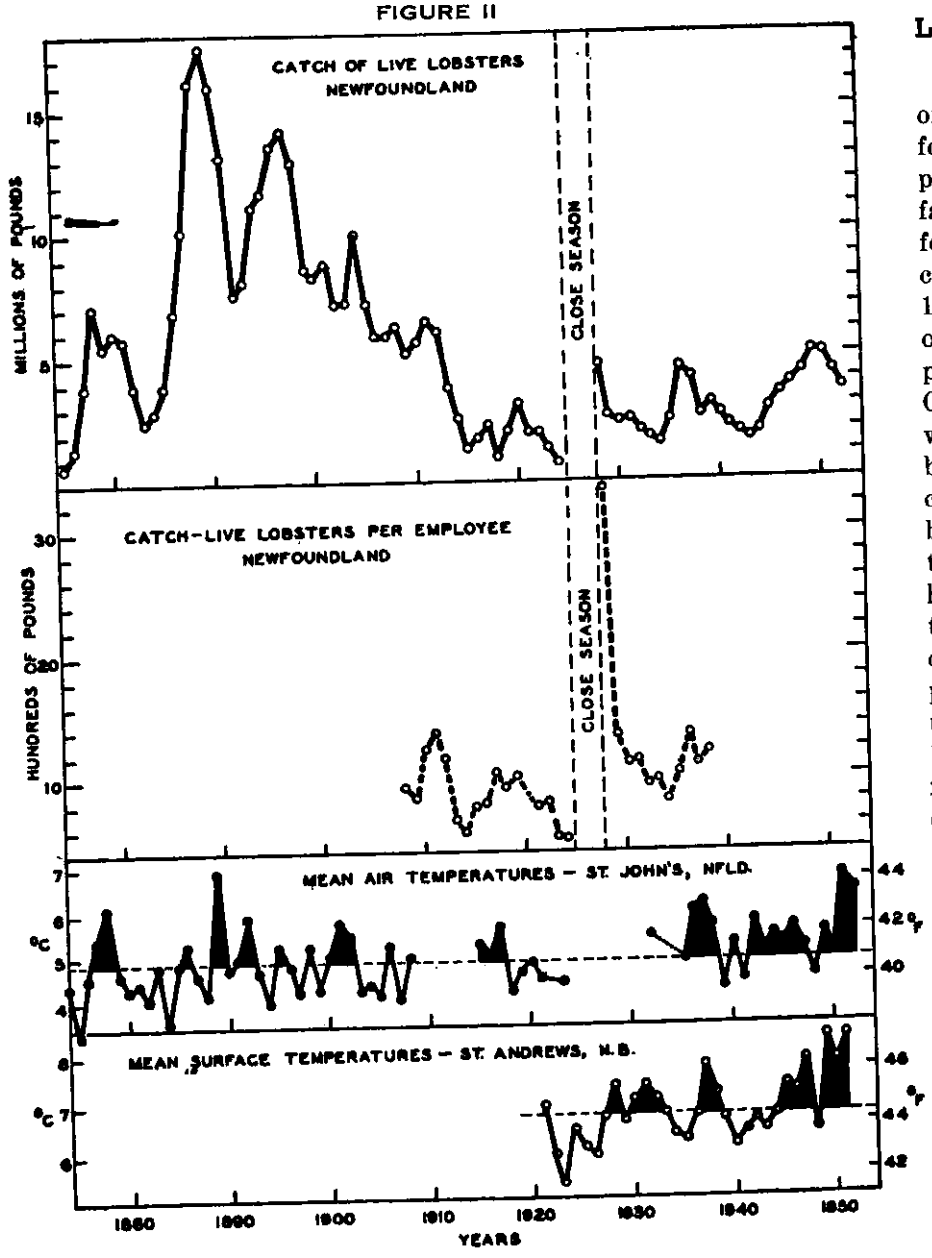
The export figures for mackerel shown in Figure 1 indicate very small quantities, less than two hundred thousand pounds per year for the earliest figures available, 1856 to 1868; about three to four hundred thousand, 1870-72; and seven to eight hundred thousand pounds in 1879-80. Less than five thousand pounds were exported in each of the years 1883, 1884, 1885, 1891 and 1897, and otherwise there were no further exports until 1936. The exports of mackerel did not rise to two hundred thousand pounds again until 1945 after which the exports increased rapidly and ranged between approximately two to four million pounds from 1947 and 1952.

The recent increase in mackerel appears to be an increase in population presumably due to a recent warm period, the east coast being during cold periods a too-low-temperature environment for the success of this species.

