La mer 48 : 1-16, 2010
Société franco-japonaise d'océanographie, Tokyo

Observations of eleven *Pseudo-nitzschia* species in Tokyo Bay, Japan

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Abstract: Appearance of *Pseudo-nitzschia* species was observed in samples collected biweekly in Tokyo Bay during April 2008—August 2009. Species identification was based on morphological characteristics observed under light microscope (LM) and transmission electron microscope (TEM). This is the first time that a periodic survey of this genus at species level was done in the area. The following 11 species were found: *P. americana, P. brasiliana, P. caciantha, P. calliantha, P. delicatissima, P. galaxiae, P. fraudulenta, P. multistriata, P. multiseries, P. pseudodelicatissima and P. pungens*. The presence of five species, *P. americana, P. brasiliana, P. caciantha, P. calliantha* and *P. galaxiae* is reported for the first time in Tokyo Bay.

Keywords: *diatom, Pseudo-nitzschia species, Tokyo Bay*

Introduction

Currently there are 32 species known in the genus *Pseudo-nitzschia* (AMATO and MONTRESOR, 2008; CLEVE, 1897b; HASLE, 1965; HASLE, 1993; LUNDHOLM *et al.,* 2002a; LUNDHOLM and MOESTRUP, 2002; LUNDHOLM *et al.,* 2003; PRIISHOLM *et al.,* 2002; SKOV *et al.,* 1999; TAKANO, 1995). The type species of the genus, *P. seriata* was renamed from *Nitzschia seriata* CLEVE by PERAGALLO in (1897–1908). But it was only in 1993 that half, *i.e.,* 14 of the species were transferred from *Nitzschia* to *Pseudo-nitzschia* (HASLE, 1993).

Studies on this genus are numerous particularly in Europe and North America. In contrast studies of *Pseudo-nitzschia* in Southeast Asia remain to be scant. Notable are taxonomic works by LARSEN and NGUYEN (2004) that identified *Pseudo-nitzschia* species in Vietnam waters and PRIISHOLM *et al.* (2002) that described a new species, *P. micropora* found in Thailand. TAKANO and KUROKI (1977) found seven species of *Pseudo-nitzschia,* still under *Nitzschia* that time, in various coastal waters of Japan. These are *P. delicatissima* (*N. actydrophila*), *P. fraudulenta, P. multiseries* (*N. pungens* forma *multiseries*), *P. pungens, P. pseudodelicatissima, P. subfraudulenta,* and *P. turgidula.* Regular surveys of phytoplankton in Tokyo Bay have reported the presence of *Pseudo-nitzschia,* but their identification and enumeration have been done only at the genus level. As of this year 2010, there is no clear assessment of *Pseudo-nitzschia* species composition in Tokyo Bay. Thus the purpose of this study is to elucidate species composition of the genus *Pseudo-nitzschia* in Tokyo Bay. Descriptions and documentations put forth here are for morphometric characterizations of local populations and baseline data for future investigations of toxic or newly discovered taxa to further ecological studies of *Pseudo-nitzschia* in the area.

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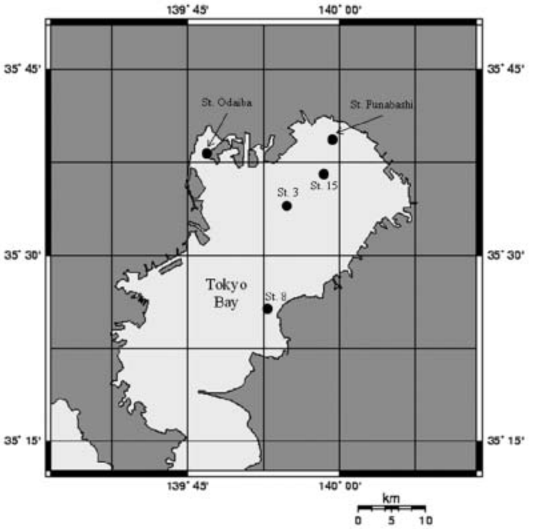


