Reproductive Strategy of the Tiny Abyssal Scallop (Delectopecten vitreus macrocheiricolus) Collected on the Bottom of the Japan Sea, Surmised from Histological Observations of the Gonads

Authors: Sasayama, Yuichi, and Takeuchi, Akira

Source: Zoological Science, 20(6) : 759-763

Published By: Zoological Society of Japan

URL: https://doi.org/10.2108/zsj.20.759

ZOOLOGICAL SCIENCE **20**: 759–763 (2003)

Reproductive Strategy of the Tiny Abyssal Scallop (*Delectopecten vitreus macrocheiricolus*) Collected on the Bottom of the Japan Sea, Surmised from Histological Observations of the Gonads

Yuichi Sasayama[1]* and Akira Takeuchi[2]

[1]*Division of Biodiversity, Noto Marine Laboratory, Institute of Nature and Environmental Technology, Kanazawa University Uchiura, Ishikawa 927-0553, Japan*
[2]*Department of Earth Sciences, Toyama University, Toyama 930-0887, Japan*

ABSTRACT—Two hundred and fifteen individuals of the tiny abyssal scallop (*Delectopecten vitreus macrocheiricolus*) were collected at a depth of around 3,000 m on the bottom of the Japan Sea during a cruise of the Yokosuka/Shinkai 6500 YK 01-06. The scallop population included specimens of 4 sizes, *i.e.,* very small, small, middle, and large, with mantle sizes of 1–2mm, 3–5mm, 6–9mm, and 10–12mm, respectively. Histological observations revealed that the large-size group was at the stage just after oviposition or spermiation, or in the regressed stage of gametogenesis. The small- and middle-size groups were in the growing stage of gametogenesis. These results suggest that only the large-size individuals were responsible for reproduction and that the small- and middle-size individuals would participate in subsequent reproductions. This paper will discuss the reproductive strategy of this scallop living at such great depth.

Key words: abyssal scallops, reproduction, Japan Sea, Shinkai 6500

INTRODUCTION

We conducted a tectonic, geochemical, and biological survey on the eastern margin of the Japan Sea (Long.:139-40.18E to 138-28.75E, Lat.:43-36.06N to 39-43.38N) in the Yokosuka/Shinkai 6500 YK 01-06 cruise from July 5 to 16, 2001. While diving in the manned submersible “Shinkai 6500”, we observed many colonies of tiny white bivalves on the flat rocks of the sea bottom at a depth of around 3,000 m through a fenestra of the submersible. The bivalves were collected with rocks they were attached. The shell height of the largest shells was around 15 mm. The shells were very thin and nearly transparent (Fig. 1a). This bivalve was identified to be *Delectopecten vitreus macrocheiricolus* on the basis of some characters (Hayami, 2000; Rombouts, 1991) (Fig. 1a, b). This bivalve uses its byssus to attach to rocks and seems to feed on the minute organic detritus that falls to the sea bottom, filtering it through its gills. According to Hayami (2000), the distribution area of this bivalve is the sand and mud bottom in the sea of central and south Japan at depths of 150–1,000 m. However, our survey showed that this species is also distributed in deeper areas than those hitherto known.

In the bivalves of the family Pectinidae, hermaphroditic and dioecious species are intermingled (Coe, 1945). The Ezo scallop (*Patinopecten yessoensis*), which is important for fisheries, comprises only males at the juvenile stage and differentiates into males and females during the growth stage (Maru, 1985). Therefore, it would be interesting to determine whether or not this tiny scallop is hermaphroditic.

Sunshine never penetrates to the 3,000m depth sampled. At this depth, the seawater temperature was 0.5°C. The velocity of the water current was about 5 cm/sec. In most abyssal bivalves, there is no clear reproductive season. For instance, two species of bivalves, *i.e., Bathymodiolus thermophilus* (Berg, 1985) and *Malletia cuneata* (Giles *et al*., 1991), always have a few mature gametes in the gonads and breed successively through the year. On the contrary, *Ledella pustulosa* shows seasonal changes in the reproduction (Giles *et al*., 1991). In our study, we examined the histology of the gonads in the present species and discussed the reproductive strategy of this bivalve on the basis of the results.

