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Fluctuations in Climate Over Greenland and Their Influence on the Marine Environment and the Cod Stock

by

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Abstract.

The climatic changes over Greenland in the present century are described in the light of the climatic conditions during previous centuries. Some of the effects of the fluctuations in climate on the marine environment and its living species are evaluated.

1. Introduction.

The activities in the field of climatic research has for many reasons intensivated during the last decades. First of all there is the question of evaluating the effects of the increasing amount of carbondioxide in the atmosphere, and also an increasing realization of the coupling between climatic changes and the yields in agriculture and fisheries is an inspiring element in the climate research programme. However, the most important reason for the increased activities are the technological development, where for instance launching of a number of satellites well equipped with high precision measuring instruments together with advanced computer technology have made it possible to investigate some of the fundamental physical processes governing the climate.

The purpose of this paper is not to discuss the importance of the physical processes on the climate, rather to describe the climatic changes observed in the West Greenland area in the present century, and to discuss the possible effects on the West Greenland cod stock.

2. Variations in climate.

When discussing variations in the climate two things are important to realize:

a. The geographical area in question!

This is illustrated in Fig. 1., where the front between areas with positive respectively negative temperature anomalies is shown , which means that a Greenlander and a European would give different answers to the question: " How is the present climate in relation to normal conditions?"

b. The time scale important to the specific problem in question.

All of us more or less have a feeling, whether the present day, week, month or year has been colder or warmer than the preceding one. This can often be valuable information , but in a discussion of problems like: Are we moving towards a new iceage, or as in this paper: The possible effect of climate to fluctuations in fish stocks, it is necessary to use time scales of several years or decades. Fig. 2 illustrates this way of presenting the problem.

Figure 2 also shows that in this century a period of general heating starting around 1920 has been observed over the northern hemisphere as a whole, as well as in the arctic region. Maximum temperature occured around 1940, followed by a cooling tendency until 1970, when a new heating period seems to have started.

It may also be noted that the fluctuations in the arctic area are greater than in the northern hemisphere as a whole , and that the minimum temperature around 1970 was not as low as the temperatures prior to 1920.

A relevant question at this stage is: "Does the heating in this century reflect an extraordinaryly warm period, or are the temperatures only returning to normal conditions?".

This question can not be answered directly, because reliable meteorological observations have only been carried out for about 100 years. It is, therefore, necessary to use indirect observation methods, of which an excellent one has been developed at the University of Copenhagen, by Dansgaard et al (1973). The method uses the known correlation of content of the oxygen isotope O_{18} in precipation - in this case stored by nature in the Greenland ice cap - with the atmospheric temperature at the time of precipation. By analysing ice samples obtained from cores by drilling into the Greenland icesheet, Dansgaard has been able to quantify the air temperature many centuries back in the history.

Since we are now focusing on a specific geographical area,

Greenland, the temperature or climatic changes in this century, represented by temperature observations from the Godthåb/Nuuk meteorological station, are shown in Fig. 3 in order to be able to compare the climatic development at Greenland relative to the areas shown in Fig. 2 . It is seen that the climate of Greenland in this century has followed the same tendencies as that in the rest of the arctic region.

Dansgaards O_{18} measurements (Fig. 4) indicate that the warm conditions in the twentieth century are extraordinary, and that we must go about 1000 years back in time to find similar conditions, i. e. at the time when Erik the Red colonized Greenland.

Fig. 3 also reveals that besides the varm period from 1920 - 1965 and the cold period around 1970 West Greenland has experienced a second cold period at the start of the 1980'es which has been thoroughly described by Rosenoern et al (1985).

3. Sea temperatures.

The temperatures of the surface layer in the waters off West Greenland are to a high degree governed by interaction with the atmosphere (Buch, 1986), therefore the principal lines of changes in climate/air temperatures outlined in the preceding chapter (Fig. 3) are expected to be reflected in time series of surface layer temperatures.

At ICES' Service Hydrographique, Smed for many years collected sea-surface-temperature observations from the Davis Strait area as well as other parts of the North Atlantic, and published them each year in Annales Biologique. The results of these analysis for the West Greenland area are shown in Fig. 5.