Fig 1. Map of sampling stations. (http://gmt.soest.hawaii.edu/)

Material and Methods

Field sampling

Samples collected by bucket from Odaiba station (35° 36′55″N, 139° 46′32″E) or by Van Dorn Water Sampler from Stations 3 (35° 33′16″N, 139°54′29″E), 8 (35°25′24″N, 139°51′42″E), 15 (35° 36′24″N, 139° 57′48″E) and Funabashi (35°38′43″N, 139°59′19″E) in Tokyo Bay (Fig. 1) during April 2008—August 2009 were assessed for presence of *Pseudo-nitzschia.* One liter of sample was preserved with neutralized formaldehyde at a final concentration of approximately 1 %. Another liter of sample remained unfixed for culture strains establishment.

Culture establishment

Pseudo-nitzschia cells were isolated by picking up single chains by capillary method (Throndsen, 1978). These were washed at least three times with sterilized sea water under a compound microscope and placed in 24-well plates filled with f/2 media (Guillard, 1975). When cells are numerous enough, these were then transferred to screw capped test tubes with the same media. The culture conditions were as follows: temperature 15℃ (and/or 20℃), light intensity 100 μmol photons $m^{-2}s^{-1}$ (daylight fluorescent lamps), salinity at 30 and 12L: 12D photoperiod.

Species observation and species confirmation by TEM

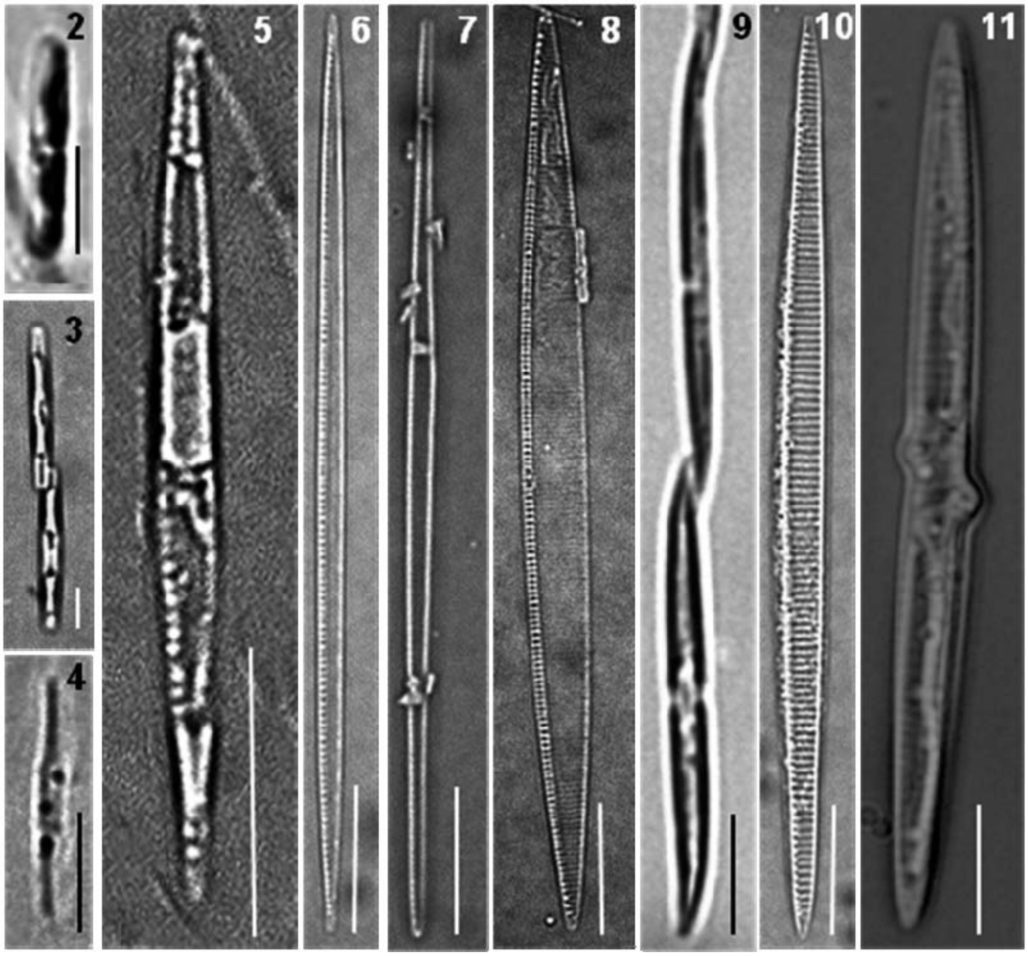
Light microscope (LM) photomicrographs were taken of live cells from the field, in culture and preserved cleaned valves devoid of organic material. Organic material was removed from the cells as follows:

Aliquots of fixed *Pseudo-nitzschia* cells from field and live cells from cultures were transferred to 15 ml centrifuge tubes. The live cells were fixed with neutralized formaldehyde. Cells were washed with milliQ water at least three times prior to acid washing. Centrifugations were done at 35,000 rpm for 10 minutes. Organic material was dissolved following Lundholm *et al.* (2002b). The condensed samples (1 ml) were treated with 0.2 ml of 30% sulfuric acid and 0.5–1 ml of saturated potassium permanganate ($KMnO_4$) solution and were left for 24 hours. And then 1–2 ml saturated oxalic acid ($(COOH)_2$) was added until the purple color turned out before the valves were washed several times with distilled water to wash out the acids. Drops of cleaned cells were mounted on formvar coated copper grids and allowed to dry. These were then observed under a JEM 2000EX JEOL Transmission Electron Microscope (TEM). General shape of a cell, its length and width, number of poroid rows, number of poroid in 1 μm, number of interstriae in 10 μm, number of fibulae in 10 μm and inner poroid features were measured and noted. *Pseudo-nitzschia* species were identified the following several manuals and recent articles (Hasle and Syvertsen, 1997; Skov *et al.,* 1999; Lundholm *et al.,* 2002a and 2003; Amato and Montresor, 2008).

Results

Culture strains

Ten species out of the 11 species of *Pseudo-nitzschia* found in Tokyo Bay from sampling period starting April 2008—May 2009 were established into culture (Table 1). These were the following: *P. americana* (4), *P. brasiliana* (3), *P. caciantha* (1), *P. calliantha* (6), *P. delicatissima* (1), *P. fraudulenta* (6), *P. galaxiae* (1), *P. multistriata* (2), *P. multiseries* (2) and *P. pungens* (7). Numbers in parenthesis are the number of culture strains, all non-axenic, for



Figs. 2–11. LM micrographs of 10 species.
Fig. 2. *P. americana,* Fig. 3. *P. brasiliana,* Fig. 4. *P. galaxiae,* Fig. 5. *P. caciantha,* Fig. 6. *P. calliantha,* Fig. 7. *P. delicatissima,* Fig. 8. *P. fraudulenta,* Fig. 9. *P. multistriata,* Fig. 10. *P. multiseries,* Fig. 11. *P. pungens.* Figs. 2, 3, 9: LM micrographs of live samples; Figs. 4–8, 10: LM micrographs of cleaned valves of cells in culture. Fig. 11. DIC micrograph of cell in culture. Scale bar = 10 μm.

each species. These were useful for morphometric measurements of species that rarely occurred e.g.: *P. delicatissima* and *P. galaxiae* and for tidy TEM photomicrographs. Dates of isolation provide information on the days a particular species appeared in the bay during the sampling period.

Species Descriptions

Descriptions of each species in alphabetical order follow herein. A summary of morphological characteristics of these species in Tokyo Bay is shown in Table 2. Except for *P. delicatissima* and *P. galaxiae* morphometric measurements of which are from newly established cultures, all measurements are from field samples in Tokyo Bay.

