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Microstructure of Otoliths, Age Readings and Growth Determinations of Silver Hake (*Merluccius bilinearis*) on Early Development Stages on the Scotian Shelf

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ABSTRACT

Based on the specialized collections of otoliths taken from embryos, larvae and fries of the Scotian silver hake the equations to calculate the absolute and relative body growth rates, otolith growth as related to the number of their daily increments and fish age as related to their body lengths have been developped.

INTRODUCTION

The microstructure of fish otoliths on their early development stages has been studied by many researchers (Campana and Neilson, 1985; Campana, 1989; Campana and Hurley, 1989). The initial studies of the silver hake otolith microstructures from the Gulf of Main and off Southern New England made by Nichy (Nichy, 1967, 1969) did not include the readings of the embryo and larval otoliths.

The purpose of the present paper was to develop the methods of age and growth determinations for the Nova Scotia silver hake on their early life stages.

MATERIALS AND METHODS

When conducting the joint Soviet-Canadian research to count the silver hake youngs-of-the-year on the Scotian Shelf in October-November, 1989 the eggs (development stage IV), larvae (3-22 mm in length) and fries (23-32 mm in length) were collected simultaneously using a plankton net (opening diameter 36 cm, mesh size 505 μm) attached to the trawl cod-end. The area of sampling was limited to the shallow waters of the Sable Shallows were some

specimens of silver hake were still spawning. Eggs, larvae and fries from the planktonic samples were preserved in 95% alcohol and stored in it for 4 months until the vessel returned to the home-port. A total of 3 eggs, 60 larvae and 28 fries of silver hake have been sampled. At laboratory larvae and fries were measured from the snout tip to the chord end (l) to the nearest 0.1 mm before the otoliths were extracted. A strong positive linear relationship does exist between l and standard length (SL) of a fry and a larva: $SL=-0.148+1.114 \cdot l$ ($r=0.99$; $N=228$). To study the microstructure of the silver hake otoliths the largest pair of otoliths (Sagitta) out of the three ones existing in this fish has been used. Otoliths of 0.5-mm diameter were placed on a glass slide in a drop of the immersion oil and dried for 6-7 days. Those of larger diameter after extraction and cleaning were mounted on the glass slide and fixed with "Supercement". Then the otoliths were ground from both sides, washed with distilled water and treated with 1-% HCl for 1-10 min (depending on the size of an otolith). After that the ground sections were washed with distilled water once again and placed into the Canada balsam under the cover glass. The otolith microstructures were analysed using the binocular MBI-15Y with a multiplication of 800-1000 times. Length, width and posterior radius of the otolith were measured under the eyepiece micrometer to the nearest 1μ. A total number of the daily increments were calculated. A structure consisting of one light and one dark rings separated by eye from the exterior (Markov, 1989) was considered as a daily increment. In estimating growth rates for fry and larvae the following formulas were used to calculate the specific absolute and relative growth rates:

$$C = \frac{l_n - l_o}{n} \quad \text{and} \quad G = \frac{C}{l_n} \times 100, \text{ where}$$

C - a specific absolute growth rate, mm;

G - a specific relative growth rate, % l;

l_n - larva (fry) length, mm;

l_o - mean length of a silver hake larva at hatching is 3.02 mm (Colton and Marak, 1968);

n - number of daily increments on a larva (fry) otolith.

The regression analyses was used to find the relationship between fish length (l), specific absolute growth rate (C), specific relative growth rate (G) and fry and larvae age (A) as well as between the posterior radius (OR), otolith length (OL) and daily increments (n) on the otoliths.

The present peper is based on the following assumptions: growth increments in the otoliths are formed during 24 hours; the first ring on the otolith appears during its first day of life after hatching.

