Fol. 41 G

(Biolog)

International Council for
the Exploration of the Sea

C.M. 1990/G:49
Demersal Fish Committee/
Ref.C Hydrography Committee

GROWTH OF 0-GROUP FISH IN RELATION TO TEMPERATURE CONDITIONS IN THE BARENTS SEA DURING THE PERIOD 1965-1989

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ABSTRACT

Since 1965 the International 0-group fish survey has been carried out in the Barents Sea during late August and early September. The main purpose is to determine the year-class strength of some commercial fish species at an early stage in their life history. The present contribution is a preliminary study on the growth of the 0-group during the first half year after spawning. Comparisons of lengths of cod, haddock, herring and capelin strongly indicate similar variations from year to year. Since these species inhabit partly the same water masses the first six months, it is likely that the variation in growth depends on some common factors. One of these may be the temperature of the environment. The results so far indicate a relationship between the growth of larvae and temperature.

INTRODUCTION

The large temperature variations in the Barents Sea during the last 20 years have initiated a lot of investigations in order to study the influence of temperature on different fish population parameters, and some of these results have been reviewed by Loeng (1990). Especially, recruitment mechanisms of Arctic cod (Gadus morhua) have been focused on. Sætersdal and Loeng (1987) showed that medium and strong year-classes of cod in the Barents Sea mainly occured in years with temperature above the mean value. They also indicated that strong year-classes of herring (Clupea harengus) and haddock (Melanogrammus aeglefinus) occured simultanously with strong year-classes of cod. The conditions at the spawning field are also important for recruitment of cod. This has been clearly demonstrated by Ellertsen et al. (1987, 1989). Abundance and distribution of 0-group cod and haddock in the Barents Sea has been studied by Randa (1984).

The growth of larvae at the spawning ground in relation to environmental condition has also been discussed by Ellertsen et al. (1987). However, little attention has been paid on the growth development of larvae during the period prior to the 0-group survey in the Barents Sea, when the larvae are about half a year old. The present paper is a preliminary study on some simple relations between growth of larvae of some commercial important fish species and the temperature conditions the larve have experienced during their first half year of life.

MATERIALS AND METHODS

Since 1965, an International 0-group fish survey has been carried out in the Barents Sea and adjacent waters. The survey has taken place in late August and early September. The geographical distribution of 0-group fish were estimated by fishing with a small mesh midwater trawl at every 30-40 nautical miles (n.m.). The standard procedure consist of towings of 0.5 n.m. in each of three standard depth, with the headline of the trawl at 0, 20 and 40 m. An additional tow at 60 m is made when 0-group fish layer is recorded with echosounder at that depth. The catches were sorted, and the length measuered. The mean length is calculated as the aritmetic mean.

Hydrographical observations were made along all the survey tracks with 5-40 n.m., usually 30 n.m., between stations. Observations in several fixed sections crossing the inflowing currents to the Barents Sea were carried out. The observations have been made either by Nansen bottles or CTD-sonde. Mean values were calculated for different depth layers, but mainly 0-200m (bottom).

The data used in this paper are all taken from the reports of the 0-group surveys (e.g. ANON. 1989). Fig.1 shows the distribution of trawl stations in 1989, and is in addition an example of the distribution of 0-group fish. The temperature section used in the present study, is the section between Nordkapp (North Cape) and Bjørnøya (Bear Island). This section is choosen because it runs through the midle of the distribution area. However, the year to year variation in temperature is almost similar in all hydrographic sections crossing the inflowing Atlantic water to the Barents Sea.