Pseudo-nitzschia americana **(Hasle) Fryxell in Hasle**

Figs. 2, 12
Lundholm *et al.,* 2002a. pp. 483–484, Figs. 1–20. Orlova and Shevchenko, 2002, pp. 336–339, Fig. 1. Kaczmarska *et al.,* 2005, pp. 4–7, Figs. 2–13, Table 1.
Synonym: *Nitzschia americana* Hasle

Table 1. Strains of *Pseudo-nitzschia*and their corresponding origin and dates of isolation.

Name	Strain No.	Origin	Date of Isolation	Collector/Isolator
P. americana	TBaM01	Tokyo Bay, JP	16 March 2009	L. Yap-Dejeto
P. americana	TBaA01	Tokyo Bay, JP	04 April 2009	L. Yap-Dejeto
P. americana	TBaA02	Tokyo Bay, JP	04 April 2009	L. Yap-Dejeto
P. americana	TBaA03	Tokyo Bay, JP	04 April 2009	L. Yap-Dejeto
P. brasiliana	TBbA01	Tokyo Bay, JP	09 April 2008	L. Yap-Dejeto
P. brasiliana	TBbS01	Tokyo Bay, JP	24 September 2008	L. Yap-Dejeto
P. brasiliana	TBbS02	Tokyo Bay, JP	24 September 2008	L. Yap-Dejeto
P. caciantha	TBcc03	Tokyo Bay, JP	18 November 2008	L. Yap-Dejeto
P. calliantha	TBcl1101	Tokyo Bay, JP	11 May 2009	L. Yap-Dejeto
P. calliantha	TBcl1102	Tokyo Bay, JP	11 May 2009	L. Yap-Dejeto
P. calliantha	TBcl2502	Tokyo Bay, JP	25 May 2009	L. Yap-Dejeto
P. calliantha	TBcl2503	Tokyo Bay, JP	25 May 2009	L. Yap-Dejeto
P. calliantha	TBcl2507	Tokyo Bay, JP	25 May 2009	L. Yap-Dejeto
P. calliantha	TBcl2508	Tokyo Bay, JP	25 May 2009	L. Yap-Dejeto
P. delicatissima	TBd05	Tokyo Bay, JP	07 July 2008	L. Yap-Dejeto
P. fraudulenta	TBfJ02	Tokyo Bay, JP	07 July 2008	L. Yap-Dejeto
P. fraudulenta	TBf1101	Tokyo Bay, JP	11 May 2009	L. Yap-Dejeto
P. fraudulenta	TBf1102	Tokyo Bay, JP	11 May 2009	L. Yap-Dejeto
P. fraudulenta	TBf2504	Tokyo Bay, JP	25 May 2009	L. Yap-Dejeto
P. fraudulenta	TBf2505	Tokyo Bay, JP	25 May 2009	L. Yap-Dejeto
P. fraudulenta	TBf2506	Tokyo Bay, JP	25 May 2009	L. Yap-Dejeto
P. galaxiae	TBg01	Tokyo Bay, JP	25 May 2009	L. Yap-Dejeto
P. multiseries	Kums	Kushimoto, JP	5 March 2008	T.OMURA/L. Yap-Dejeto
P. multiseries	TBms01	Tokyo Bay, JP	15 June 2008	L. Yap-Dejeto
P. multistriata	TBma01	Tokyo Bay, JP	21 October 2008	L. Yap-Dejeto
P. multistriata	TBma02	Tokyo Bay, JP	21 October 2008	L. Yap-Dejeto
P. pungens	TBpuA00	Tokyo Bay, JP	15 April 2008	L. Yap-Dejeto
P. pungens	TBpuA01	Tokyo Bay, JP	15 April 2008	L. Yap-Dejeto
P. pungens	TBpuA03	Tokyo Bay, JP	15 April 2008	L. Yap-Dejeto
P. pungens	TBpuJ01	Tokyo Bay, JP	07 July 2008	L. Yap-Dejeto
P. pungens	TBpuJ02	Tokyo Bay, JP	07 July 2008	L. Yap-Dejeto
P. pungens	TBpuJ03	Tokyo Bay, JP	07 July 2008	L. Yap-Dejeto
P. pungens	TBpu03	Tokyo Bay, JP	16 March 2009	L. Yap-Dejeto

Hasle, 1964, pp. 41–44, Pl. 1, Fig. 4, Pl. 14, Figs. 13–19, Pl. 15, Figs. 7–10.

