

## SHORT NOTE

### OTOLITH MICROSTRUCTURE OF JUVENILE MACKEREL ICEFISH (*CHAMPSOCEPHALUS GUNNARI*) (CHANNICHTHYIDAE) IN THE SOUTH GEORGIA AREA

L.V. Shcherbich  
AtlantNIRO  
5 Dmitry Donskoy Street  
Kaliningrad 236000, Russia  
Email – atlant@baltnet.ru

#### Abstract

The otolith microstructure of juvenile mackerel icefish (*Champscephalus gunnari*) (5.5–13.3 cm in length) was analysed using samples taken during a trawl survey of juveniles in February–March 2002 on the South Georgia shelf. Juvenile fish comprised two year classes arising from spawning in the 1999/2000 and 2000/01 split-years. The mean width of daily otolith growth increments decreased from 6  $\mu\text{m}$  during the first 100 days (total length (TL) 4.5 cm) to 2.8  $\mu\text{m}$  at 500 days (TL 13.1 cm). The pelagic stage of egg incubation development for fish of the 2001/02 year class lasted four months. This was estimated based on a retrospective count of daily increments. TL varied from 5.5 to 10.4 cm for fish in their first year (120–250 days) to 12.5–13.3 cm in 1-year-old fish (477–533 days). The radius of the first annulus ranged from 0.7 to 1.3 mm. The relationship found between fish length and daily otolith increments could be used for age differentiation of juvenile fish between consecutive year classes.

#### Résumé

La microstructure des otolithes des juvéniles du poisson des glaces (*Champscephalus gunnari*) (5,5–13,3 cm de longueur) est analysée sur des échantillons prélevés lors d'une campagne d'évaluation des juvéniles menée en février–mars 2002 sur le plateau de la Géorgie du Sud. Les juvéniles se composent de deux classes d'âges issues de la ponte des années australes 1999/2000 et 2000/01. La largeur moyenne des anneaux de croissance journaliers des otolithes a diminué, passant de 6  $\mu\text{m}$  pendant les 100 premiers jours (longueur totale (LT) 4,5 cm) à 2,8  $\mu\text{m}$  à 500 jours (LT 13,1 cm). Le stade pélagique de la période d'incubation des œufs chez les poissons de la classe d'âge de 2001/02 a duré 4 mois. Cette estimation est fondée sur le comptage rétrospectif du nombre d'accroissements journaliers. La LT varie de 5,5 à 10,4 cm pour les poissons dans leur première année (120–250 jours) à 12,5–13,3 cm pour les poissons de 1 an d'âge (477–533 jours). Le rayon du premier anneau varie de 0,7 à 1,3 mm. La relation établie entre la longueur du poisson et les accroissements journaliers des otolithes pourrait servir à la différenciation des âges des juvéniles de poisson entre des classes d'âges consécutives.

#### Резюме

При анализе микроструктуры отолитов молоди щуковидной белокровки (*Champscephalus gunnari*) длиной от 5.5 до 13.3 см использовались материалы, полученные в результате траловой съемки молоди в феврале–марте 2002 г. на шельфе Южной Георгии. Молодь рыбы состояла из двух годовых классов – нереста 1999/2000 и 2000/01 разбитых годов. Средняя ширина суточной зоны роста отолита сократилась с 6 мк в первые 100 дней (общая длина (ОД) 4.5 см) до 2.8 мк на 500-й день (ОД 13.1 см). Пелагическая стадия инкубационного периода развития икры для рыбы годового класса 2001/02 г. продолжалась четыре месяца. Это было оценено на основе ретроспективного подсчета суточных зон роста. ОД менялась от 5.5 до 10.4 см для рыбы первого года жизни (120–250 дней) и до 12.5–13.3 см

у однолетней рыбы (477–533 дня). Радиус первого годового кольца варьировал от 0.7 до 1.3 мм. Выявленное соотношение между длиной рыбы и суточными зонами роста отолитов может использоваться для определения возраста молоди смежных годовых классов.