MATERIALS AND METHODS

In total, 215 individuals were collected. The shells were quite weak and easily torn by handling, suggesting the poor calcification of the shell. All specimens were immediately fixed in a 5% formalin-seawater solution after sampling at the onboard laboratory. After-

* Corresponding author: Tel. +81-768-74-1151;
FAX. +81-768-74-1644.
E-mail: sasayama@sweet.ocn.ne.jp

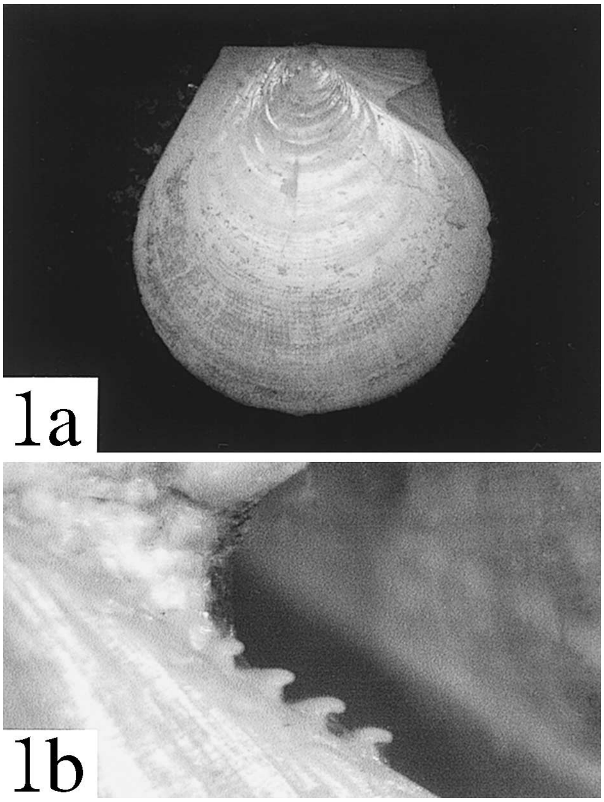


Fig. 1. *Delectopecten vitreus macrocheiricolus*. The shell height of this individual is 15 mm. The shell surface has fine radial ribs (a). A deep byssal notch has a distinct ctenolium (b).

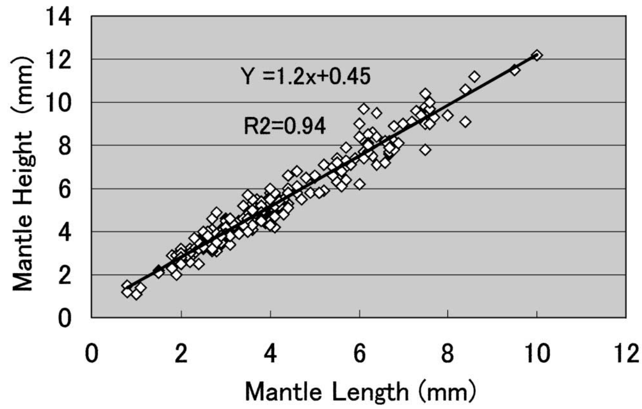


Fig. 2. Growth curve based on the mantle size.

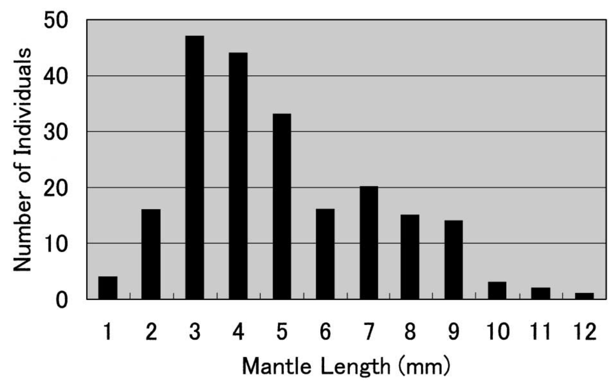


Fig. 3. Distribution pattern of the body size based on the size of the mantle.

ward, in the laboratory on land, they were re-fixed in Bouin's solution for the histological observation of the gonads. Unfortunately, the shells melted after 1 hr in the solution. As the shells were no longer available, the size of the specimens had to be determined on the basis of the measurements of the mantle. The height of the mantle was used as the Y-axis, and the length, as the X-axis. The sizes of 215 individuals were plotted.

Histological sections were made on the gonads of 34 large-, medium- and small-size individuals with mantle length of 10–12, 6–9, and 3–5 mm, respectively. The gonads of very small individuals with mantle length of 1–2 mm were not examined. Before making the paraffin sections, the byssus was removed from the body because of the possibility that it could contain sand. The remaining part was sectioned serially at 10 μm by the routine paraffin method and stained with hematoxylin and eosin.