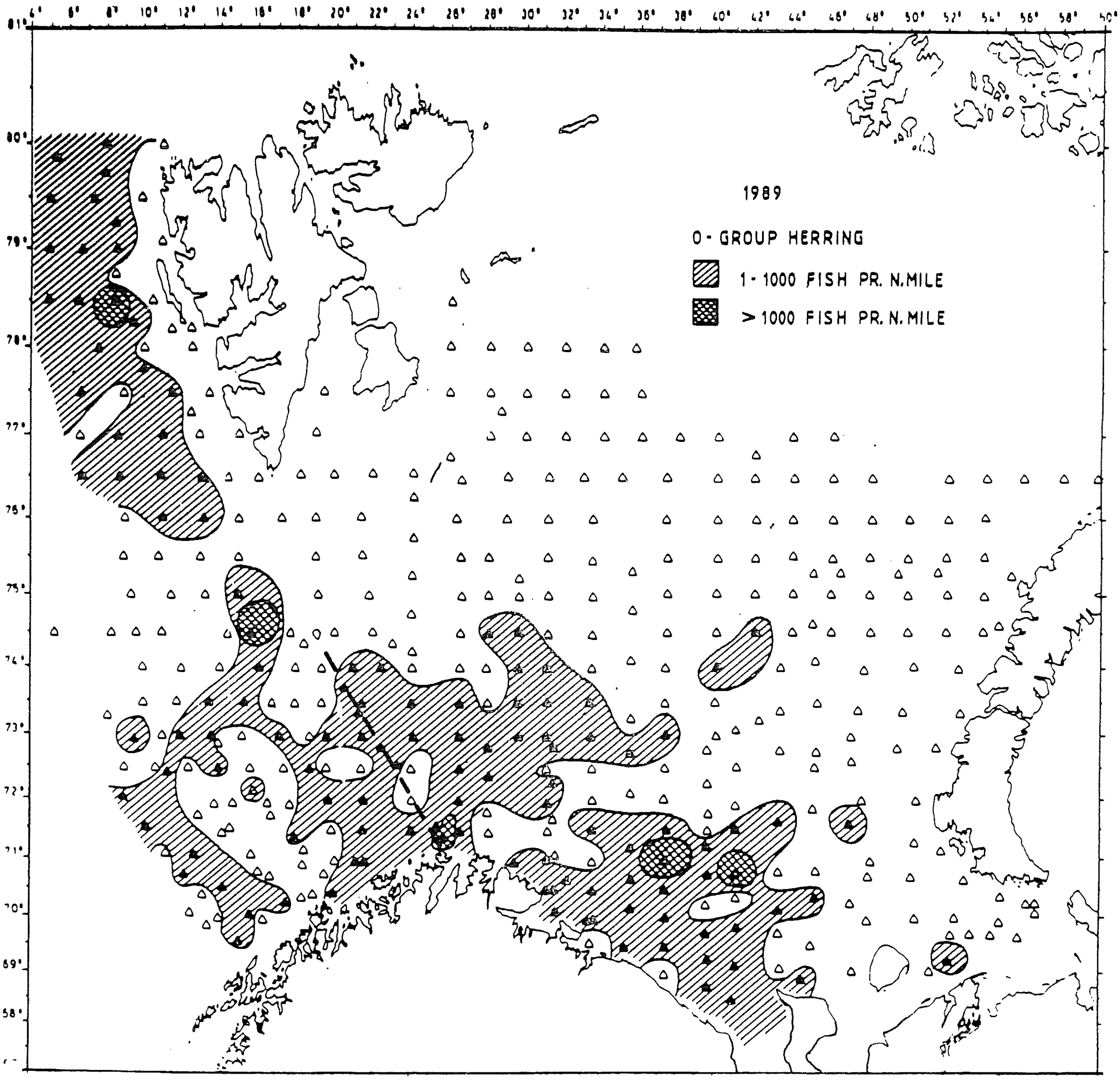

Fig. 1. Trawl stations (triangles) and distribution of 0-group herring in 1989. The section Nordkapp-Bjørnøya is shown by the broken line. (ANON. 1989).

RESULTS

Fig. 2 shows the length distribution of 0-group cod, haddock, herring and capelin (Mallotus villosus) during the period of observation. There seems to be a covariation between the length distribution of the different species, especially during the last 10-15 years. The length of larvae were at a maximum in the beginning of the 1970's. Then the length decreased and reached a minimum in late 1970's. A new maximum occured for all species during the period 1983- 85, while a new minimum was observed in 1987.