#### Resumen

Se analizó la microestructura del otolito de draco rayado juvenil (*Champsocephalus gunnari*) (5.5–13.3 cm de longitud) de las muestras tomadas durante una prospección de arrastre de peces juveniles realizada de febrero a marzo de 2002 en la plataforma de Georgia del Sur. Los peces juveniles comprendieron dos clases de edad nacidas en los años emergentes de 1999/2000 y 2000/01. El ancho promedio de las bandas de crecimiento diario en el otolito disminuyeron de 6  $\mu\text{m}$  durante los primeros 100 días (largo total (TL) 4.5 cm) a 2.8  $\mu\text{m}$  a los 500 días (TL 13.1 cm). La fase pelágica del período de incubación del desarrollo de huevos de los peces de clase 2001/02 duró 4 meses. La estimación se basó en el recuento retrospectivo de las bandas de crecimiento diario. El largo total de los peces en su primer año (120–250 días) varió de 5.5–10.4 cm a 12.5–13.3 cm en los peces de un año de edad (477–533 días). El radio del primer anillo varió entre 0.7 y 1.3 mm. La relación entre la longitud del pez y las bandas de crecimiento diario en el otolito puede utilizarse para diferenciar la edad de los peces juveniles de dos clases de edad consecutivas.

Keywords: annulus, daily growth increment, year-class, otolith, mackerel icefish, CCAMLR

## Introduction

Research on juvenile mackerel icefish (*Champsocephalus gunnari*) (Olsen, 1955a, 1955b; Andryashev, 1964; Permitin, 1973; Efremenko, 1979; Kock, 1981; Kochkin 1980, 1982, 1985; Lisovenko, 1982; Frolkina, 1989, 1999, 2001, 2002) has demonstrated that fish with gonads at stages II–III have been observed throughout the year, while females with gonads at stage IV have only been observed from November to July. The highest number of females at stage V was found in April–May. Spawning occurs from March to July, while the onset of spawning varies depending on hydrological conditions. The pelagic stage of egg development continues for two to four months. Some specimens of pre-larval and larval icefish were collected from August to October and in February.

Age reading of *C. gunnari* otoliths is complicated by the fact that the otoliths are brittle and not very transparent, and the annual growth increments are poorly defined. This difficulty in ageing fish may account for the variation in the published length estimates for fish of the same age. Kock (1981) reported the mean length of a yearling to be 5.6 cm and the mean length of 2-year-old fish to be 15.4 cm, while Kochkin (1980, 1982, 1985) reported the values to be 13.5 and 19.2 cm respectively; and Frolkina (1989, 2001) reported the mean length of a yearling to be 9–11 cm and that of 2-year-old fish to be 17–19 cm. For consecutive age groups, differences in published fish length estimates are even more evident. The analysis of otolith microstructure carried out during this study was used in order to estimate the age of juvenile *C. gunnari*.

## Material and methods

Samples were collected during the juvenile fish trawl survey conducted from mid-February to early March 2002 on the South Georgia shelf. Few specimens were collected at depths of 140–244 m. Catches of *C. gunnari* increased in pelagic trawl samples in the 15–95 m depth stratum over depths of 140–173 m; 100–500 specimens were collected per standard 0.5 h trawling and the total length (TL) of fish ranged from 5.5 to 13.3 cm. Twenty-five of these specimens were used for age–growth analyses.

One otolith of each pair was immersed in an alcohol–water solution and examined using iridescent light under a binocular microscope at 8 x 2 magnification. Total otolith radius and annulus were measured by the ocular-micrometer (20 units = 1 mm).

The second otolith was polished following Panella's method (1971), using extra-fine abrasive paper. The otolith radius was measured periodically to avoid the loss of the otolith edge in the process of polishing. The polished otoliths were mounted with Canada balsam on a slide under a glass cover without any prior treatment in hydrochloric acid, as the otoliths of juvenile icefish would be dissolved immediately by the acid.