FIGURE II



Lobsters.

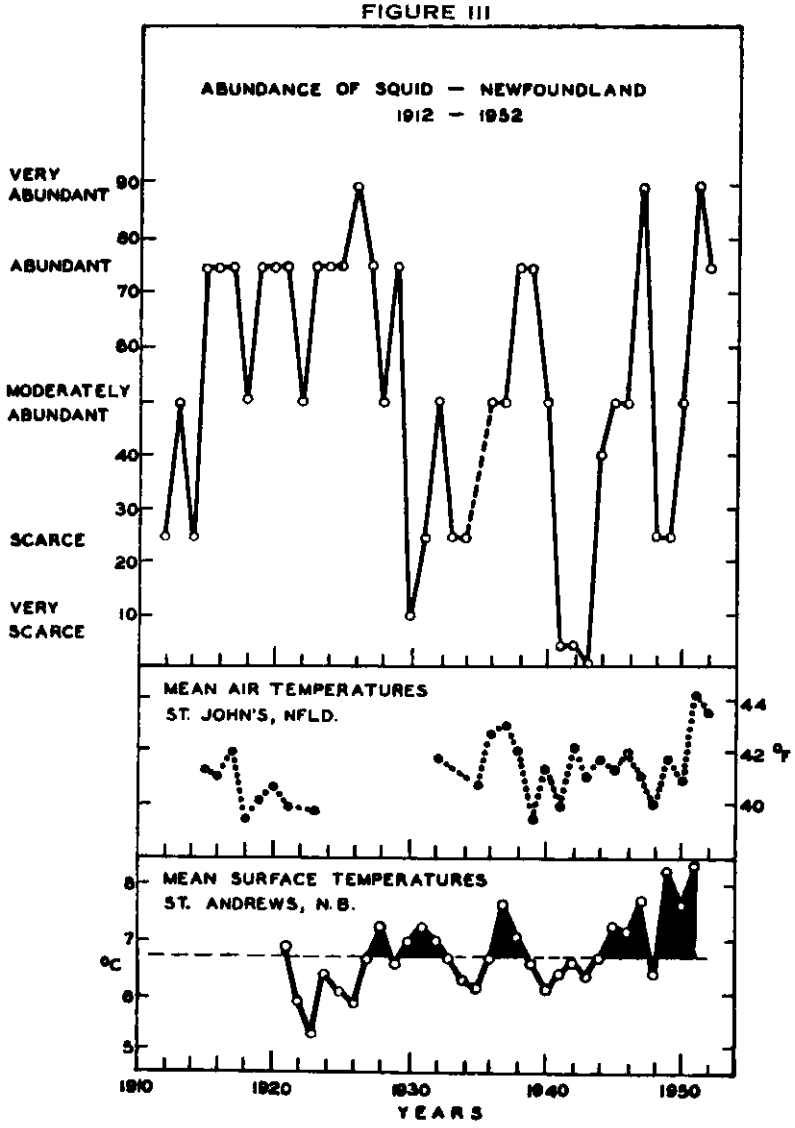
Figure 2 shows the relation of the catch of lobsters in Newfoundland to St. John's air temperatures and St. Andrews surface sea temperatures. In Newfoundland, lobsters were first caught commercially in the 1870's with the highest catch of sixteen to eighteen million pounds from 1888 to 1890. Over six million pounds a year were caught in almost all years between 1886 and 1912. The catch was at its lowest ebb between 1915 and 1924. In the recent twenty years there has been a fluctuating but on the average progressive increase in catch (for more complete information on the period up to 1939 see Templeman, 1941). There are only a few figures available on the number employed in the lobster industry.

The early large catch represented the fishing-out of a relatively abundant virgin stock. Since lobsters in Newfoundland, especially on the north-east coast, are at the northern limit of their range, any increase in temperature should be beneficial to the survival of the young and for ease of trapping the adults. It is

possible that the recent improvement in the fishery is a response to higher temperatures. If this is true, it is note-worthy that the increase has not been nearly as great as in northern Norway and in the north-eastern U.S.A. in Maine. Summer surface temperatures in Newfoundland lobster producing areas would probably be higher, however, than those in northern Maine so that Maine might benefit more by increased temperatures.

To consider shorter term trends in recent years since the early nineteen-twenties, it is evident by a comparison with St. Andrews temperatures that the three recent prolonged periods of below average temperatures correspond fairly well with decreases in the lobster catch. This correlation has already been pointed out by Martin (1953) for the lobster catch in the Maritime Provinces and is apparently due to the fact that temperature controls feeding rate and rate of movement and thus affects the capture of lobsters in baited traps. In the limited information available the catch per employee is similar in trend to the total catch.