RESULTS AND DISCUSSION

At hatching hake embryos have their otoliths of a hemisphere form with their inner structures being indiscernible, i.e. the daily growth increments are absent. Small larvae of 5 mm in length (OR-0.115 mm) already have a well difined nucleus and 10 alternating daily increments. As the larvae grow (up to 5.6 mm, 20 growth increments) their otoliths become elongated like in a big fish. In a 10-15-mm larvae (OR 0.3-0.4 mm) 35-40 growth increments are produced on the otolith and supplementary growth centres are formed (Fig. 1). Based on the readings of all otoliths a regression equation between body length end age (Fig. 2) was developped. The calculated data were best approximated by the linear relationship equation. Using this equation the negative length values immediately after hatching were obtained which seems to be explained by deviations in the growth rates at early life stages. Having this in mind the dependence of the specific absolute growth increments upon the number of increments on the otolith was determined. The data obtained were approximated by a degree equation (Fig. 3): $C = 0.0297 \times A^{0.6436}$. According to this expression the minimum values of a specific absolute growth rate (0.12-0.16 mm/day) are observed on the early stages of development (first 10-15 days after hatching) gradually increase and reach maximum ones (0.31-0.42 mm/day) in 60-70-day fish. These data agree well with the values of the absolute daily linear growth obtained from an indirect indicator of the growth rate-changes in the mean 0-group fish length with time. The absolute daily linear body length increment in larvae after hatching (body length

3.0-6.4 mm) was 0.14-0.28 mm/day and by the metamorthosis (body lenth 23-24 mm).it reached 0.44-0.50 mm/day and later on, while the fish grew, it almost remained on the same level -0.36-0.68mm/day (Sherstyukov, 1990). A degree relationship was also obtained between the values of the specific relative growth rate and the number of growth increments on the otolith (Fig. 4): $G = 13.99 \times A^{(-0.5367)}$. Maximum values of the relative growth rate (2.7-3.8% l) are registered immediately after hatching and then with the fish growth (up to the age of 60-70 days) they gradually go down and reach their minimum (1.1-1.4% l).

To study otolith growth a relationship between length, otolith posterior radius and a number of daily increments on the otolith was investigated. The data obtained were approximated by the linear relationship equations : $OR = 0.052 + 0.007 \cdot n$ and $OL = 0.089 + 0.0159 \cdot n$ (Fig. 5,6). Both equations demonstrate the directly proportional otolith growth in time.

The last stage of our studies on the silver hake age at early development stages was the development of the fish age (FG) determination from their length (l). Its form was as follows: $FG = 9.5962+1.763 \cdot l$ ($r=0.91; \sigma = \pm 6.66$), where FG - age of fish in days.

CONCLUSIONS

1. This in the first description of the otolith microstructure in the Scotian silver hake embryos, larvae and fry; the directly proportional growth of otoloths in time is established.

2. The relationship obtained between fish age and their length would allow to back-calculate the date of the massive silver hake spawning and, hence, to analyse the factors causing the migration of hake to spawn on the Sable Island shoals which factors could be accounted when making up the short-term forecasts.

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Fig. 1. Sagittal otolith microstructure of the Nova Scotia silver hake larva. Larva length (l) - 9.5 mm, posterior otolith radius (OR) - 120 µm, 35 growth increments (n). Start of counting of the daily growth increments (arrow). Bar scale = 20 µm.