The width of a daily increment for a 100-day period was estimated in the following way: increment zones were selected at the beginning, middle and end of the period, then their width was measured, the number of increments in each zone

identified and the mean width of increments per zone and the mean otolith width at the end of the 100-day period estimated.

Daily increments were counted and photographs of otoliths taken using the microscope. Otolith sections of fish of 6, 10.4 and 13.3 cm TL at  $\times 200$  magnification and otolith fragments at  $\times 400$  magnification are shown in Figures 1, 2 and 3.

For age-reading purposes, the Antarctic split-year system was used, in which the year is defined as the period from 1 July to 30 June of the next year (Shcherbich, 1975). From the second half of the split-year, or in the Antarctic autumn, fish were considered to be in their first year (first-year fish); overwintered fish with the first growth zone were called yearlings (Chugunova, 1952). Thus, fish of the 1999/2000 year class were considered to be first-year fish (0+) in February–March 2000, yearlings (1) from 1 July 2000, 1-year-old (1+) in February 2001, 2-year-old (2) from 1 July 2001 etc.

## Results

The age of juvenile icefish from 5.5 to 13.3 cm TL, caught from late February to mid-March 2002, varied from 120 to 533 days. The number of daily increments was fitted to a polynomial curve representing the relationship between fish length and the number of daily increments. The curve is described by the following equation:

$$L = -0.000039n^2 + 0.45n + 0.34$$

where  $L$  is total fish length (TL) and  $n$  is age expressed in days. The coefficient of correlation  $R = 0.99$ .

By using this equation it was estimated that in the first 100 days of life the mean width of a daily increment was 6  $\mu\text{m}$  for a fish of 4.5 cm in length. Later the mean width of the increments decreased to 4.2  $\mu\text{m}$  on day 200 (7.8 cm), 3.5  $\mu\text{m}$  on day 300 (10.3 cm), 3.1  $\mu\text{m}$  on day 400 (12.1 cm) and 2.8  $\mu\text{m}$  on day 500 (13.1 cm).

Back calculation gave the hatching date of individual fish. It appeared that hatching occurred in September–October 2000 and in June–October 2001 (Figure 4). Therefore, the specimens examined represented a mixture of two year classes which correspond to spawnings in the 1999/2000 (5 specimens) and 2000/01 (20 specimens) split-years. The 1999/2000 year class included 1-year-old fish (1+), which reached a length of 12.5–13.3 cm by the age

of 477–533 days. The total otolith radius was from 1.6 to 1.8 mm and the radius of the first annulus was from 0.7 to 1.3 mm.

The 2000/01 year-class included first-year fish 5.5–10.4 cm in length at the age of 120–250 days. The length range of fish varied widely due to the protracted spawning period. No annual marks were observed on otoliths and the total otolith radius was 0.50–1.15 mm. The first increment noted corresponds to fish aged 18–25 days and could be distinctly traced at some distance from the otolith centre (Figures 1 to 3). It is assumed that the development of this ring was related to resorption of the yolk sac.

The 2000/01 year class was represented by several age groups. On the basis of fish age reconstruction, it is concluded that the examined specimens comprised fish hatched from mid-June to mid-October, i.e. the spawning period in 1999/2000 split-year lasted for four months.

## Conclusions

The analysis of otolith microstructure of juvenile *C. gunnari* from the South Georgia shelf has indicated that the relationship between fish length and daily otolith increments could be used for the age differentiation of juvenile fish between adjacent year classes.

