

Ecological Distribution of *Halla okudai* (Polychaeta: Lysaretidae) in the Intertidal Flats of Hiroshima Bay

Hidetoshi SAITO and Hiromichi IMABAYASHI

*Faculty of Applied Biological Science, Hiroshima University,
Kagamiyama 1-4-4, Higashi-hiroshima, Hiroshima, 739, Japan*

Received April 30, 1997

Abstract Distribution of the bivalve-feeder, *Halla okudai* (Polychaeta: Lysaretidae), was investigated in the 23 intertidal flats of Hiroshima Bay, the Seto Inland Sea, from April to July in 1994 and 1995. At mean low waters of spring tides in inner part and central part of the bay, 46 individuals (14.7~76.0 cm in body length) were collected together with the bivalves, e. g., *Crassostrea gigas*, *Ruditapes philippinarum* and *Mytilus edulis*. However, abundance of the polychaete did not necessarily showed a positive correlation to that of these bivalves. The habitat conditions indicated 28.7~32.9‰ in salinity, -1.4~1.7 in median diameter (ϕ) and 1.2~4.2% in ignition loss. The trellis and mat of *C. gigas* were discussed in relation to a suitable substratum for larval polychaete.

Key words: *Crassostrea gigas*, ecological distribution, *Halla okudai*, larval settlement, polychaete, *Ruditapes philippinarum*

INTRODUCTION

Carnivorous polychaete, *Halla okudai* (Lysaretidae), is a large infaunal organism (90 cm in maximum body length), and inhabits the low waters of spring tides in the intertidal flats, the Seto Inland Sea and the Ariake Sea (OKUDA, 1933; ITAZAKI, 1982a; UCHIDA, 1992). The unique foraging behavior was observed in aquarium; the polychaete attacks a live bivalve by enveloping its shell with jelly-like materials secreted from the body wall (ITAZAKI, 1982b; IMABAYASHI *et al.*, 1996).

Distributional pattern of the polychaete was studied in relation to abundance of food organisms, especially the clam, *Ruditapes philippinarum* (MORI *et al.*, 1932; ITAZAKI, 1982a). In Hiroshima Bay, most of the polychaetes were found in the clam farm of intertidal zone, where the other bivalves, e. g., *Crassostrea gigas*, *Mytilus edulis*, *Musculus senhousia* and *Notochione jodoensis*, were generally dominant. Laboratory experiment showed that *R. philippinarum* was preferred to the other four bivalves (SAITO & IMABAYASHI, 1994). In the Ariake Sea, however, the polychaete occurred also at the intertidal flat without *R. philippinarum* (ITAZAKI, 1982a).

The polychaete habitat of the Ariake Sea seemed to be sandy-gravel flat, excluding estuarine one (ITAZAKI, 1982a). The watery and sedimental conditions have not been studied in detail. This is mainly due to difficulty in capturing the individual whose burrows

is so deep and movement is quick.

Recently in Hiroshima Bay, the small polychaetes (10~30 cm in body length) were abundantly collected on rafts of the oyster, *C. gigas*, at the subtidal zone (SAITO & IMABAYASHI, unpublished). On the other hand, trellis or mat of the oyster is located in the intertidal flats. This suggests that oyster substratum, i. e., raft, trellis and mat, is used for the settlement of the larvae, whose body form has not yet been identified.

This study deals with the ecological distribution of *H. okudai* in the intertidal flats of Hiroshima Bay, in relation to its watery and sedimental variables and food organisms. Effect of oyster substratum on the larval settlement is also discussed.

