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Survival of Larvae of the Barents Sea Cod in Connection with the Feeding Conditions and Water Temperature

by

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Summary

Investigations of the life and feeding conditions of larvae of the Barents Sea cod during the first three months from the beginning of their active feeding made it possible to define the relation between larval survey and feeding conditions and water temperature. It was found that larval survival depends primarily on food consumption by the larvae in April-May and on their fatness by June. Water temperature is responsible for the pattern of development of food organisms, mainly *Calanus finmarchicus* , thus providing feeding and survival of cod larvae.

In order to study the role of feeding conditions for the survival of larvae it is apparently necessary to compare the coefficients of survival with the feeding indices. For the Barents Sea cod there are only indirect indications of the dependence of survival of different year classes on the feeding conditions of the larvae. Thus, Corlett (1965) has found a correlation between the abundance of separate year classes of cod in the Bear Island-Spitsbergen area and the indices of wind and plankton that characterise the feeding conditions and transport of larvae and eggs by currents. Wiborg (1957) indicating the importance of the transport of the eggs and larvae by currents, has also in mind larval drift to the feeding areas, i.e. their supply with food.

An attempt is made in the present paper to correlate the coefficient of survival of cod larvae with the feeding indices, food plankton indices and water temperature on the migration routes of larvae. For this purpose, samples taken during 1959 - 1965 and 1969 were used. Each year two special cruises were made in the spring-summer period. During these, the main migration routes of fish eggs and larvae from the spawnig grounds were investigated. The times of collection and length and number of dissected larvae are shown in Table 1.

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Indices of food consumption and condition factors of larvae were used as feeding indices. The index of food consumption is a ratio of food weight to weight of the larvae, multiplied by 10 000. Food weight was determined by standard weights of food organisms. The weight percentage ratio of larvae of a particular year class to the long-term mean weight of larvae was chosen to characterise larval fatness. The ratio of larvae and fry abundance in June-July to eggs and larvae abundance in April-May is taken as the coefficient of survival (in percentage). It should be noted that the coefficient of survival for 1964 is listed only for reference. The data collected that year suffered from serious shortcomingsand consequently the coefficient of survival is apparently significantly underestimated. As plankton indices were used, data received from Degtereva on the abundance of Calanus finmarchicus nauplii (average quantity of specimens under1 m^2 in the 0-50m layer).

It has been found that pelagic larvae and fry of the Barents Sea cod during their first three months mainly feed on C. finmarchicus at all stages of development. During this period one distinguishes four stages in the life of the larva and fry characterised by feeding features and larval morphology. Eggs and larvae of the first stage (length 3 - 7mm) are usually observed in the third decade of April and in May. The second stage larvae (length 7 - 9mm) are most abundant in June. The third and fourth stages (length 19 - 35 mm and > 35 mm respectively) appear from the second half of June and in July.

The coefficient of larval survival should have been calculated from stage to stage, but to get reliable data on larval abundance for each stage, more frequent surveys would have been necessary. Only a very rough index can be obtained on the basis of the material of two surveys and it is possible to determine only very approximately the period of the greatest mortality of the larvae.

Investigations of Barankova and Khokhlina showed that there are no agreements between the abundance of eggs and larvae in April-May and the abundance of larvae and fry in June-July. Thus, in June-July 1959 a comparatively small number of larvae (0.19 specimens per haul) survived from a great quantity of eggs and larvae in April-May (95.92 specimens per haul), whereas by June-July 1961 a great quantity of larvae survived (11.1 specimens per haul) from a smaller quantity of eggs and larvae registered in April-May (24.8 specimens per haul). In June-July 1965 only 0,004 specimens per haul remained from 32.55 specimens per haul in April-May. The coefficient of correlation between these indices is close to 0. At the same time, a relation was found between the coefficient of survival in the period from April-May to June-July and the index of larvae and fry abundance in June-July ($r = +0.728$; $n = 9, P_1$). Thus, the abundance of larvae and fry in June-July depends on the survival of eggs and larvae of the first stage in April-May. There is an agreement between the index of larvae and fry abundance in June-July and the abundance of fingerlings descending to the bottom in the autumn; the coefficient of correlation of these indices is +0.699 ($n = 9, P_1$). If we exclude the inaccurate data of 1964, it is $r = +0.812$ ($n = 8, P_1$).

The correlation between the feeding indices and the coefficient of survival for the first three months after the beginning of active feeding shows their close relationship. It is interesting that a certain regularity is outlined : the coefficient of larval survival depends on the index of food consumption of the larvae in the first stage (April-May) and on the condition factor of the second larval stage in June (Figure 1, curves I, II, III). In the first case the correlation coefficient is $r = +0.89$ ($n = 6, P_1$); in the second case it is $r = 0.85$ ($n = 9, P_2$). Neither the condition factor of the first stage larvae nor the index of food consumption of the second stage larvae, although it varies by years, is correlated with changes in the coefficient of survival. In the first stage of larval life, their fatness depends little on the feeding conditions because active feeding only begins at that time.