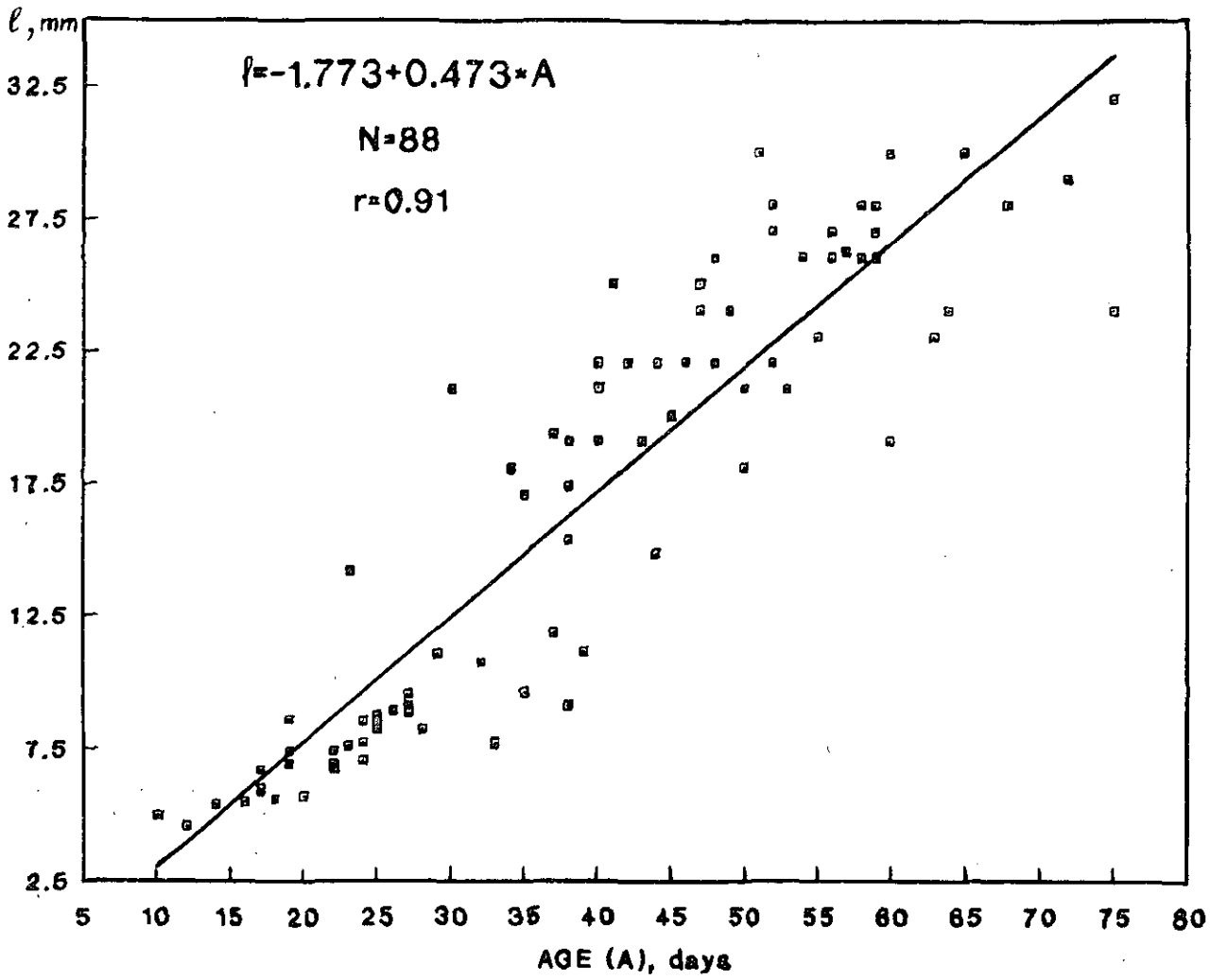

Fig. 2. Relationship between fish length (l) and their age (A) for the Nova Scotia silver hake larvae and fry.