MATERIALS AND METHODS

The survey was conducted from March to July in 1994 and 1995 in 23 intertidal flats ranging from inner part to mouth part of Hiroshima Bay (Fig. 1). Schematic habitat for the polychaete at intertidal zone was shown in Fig. 2. The polychaetes and bivalves dwell main-

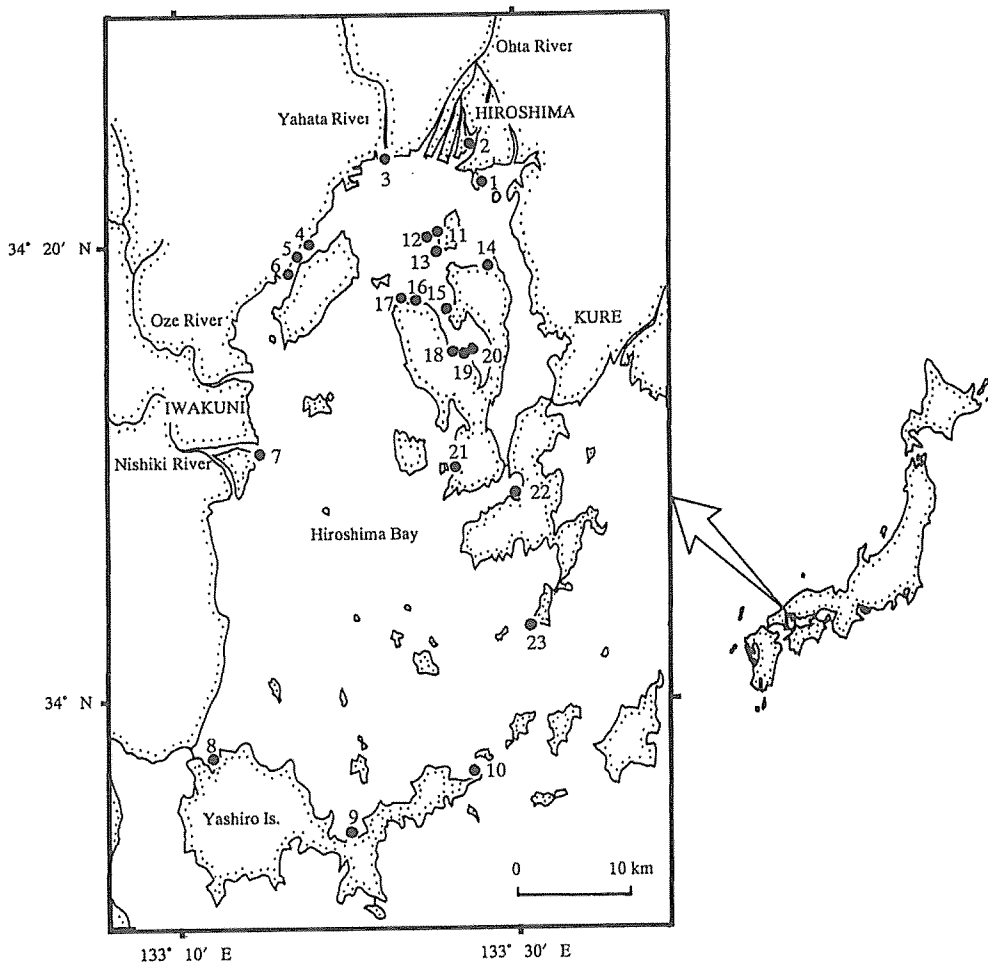


Fig. 1. Sampling stations (solid circles) in Hiroshima Bay.

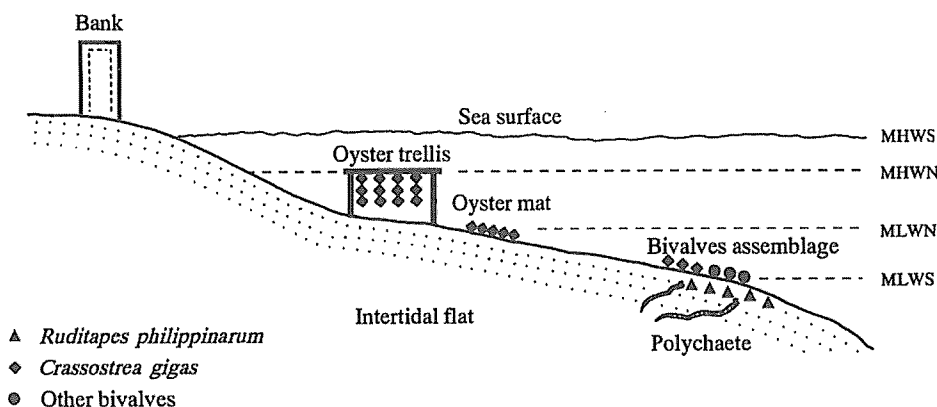


Fig. 2. Schematic habitat for the polychaete in the intertidal flat of Hiroshima Bay. MHWS: mean high water of spring tides. MHWN: mean high water of neap tides. MLWN: mean low water of neap tides. MLWS: mean low water of spring tides.