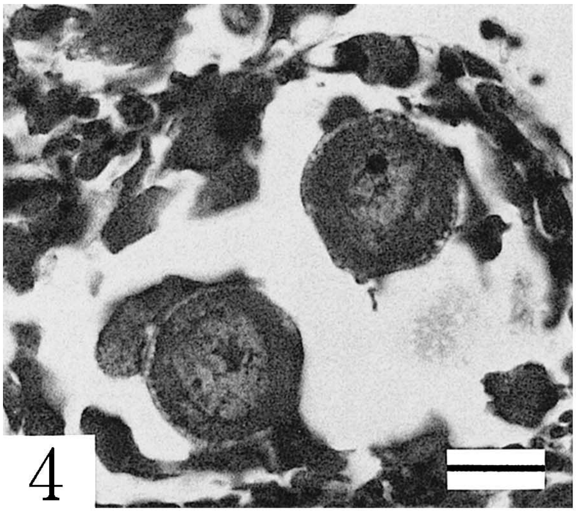
RESULTS

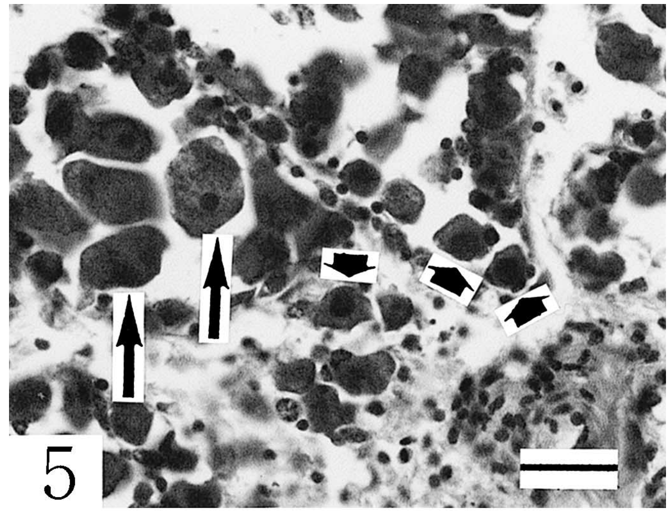
Distribution pattern of the body size

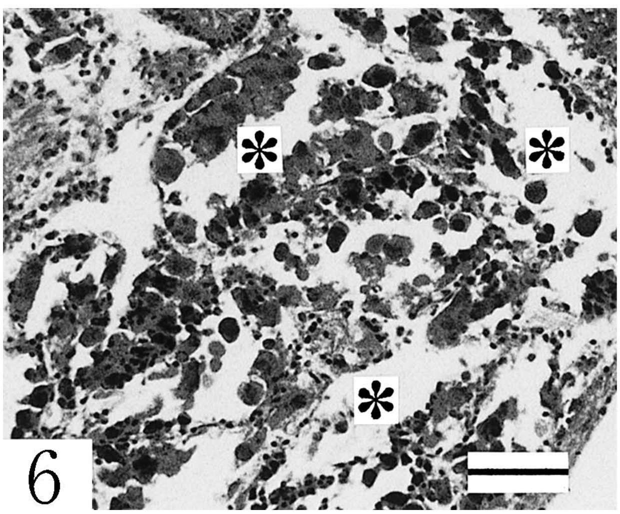
In the relationship between the mantle height and the mantle length, the regression line of Y=1.2x+0.45 was obtained by the least squares method (Fig. 2). This line clearly indicated that this species retains its shape as it grows. When the distribution pattern of the body size was examined, it was determined that these bivalves could be divided into 4 groups according to the mantle length, *i.e.*, very small (1–2mm), small (3–5mm), middle (6–9mm), and large (10–12mm) (Fig. 3).