It is apparently affected by other factors, such as the quality of the eggs and spawners which are not discussed in this paper. The index of food consumption is more variable than the condition factor. It characterises the feeding conditions in a particular moment; in this case it characterises the feeding conditions of the first stage larvae in April-May. Alternatively, the condition factor i comparatively stable, that is indicative of the feeding conditions of the larvae during the preceding period of time. In this case the fatness of larvae of the second stage is largely dependent on the feeding conditions of the first stage larvae. It is precisely this fact that explains the dependence of larval survival in the period from April-May to June-July on the index of food consumption of larvae in April-May on the one hand and on the fatness of the larvae by June on the other hand.

As the survival of larvae depends on their food consumption and their fatness, one can expect that fatness in turn depends on the quantity of food organims in the sea. Such relationships were found by Ponomarenko (1971) in the bottom fry of the O-group cod.

A comparison of the indices of feeding and the coefficients of survival of cod larvae with the abundance of nauplii or Calanus in April-May, outlines their relationship, but it is not clearly marked (Figure 1, curves I, II, III and V). Perhaps this results from shortcomings when the data were collected; it is not always possible to collect material during the peak of nauplius development. Thus, in the warm 1960 the spawning of Calanus occurred very early. In the period of the April-May survey Calanus in the III-IV copepodite stages had already appeared off the north-western coast of Norway. In the cold 1963, on the other hand, the spawning of Calanus was late, that is why there was still a small number of Calanus nauplii in plankton at the time of the spring survey. These two years are extreme by their temperature condition and disturbe the total picture changing by years the indices of feeding, larval survival and abundance of Calanus nauplii.

Some indirect data indicate the relation between the feeding of cod larvae and their food base; there is particularly a rather close agreement in the distribution of cod larvae and Calanus. This is specially well traced when correlating the indices of plankton biomass and Calanus abundance along the Kola Meridian (33°30'E) with the abundance of fingerlings descending to the bottom in the southern Barents Sea (Degtereva, 1970).

An indirect index of the relation between the survival and larval fatness and their food base is also clearly correlated between the coefficient of survival and the condition factor of the larvae and the average water temperature in the 0-200 m layer on the section in the Andöy island area in the beginning of June (Figure 1, curves II, III, IV). The correlation coefficient between the coefficient of survival and water temperature on this section is +0.74 ($n = 9, P_1$); and between the condition factor of the second stage larvae and the same temperature it is +0.79 ($n = 9, P_1$). Water temperature on the migration routes of the larvae (North Cape - Bear Iland and Kola sections, and the section along 74°30'N through the eastern branch of the Norwegian Current) shows only a weak correlation with the condition factor. And it is only the water temperatur on the section in the Andöy Island area in the beginning of June that might serve as a rather good index of the survival conditions and larval feeding in the period from April-May to June-July. Apparently the water temperature indicates in this case the pattern of development of food plankton. According to data from Degtereva (1970) there is a positive correlation between water temperature and Calanus abundance and plankton biomass on the Kola Meridian in May. The times of spawning and rate of Calanus development depend on the water temperature.

Apparently the position of the section off Andöy Island and the time of investigations are a good combination, that is why the water temperature on this section characterises so well the conditions of feeding and survival of cod larvae in the period from April-May to June-July.

Conclusions

1. Larvae and fry abundance in June-July does not depend on eggs and larvae abundance in April-May and is defined by eggs and larvae survival in the period from April-May to June-July ($r = +0.728$, $n = 9, P_1$).

2. Survival of cod larvae from April-May to June-July is closely connected with the feeding conditions; the index of food consumption and the condition factor of larvae serve as indices. There is a relationship between the coefficient of survival and the food consumption index in larvae caught in April-May ($r = +0.89$, $n = 6, P_1$), and with the condition factor in June ($r = +0.85$, $n = 9, P_2$). This results from peculiarities of the indices used.

3. A relationship between feeding and survival of larvae and the abundance of Calanus nauplii in April-May is observed. However, it is not clearly marked which apparently is connected with the conditions of data collection.

4. Water temperature in the beginning of June in the 0-200 m layer on the section in the Andöy Island area proved to be a good index of the feeding conditions and survival of larvae. A relationship between the condition factor of the second stage larvae and water temperature is expressed as $r = +0.79$, ($n = 9, P_1$); between the coefficient of survival and water temperature it is $r = +0.74$ ($n = 9, P_1$).