ly at mean low waters of spring tides (MLWS). Oyster trellis and oyster mat are located from mean low water of neap tides (MLWN) to mean high water of neap tides (MHWN).

The polychaetes were collected with a hoe from a quadrat (3 m × 3 m; 0.5 m below bottom surface) at each flat. Bivalves were collected with a 1 mm mesh sieve from three quadrats (0.3 m × 0.3 m; 0.1 m below bottom surface). Both of the organisms were fixed with 10% neutralized formalin solution, and thereafter those body size were measured. In the polychaete with its posterior portion lost at sampling, body length (y_1 , cm) and body weight (y_2 , g wet) were estimated from body width of 50th segment (x , cm) as shown in the following equations; $y_1 = 55.1x^{1.09}$ ($n=44$, $r=0.808$, $p<0.01$); $y_2 = 39.8x^{2.73}$ ($n=44$, $r=0.930$, $p<0.01$).

Salinity and temperature were measured with water quality checker (WQC-20A, Toa Electronics Ltd). Particle size of sediment was classified with sieves. Ignition loss was measured with muffle furnace (FM-36, Yamato Scientific Co. Ltd) by burning the sediment at 600°C for 2 hours.

Location of oyster trellis or oyster mat were examined at each flat.

RESULTS

Polychaete

A total of 46 individuals was collected from inner part to central part of Hiroshima Bay (Fig. 3). The body length (14.7~76.0 cm) did not show a definite difference between both parts. The density was highest (1~9 indiv/9 m²) at Stn. 13. However, no occurrence was observed from estuarine flats (Stns. 2, 3 and 7) and mouth part (Stns. 8, 9, 10 and 23) of the bay.

Water and sediment environment

Salinity in the bay ranged from 4.0 to 32.9‰ (Fig. 4). The polychaetes dwelled at a salinity of 28.7~32.9‰, while no individual was collected in the less saline waters (estuarine flats) and the more saline waters (mouth part). Water temperature (16.4~28.0°C) hardly