Histological observations of the gonads

From the large- and middle-size group, 24 individuals were histologically examined. Twelve females had ovaries, and 12 males had testes. No individuals with both ovaries and testes were found. As a result, this species was determined to be dioecious, the sex ratio being 1:1. Their gonads were composed of small lobules, and the maturity among lobules was almost synchronized. There were no full-fledged females filled with mature eggs. A few mature eggs were found in only 2 individuals (Fig. 4). In other females, premature eggs were observed to remain (Fig. 5). The eggs were not round, and the nuclei were pycnotic. With the passing of time, these eggs are assumed to be absorbed. In some females, there were spaces in the lobules where remaining eggs had been absorbed (Fig. 6). On the other hand, among the males, only 1 individual was mature (Fig. 7). This male seemed to be at the stage just before spermiation, as the testes contained many lobules filled with sperms. The testes of other males were undergoing spermiation (Fig. 8) or at the stage just after spermiation (Fig. 9). In most males, the amount of sperms was largely reduced. It seems that the maturation stages of males and females of this species were almost synchronized, although the male stages were slightly behind those of females.







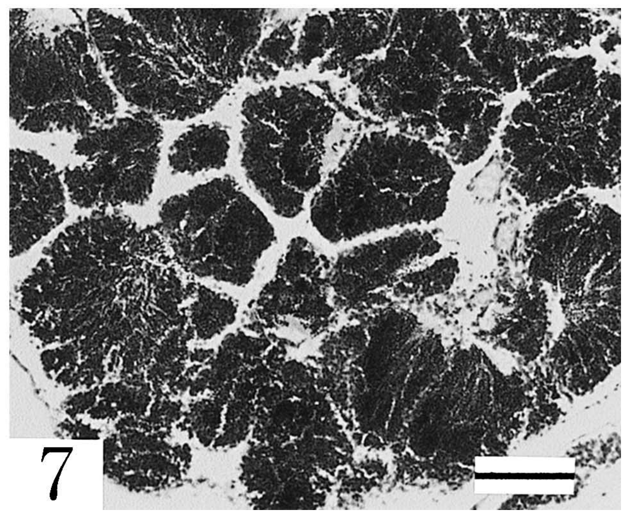


Fig. 4. Two mature eggs in the ovary. Bar, 20 µm.
Fig. 5. Premature eggs (arrows) remained in the ovary and eggs with pycnotic nuclei(arrow heads). Bar, 20 µm.
Fig. 6. Spaces (asterisks) in the lobules of the ovary where remaining eggs had been absorbed. Bar, 50 µm.
Fig. 7. Mature testis. Bar, 100 µm.

In the group of small individuals with mantle length of 3–5 mm (Fig. 3), 10 specimens were examined. Although these were the largest in number, they were all immature. Their gonads were young in both females (Fig. 10) and males (Fig. 11). In some individuals, their sex was determined.

DISCUSSION

The reproductive pattern of the abyssal Mollusca can be classified into three categories, namely, successive, intermittent, and cyclic (Scheltema, 1994). In the case of successive reproduction, oocytes in various stages of the maturation exist in a single ovary, as oogenesis is not synchronized. Consequently, a few mature eggs are successively ovulated during the year. In the case of intermittent reproduction, the periodicity of the reproduction cannot be concretized, irrespectively of the histological condition of the gonads. In the case of cyclic reproduction, the changes in gonads occur periodically, which may reflect the seasonal changes.

In invertebrates that inhabit the abyssal depth, at least in some bivalves of the Order Protobranchia, reproduction seems to be related to the amount of detritus in the phytoplankton (Tyler *et al.*, 1994). It has been reported that there are seasonal changes in the amount of organic particles convoyed from the sea surface to a depth of 3,200 m (Deuser and Ross, 1980). A similar result was reported in the abyssal depth of the North Atlantic Ocean (Billett *et al.*, 1983). It is known that, in the abyssal depth, where the water current velocity is 7 cm/sec, organic particles once sedimented are re-intermixed at a height of 1 m from the sea bottom (Lampitt, 1985). These reports suggest that the abyssal zone is not a completely dormant world.

Studies using remote sensing mechanics with a satellite have demonstrated that, on the surface of the Japan Sea,