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Table 1 The times of data collection, length and number of larvae dissected

Year	Time of data collection	No. of larvae treated	Range of length of larvae (mm)
1959	15 Apr.-25 May	224	3.0 - 7.0
	6 June-15 July	121	4.0 -35.0
1960	18 Apr.-26 May	9	4.5 -10.0
	4 June-27 June	128	6.0 -38.0
1961	17 Apr.-24 May	98	3.1 - 9.0
	3 June-6 July	288	4.0 -38.0
1962	14 Apr.-30 May	75	3.0 - 9.5
	6 June-15 July	457	5.0 -41.2
1963	17 Apr.-22 May	29	3.0 - 6.0
	10 June-12 July	657	5.0 -40.0
1964	1 Apr.-25 May	226	2.3 -19.7
	4 Apr.-11 July	50	6.6 -39.5
1965	21.Apr.-28 May	65	3.6 - 8.2
	9.June-27 July	14	8.6 -22.4
1968	17 Apr.-25 May	0	
	9 June-9 July	23	9.0 -22.0
1969	24 Apr.-23 May	17	3.0 - 6.5
	4 June-8 July	52	7.0 -34.0

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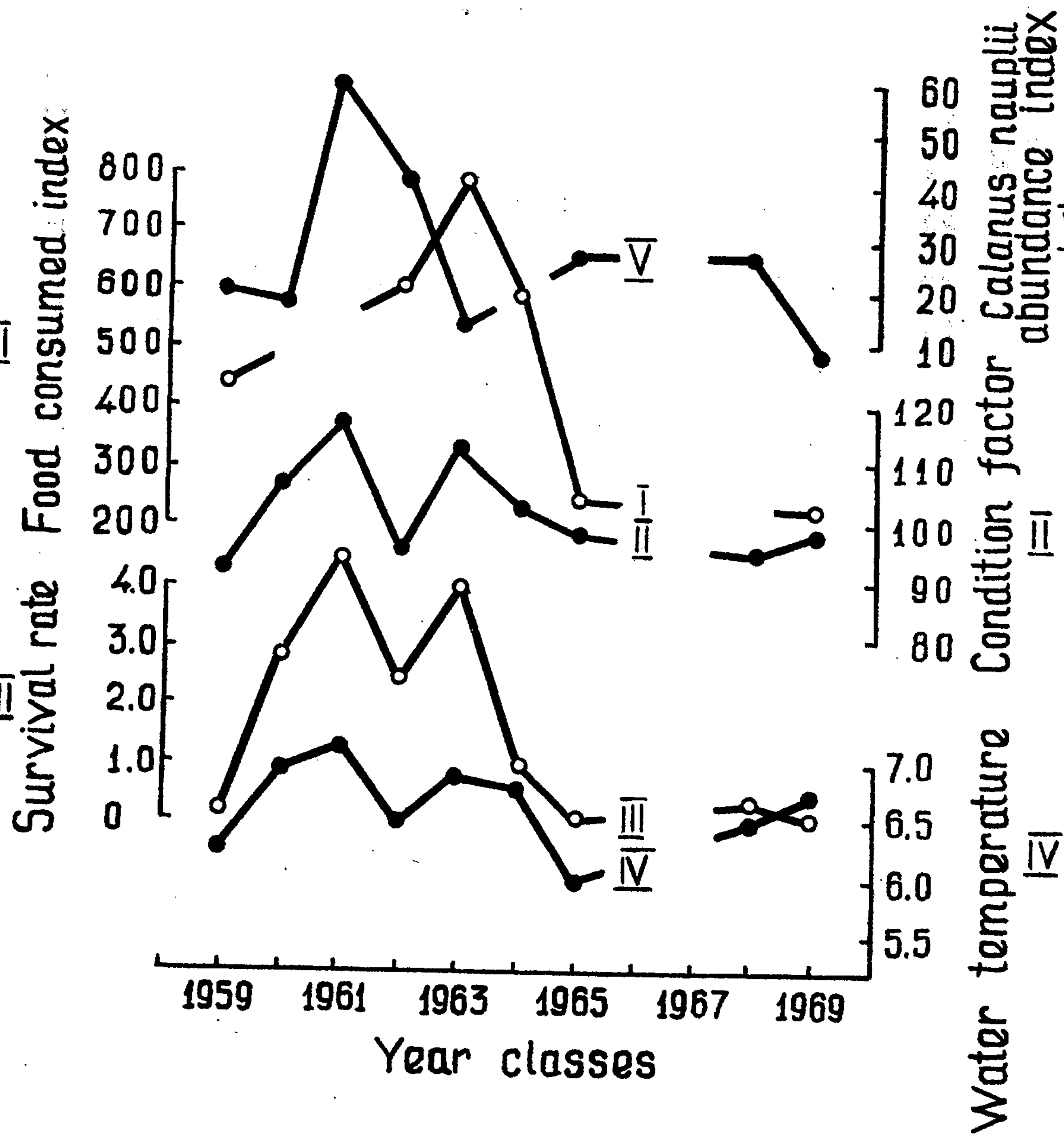

Figure 1. Indices of plankton, feeding and survival of cod larvae and water temperature at the beginning of June on the section in the Andöy Island area.