Hasle, 1974, p. 427. Hasle and Syvertsen, 1997, p. 324, Pl. 73.

Morphological Description:

Cells are linear to lanceolate with broadly rounded ends with no central interspace in valve view and almost linear with cut ends in girdle view. This cell's apical axis is between 15–21 μm and transapical axis about 2.3–2.9 μm. Two rows of poroids, sometimes three are present in striae (circled with arrow, Fig. 12b). Poroids in 1 μm are about 8–10. Interstriae in 10 μm are about 38–43, and fibulae in 10 μm are from 19–23.

Occurrence in Tokyo Bay:

This species was observed in March, April, June, July, August and September at temperatures of 14.5–27.5℃ and salinity at 31–34. *P. americana* is reported to for the first time here. Lundholm *et al.* (2002a) reported *P. americana* from Japan (34°50′, 139°31′) to be epiphytic to *Chaetoceros*. We also found *P. americana* to be epiphytic to some *Chaetoceros* species e.g.: *C. affinis, C. lorenzianous, C. socialis* among others from Tokyo Bay (Fig. 23).

Remarks:

This species was first described as *Nitzschia americana* by Hasle in 1964. It was recently redefined by Lundholm *et al.* (2002a) to separate two species within *P. americana* complex, *P. brasiliana* and *P. linea*.

Table 2. Morphometric characteristics of the eleven species observed during April 2008- August 2009 in Tokyo Bay. Numbers in italics found below an entry are from original descriptions of the species. (*Amato *et al.*, 2007; ** based from photomicrograph of original description)

	Shape	central interspace	length (μm)	width (μm)	rows of poroids	poroids in 1 μm	Interstriae in 10 μm	Fibulae in 10 μm	poroid sectors
P. americana	linear	absent	15–21	2.3–2.9	2–3	8–10	38–43	19–23	
(n=18)			*16–24*	*2.5–4.5*	*2–3*	*8–10*	*26–31*	*18–24*	
P. brasiliana	linear	absent	23–52	2.4–3	2–3	7–8.5	24–26	19–24	
(n=14)			*12–65*	*1.8–1.6*	*2–3*	*7–10*	*20–26*	*20–26*	
P. caciantha	lanceolate	present	32–33	2.1–2.2	1	3–5	32–35	16–19	2–6
(n=6)			*53–75*	*2.7–3.5*	*1*	*3.5–5*	*28–31*	*15–22*	*2–6**
P. calliantha	linear	present	69–87	1.3–2.3	1	3–5	32–39	15–20	4–13
(n=50)			*44–86*	*1.4–4.7*	*1*	*4–6*	*34–39*	*17–22*	*several*
P. delicatissima	linear	present	50–65	1.3–1.5	2	11–12	36–38	23–25	
(n=20)			*40–78*	*1.1–2*	*2*	*10–12*	*36–41*	*19–25*	
P. fraudulenta	spindle-shaped	present	55–89	3.4–10	2–3	4.5–7	21–27	19–25	
(n=26)			*50–119*	*4.5–10*	*2–3*	*5–7*	*18–24*	*12–24*	
P. galaxiae	lanceolate	present	24–25	1.5–1.6	—	—	55–57	15–16	
(n=20)			*25–41*	*1.2–1.7*			*56–64*	*16–26*	
P. multistriata	linear	absent	47–53	2.3–3.2	2	9–12	40–42	24–29	
(n=44)			*55–65*	*3.1–3.6*	*2*	*11***	*37–42*	*23–26*	
P. multiseries	linear-lanceolate	absent	76–89	2.9–5.6	3–6	5–6	11–16	12–16	
(n=22)			*68–140*	3.4–6	3–4	4–6	10–19	10–19	
P. pungens	linear-lanceolate	absent	70–92	2.9–5	2	3–5	11–17	12–17	
(n=32)			*74–174*	*2.4–5.3*	*1–2*	*3–4*	*9–16*	*6–16*	
P. pseudodeli-	linear	present	—	1.8	1	4–4.8	30	16	2
catissima (n=1)			*50–140*	*0.9–1.6*	*1*	*4–6*	*30–46*	*14–16*	*2*