Right after the foundation of the Greenland Fisheries and Environment Research Institute in 1946 , continious hydrographical observations at the Fylla Bank Section were started and the mean temperature of the upper 40 m on top of Fylla Bank (St. 2) for the years 1950 - 1985 is shown in Fig. 6.

The two figures together clearly reflects the main points in the picture of climatic trends for the West Greenland area in the present century.

4. Biological effects.

Numerous examples of the reaction of living species in the sea to climatic changes could be listed as has been done by for instance Cushing and Dickson (1976). However, the present paper restricts itself to a preliminary consideration of the climatic influence on

the West Greenland cod stock.

After having been absent from the West Greenland Fishing Banks for a period of 50 - 75 years, cod returned to these waters during the 1920´es.

The development in the West Greenland cod fishery is illustrated in Fig. 7. In the twenties and thirties a fairly good cod fishery developed, carried out mainly by foreign vessels. During World War Two the fishery was reduced to what could be taken by the Greenland fishing fleet of small boats . After the war period, when foreign nations gradually returned to the area with modern and effective vessels, the West Greenland cod fishery experienced an explosive development, and the stock may have been overfished.

Around 1970 the catches decreased drastically, although with a temporary slight improvement in the late 70´ies, whereafter the fishery decreased again reaching its lowest catch since 1940 in 1985.

The curve in Fig. 7 can not be compared directly to the air temperature curves (Fig. 3) or the sea surface temperature (Fig. 5), because the catch depends on the fishing effort, the effectiveness of the vessels and gear used etc. But the interesting features in Fig. 7 is:

i. When the warm period started, cod returned to West Greenland Waters.

ii. When the cooling around 1970 started, catches decreased nearly instantaneously.

iii. When a second cooling occured in 1982 - 1983 the catches of cod declined to almost nil.

All this indicates a clear connection between the size of the cod stock and the climatic conditions.

The next thing to consider is - what is the mechanism behind the effects of climate on cod?

i. Is cod directly sensitive to the temperature fluctuations?

ii. Is the climatic influence of an indirect nature, for instance through a reduced production of species serving as food for cod.

Adult cod is usually living at great depths (300 - 600 m), a depth range , which is not directly influenced by the temperature

fluctuations in the atmosphere, and as seen from Fig. 8. the temperature at these depths show only small variations. Although some decrease in temperature has been observed during the recent cold years it is not believed that adult cod is affected directly by the climatic changes.

On the other hand, a direct temperature effect has been observed in the West Greenland area with regard to reproduction of cod, as discussed by Hermann et al (1965) and Hansen and Buch (1985), see Fig. 9.

Regarding the indirect effects no evidence can be presented for the time being, but the immediate impression from plankton hauls and secchi disc depth measurements carried out during summer along the west coast of Greenland is that the primary and secondary production were reduced during the latest cold years, which possibly can be explained by changes in the stability conditions of the water masses.

5. Conclusion.

From the above presentation it can be concluded that the marine environment of West Greenland is sensitive to climatic changes, and that the living species react directly as well as indirectly to the changes in the marine environment.

Although the importance of proper management of stocks should not be neglected, climatic conditions seem to play the major role for occurrence, distribution and density of cod at West Greenland.

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Fig. 1.

Front between areas with air temperatures lower respectively higher than normal.