Fitting a linear regression to the mean lengths of cod versus those of haddock, of cod versus herring and cod versus capelin, yields the coefficient of determination, r^2, of 0.60, 0.77 and 0.30 respectively.

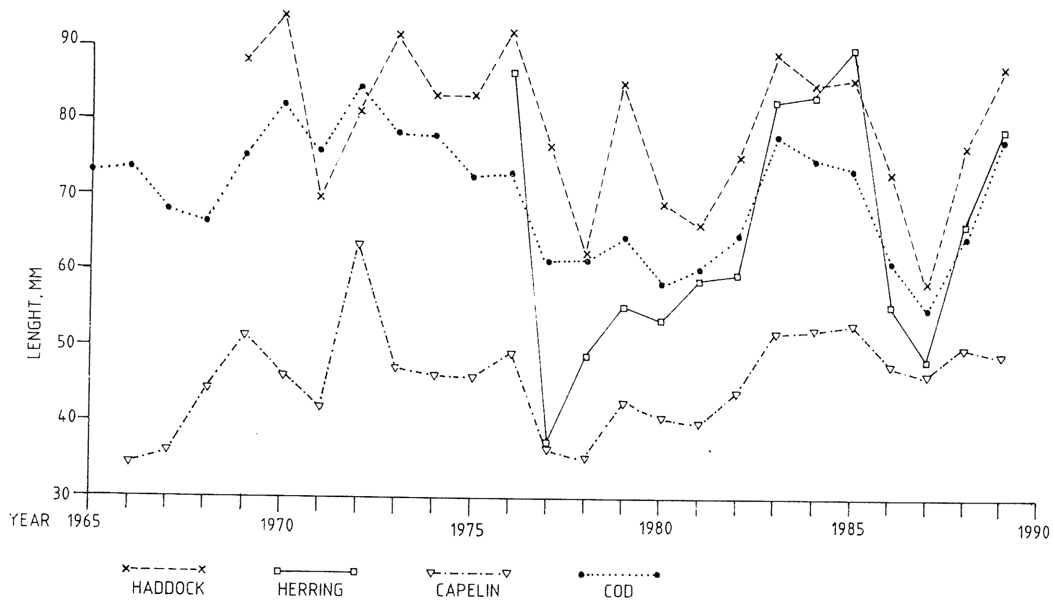

Fig. 2. Length distribution of 0-group cod, herring and capelin in August-September during the period 1965-1989.

Figs. 3 - 6 show the length of 0-group fish plotted against the mean temperature from 0 to 200 m in the section Nordkapp - Bjørnøya. For all the four species considered, there is an incrasing length with increasing temperature. For cod (Fig. 3) there seems to be an almost linear relationship if a few years are excluded. If we take away 1965 and 1985, which had long larvae compared to the temperature, and 1980, 1982 and 1986, which had short larvae compared to temperature, we find a correlation coeffesient, $r^2 = 0.72$ (n=20). If we take all year (n=25), we find $r^2 = 0.4$. For the other species r^2 varies from 0.3 (capelin and haddock) to 0.6 (herring) if all years are included.

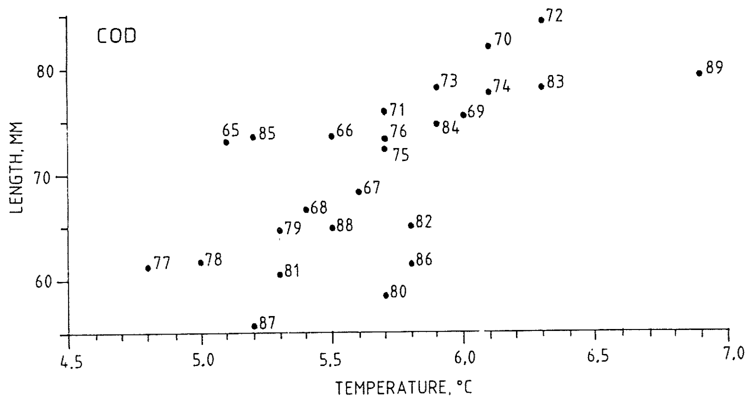

Fig. 3. Length distribution of O-group cod versus temperature in the Nordkapp-section.