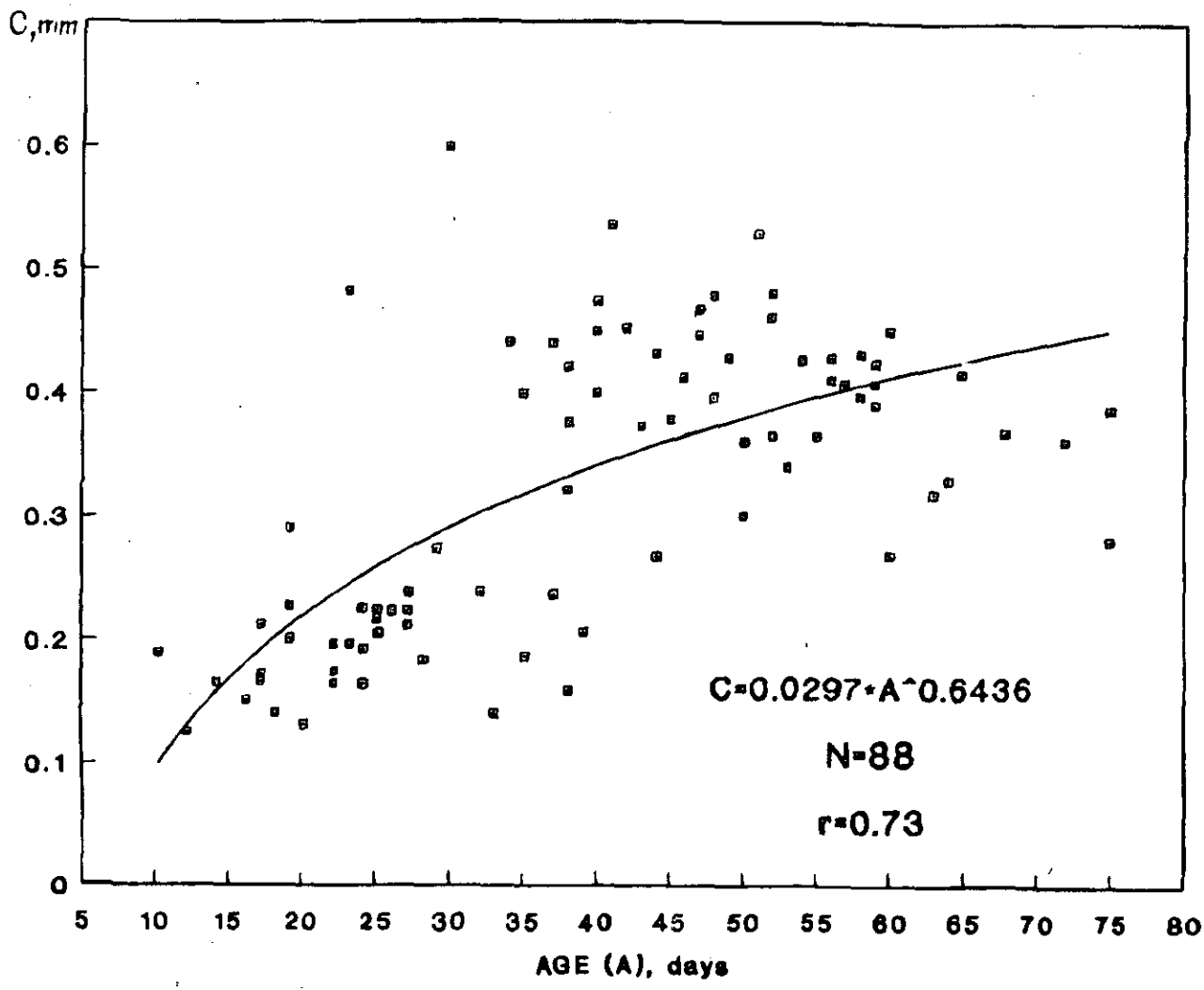

Fig. 3. Relationship between specific absolute growth rate (C) and age (A) for the Nova Scotia silver hake larvae and fry.