FIGURE III



Squid

The squid *Illex illecebrosus* is seasonally very common in the Newfoundland inshore area. Squid can usually be caught at a depth of about a hundred fathoms or over on the south-west edge of the Grand Bank in May. They gradually move shoreward across the bank and are numerous in the inshore areas usually in late July or early August, leaving again in November. In some years they may be extremely abundant and in other years scarce or absent. When inshore they are in the warmer and shallower water only several fathoms deep. From its habits one would expect this animal to be associated with rather warm water.

The only long-term information available is qualitative from fisheries reports and other sources indicating abundance. The various degrees of abundance have been given a numerical rating and from this rating the graph below has been drawn (Figure 3). It is seen that contrary to what might be expected there has been no increase in abundance in recent years. There was a period of general abundance with no very bad years between 1915 and 1929, generally lesser abundance from 1930 to 1934, a period of extreme scarcity from 1941 to 1943 and of relative scarcity in 1948 and 1949. There have been more periods of scarcity and greater average scarcity since 1930 than in the fifteen years previous to 1930. We are unable to draw inferences regarding the possible long-term effects of water temperatures.

If short-term local abundance of squid is considered, using St. Andrews temperatures it will be noted that the 1934, 1941 to 1943 and the 1948 lack of abundance occurred during periods of below-average temperatures while the 1930, 1931 and 1949 low abundance occurred with above-average temperatures. The 1922-26 period of considerable abundance occurred during periods of below-average temperatures.

Billfish (*Scomberesox saurus*)

In recent years billfish have often been abundant in Newfoundland waters. Our earliest record is for 1885 when billfish were reported abundant in September in Torbay Harbour. From 1931 to 1934 there are some individual records of billfish by the Fisheries Research Station. In 1936 billfish were plentiful at Bay Bulls and Dildo. The correspondent reported that some had been caught at Bay Bulls thirty years previously. In 1945 the newspaper correspondent from St. Fintan's on the west coast of Newfoundland reports that a school of billfish was encountered. The correspondent says that this fish is a newcomer, he has only heard of them recently. In 1947 in October and November billfish were present in great numbers in Conception Bay. In early October a very large catch was made at Harbour Breton on the south coast while mackerel were being seined. These were the first the correspondent had ever seen. Mr. Colin Storey seined 40 barrels in Trinity Bay in a day during the first week of October. On November 13 and 20, thousands of billfish were driven ashore at Holyrood in a storm. In 1951, billfish were extremely numerous in September and October on the east coast of Newfoundland in Notre Dame, Bonavista, and Trinity Bays. While we cannot be certain of billfish abundance during the years between 1885 and 1931 from absence of records, it seems to be fairly certain judging by the lack of knowledge of billfish among the local population when they became abundant in recent years, that they had not been generally in evidence in numbers for a considerable time previously.

Capelin (*Mallotus villosus*)

The capelin is abundant throughout the Newfoundland area, is near the southern part of its range on the warmer southwest part of the Newfoundland coast and might thus be expected to show variation in abundance with changing climatic conditions.

In Newfoundland, capelin are used mainly for bait and for fertilizer, consequently no record of former abundance can be found in the fisheries statistics. Over most of the coast it rarely fails to appear in numbers. On the western part of the south coast and the southern part of the west coast of Newfoundland, however, by the time capelin are ready to spawn, inshore temperature conditions in warm periods may often be too high for the beach spawning which occurs on all suitable beaches on the colder east coast of the island.

The latest reports on capelin abundance in the Newfoundland area were obtained by a questionnaire in 1941 (Templeman, 1948). It was apparent that in the period between about 1929 and 1940 or later there was an inshore scarcity of capelin on the warmer parts of the Newfoundland coast. From the western part of the south coast, with centre at Burgeo, we have the report in 1941 from the fisheries inspector that capelin had been plentiful in every year until 1929 and none had spawned there since.

From Bay L'Argent and English Harbour West, Fortune Bay, two fisheries inspectors reported separately in 1941 that this year saw the first appearance of the capelin in many years. The fishery inspector at Port aux Basques reported regarding the area from Cape Ray to Fox Roost in 1941 that there had not been any capelin in the area for ten to fifteen years.

Cod

Figures for cod exports and export values of dried salt cod are available since 1807. For purposes of the graph shown below (Figure 4), the exports in recent years of fillets have been converted to dried salted cod. Unfortunately there is no record of the number of fishermen engaged except for a brief recent period.

