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GROWTH OF THE YOUNG FLOUNDER (*PLATICHTHYS FLESUS*) IN INSHORE SHALLOW WATERS OF THE GULF OF GDAŃSK

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Abstract

The age and rate of growth of the flounder from inshore shallow waters of the Gulf of Gdańsk (from shore to 1-m depth) have been investigated. Mainly the flounder from 0 and 1-year age group exists in this zone. Flounders from 0-year age group enter shallow waters of the Gulf of Gdańsk in June or July. They stay in this area till the end of the year. Flounders from 1-year age group are represented in the investigated zone all year. Bigger individuals from this group migrate into deeper waters.

INTRODUCTION

The flounder (*Platichthys flesus*) is the most common flatfish occurring in the Baltic. It plays an important role in shallow water fishery and functioning of the Baltic ecosystem. The majority of studies done on this species have been based on fish provided by commercial fishery.

The research on young flounders from the Gulf of Gdańsk deals mainly with their abundance (Mulicki 1955) and ecology (Malorny 1990, Szypuła and Załachowski 1978). The investigations on age and growth have been usually carried out for individuals fished at bigger depths (Cięglewicz et al. 1969, Draganik and Kuczyński 1993). Studies on the flounder growth during the first year of its life (Draganik and Kuczyński 1985) have included also individuals from a depth of several meters. The growth of flounders from shallow inshore waters of the Gulf of Gdańsk was investigated over sixty years ago (Cięglewicz 1935).

The aim of this study is:

- the description of growth of the young flounder in shallow inshore waters of the Gulf of Gdańsk
  - how old are flounders living in this zone?
  - what is their growth rate?
- the comparison of current results with the data from the past in order to find out how changes in biocenosis of the Gulf of Gdańsk influence the growth of the young flounder in inshore shallow water.

MATERIAL AND METHODS

Flounders were collected from April 1994 to October 1995 (1994 - from April to November, 1995 - from February to October) in the western part of the Gulf of Gdańsk. Trawls were made in shallow inshore zone, approximately at 1 m izobath parallel to the shore. The main set of fish was collected at Hel, the place displaying the highest flounder abundance in the investigated zone (Sapota and Kamińska 1998). According to previous reports (Cięglewicz 1947), all flounders were considered as originating from the same population.

Each flounder was measured (L_t down to the nearest 0.1 mm) and weighed (with 0.01 g accuracy), then the correlation between length and weight for 0 and 1-year age group were computed.

Frequencies in 2-mm length classes and the average lengths and weights of fish in each month were established.

Otoliths (sagitta) were dissected from 715 flounders.

In flounders whose total length was smaller than 70 mm, the area of otolith, *i.e.* its maximum diameter and perimeter were determined, using OPTIMAS program. The correlation between these values and fish size (total length) was computed. In order to describe changes in the otolith shape with age, computer coordinates of otoliths edges were saved.

In 184 individuals, the longer radius of otolith (from the centre to the rostrum edge) was measured using stereoscopic microscope. This radius is known to be strongly correlated with flounder length (Cięglewicz *et al.* 1969). Similarly to previously described variables, its relation to body size was established. Also the character of the edge of otolith (hyaline or opaque zone) was examined.

January the 1st was assumed as the day of fish birth. This assumption is not really close to reality but commonly used. The hatch of the flounder in the Gulf of Gdańsk takes place from March to May (Cięglewicz 1935).

RESULTS

LENGTH

FREQUENCY IN LENGTH CLASSES

The smallest flounders were observed in June/July. In the subsequent months, the minimum length of caught fish was gradually increasing. The frequency of individuals longer than 100 mm was very low all year (Fig. 1). The average maximum length for all samples was equal to 83 mm.

Taking into account length ranges and frequencies in length classes, a year could be divided into two periods:

- from January to May/June when only one group of flounders were observed with the average length of about 40-55 mm;
- from June/July two groups occurred; the first one, the same as observed in previous months with the average length of 55-77 mm, and the second consisting of much smaller individuals with the average length from 15 mm in July to 45 mm at the end of the year.

