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Some Aspects of Reproduction, Growth and Distribution of Benthosema glaciale in the Grand Bank and Flemish Cap Slope Areas

by

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ABSTRACT

The reproduction and growth of different age groups of benthosema from the area of Grand and Flemish Cap Banks slopes were studied using the 1982-85 data. Growth parameters were calculated by the von Bertalanffy equation: K = 0.419, L_∞ = 73.7 mm.

The allometric growth equation was obtained in the form: $W = 0.309 \cdot 10^{-5}\ l^{2.26}$; $W_\infty = 5.14$ g.

The hydrological situation was analysed when a sharp lapse rate limited the vertical migrations of the given species of Myctophidae.

INTRODUCTION

The growth and reproduction of benthosema inhabiting the fjords of West Norway (Gjosaeter, 1970, 1981) and waters of New Scotland (Halliday, 1970) were studied in the North Atlantic. Gjosaeter indicated that in the Northeast Atlantic benthosema spawned mainly in summer, the growth parameters varied within a wide range over the area, according to von Bertalanffy L_∞ of the growth curve was 70-87 mm and K - 0.19-0.46. In Halliday's opinion benthosema spawned in early spring in the area of New Scotland; maturing fish were caught in January and February while postlarvae were found in May and July. The author assumed that the West-Atlantic B.glaciale lived at least for 4.5 years reaching at most about 68 mm in length and the growth parameters agreed with the equation: $L_\infty = 68.28\ (I-\exp(-0.36(t+0.49)))$.

The data on benthosema growth and reproduction in the area of southeastern slopes of Grand and Flemish Cap Banks are listed in the present paper.

The aspects of vertical distribution of the species were also considered. The influence of different external factors on daily vertical migrations of aquatic organisms were studied long ago. Light was concluded to be the major regulator of vertical migrations. From the time of detecting the sonic scattering layers (SSL) in the ocean and elucidating the influence of different organisms, in particular Myctophidae, on their formation the importance of light in vertical displacement of SSL was often assumed (Bekker, 1967; Zhitkovsky and Mozgovoy, 1980; Backus, 1968; Halliday, 1970). Many authors pointed to daily vertical migrations reaching some hundred meters as the most peculiar feature of Myctophidae biology when sometimes the fish quickly changed the depths with rather different temperatures passing through thermocline (Bekker, 1983; Bekker and Borodulina, 1968).

The active daily migration of benthosema was practically observed in all areas of survey: in the Northwest Atlantic where the depth of occurrence in the day-time reached 500 m and at night the bulk of population moved in the 185-300 m layer (Zahuranec and Pudh, 1971); in the Northeast Atlantic where the species occurred in the day-time at 250-450 m and at night migrated to the surface layers (Roe and Badcock, 1984). In the Azores area the fish kept to 500-600 m in the day-time and to 0-100 m at night (Badcock and Merrett, 1977); Gjosaeter mentioned of <u>B.glaciale</u> migration to the Norwegian deepwater fjords. We considered the case when benthosema did not perform diel vertical migrations, and elucidated the reasons of this phenomenon.

MATERIAL AND METHODS

The results of ichthyoplankton surveys and also analysis of biological data collected from trawl catches of research vessels for 1982-85 in the area of Grand and Flemish Cap Bank slopes were used in the present paper. Ichthyoplankton was mainly sampled with a conic IKS-80 net, Isaacs-Kidd midwater trawl and trawl-attached BR-2 net without locks. The samples were fixed in the 4% formalin. The larvae were examined and measured with an accuracy of 0.1 mm (TL).

A pelagic trawl with the 12 mm mesh netting was used for adult fish sampling. The standard length was measured accurate within 1 mm. The fish were weighed to within 0.01 g.

To determine the age the otoliths were examined with a binocular microscope in the reflected light. Diameters and pertinent hyaline zones were measured with an eyepiece micrometer. The maturity stages of newly-caught B.glaciale were determined according to 6-division scale.

Field analyses were the basis of the feeding characteristic, the frequency of occurrence of some components was calculated of the number of stomachs including the empty ones.

Studying the Myctophidae distribution and considering a complex origin of water masses in the given area we analysed the peculiarities of benthosema vertical migrations in concrete hydrological situations. The data obtained in cruise of RV "Vilnyus" in July 1984 were discussed.

RESULTS AND DISCUSSION

Reproduction and growth

The data from certain surveys collected in different seasons permitted to analyse the state of benthosema sex products and to imagine a general view of gonad maturation and preparation of the species for spawning.