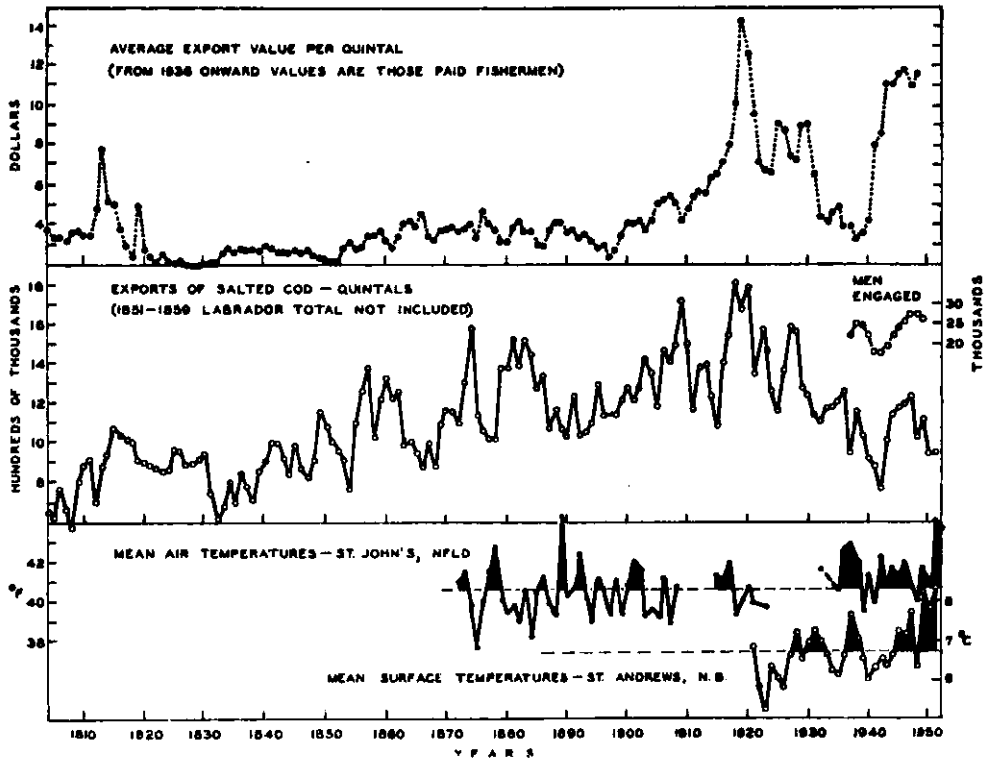
During the period under review, the cod catch largely inshore in Newfoundland and Labrador gradually increased to an average of almost one million eight hundred thousand quintals

of dried salted cod from 1918-1920 and has since gradually declined to about a million quintals.

Some of the increases in catch seem to coincide with or follow price increases. In the early part of the fishery the highest price was reached in 1813 during the Napoleonic wars. The general high prices of the period were soon followed by an increase in catch with a peak catch in 1815. The high prices during and immediately after the first World War with a peak price in 1918 also corresponded with the peak catches of the whole period. The catch continued at a very high level until 1920 when prices fell rapidly and this was followed by a decrease in production. The very low prices of the depression period from 1931 to 1940 corresponded with a severe reduction in the catch and the increased prices from 1941 onward did not immediately result in the production of a large catch since the number of fishermen declined rapidly through overseas service and because during the early war years large numbers of fishermen gave up fishing to work at the construction of military bases in Newfoundland. Following the return of the fishermen to their fishing trade and with prices still high, the catch increased correspondingly. Still more recently the dory-schooner fishery for cod on the Grand Bank and the schooner fishery for cod on the Labrador coast have been largely abandoned for lack of crews. Many of the fishermen, particularly the younger ones, have again left the fishery to engage in construction and other work. Since these two fisheries have a much greater production per man than the Newfoundland inshore fishery and since there is a reduction in the numbers of inshore fishermen also, there has been an inevitable reduction in total catch. The trawlers which are taking the place of the dory-schooners do not usually fish for cod.

Both the increase in catch from 1870 to 1920 and the decline in the cod catch since 1920 have apparently been in a period of increasing temperatures with the temperatures since 1930 being considerably higher. However, so many other factors are responsible for fluctations in the catch of cod throughout the years that it is very doubtful whether lack of abundance or availability of cod has had anything to do with the overall decline in catch.

FIGURE IV



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