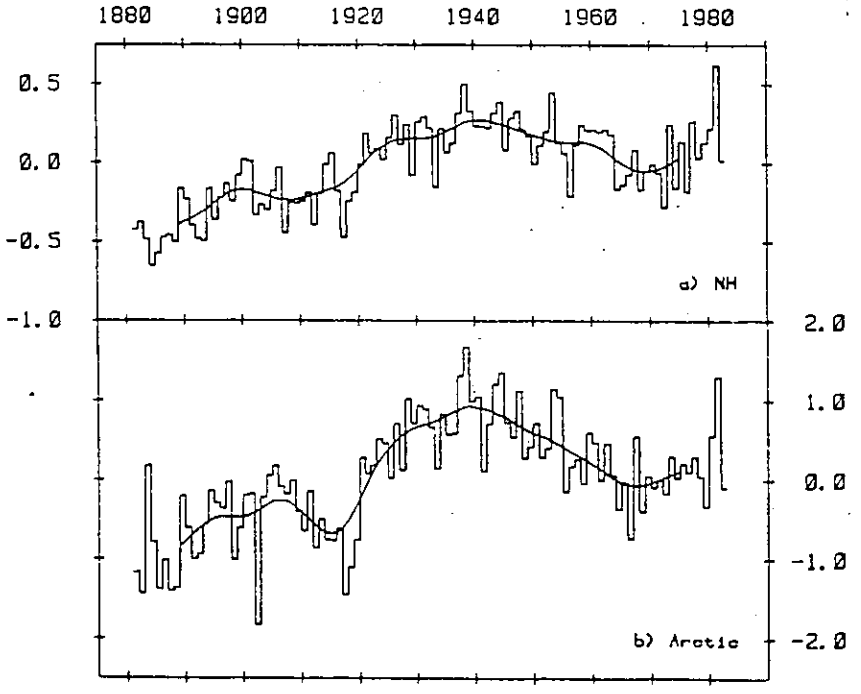

Fig. 2.

Annual surface air temperatures for a) the northern hemisphere (0-85°N), b) arctic regions (65-85°N).
Data are expressed as departures in degrees Celsius, from the 1961 - 1975 reference period.
After Kelly (1984).

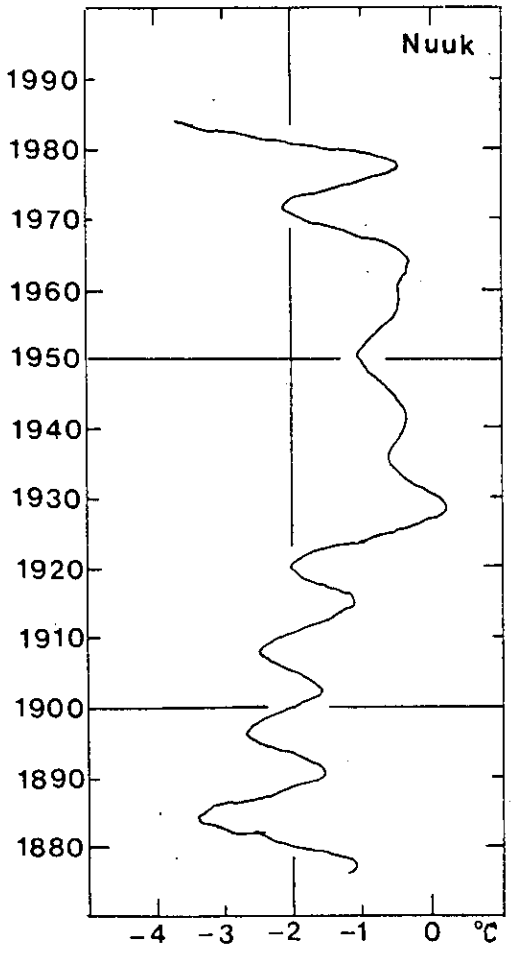

Fig. 3.

Average airtemperatures at the Nuuk meteorological station, 1976 - 1984. After Dansgaard (1985).