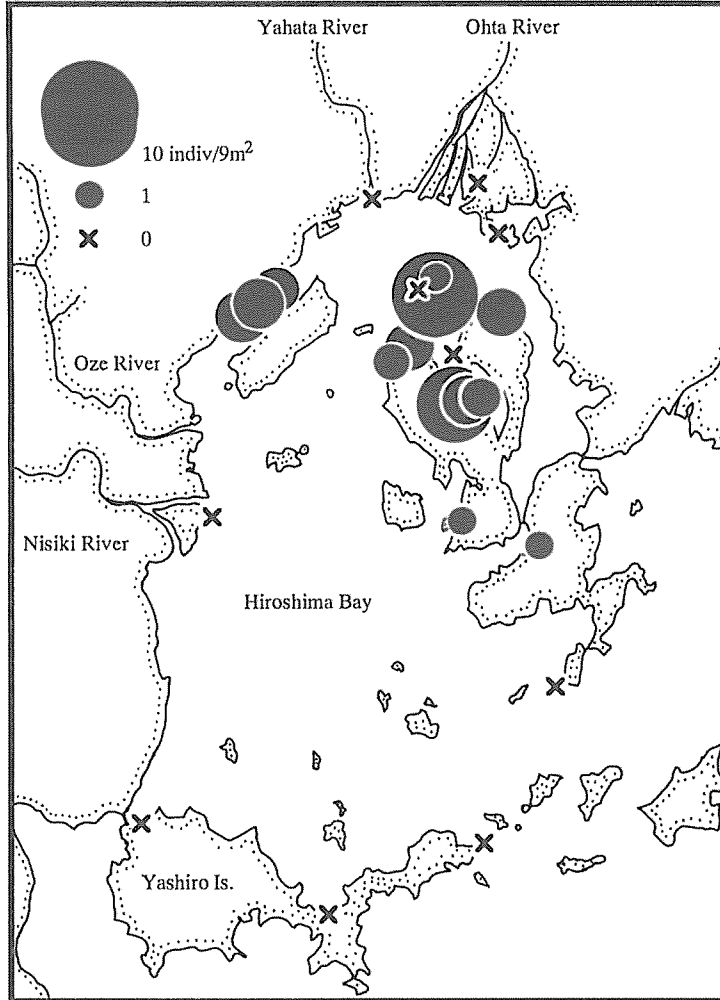


Fig. 3. Distribution of the polychaete in Hiroshima Bay. Size of circles is proportional to the density (indiv/9m²). Negative stations are indicated with ×.

showed a definite correlation with occurrence of the polychaete.

The sediment in the polychaete habitat indicated 1.2~4.2% in ignition loss and -1.4~1.7 in median diameter (ϕ) (Fig. 5). The high density (5 indiv/9m²) was observed in coarse flat with higher amount of organic matters.

Food organisms

Bivalves, e. g., *C. gigas*, *R. philippinarum*, *M. edulis*, *M. senhousia*, *N. jedoensis* and *Solen strictus*, were mainly distributed from inner part to central part of the bay, where the polychaetes were invariably collected (Table 1). Especially, the high density (5~9 indiv/9 m²) was observed in the intertidal flat with *C. gigas* or *R. philippinarum*. Excepting the artificial flats (Stns. 12 and 15) used only for clam farm, abundance of the polychaete showed a significant correlation to that of bivalves ($P < 0.01$) (Fig. 6).

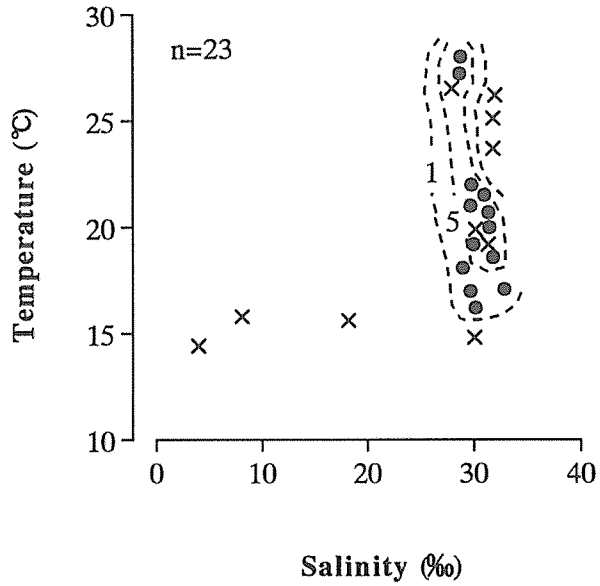


Fig. 4. Abundance of the polychaete in the intertidal flats of Hiroshima Bay, in relation to salinity and temperature. Isopleth denotes the density (indiv/9m²). Negative stations are indicated with ×.