Type locality of *P. americana* is in Atlantida, Uruguay (Lundholm *et al.,* 2002a). *P. americana* is a common epiphyte on *Chaetoceros, Odontella* (Lundholm *et al.,* 2002a) and sometimes *Bacteriastrum* (Fryxell *et al.,* 1990; Hasle and Syvertsen 1997). It has been found in tropical to temperate waters in the world (Lundholm *et al.,* 2002a).

Pseudo-nitzschia brasiliana Lundholm, Hasle and Fryxell

Figs. 3, 13

Lundholm *et al.,* 2002a, pp. 484–487, Figs. 21–45.

Larsen and Nguyen, 2004, pp. 30–31, Pl. III, Figs. 1, 3–4. Villac *et al.,* 2005, pp. 139–145, Figs.2–3. Quijano-Scheggia *et al.,* 2009a, pp. 100–107, Fig. 2.

Morphological Description:

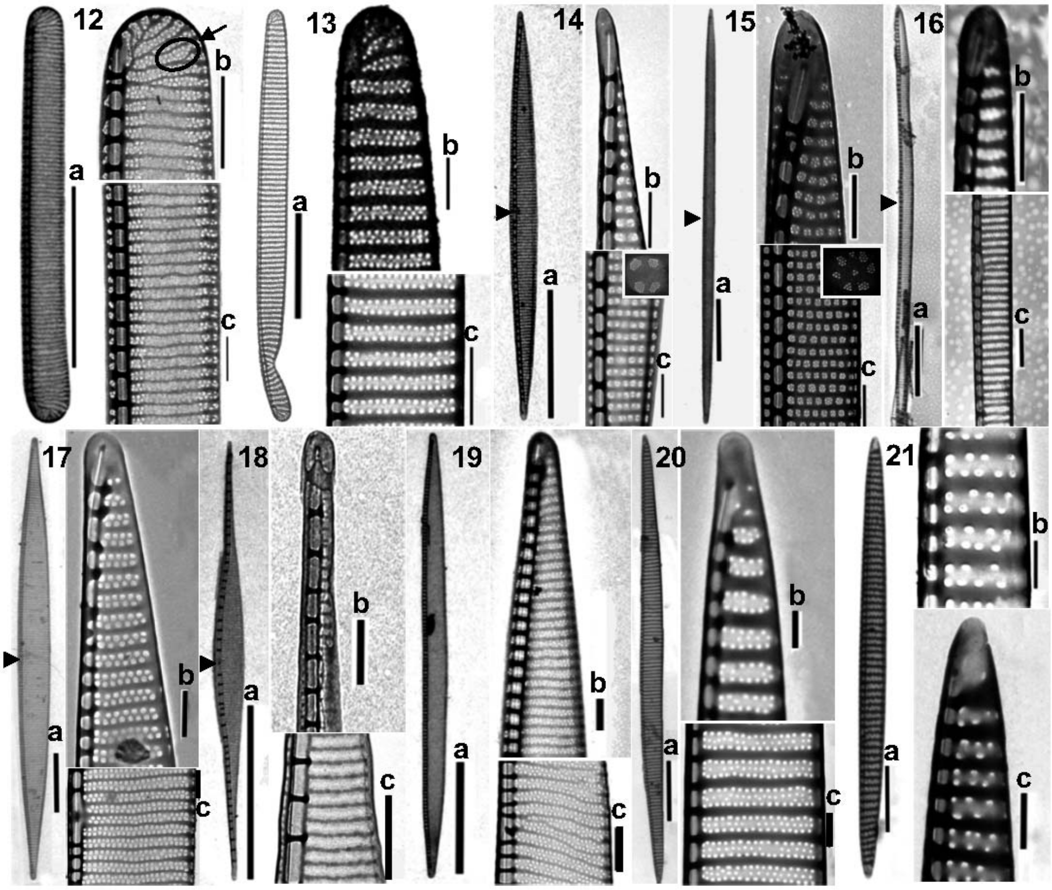
Cells are broadly linear, cigarette-shaped with broadly rounded tips in valve view and linear with truncate ends in girdle view. Apical axis is from 23–52 μm and transapical axis at 2.4–3 μm. No central interspace is found. Two rows of poroids, sometimes three near the border between valve face and mantle can be clearly seen under TEM (Fig. 13b). Poriods in 1 μm are about 7–8.5 small and closely spaced. Interstriae in 10 μm are about 24–26 and the fibulae in 10 μm are in the range of 19–24. Overlap of chains is within 1/8–1/11 of the cell's length.