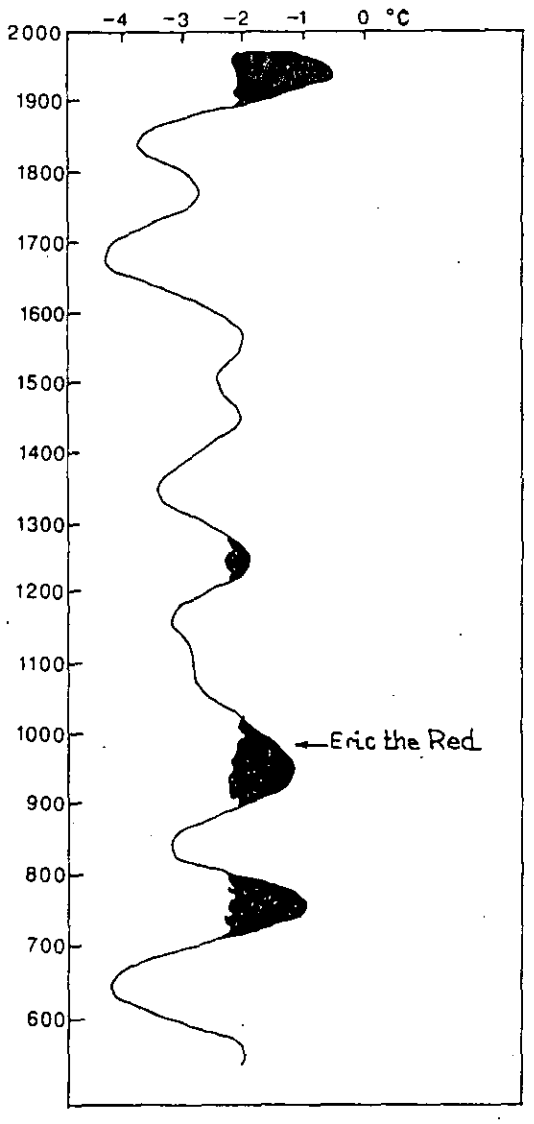

Fig. 4.

Climate in Greenland from 553 - 1975, evaluated from isotop measurements on ice cores from the Greenland Icesheet.
Black areas indicate positive temperature anomalies.
After Dansgaard (1985).

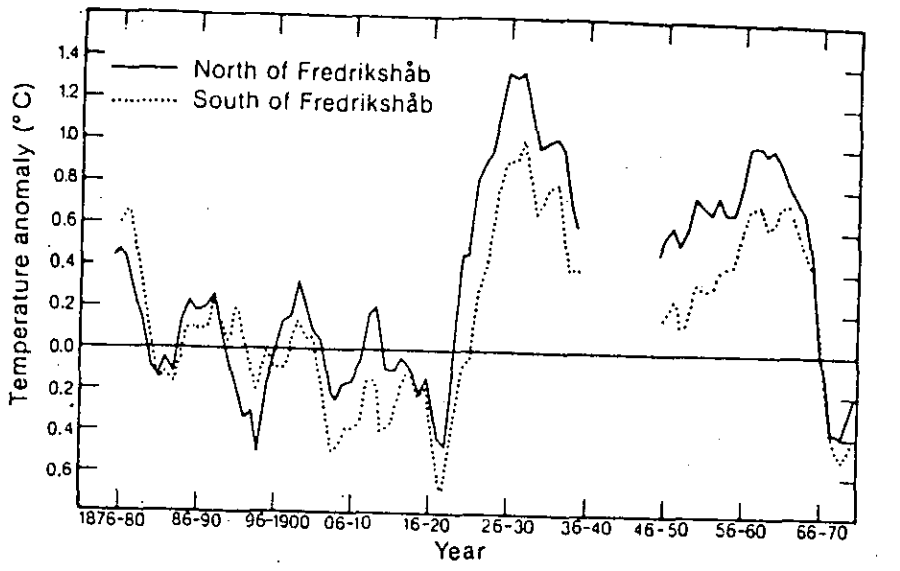

Fig. 5.

Surface temperature anomalies (5 year running means) for West Greenland, 1876 - 1974.

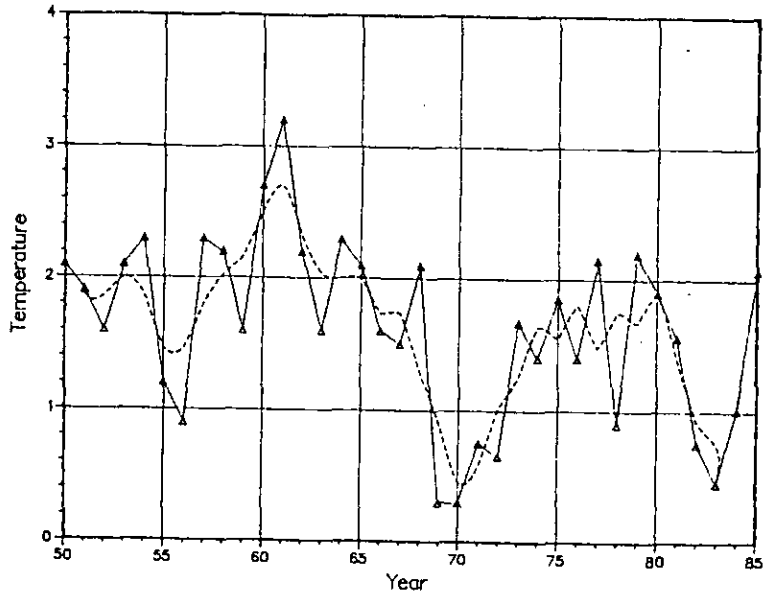

Fig. 6.