In some samples, these two groups are distinctly differentiable but in others precise differentiation is impossible.

AGE

From the beginning of the year till June, almost all caught flounders were one year old (1-year age group). In June/July, flounders from current year spawn appeared. From June till the end of the year, they dominated in all samples. Older individuals (2-year age group) were very rare.

RATE OF GROWTH

In the case of flounders from 0-year age group, increase of average month length was observed from time of their first appearance to the end of the year (Fig. 2). The greatest rate of growth took place in summer, from June to August. From October, distinct decrease in growth rate was observed.

For flounders from 1-year age group, caught in the investigated zone, the trend of size changes was not clearly visible. Average lengths seemed to oscillate between 40 and 70 mm (Fig. 2). Similarly as in the case of younger fish the lengths in one sample varied considerably. At the end of the year, the range of lengths of 1-year age group decreased.

CORRELATION BETWEEN LENGTH AND WEIGHT

Correlation between length and weight was computed for both 0 and 1-year age groups (Fig. 3). The value of exponential coefficient turned out to be higher in the case of older flounders.

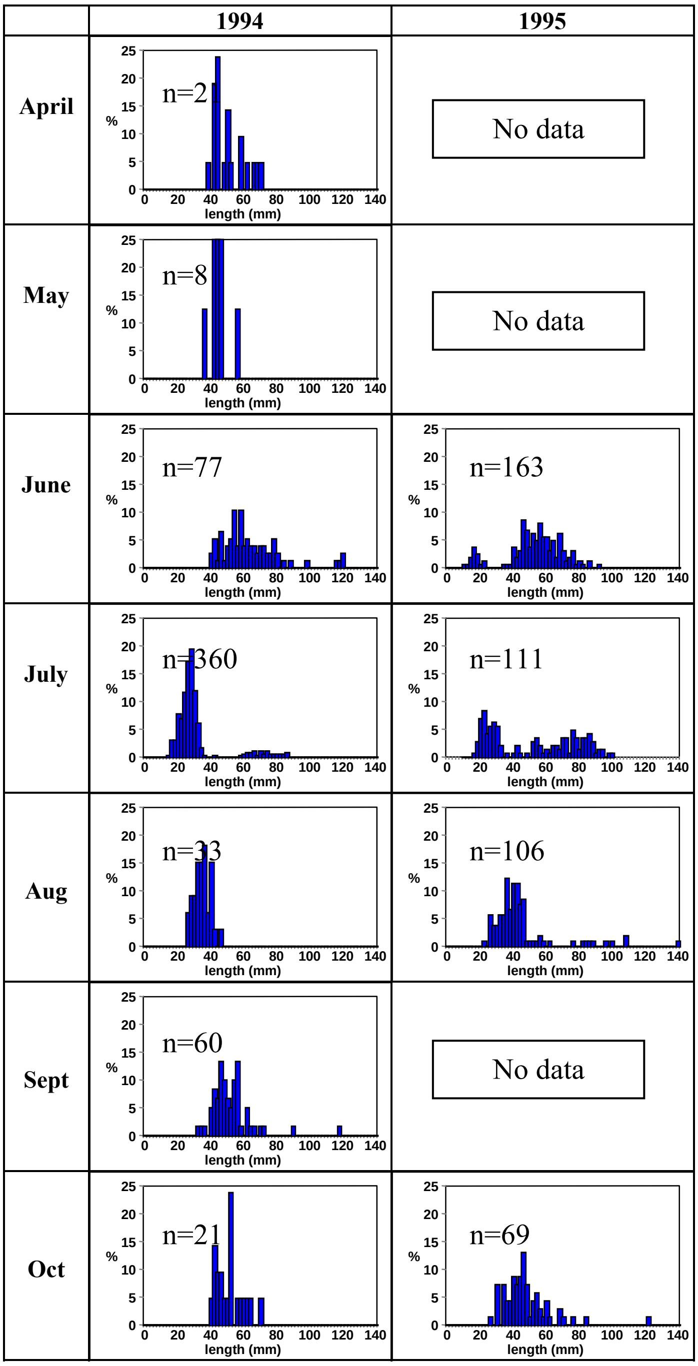

Fig. 1. Temporal distribution of frequency, in length classes, of young flounders from inshore waters of the Gulf of Gdańsk