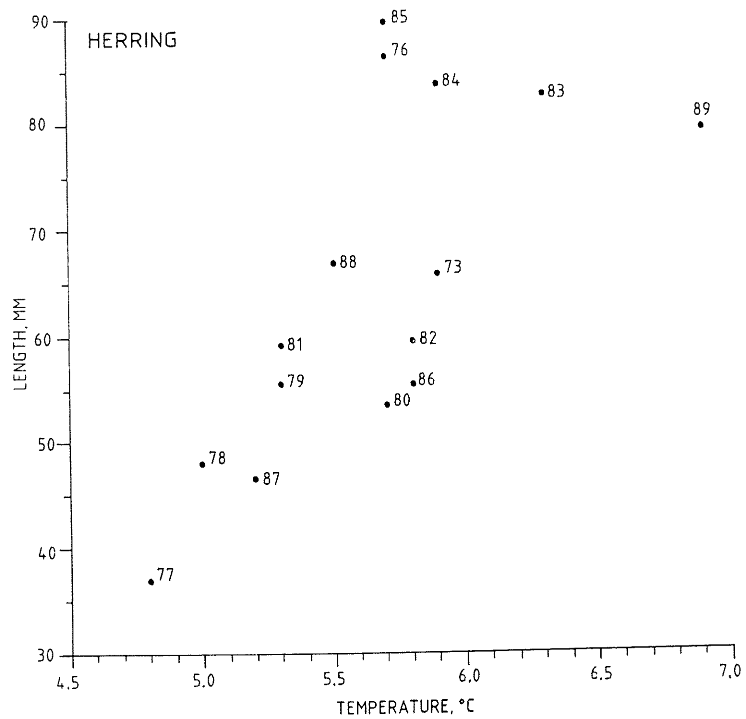

Fig. 4. Length distribution of O-group herring versus temperature in the Nordkapp-section.

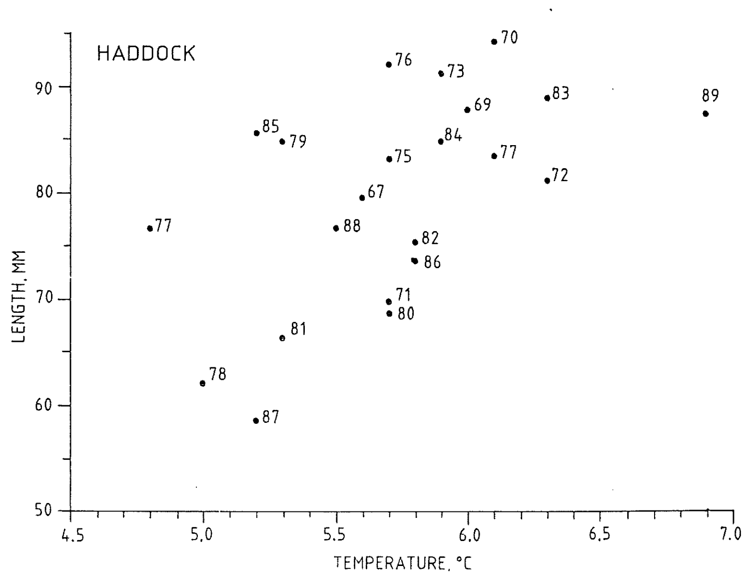

Fig. 5. Length distribution of 0-group haddock versus temperature in the Nordkapp-section.