Mean temperature of the upper 40 m on Fylla Bank by the middle of June, 1950 - 1985.

——— actual observations.
..... 3 year running mean.

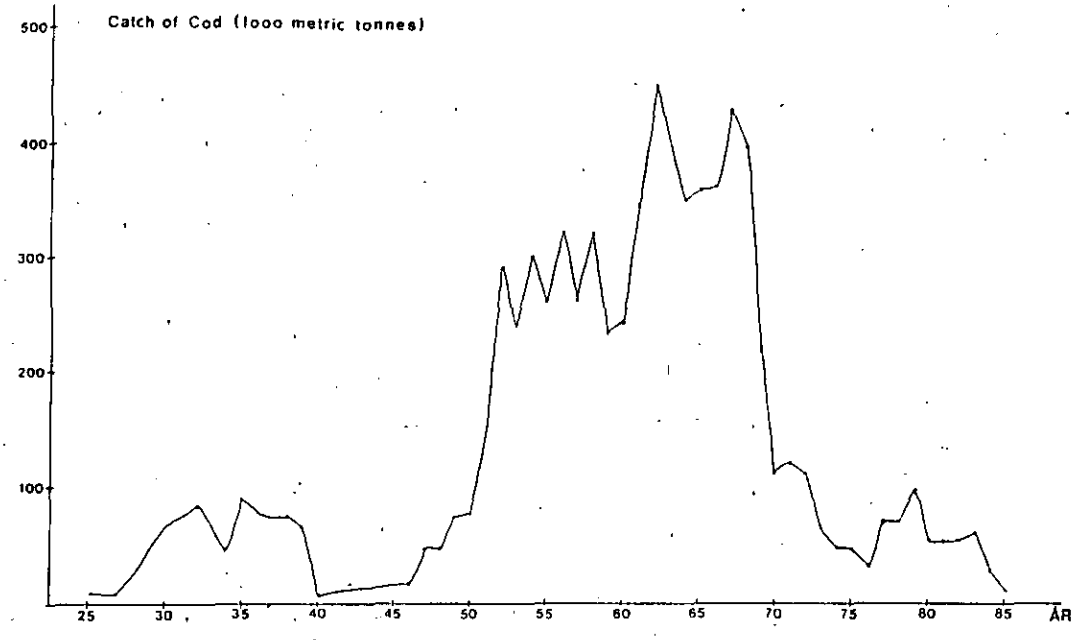

Fig. 7

Catches of cod off West Greenland, 1925 - 1985. (Unit: 1,000 metric tonnes).