## References

- Andryashev, A.P. 1964. A review of Antarctic fish fauna. In: *Studies of Ocean Fauna (Biological results of the Soviet Antarctic expedition 1955–1958)*, Vol. 2: 335–386 (in Russian).
- Chugunova, N.I. 1952. *Methods for the Study of Fish Age and Growth*. M. *Sovietskaya Nauka*: 115 pp. (in Russian).
- Efremenko, V.N. 1979. Description of larvae of six channichthyid species from the Scotia Sea. *J. Ichthyol.*, 19 (3): 458–469 (in Russian).
- Frolkina, Zh.A. 1989. Methods of age determination for mackerel icefish (*Champscephalus gunnari* Lönnberg, 1905) from the South Georgia Island shelf. In: *Selected Scientific Papers, 1989 (SC-CAMLR-SSP/6)*. CCAMLR, Hobart, Australia: 37–49.
- Frolkina, Zh.A. 1999. Distribution and some biological features of mackerel icefish (*Champscephalus*

- gunnari*) at different life cycle stages in the South Georgia subarea. Document WG-FSA-99/65. CCAMLR, Hobart, Australia.
- Frolkina, Zh.A. 2001. Age-length composition of mackerel icefish (*Champscephalus gunnari*, Perciformes, Notothenioidei, Channichthyidae) from different parts of the South Georgia shelf. *CCAMLR Science*, 8: 133–146.
- Frolkina, Zh.A. 2002. Distribution of mackerel icefish (*Champscephalus gunnari*) (Channichthyidae) around South Georgia at various stages of its life cycle. *CCAMLR Science*, 9: 49–69.
- Kochkin, P.N. 1980. A method of icefish age determination using *Champscephalus gunnari* Lönnberg as an example. In: *Trudy VNIRO*. VNIRO, Moscow: 1–32 (in Russian).
- Kochkin, P.N. 1982. Study of icefish *Champscephalus gunnari* Lönnberg (Channichthyidae) age and growth. *Voprosy Ichthyologii*, 22 (3): 390–400 (in Russian).
- Kochkin, P.N. 1985. Analysis of recorded structures and linear growth of icefish *Champscephalus gunnari* Lönnberg (Channichthyidae) population. *Voprosy Ichthyologii*, 25 (2): 834–843 (in Russian).
- Kock, K.H. 1981. Fishereibiologische Untersuchungen an drei antarktischen Fischarten: *Champscephalus gunnari* (Lönnberg, 1905), *Chaenocephalus aceratus* (Lönnberg, 1906) und *Pseudochaenichthys georgianus* Norman, 1937 (Notothenioidei, Channichthyidae). *Mitt. Inst. Seefisch. Hamburg*, 32: 1–226.
- Lisovenko, L.N. 1982. Reproduction of icefish in the South Georgia and South Orkney Island areas. *CNIITEIRH, VNIRO*, Moscow: 12 pp. (in Russian).
- Olsen, S. 1955a. A contribution to the systematics and biology of Chaenichthyidae fishes from South Georgia. *Nytt. Mag. Zool. Oslo*, 3 (1): 79–93.
- Olsen, S. 1955b. South Georgian marbled rockcod (*Notothenia rossii marmorata*, Fischer), *Norsk Hvalfangst-Tidende*, 43. A contribution to the systematics and biology of Chaenichthyidae fishes from South Georgia. *Nytt. Mag. Zool. Oslo*, 3.
- Panella, G. 1971. Fish otoliths: daily growth layers and periodical patterns. *Science*, 174: 1124–1127.
- Permitin, Y.Y. 1973. Fecundity and reproductive biology of icefish (Channichthyidae), fish of the family Muraenolepidae and dragonfish (Bathydraconidae) of the Scotia Sea (Antarctica). *J. Ichthyol.*, 13 (2): 204–215.
- Shcherbich, L.V. 1975. On the methods of marbled notothenia ageing and maturity assessment. *Voprosy Ichthyologii*, 15 (1): 96–100 (in Russian).