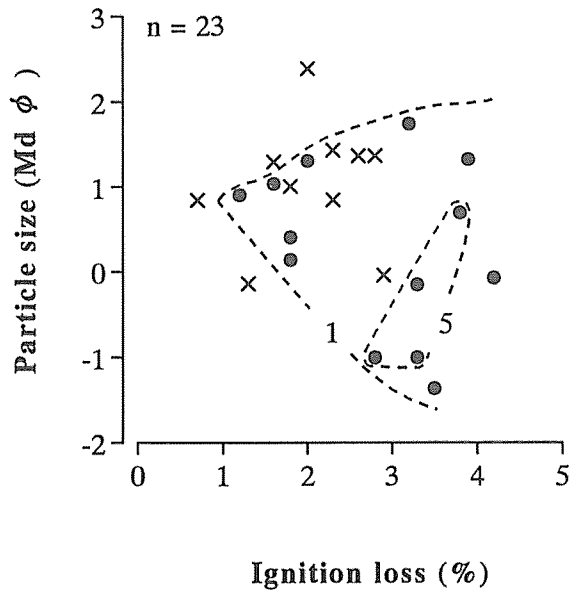


Fig. 5. Abundance of the polychaete in the intertidal flats of Hiroshima Bay, in relation to ignition loss and sedimental particle size. Isopleth denotes the density (indiv/9m²). Negative stations are indicated with ×.

Table 1. Abundances (mean \pm SD) of the polychaete and bivalves in the intertidal flat of Hiroshima Bay.

Part of the bay	Station	Polychaete (indiv/9 m ²)	Bivalve (indiv/0.09 m ²)* ¹				
			<i>Crassostrea gigas</i>	<i>Ruditapes philippinarum</i>	<i>Mytilus edulis</i>	Others* ²	
Inner	1	0	0.7 \pm 0.9	5.7 \pm 3.3	0	0	
	2* ³	0	0.3 \pm 0.5	5.0 \pm 4.2	0	0	
	3* ³	0	0	9.0 \pm 1.4	0	0.3 \pm 0.5	
	4	4	9.0 \pm 12.7	12.0 \pm 17.0	0	3.0 \pm 4.2	
	5	5	3.0 \pm 4.2	10.5 \pm 9.6	0	3.0 \pm 4.2	
	6	5	0.3 \pm 0.5	6.0 \pm 4.2	0	12.0 \pm 11.2	
	11	1	0	2.7 \pm 0.9	0	0.7 \pm 0.9	
	12	0	0	49.0 \pm 14.2	0	0	
	13	9	7.7 \pm 7.6	0	0	0	
	14	3	0	0.3 \pm 0.5	0	0	
	15	0	0	42.0 \pm 40.5	0	0	
	16	4	9.7 \pm 7.1	0	0	0	
	17	2	0	0	7.0 \pm 9.9	0	
	18	6	0	0.7 \pm 0.5	0	0.3 \pm 0.5	
	19	3	0	0.3 \pm 0.5	0	0	
	20	2	10.7 \pm 7.7	0	0	0	
	Central	7* ³	0	0	2.0 \pm 1.4	0	1.0 \pm 0.8
		21	1	3.0 \pm 4.2	0	0	0
		22	1	0	0	0	1.0 \pm 0.8
	Mouth	8	0	0	0	0	0
9		0	0	0	0	0	
10		0	0	1.3 \pm 1.9	0	0	
23		0	0	0	0	0	

*¹ Most of the bivalves are 10~40 mm in shell length, while *Solen strictus* is 10~40 mm in shell height.

*² *Solen strictus*, *Mytilus edulis*, *Musculus senhousia* and *Notochione jedoensis*.

*³ Estuarine flat.

Dominant food organisms in the polychaete habitat tended to change from *C. gigas* to *R. philippinarum* with increasing its body length (Fig. 7).

Oyster substratum

It is given in Table 2 whether the polychaete, bivalves and oyster substratum (trellis or mat) in the intertidal flat were observed or not. In the inner part with occurrence of the polychaete, excluding estuarine flat (Stns. 2 and 3), bivalves and oyster substratum also existed. However, the polychaetes were not collected in the inner (Stns. 1, 12 and 15) and mouth (Stns. 9 and 10) parts lacking either oyster substratum or bivalves.