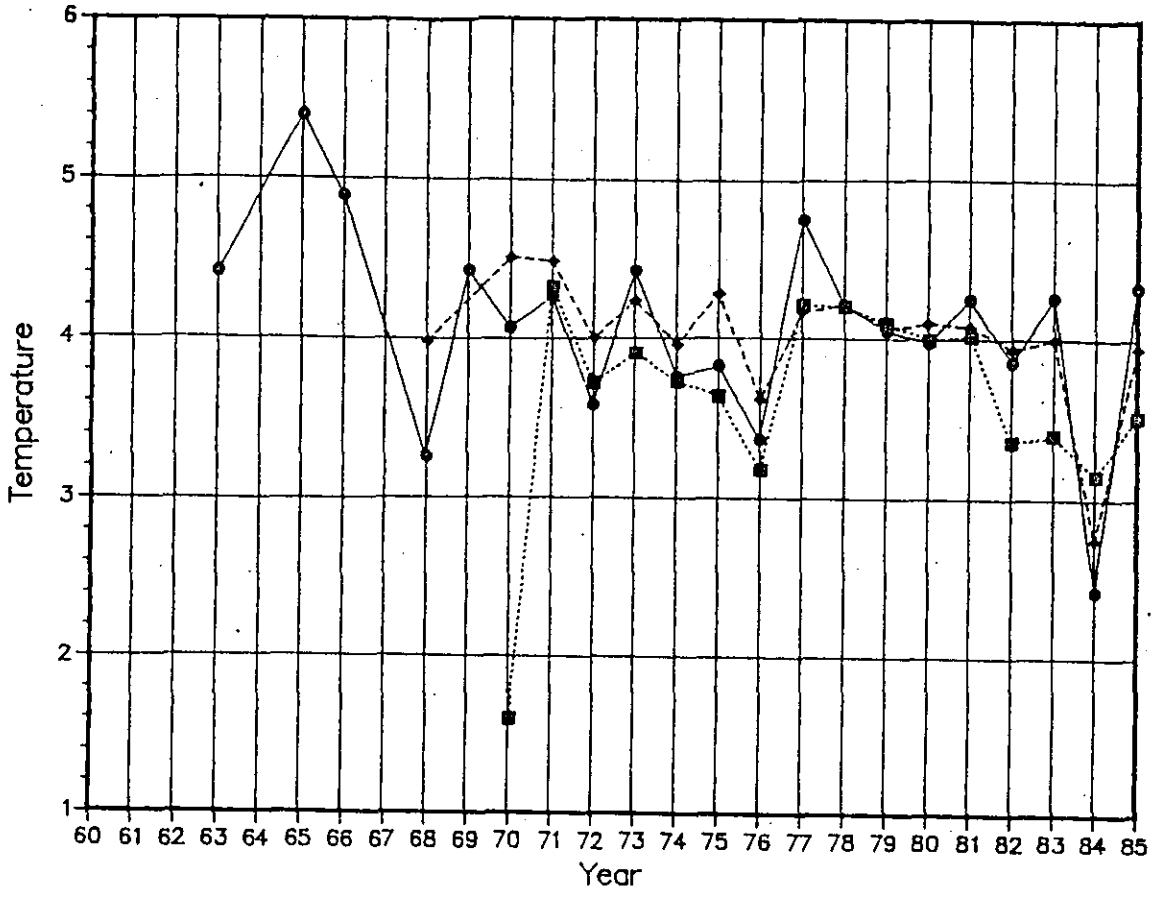

Fig. 8.

Mean temperatures of the depth interval 400 - 600 m at 3 stations west of the West Greenland fishing banks.

——— Fylla Bank St. 4

- - - - - - - - Lille Hellefiske Bank St. 5

. . . . . Store Hellefiske Bank St. 6

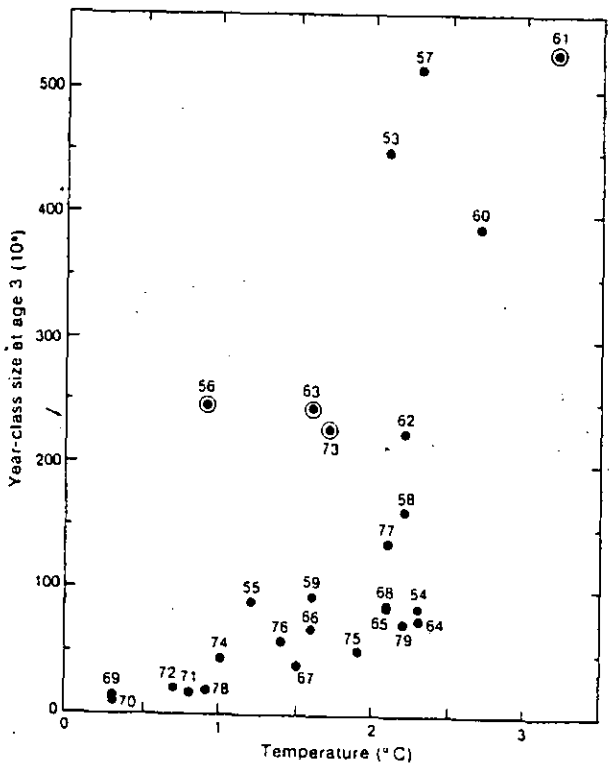

Fig. 9.

Relation between year-class strength of age 3 cod and temperature off West Greenland. (Circled dots indicate year-classes, which were classified as being mainly of eastern origin).