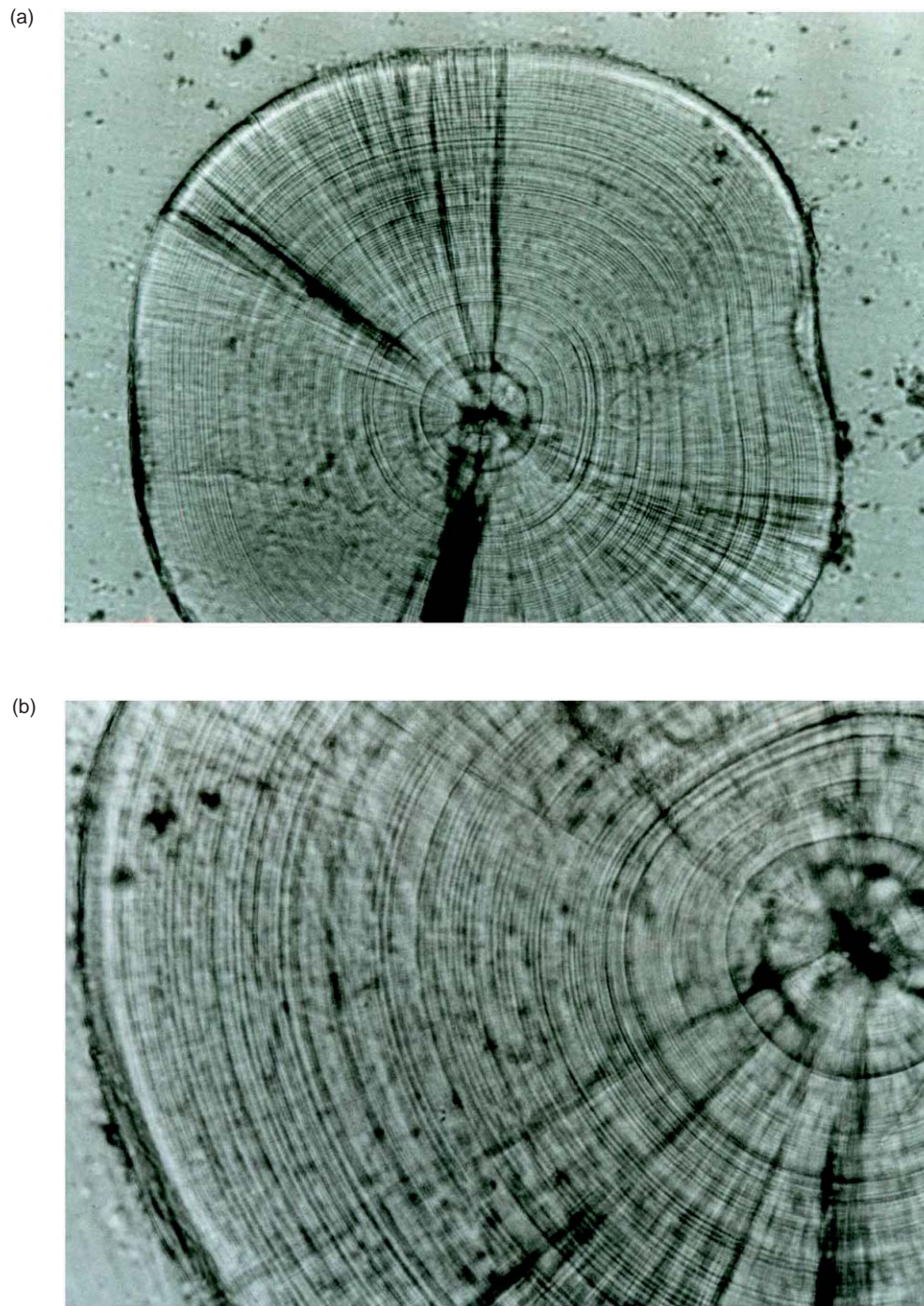


Figure 1: Otolith microstructure of *Champscephalus gunnari*, TL = 6 cm; age = 150 days: (a) general view of the otolith, (b) a fragment.