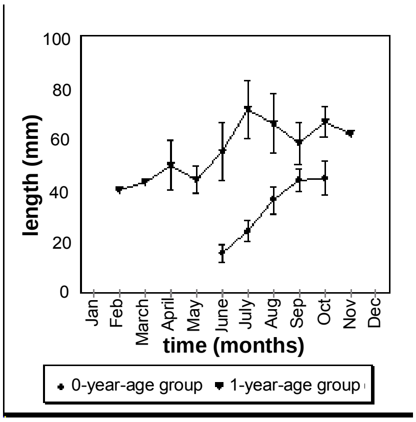

Fig. 2. The average monthly lengths (with standard deviations) of flounders from 0 and 1-year age groups

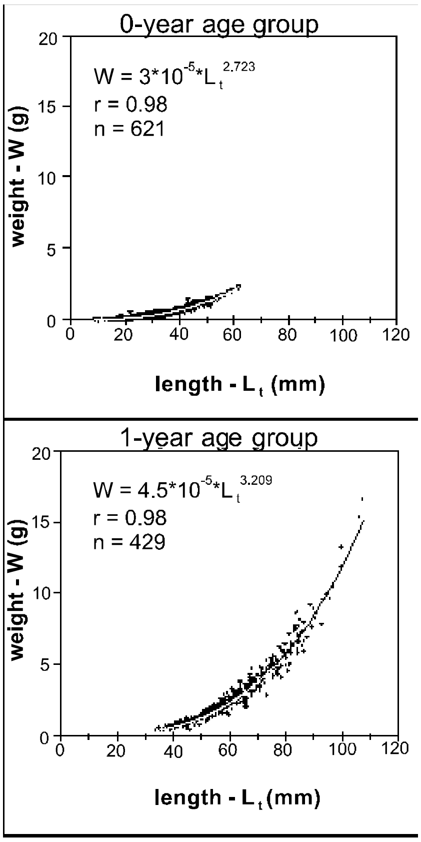

Fig. 3. Correlation between weight and length for flounder from 0 and 1-year age groups

OTOLITH MORPHOLOGY

The formerly reported linear relationships between the total fish length and radius of otolith (Fig. 4), otolith diameter (Fig. 5) and otolith perimeter (Fig. 6) were confirmed by this study. It was found that in older flounders, the area of otolith grew faster than the total fish length (Fig. 7). This relationship can be described using two different lines. The first one for fish of the total length up to 30 mm and the other for longer flounder (Fig. 8).

During the growth of otoliths, changes in their shapes were observed: from rounded to more elongated with a distinct rostrum and antirostrum. Some otoliths exhibited very unusual shapes and different (crystal) structure. Most often, the second otolith from the pair had standard characteristic. Often, in otolith structure, additional centres of growth and non-year growth rings were observed.

From April to July, the edge of examined otoliths was opaque: from August to March the most outer zone was hyaline. However, the characteristic features of the otolith edge were not always easily differentiable.