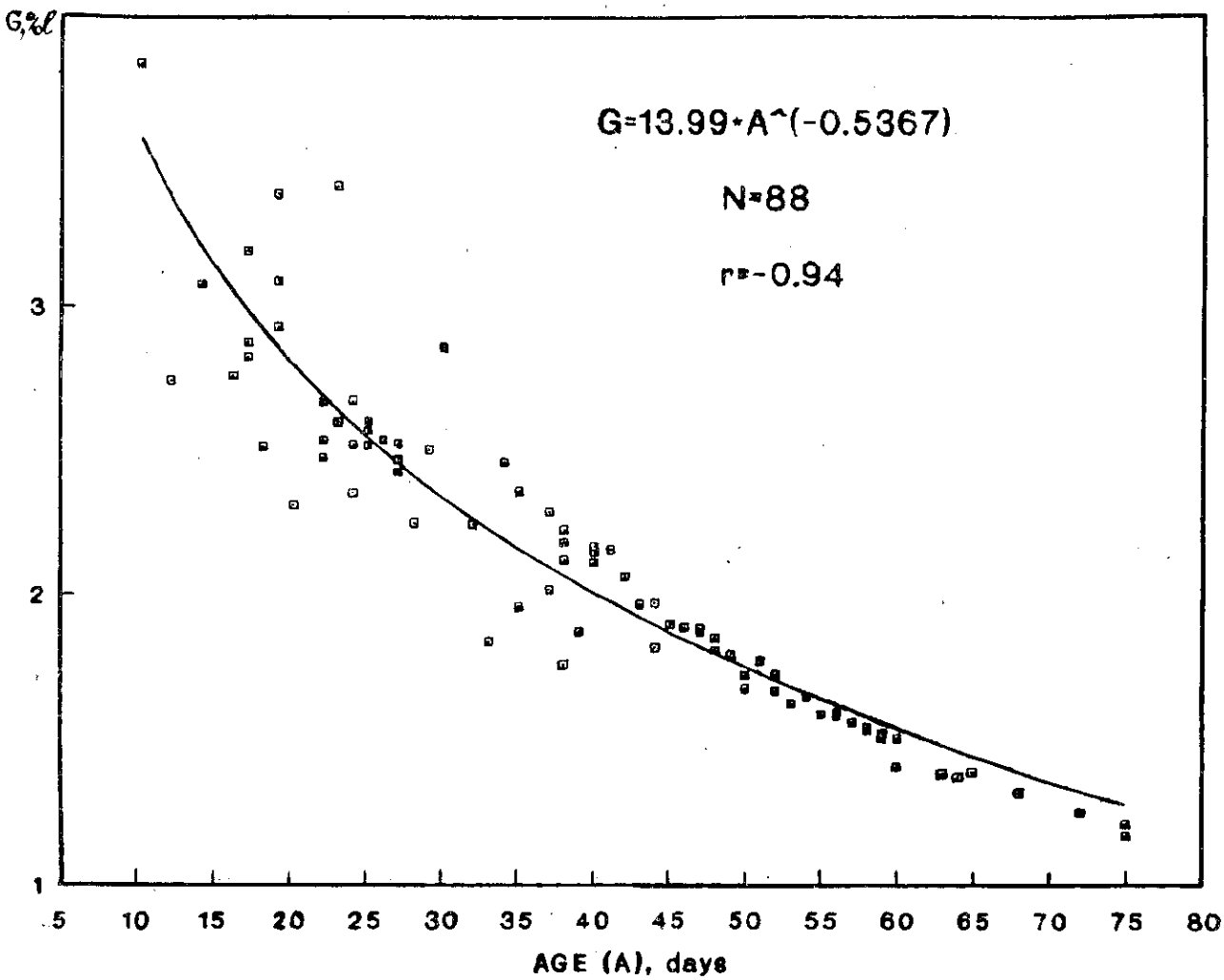

Fig. 4. Relationship between specific relative growth rate (G) and age (A) for the Nova Scotia silver hake larvae and fry.