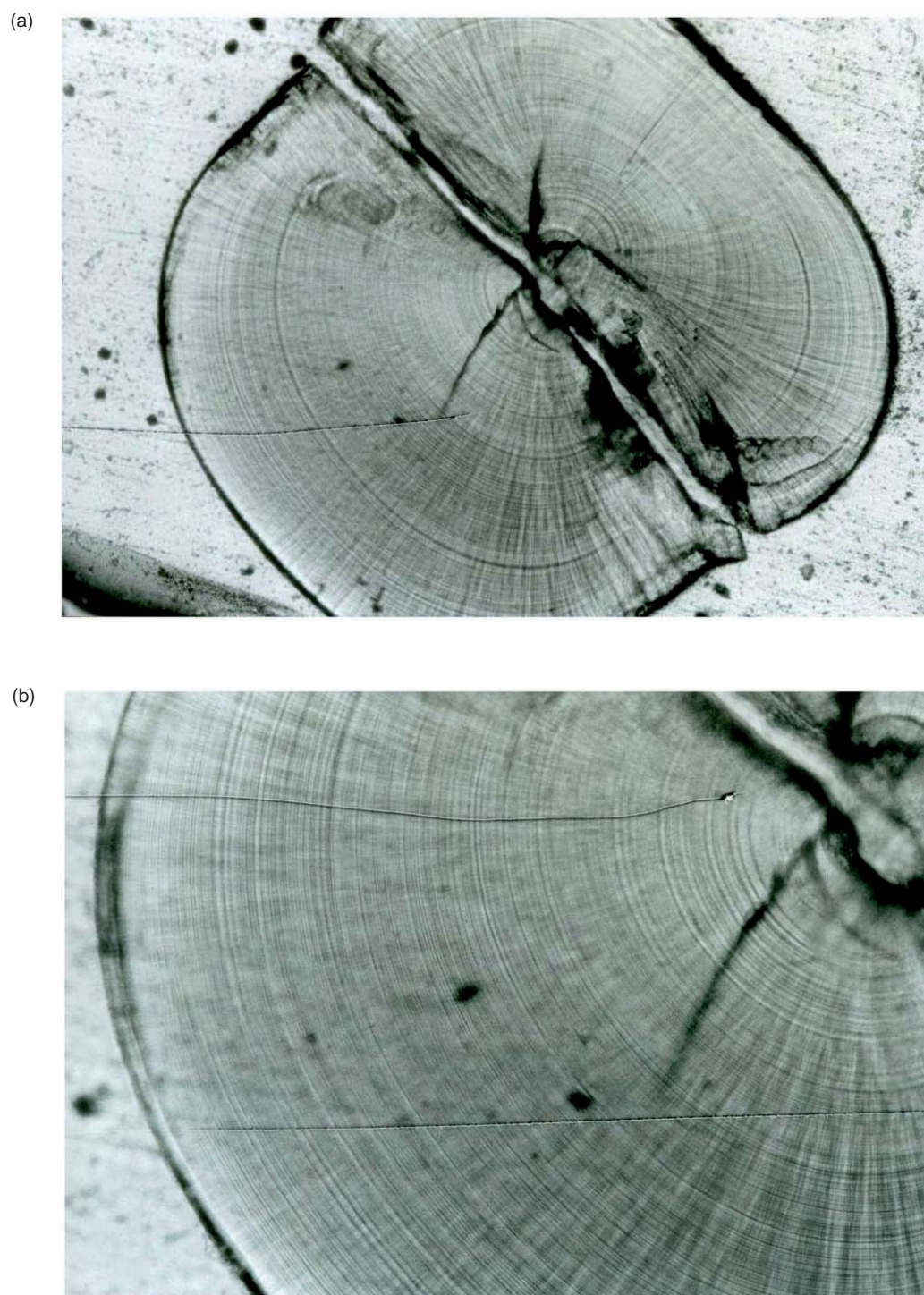


Figure 2: Otolith microstructure of *Champscephalus gunnari*, TL = 10.4 cm; age = 250 days: (a) general view of the otolith, (b) a fragment.