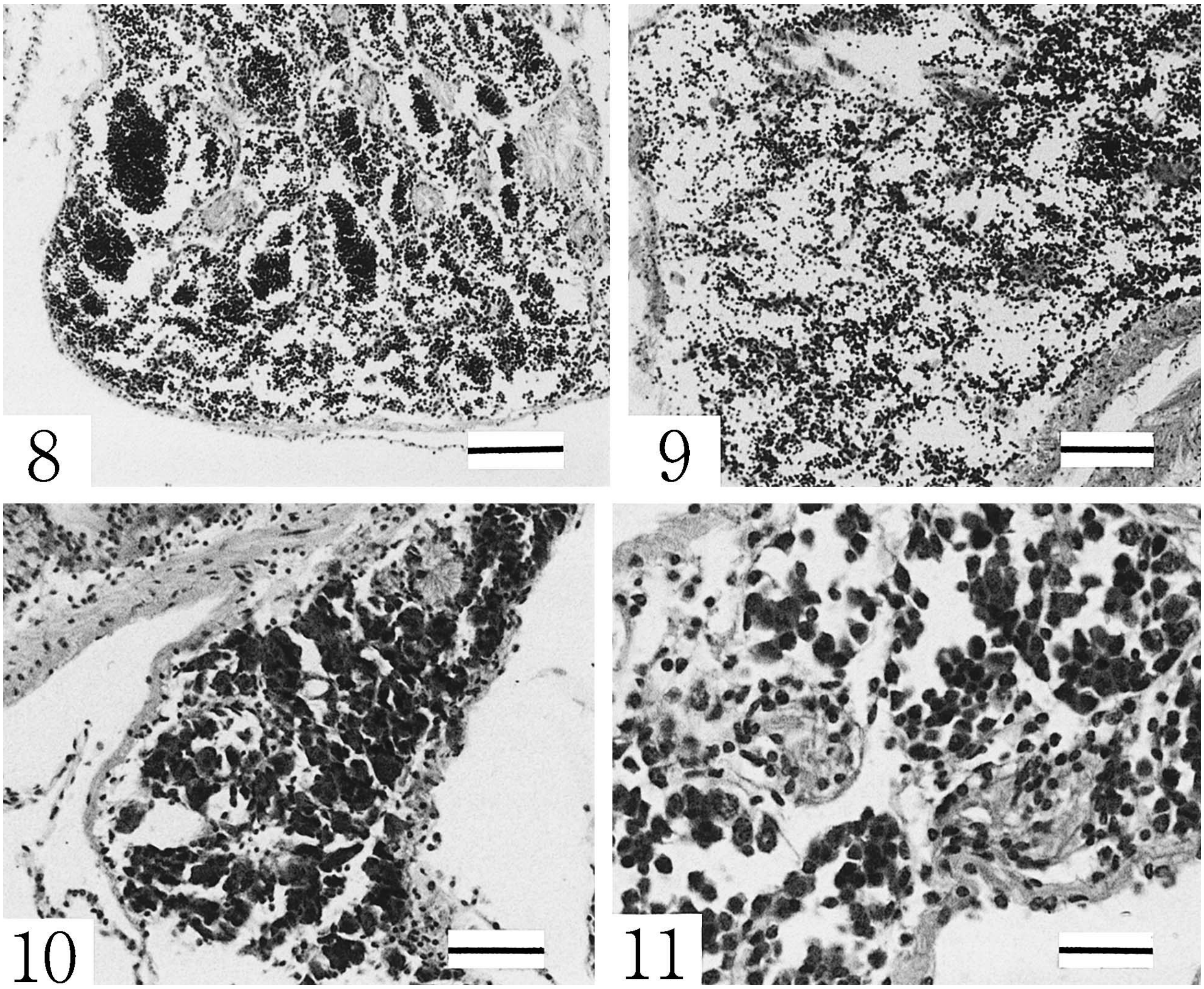


Fig. 8. Testis under spermiation. Bar, 100 µm.
Fig. 9. Testis after spermiation. Bar, 100 µm.
Fig. 10. Young ovary. Bar, 50 µm.
Fig. 11. Young testis. Bar, 20 µm.

phytoplankton blooms intensely in April and slightly in November (Senga and Horiuchi, 1999). It is also known that, on the surface of the cold water in the northern Japan Sea, blooming of the phytoplankton occurs in April and May (Nishimura, 1982). Therefore, on the bottom of the Japan Sea, there may also be seasonal changes in the amount of organic particles supplied from the surface water, and the possibility that the reproductive activity of abyssal animals could be affected by these changes is suggested.

Taking all these findings into consideration, it is clear that the present species does not belong to the first category of Scheltema (1994), although the sampling was done at only one time in the month of July. The distribution pattern of the body size in 215 individuals was not equal. The 3–5 mm and 6–9 mm groups were the first and second most numerous, respectively (Fig. 3). Therefore, it could be concluded that the reproductive pattern of this species may not be intermittent but cyclic. In the present species, larger individuals may be involved in reproduction by synchronizing their maturation. Smaller individuals may be involved in the subsequent reproductive period.