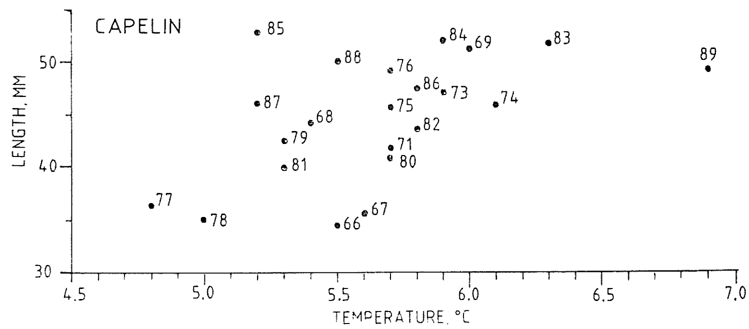

Fig. 6. Length distribution of 0-group capelin versus temperature in the Nordkapp-section.

DISCUSSION

It may be questioned if the temperature used, is representative for what the fish larvae has experienced during their first half year of life. The answer is "no". The temperature from the Nordkapp-section, however, very well represents the variation from one year to another. By using the depth layer from 0-200 m, both long term variations in the Atlantic inflow and local warming during summer have been taken care of. In a more detailed investigation, temperature from different localities along the drift pattern of larvae should be used.

In growth studies of cod, Nakken and Raknes (1987) concluded that the coupling between environmental changes and population parameters, was far more complex than a simple length-temperature relationship. Gjøsæter and Loeng (1987) came to the same conclusion when they studied the growth of capelin. Both papers, however, indicated best growth at high temperatures. It is apparent that temperature effects linked to the availability of food my be as important as direct effects. The feeding conditions for fish larvae also influence the year-class strength. The temperature dependent spawning of the copepod Calanus finmarchicus at the spawning field of cod, may be the most important process to cause variability in cod larval survival (Ellertsen et al., 1989). It is therefore reasonable to believe that food conditions are also important for the growth of larvae. Consequently, no simple relationship between temperature and growth should be expected.

Larvae of cod and herring, and partly also haddock have the same type of environment during the first six month of their life, and one would expect that they would be similary affected. The relatively high covariation between the length of these species confirm this assumption. It should be mentioned, however, that the length distribution of haddock some years are bimodal, indicating two different periods of spawning and/or different spawning areas. This may also partly explain the lower covariation between cod and haddock than between cod and herring. The weaker interrelation between cod and capelin is probably due to the fact that the caplin larvae partly growth up in a different area where the water masses have changed their characteristics. Another factor is that for capelin, the time of spawning is much more variable than for instance for cod (Sætre and Gjøsæter, 1975). In some years, parts of the capelin stock also spawn during summer. In these years, the earliest hatched larvae from the summer spawning may be caught in the trawl and included in the the calculation of the mean length.

There was a close relation between temperature and length of cod larvae if five years were excluded. The years 1980, 1982 and 1986 were all cold at the spawning ground with a temperature about 0.5^0C below the mean value for the spawning season. The year 1965, however, was 0.5^0C above the mean at the spawning ground. This can partly explain why these years did not fit into the usual pattern. 1985 was cold both at the spawning area and along the drift route into the Barents Sea. The food (plankton) availability in 1985 was not so good as in 1986 (ANON. 1990), so the relatively high growth in 1985 can not be explained by good feeding conditions, either. Looking at the growth of larvae at the spawning area, the growth of larvae in 1985 was less than in both 1982, 1983 and 1984 (Ellertsen et al., 1987). Also for all the other species considered, the growth of larvae were good in 1985. Consequently, there must have been something, which not can be explained from existing information, that has favoured this growth.

No further attempt has been made in order to analyse in detail the time series data (Fig. 2) and the linear regression data (Figs. 3-6). Neither is the aim of this paper to argue for use of linear models rather than other possible models. It seems, though, that high mean length of 0-group in August is associated with high mean temperature in the water masses where the larvae have spent most of their life.

The direction of further work should be to include variable age due to variable spawning time in the regression models and to look at larval distribution prior to the 0-group survey in August compared to the water masses where the temperatures were measured. This could probably, especially for capelin and haddock, reduce some additional sources of variation appearing as noise in the shown relationship.

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