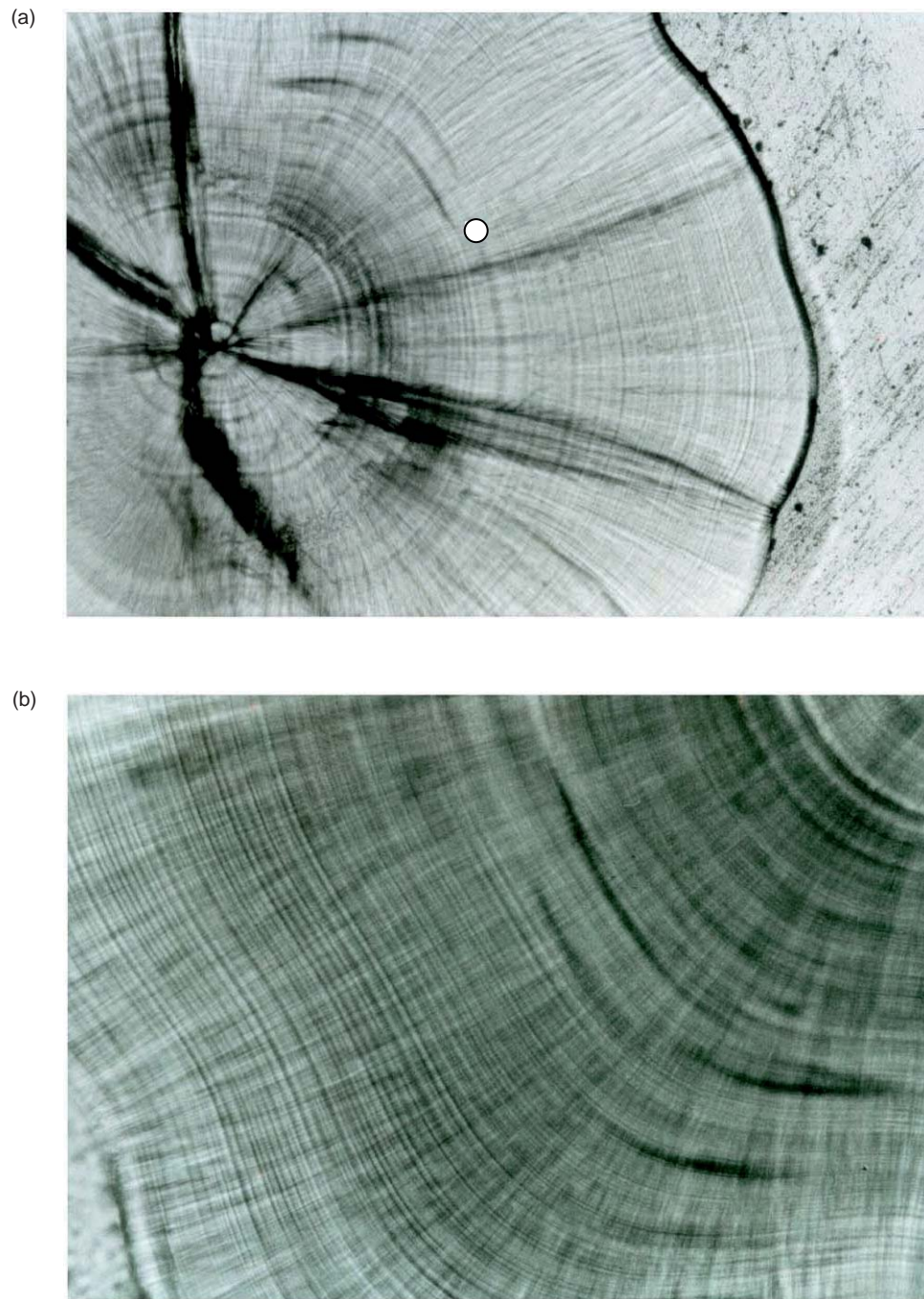


Figure 3: Otolith microstructure of *Champsocephalus gunnari*, TL = 13.3 cm; age = 533 days: (a) general view of the otolith (annulus is marked with a circle), (b) a fragment.