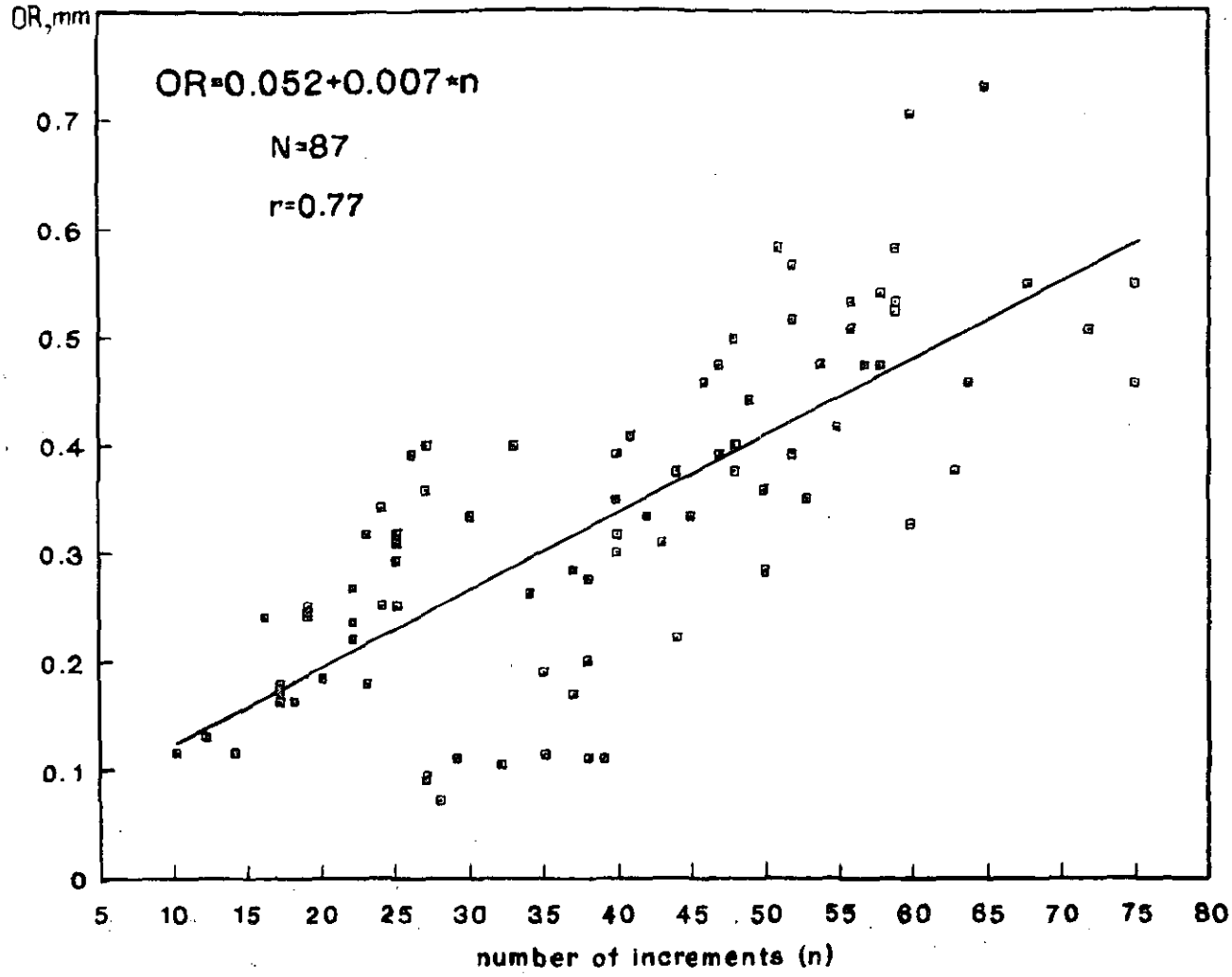

Fig. 5. Relationship between posterior otolith radius (OR) and daily growth increments on the otoliths (n) for the Nova Scotia silver hake larvae and fry.