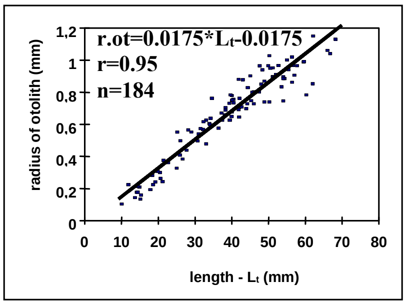

Fig. 4. Correlation between the radius of otolith and flounder length

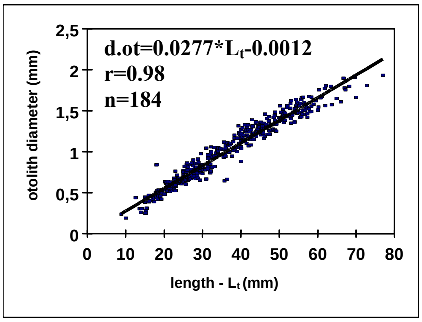

Fig. 5. Correlation between the otolith diameter and flounder length

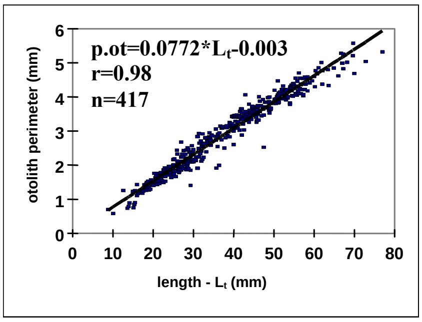

Fig. 6. Correlation between the otolith perimeter and flounder length

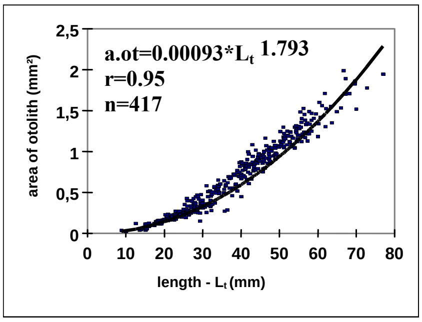

Fig. 7. Exponential correlation between the area of otolith and flounder length

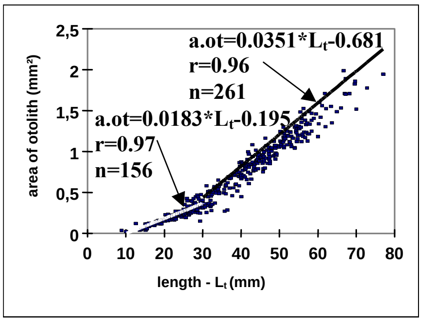

Fig. 8. Linear correlation between the area of otolith and flounder length

DISCUSSION

The shallow inshore waters of the Gulf of Gdańsk are inhabited by the flounder mainly from 0 and 1-year age groups. The same situation was observed previously (Cięglewicz 1935, Mulicki 1955, Szypuła and Załachowski 1978, Malorny 1990).

Flounders from 1-year age group are present in the investigated area all the time. At the beginning of the year, this group accounts for almost all flounder quantity (older individuals are very rare). In June/July young, this year born, flounders enter inshore shallow waters of the Gulf of Gdańsk.

The growth of flounders from 0-year age group can be followed based on the increase of average monthly lengths and shift in the range of lengths. The growth of flounders from 1-year age group is best estimated based on the value of their minimum length since bigger individuals from this group migrate to deeper waters. The existence of more or less constant value of length above which the flounder migrates to deeper waters (Demel 1927) was confirmed. Without doubt, at the end of the year, only a part of 1-year age group occurs in shallow inshore waters. The observed wide ranges of lengths in age groups (at the same time the biggest individuals can be two or three times larger than the smallest ones) are probably caused mainly by long period of flounder spawn (Cięglewicz 1935).

The rate of growth of individual flounders in the Baltic is independent of density of population and food availability (mostly present in excess quantities). The water temperature, mainly in intensive grazing period, seems to be the governing factor (Cięglewicz 1962).

Investigations on plaice and soil from The North Sea (Rijnsdorp and van Beek 1991) have shown that also for these fishes the density of population is not the main factor influencing the rate of growth. More important is the availability of food. In the Gulf of Gdańsk, during past years, the major changes in food web composition have been observed (Skóra 1993). Increase in the number of bivalves and decrease of arthropod number occurred. These changes seem not to be so important for the flounder because of its very wide spectrum of food preferences (Mulicki 1947).