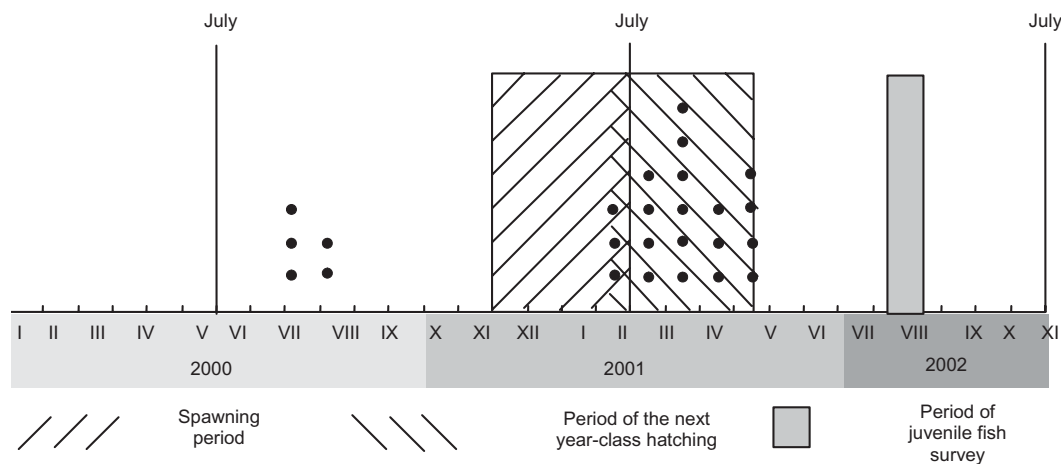


Figure 4: Spawning period and hatching dates for successive year classes of *Champsocephalus gunnari* in the South Georgia shelf area from 2000 to 2002.

Liste des figures

- Figure 1: Microstructure des otolithes de *Champsocephalus gunnari*, LT = 6 cm; âge = 150 jours : (a) vue générale de l'otolithe, (b) un fragment.
- Figure 2: Microstructure des otolithes de *Champsocephalus gunnari*, LT = 10,4 cm; âge = 250 jours : (a) vue générale de l'otolithe, (b) un fragment.
- Figure 3: Microstructure des otolithes de *Champsocephalus gunnari*, LT = 13,3 cm; âge = 533 jours : (a) vue générale de l'otolithe (un cercle marque l'anneau), (b) un fragment.
- Figure 4: Période de frai et dates d'éclosion des classes d'âges successives de *Champsocephalus gunnari* dans le secteur du plateau de la Géorgie du Sud de 2000 à 2002.

Список рисунков

- Рис. 1: Микроструктура отолитов *Champsocephalus gunnari*, ОД = 6 см; возраст = 150 дней: (а) общий вид отолита, (б) фрагмент.
- Рис. 2: Микроструктура отолитов *Champsocephalus gunnari*, ОД = 10.4 см; возраст = 250 дней: (а) общий вид отолита, (б) фрагмент.
- Рис. 3: Микроструктура отолитов *Champsocephalus gunnari*, ОД = 13.3 см; возраст = 533 дней: (а) общий вид отолита (годовое кольцо отмечено кружком), (б) фрагмент.
- Рис. 4: Нерестовый период и даты выклева очередных годовых классов *Champsocephalus gunnari* в районе шельфа Южной Георгии с 2000 по 2002 гг.

Lista de las figuras

- Figura 1: Microestructura del otolito de *Champsocephalus gunnari*, TL = 6 cm; edad = 150 días: (a) vista general del otolito, (b) un fragmento.
- Figura 2: Microestructura del otolito de *Champsocephalus gunnari*, TL = 10.4 cm; edad = 250 días: (a) vista general del otolito, (b) un fragmento.



Figura 3: Microestructura del otolito de *Champsocephalus gunnari*, TL = 13.3 cm; edad = 533 días: (a) vista general del otolito (el anillo se ha marcado con un círculo), (b) un fragmento.

Figura 4: Período de desove y fechas de eclosión para las clases anuales consecutivas de *Champsocephalus gunnari* en la zona de la plataforma de Georgia del Sur desde 2000 hasta 2002.