Samples collected in April-June 1984 consisted of fish with gonads at maturity stage II. In July/August about 5% of females occurred with gonads at stage III. From October to November 1985 the portion of these females increased constituting in December about 72%. In November 1984 30% of females analysed had gonads at maturity stage IV. The maturation coefficient made up 2-4%. By mid-January 1985 3% of females were found to be completely spawned-out. About 10% had gonads at stage VI-IV, i.e. instead of one portion of eggs the next portion was developing in the ovaries. 68% of females had gonads at stage IV, the maturation coefficient reached 5% (Fig.1).

Ichthyoplankton samples collected in spring comprised B.glaciale larvae. In April 1984 21 benthosema specimens 5 to 10 mm long (M=6.6 mm) were caught. In June 1981 the sample consisted of 136 B.glaciale larval and postlarval specimens 5 to 19 mm long. The length frequency had two peaks with modes of 6 and 13 mm (Fig.2). The peaks conformed to all appearances with the first and second generations of B.glaciale larvae. Specimens with the length exceeding 12 mm suffered mainly a complete metamorphosis and assumed the features of adult organism. According to literature data the metamorphosis took place at the length of 11-15 mm (Halliday, 1970; Shiganova, 1977).

Thus, our data supported those available in literature on synchronous occurrence of fish larvae in the area of survey and the highest number of young zooplankton (in particular, eggs, I-III copepodite stages of nauplii - possible items of Myctophidae larvae diet) in April/May (Konstantinov et al., 1985).

Samples from trawl catches consisted mainly of adult fish aged 3-4 (M=53-59 mm), the number of 5-year-olds did not exceed 17%. A small number of 2-year-olds and lack of yearlings were indicative of trawl selectivity and quick response of young benthosema to damage (Albikovskaya, 1985). Therefore, due to lack of data on the young the length of fish aged 1 and 2 was calculated by a method of direct proportionality.

The linear growth rate was studied for different age groups. It was proved that the fish grew most rapidly in the first 2-3 years of life. The increment accounted for about 30-40% of the fish body length (Fig.3). To all appearances the fish matured at that time. Then the growth rate decreased accounting for 4-5% of the fish length. A quick growth was also observed in other mesopelagic species prior to the fish maturation and later it sharply decreased (Go et al., 1977).

Studying the benthosema from different areas showed that the age of first spawners was similar in the Norwegian and Canadian waters: about 50% of females started spawning at the age of 2 (Halliday, 1970; Gjosaeter, 1981).

All matured fish from our samples were longer than 50 mm. Maturation of benthosema might depend rather on a certain length than age. Gjosaeter pointed to a great importance of length for spawning, its lower limit fell within 45-50 mm. In that case the maturation depended directly on the growth rate and according to our data it was also observed at the age of 2-3.

The analysis of parameter values of the fish allometric growth equation determined by the least squares method showed that in each month of 1982-85 the parameter values for samples of various years differed little. For instance, for April 1982 and 1983 these equations were in the form:

$$W = 0.298 \cdot 10^{-6}\, l^{2.82} \qquad (1982)$$

$$W = 0.235 \cdot 10^{-6}\, l^{2.88} \qquad (1983)$$

where W - weight of fish, g;

l - length, mm.

Under such conditions the average annual parameter values of the fish allometric growth equation also differed little from each other. So, for 1984 the equation will assume the form:

$$W = 0.280 \cdot 10^{-5}\, l^{2.29},$$

for 1985:

$$W = 0.251 \cdot 10^{-5}\, l^{2.32}.$$

That is why, summarizing of the data available for 1982-85 was quite reasonable. Obtained on this basis the long-term mean values of parameters allowed to write down this equation in the form:

$$W = 0.309 \cdot 10^{-5}\, l^{2.26} \quad \text{(Fig.4)}.$$

Using the method of Hohendorf we obtained the following parameter values of the von Bertalanffy equation from the long-term mean data:

$K = 0.419$

$L_{\infty} = 73.7$ mm

$T_0 = 0.006$

Thus, the von Bertalanffy equation looked like this:
$l_t = 73.7$ mm $(I-\exp(-0.42\,(t-0.006)))$ (Fig.5). Accordingly $W_{\infty} = 5.14$ g.