DISCUSSION

The main habitat for *H. okudai* in Hiroshima Bay was the intertidal flats from inner part to central part. A high salinity (28.7~32.9‰) was suitable for the polychaete, while a low saline water (4.0~18.2‰) of estuarine flats is less tolerant. Laboratory experiment also indicated that a tolerable lower limit was 20‰ (TAMURA, 1933). Since the surveys were conducted in high temperature season (16.4~28.0°C) when the polychaete was active in forag-

ing behavior (ITAZAKI, 1982b), influence of low temperature failed to be revealed in this study. The lowest temperature (4°C) in esturine flats nearly coincided with a physiological

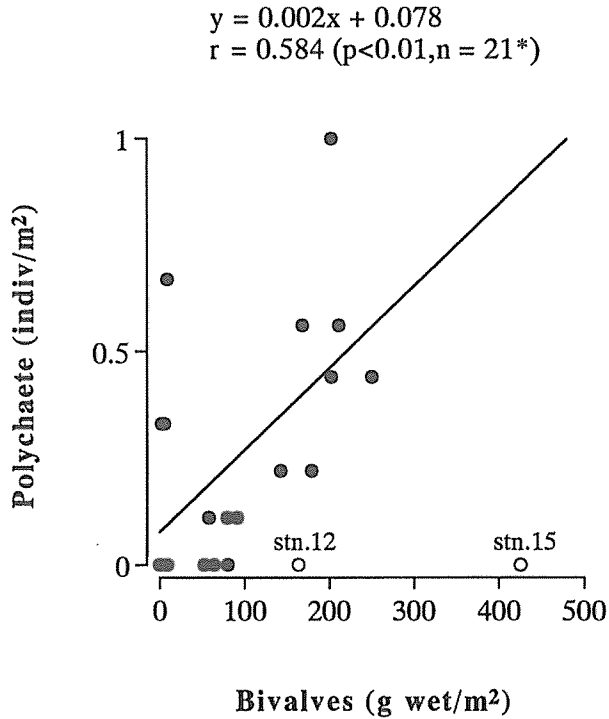


Fig. 6. Abundance relation between bivalves and the polychaete in the intertidal flats of Hiroshima Bay. *Stns. 12 and 15 are excluded.

Table 2. Occurrences of the polychaete, bivalves and oyster substratum in the intertidal flat of Hiroshima Bay.

MLWS*1		MLWN*2~MHWN*3		Station
Polychaete	Bivalves*4	Oyster trellis*5	Oyster mat*5	
○	○	○	○	13, 16, 20
○	○	○	×	14, 17, 18, 22
○	○	×	○	4, 5, 6, 11, 19, 21
×	○	×	○	2, 3, 7
×	○	×	×	1, 10, 12, 15
×	×	○	○	9
×	×	×	×	8, 23

○: Present ×: Absent

*1 Mean low water of spring tides.

*2 Mean low water of neap tides.

*3 Mean high water of neap tides.

*4 *Ruditapes philippinarum* and *Crassostrea gigas* are predominant.

*5 Substratum formed by *Crassostrea gigas*.

- ▣ *Crassostrea gigas* : Stns.13,16,20 and 21
- ▤ *Crassostrea gigas* & *Ruditapes philippinarum* : Stns.4,5 and 6
- ▥ *Ruditapes philippinarum* : Stns.11,14,18 and 19
- *Mytilus edulis* : Stn.17

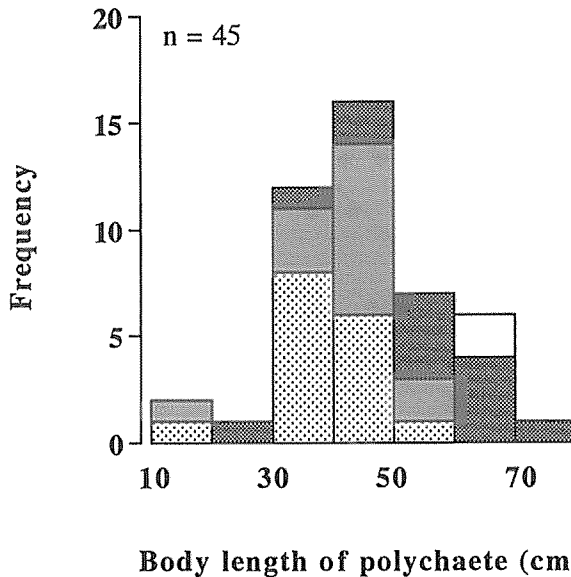


Fig. 7. Habitat composition of the polychaete in the 12 intertidal flats of Hiroshima Bay. Habitat types were divided by three kind of food organisms.

tolerance of the polychaete (TAMURA, 1933; HIROSHIMA PREFECTURE, 1995). Thus, water temperature also indicates that estuarine flats are not a suitable habitat for the polychaete.