Comparing results from the Gulf of Gdańsk with occurrence and growth of the flounder in the central part of Polish coast (Szypuła and Załachowski 1978), it can be stated that in both regions similar yet not identical tendencies are seen. In the Gulf of Gdańsk, differences in frequencies in length classes in the same months in different years are noticed (Fig. 1). In contrast, in Kołobrzeg-Darłowo area, these frequencies are very stable. The decrease of the average length in July/August is much smaller in the Gulf of Gdańsk than in the other region. The main reason for that is the stable upper limit of length in shallow inshore waters of the Gulf of Gdańsk. In this location, in summer together with new 0-year age group flounder, individuals from 1-year age group occur. In Kołobrzeg-Darłowo area, until June, the flounder represents only 1-year age group. From July, only 0-year age group individuals are present. Comparing sizes of flounders from both locations it is necessary to take into account separately 1-year age group until June and 0-year age group from July. Comparing the rate of growth of the flounder from 0-year age group from both locations, it can be stated that the flounder from the Gulf of Gdańsk grows faster. Average lengths in July are similar for both locations: 28 and 24 mm. In September, they exceed 36.5 mm in Kołobrzeg-Darłowo region and 44.6 mm in the Gulf of Gdańsk. Despite differences in sampling equipment, the main reasons for observed situation can be: the different characteristics of sampling regions (the open sea and the gulf) and the difference between the flounder populations from the Bornholm and the Gdańsk Deep. Migrations between these two regions are very rare (Cięglewicz 1947). Contrary to young individuals, adult flounder shows faster growth in the western part of the Baltic (Cięglewicz 1935, Cięglewicz and Mulicki 1938).

Taking into account the data obtained for 0-year age group flounder from the Gulf of Gdańsk 60 years ago (Cięglewicz 1935), it can be stated that there are no changes in the time of appearance and basic tendencies in the rate and time of growth. At present, the average lengths in months seem to be a bit bigger than in the past.

Big changes observed in the Gulf of Gdańsk biocenosis during last two decades (Skóra 1993) are clearly visible in the inshore shallow part of that basin. The major feature of these changes is an absolute domination and very strong competition with other fish species by three-spined stickleback (*Gasterosteus aculeatus*). The comparison with the data from 1982-83 (Malorny 1990) with the present state shows that the observed changes and strong stickleback pressure are not so directly important for the young flounder.

The exponential coefficient for correlation between the flounder length and weight is lower for 0-year age group than for 1-year age group. However both values oscillate around 3. Similar values have been obtained for young flounders from the Polish coast previously (Szypuła and Załachowski 1978, Malorny 1990). Only in one case, much higher value, *i.e.* amounting to 3.55 has been reported (Draganik and Kuczyński 1985). Smaller (below 3) exponential coefficient for 0-year age group than for older groups has been also determined for plaice from Wadden Sea (Kuipers 1977).

Linear coefficients for relations between the otolith radius or diameter and flounder length are similar to those computed in the past (Cięglewicz *et al.* 1969, Szypuła and Załachowski 1978, Draganik and Kuczyński 1985, Malorny 1990). The exponential relation between the otolith area and the linear relation between otolith perimeter and flounder length are consequences of above mentioned relations and the rounded shape of otolith. The correlation between the otolith area and flounder length is different for smaller and bigger than 30 mm fish, probably due to the change in the otolith shape from oval to more elongated. Such changes in the otolith shape and the differences within a pair are commonly observed in flatfish and are correlated mainly with the presence of additional growth centres (Sogard 1991).

The additional growth rings are common in the Baltic flounder. In general, the structure of otoliths can be highly complicated. The most complicated structure was observed in individuals displaying the highest rate of growth (Witinsz

1986). Finding the environmental reasons causing the formation of additional growth rings was impossible, similarly as in previous studies carried out in the Gulf of Gdańsk region (Malorny 1990). The atypical, crystal otoliths have been sometimes observed in many other fish species (Blacker 1974).

Another important factor in description of fish growth is the time of forming a hyaline and opaque zone on otoliths. As it has been mentioned before, some flounder otoliths have a very complicated structure. Their correct description and "reading" is difficult. On unpolished otoliths, the beginning of clear opaque zone can be detected with a few weeks delay (Witinsz 1986).

The observed formation of opaque zones from April to July and hyaline zones from August to March is comparable with data for the flounder from the Eastern Baltic (Witinsz 1986) while it differs slightly from previous data for the Gulf of Gdańsk region (Draganik and Kuczyński 1985). In general, our observations agree with those for plaice and other flatfish in which the opaque zone forms in spring and early summer and the hyaline zone in autumn and winter (Blacker 1974).

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