The low values of B coefficient in the allometric growth equation deserved consideration. Benthosema should be referred to the group of "non-active" Myctophidae by ecological and some morphological characters (Bekker, 1983). Moving with the water current they completely depended on the water masses dynamics not performing feeding and spawning migrations and seemed to be nearly immobile (Gjosaeter and Kawaguchi, 1980). As a consequence, the species required little food. We revealed a very low intensity of feeding. The mean degree of stomach fullness did not exceed 1.0 in different seasons. The number of empty stomachs was usually high (Table 1). Biochemical analysis made in the Polar Institute demonstrated a high content of lipids in benthosema muscles. The low values of B coefficient (less than 3) in the allometric growth equation might serve as an indirect evidence of above morphological and biological characters of the fish. In particular, one may assume that after maturation when energetic resources were mainly expended on the weight increment the lipids having as is known a low specific gravity seemed to be intensively accumulated in benthosema body ensuring the fish floatability. These statements need certainly additional verification.

VERTICAL DISTRIBUTION

The hydrological conditions in the area surveyed were influenced by the Labrador Current characterized in spring/summer by an intermediate cold water layer at the depth of 50-200 m. In July 1984 as a result of radiation heating the temperature of the upper 10-20 m layer was 5-7°C. The 30-200 m layer involved waters with negative temperature dropping in the core to -1.5°C. Benthosema were found below the thermocline at temperature about 3.5°C at a depth of 300-400 m and they did not perform daily vertical migrations. Fig.6 illustrates diel distribution of benthosema by depths when the fish migration was limited by a thermocline. The density of concentrations at different time of a day was approximately identical. The maximum density was registered at 300-320 m in the day-time and in 250-300 m at night.

Comparing the behaviour of the species studied and characteristics of water stratification we concluded that benthosema was related to such species which amplitude and intensity of migrations as the character of vertical distribution changed depending on vertical thermal structure. An appreciable lapse rate could limit vertical migrations of benthosema.

CONCLUSIONS

1. The spawning of B.glaciale occurred in the area of Grand and Flemish Cap Bank slopes. There were found spawned-out females and larvae of this Myctophidae species.

2. The intermittent spawning of benthosema took place in winter/early spring. The larvae appeared in April.

3. The fish about 50 mm long aged 2-3 were mature.

4. In the area surveyed benthosema 74 mm long weighing 5.14 g were found. The values of B coefficient in the allometric growth equation were low. According to our data the lifetime constituted at least 5 years.

5. A low intensity of feeding was peculiar to benthosema. The mean degree of stomach fullness did not exceed 1.0, the per cent of empty stomachs was usually high.

6. The presence of vertical thermal gradient might limit the diel vertical migrations of benthosema.

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Table 1. Occurrence of different food components in B.glaciale stomachs, %, on the southern slope of Grand Bank

Food components	Month						
	Jan	May	Jun	Jul	Aug	Nov	Dec
Copepoda	3.6	33.9	0.6	2.3	4.0	-	9.6
Amphipoda	-	1.0	2.9	3.4	2.6	-	0.4
Euphausiacea	-	0.1	-	7.6	6.6	-	0.4
Digested Crustacea	-	-	1.1	4.5	11.5	-	-
Digested food	-	0.1	8.0	19.1	20.2	-	-
No. of empty stomachs, %	69.4	65.0	87.3	64.1	55.1	100.0	91.1
No. of dissected stomachs, spec.	75	880	175	975	425	30	270

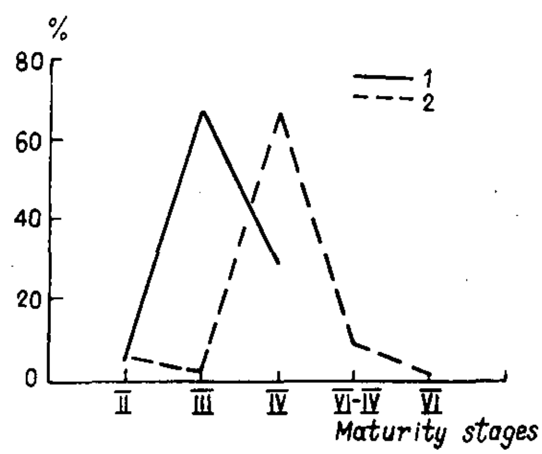

Fig.1 Gonad maturity of B.glaciale females in November 1984 (1) and January 1985 (2).

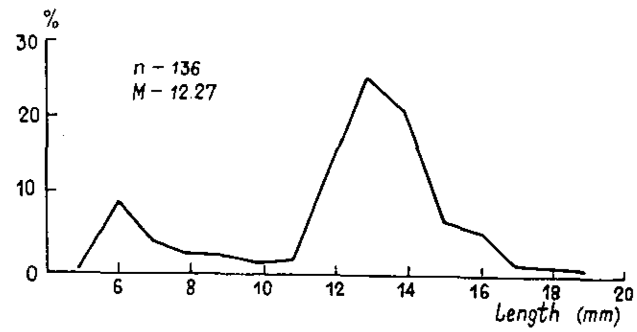

Fig.2 Length frequency of B.glaciale 0-group in June 1981.