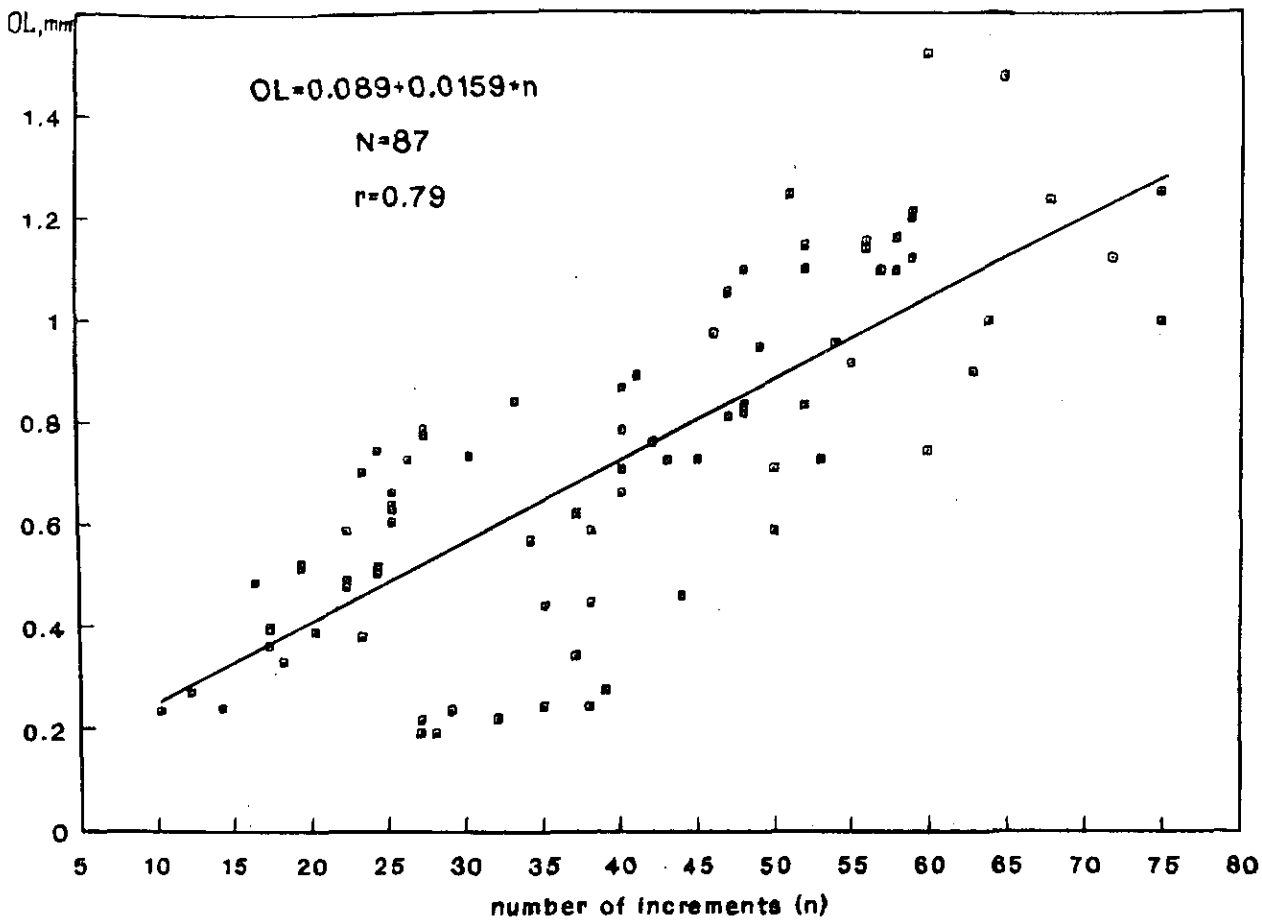

Fig. 6. Relationship between otolith length (OL) and daily growth increments on the otoliths (n) for the Nova Scotia silver hake larvae and fry.