It was well known that benthic organisms were distributed in particular size of sediment, which was closely related to their feeding types (SANDERS, 1958). A high density (5~9 indiv/9m²) of the polychaete was observed in coarse-grained flat in Hiroshima Bay. MAURER & LEATHEM (1981) reported that foraging behavior of carnivorous polychaete would probably be enhanced with an increase in pore spaces of coarse-grained sediment. The polychaete was distributed from 1.2 to 4.2% in ignition loss, especially abundant at approximately 3.5%. This result indicates that higher amount of organic matter in the intertidal flat would be suitable for the polychaete.

ITAZAKI (1982a) estimated that distributional pattern of the polychaete in the Ariake Sea was largely connected with abundance of food organisms, especially the clam *R. philippinarum*. In this study, a number of bivalves, e. g., *C. gigas*, *R. philippinarum*, *M. edulis*, *M. senhousia*, *N. jedoensis* and *S. strictus*, were collected from inner part to central part of Hiroshima Bay, while there were few or no bivalves from mouth part. The bivalves were

invariably collected from the polychaete habitats. However, abundance of the polychaete did not necessarily show a positive correlation to that of bivalves, since no polychaete was collected at Stns. 12 and 15, where *R. philippinarum* was cultivated at a high density (42.0~49.0 indiv/0.09m²). Therefore, this result indicates that distribution of the polychaete is not determined only by abundance of food organism.

Previous studies (WOODIN, 1974; GROSBERG, 1981; HUNTE *et al.*, 1991) suggested that ecological distribution of polychaetous organisms was mainly determined by adaptive ability to benthic environment, dispersal ability and substratum selection of planktonic larvae. In Hiroshima Bay, the small polychaetes (10~30 cm in body length) were found on oyster raft at the subtidal zone (SAITO & IMABAYASHI, unpublished). On the basis of the fact that the small polychaete less than 10 cm did not occur at MLWS level, substratum for the larval settlement was different from ground for the adult nursery in Hiroshima Bay. Therefore, it is assumed that the flat-dwelling polychaete settles on oyster substratum (trellis or mat) at MLWN level, and moves gradually to the nursery ground at MLWS level. It accounts for our estimation that the polychaete fails to be distributed on clam-farming intertidal flat which is lacking of oyster substratum.

This study suggests that ecological distribution of the polychaete are affected both by food organisms and by oyster substratum under favorable watery and sedimental conditions. According to STATISTICS AND INFORMATION DEPARTMENT (1982), production of *R. philippinarum* (1,837 ton/year) and *C. gigas* (151,840 ton/year) in Hiroshima prefecture were ranked tenth and top in Japan, respectively. Hiroshima Bay has a great capacity for the polychaete from the viewpoint of food and habitat. In Kumamoto prefecture adjoining the Ariake Sea, production of *R. philippinarum* (39,940 ton/year) was ranked top, while *C. gigas* (27 ton/year) was scarcely cultivated. Therefore, it is considered in the Ariake Sea that the polychaete settles also on mat-forming mussel, e. g., *M. senhousia* and *M. edulis*, which dwells together with the polychaete on the intertidal flats in Japan.

Acknowledgements We are indebted to Mr. N. Mizuguchi, Mitaka Fishery Cooperative Association, for his conscientious advice to plan on field survey. We also would like to thank Ms. E. Takamatsu, Laboratory of Aquatic Ecology, for her assistance in sampling.