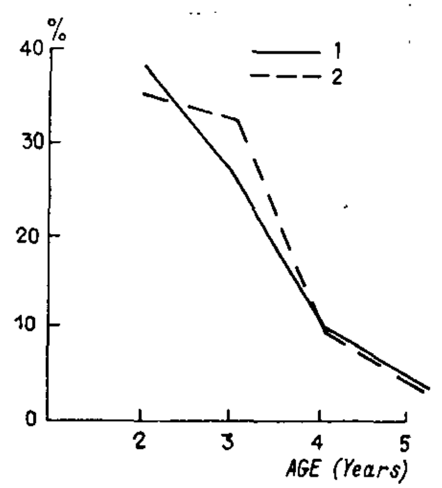

Fig.3 Growth rate of B.glaciale in per cent to the body length (observed data). 1 - males, 2 - females.

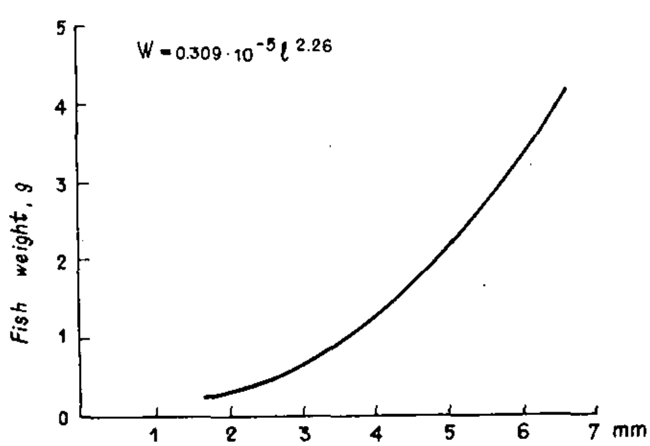

Fig.4 Weight-length ratio of B.glaciale.

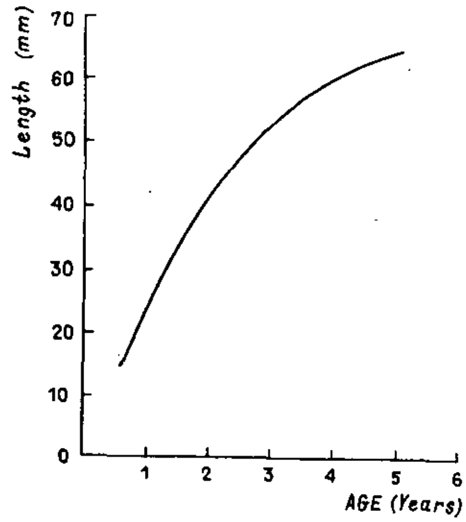

Fig.5 Linear growth of B.glaciale (calculated data).

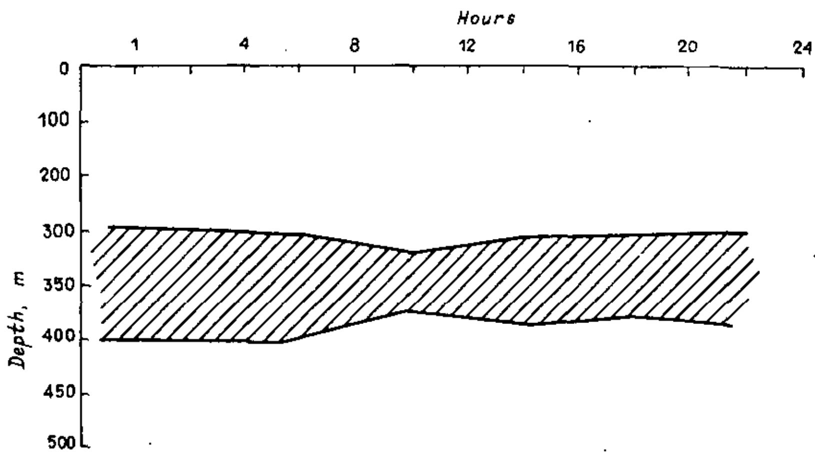

Fig.6 Diel distribution of B.glaciale by depths (second half of July 1984).