Occurrence in Tokyo Bay:

This species was observed during the months of April, July, and September at temperatures of 14.5–26.4℃ and salinity at 33–34. *P. brasiliana* is reported for the first time here.

Remarks:

The approximately equal number of fibulae and striae, the coarser silicification, the single row of poroids in the girdle bands, the slightly longer length, the formation of stepped colonies and the planktonic mode of living are



Figs. 12–21. TEM micrographs of species observed in Tokyo Bay brought in culture.
A set of micrographs per species consists of: the whole valve (a), valve tip (b), and a section of the valve showing pores (c). Fig. 12. *P. americana* (arrow point to circled striae with 3 rows of poroids), Fig. 13. *P. brasiliana* Fig. 14. *P. caciantha,* Fig. 15. *P. calliantha,* Fig. 16. *P. delicatissima,* Fig. 17. *P. fraudulenta,* Fig. 18. *P. galaxiae,* Fig. 19. *P. multistriata,* Fig. 20. *P. multiseries,* Fig. 21. *P. pungens*. Scale bars: (a) = 10 μm; valve section showing pores and tip (b and c) = 1 μm. Arrowheads point to central interspaces, respectively.

features distinguishing *P. brasiliana* from *P. americana* under LM. *P. brasiliana* differs from *P. americana* under EM by the morphometric measurements found in Table 2.

Type locality of this species is in Sepetiba Bay, Brazil (LUNDHOLM *et al.,* 2002a). *P. brasiliana* is distributed mainly in warmer waters. Brazil, Vietnam, Gulf of Panama, Gulf of Mexico, Gulf of California, Vietnam, Indonesia (Jakarta Harbour), Thailand and Jinhae Bay, and S. Korea (LUNDHOLM *et al.,* 2002a).

Pseudo-nitzschia caciantha **LUNDHOLM, HASLE and FRYXELL**

Figs. 5, 14

LUNDHOLM *et al.,* 2003, pp. 806–809, Figs. 5 A-F, Table 2.

Synonym: *P. pseudodelicatissima* (HASLE) HASLE 1993 pro parte

Morphological Description:

Cells at valve view are lanceolate tapering from the middle towards the tips and appear almost asymmetrical. A central interspace is present (Fig. 14a, arrowhead). Its apical axis is around 32–33 μm and around 2.1–2.2 μm transapical axis. One row of poroid is found in striae. Poroids are large and are 3–5 in every 1 μm partly closed by a membrane with 2–6 sectors of poroid hymen (Fig. 14c). Interstriae in 10 μm are about 32–35, while fibulae in 10 μm are about 16–19.