Kuroda *et al.* (1971) reported that this bivalve is often observed to attach to the carapace of the giant spider crab (*Macrocheira kaempferi*). According to the latest information from Dr. Okamoto (Shizuoka Prefectural Fish Farming Center, personal communication), attaching of bivalves is almost limited to the relatively large-sized crabs. In addition, since it is regarded that the molting of the giant spider crab does not occur in mature individuals (Dr. Okamoto, personal communication), this bivalve may survive a long time, once attached to the carapace of the mature individuals.

The present species lives in an environment in which the water temperature is low and there is insufficient food supply. Therefore, it may be hard for this species to achieve a large shell size. Nevertheless, the population size was very large. Other species of bivalves were never found.

These facts suggest that this species is adapted to the severe environment and thrives under these unfavorable conditions. Since it does not seem to have a large-sized predator, its thin and fragile shells may not be a problem. It could even be an advantage, as the species can save the energy required for shell thickening.

ACKNOWLEDGEMENTS

The authors would like to express their sincere thanks to their team leader, Dr. Y. Okamura (National Institute of Advanced Industrial Science and Technology) and their colleagues, Dr. K. Satake (ditto), professor T. Gamo (Hokkaido University) and Mr. T. Kodera (Nippon Marine Enterprises, Ltd.). In addition, thanks are due to the captain of the support ship (R/V Yokosuka), Mr. O. Yukawa, the commander, Mr. Y. Imai, the chief pilot of the submersible (Shinkai 6500), Mr. S. Suzuki, and the co-pilot, Mr. W. Kawama, for their skillful operation.

REFERENCES

Berg CJ (1985) Reproductive strategies of mollusks from abyssal hydrothermal vent communities. Biol Soc Washington Bull 6: 185–197

Billett DSM, Lampitt RS, Rice AL (1983) Seasonal sedimentation of phytoplankton to the deep-sea benthos. Nature 302: 520–522

Coe WP (1945) Development of the reproductive system and variations in sexuality in Pecten and other pelcypod mollusks. Trans Conn Acad Sci 36: 673–700

Deuser WG, Ross EH (1980) Seasonal change in the flux of organic carbon to the deep sea. Nature 283: 364–365

Giles LA, Tyler PA, Gage JD (1991) Diet and reproduction in the deep-sea Protobranchi *Ledella pustulosa* and *Malletia cuneata*. 6th Deep-Sea Biol Symp Copenhagen Abstract, p 84

Kuroda T, Habe T, Oyama K (1971) Seashells of Sagami Bay. Maruzen, Tokyo, pp 575–576

Maru K (1985) Ecological studies on the seed production of scallop, *Patinopecten yessoenis* (Jay). Sci Rep Hokkaido Fish Exp St 27: 1–53. (In Japanese with English abstract)

Lampitt RS (1985) Evidence for the seasonal deposition of detritus to the deep-sea floor and its subsequent resuspension. Deep-sea Res 32: 885–897

Nishimura S (1982) Okhotsku Sea, Japan Sea, East China Sea, Estuaries and enclosed seas. Elsevier Scientific Pub. Amsterdam, pp 375–401

Hayami I (2000) Pectinidae. In “Marine mollusks in Japan”. Ed by T Okutani, Tokai University Press, Tokyo, pp 906–907

Rombouts A (1991) Guidebook to Pecten Shells. Universal Book Services, Netherlands, p 79

Scheltema RS (1994) Adaptations for reproduction among deep-sea benthic mollusks: an appraisal of the existing evidence. In “Reproduction, Larval Biology, and Recruitment of the Deep-sea Benthos” Ed by CM Young and KJ Eckelbarger, Columbia University Press, New York, pp 44–75

Senga Y, Horiuchi T (1999) Light spectral analysis in the Japan Sea. Aquabiology 21: 29–35. (In Japanese with English abstract)

Tyler PA, Campos-Creasey LS, Giles LA (1994) Environmental control of quasi-continuous and seasonal reproduction in deep-sea benthic invertebrates. In “Reproduction, Larval Biology, and Recruitment of the Deep-sea Benthos” Ed by CM Young and KJ Eckelbarger, Columbia University Press, New York, pp 158–178

(Received November 7, 2002 / Accepted March 10, 2003)