REFERENCES

- GROSBERG, R. K., 1981, Competitive ability influences habitat choice in marine invertebrates. *Nature*, 290: 700-702.
- HIROSHIMA PREFECTURE., 1995, Measurement of water quality in shallow waters of Hiroshima Prefecture, Hiroshima, 937pp (In Japanese).
- HUNTE, W., B. E. CONLIN and J. R. MARSDEN., 1991, Habitat selection in tropical polychaete *Spirobranchus giganteus*. I. Distribution on corals. *Mar. Biol.*, 104: 87-92.
- IMABAYASHI, H., H. SAITO, C. OHMASA and K. KAWAI., 1996, Foraging behavior of the polychaete *Halla okudai* in aquarium. *Benthos. Res.*, 50: 11-17 (In Japanese).
- ITAZAKI, K., 1982a, Studies on the artificial propagation of sand-worm, *Halla parthenopea* (Delle Ceiaje)-I, On distribution and utilization of sand-worm in Kumamoto Prefecture. *Bull. Kumamoto. Pref.*

- Fish. Exp. St.*, 2: 2-5 (In Japanese).
- ITAZAKI, K., 1982b, Studies on the artificial propagation of sandworm, *Halla parthenopea* (Delle Ceiaje)-II, On feeding behavior of sand worm. *Bull. Kumamoto. Pref. Fish. Exp. St.*, 2: 7-8 (In Japanese).
- MORI, I., M. TAMURA and K. MAKINO., 1932, A report on the important worms used as bait in Hiroshima Prefecture. *Bull. Hiroshima. Pref. Fish. Exp. St.*, Hiroshima, 45pp (In Japanese).
- MURER, D and W. LEATHEM., 1981, Polychaete feeding guild from Georges Bank, USA. *Mar. Biol.*, 62: 161-171.
- OKUDA, S., 1933, Some polychaete annelids used as bait in the Inland Sea. *Annot. Zool. Jap.*, 14: 243-253.
- SAITO, H and H. IMABAYASHI., 1994, Food preference of the polychaete *Halla okudai*. *J. Fac. Appl. Biol. Sci. Hiroshima Univ.*, 33: 151-157 (In Japanese).
- SANDERS, H. L., 1958, Benthic studies in Buggard Bay, Animal-sediment relationship. *Limmol. Oceanogr.*, 3: 245-258.
- STATISTICS AND INFORMATION DEPARTMENT., 1982, The 58th Statistical Yearbook, Ministry of Agriculture, Forestry and Fisheries of Japan, Tokyo, pp. 381-385 (In Japanese).
- TAMURA, M., 1933, Studies on an artificial culture of worms used as bait. *Bull. Hiroshima. Pref. Fish. Exp. St.*, 12: 185-199 (In Japanese).
- UCHIDA, H., 1992, Annelida. In, *Guide to Seashore Animals of Japan with Color Pictures and Keys*, Vol. I, ed., by NISHIMURA, S., Hoikusya, Osaka, pp. 310-379 (In Japanese).
- WOODIN, S. A., 1974, Polychaete abundance pattern in a marine soft-sediment environment: The importance of biological interaction. *Ecol. Monogr.*, 44: 171-187.

広島湾干潟におけるアカムシ（多毛綱，ビクイソメ科）の生態分布

齊藤 英俊・今林 博道

広島大学生物生産学部，東広島市 739

広島湾の干潟において，貝類捕食性多毛類アカムシの生態分布を調査した。アカムシは湾奥部から湾中央部にかけての13調査地点の大潮平均低潮面で，計46個体（体長 14.7～76.0 cm）が採集された。餌生物であるマガキ，アサリ，ムラサキイガイなどの二枚貝が混在していた。しかし，アカムシ密度とこれら二枚貝量の間には，必ずしも有意な正の相関はみられなかった。生息地の環境条件は，塩分で28.7～32.9%，中央粒径値（Md ϕ ）で-1.4～1.7および強熱減量で1.2～4.2%を示した。また，小潮平均低潮面から小潮平均高潮面にかけて，幼生期の着底場と推定されるマガキ棚およびマガキマツが存在していた。

キーワード：アカムシ，アサリ，生態分布，多毛類，マガキ，幼生着底