Occurrence in Tokyo Bay:

This species was observed in Tokyo Bay during the months of July and November at temperatures of 16.9–24.1℃ and salinity at 31–33. *P. caciantha* is reported for the first time here.

Remarks:

This species was described by LUNDHOLM *et al.* (2003) from *P. pseudodelicatissima* complex. *P. caciantha* is distinguished from the "true" *P. pseudodelicatissima* by morphometric measurement observed under EM (Table 2).

The morphometric measurements of *P. caciantha* from this study matched up more with a newly described species, *P. mannii* (AMATO and MONTRESOR, 2008) than with *P. caciantha* in terms of length: measurements for this species was at 32–38 μm, *P. manni* was at 33–130 μm while *P. caciantha* was at 53–75 μm; width: this study at 2.1–2.2 μm, *P. manni* at 1.7–2.6 μm, *P. caciantha* at 2.7–3.5 μm; interstriae in 10 μm: this study at 32–38, *P manni* at 30–40, *P. caciantha* at 28–31 and fibulae in 10 μm: this study at 16–19, *P. manni* at 17–19, *P. caciantha* at 15–22. But according to AMATO and MONTRESOR (2008), *P. manni* is primarily differentiated from *P. caciantha* in three aspects: (1) the valve shape which is linear in *P. manni* while lanceolate in *P. callianatha,* (2) cell width, and (3) the pattern of sectors in *P. caciantha* where the poroids do not bear a central sector while *P. manni* has 3.6% poroids bearing central sectors. Our strain is lanceolate and all poroids do not have a central sector. Thus this was identified as *P. caciantha.*

Type locality of this species is Off Tuxpam, Mexico (LUNDHOLM *et al.,* 2003). This was found in Mexico, Andaman Sea, near Phuket Island Thailand (LUNDHOLM *et al.,* 2003).

Pseudo-nitzschia calliantha **LUNDHOLM, MOESTRUP and HASLE**

Figs. 6, 15

LUNDHOLM *et al.,* 2003, pp. 801–804, Figs. 2, A-G, Table 2.
BARGU *et al.,* 2002, pp. 480–482, Figs. 1–2.
LARSEN and NGUYEN, 2004, pp. 32–33, Figs. 5–8.
CAROPPO *et al.,* 2005, pp. 763–774, Figs. 3a and c. FEHLING *et al.,* 2006, pp. 32–33, Figs. 5–8.
BESIKTEPE *et al.,* 2008, p. 440, Figs. 2–3.
Synonym: *P. pseudodelicatissima* (HASLE) HASLE 1993 pro parte
HASLE *et al.,* 1996, pp. 149–150, Figs. 26–29, 76–81, Tables 1, 2, 8.
SKOV *et al.,* 1999, pp. 13–15, Figs. 10A-G. PHLIPS *et al.,* 2004, pp. 41–42, Fig. 2.

Morphological Description:

Cells at valve view are straight and linear and abruptly taper to rounded tips. A central interspace is present (Fig. 15a, arrowhead). A single row of poroids and about 3–5 large poroids in 1 μm are found in striae. Each poroid is divided by hymen to form "flower (calliantha) like appearance, with one "central disc" and about four to 13 "petals" around it (Fig. 15c). Interstriae in 10 μm are about 32–39; fibulae in 10 μm are from 15–20. Its apical axis is runs from 69–87 μm and transapical axis at 1.3–2.3 μm.

Occurrence in Tokyo Bay:

This species was observed during the months of May, June, July, August, September and November at temperatures of 17.8–27.5℃ and salinity at 31–33. *P. calliantha* is reported for the first time here.

Remarks:

P. calliantha is distinguished from the "true" *P. pseudodelicatissima* by the following features observed under EM: Poroids in 1 μm for *P. calliantha* is 4–6 while for *P. pseudodelicatissima,* it was 5–6. Interstriae in 10 μm for *P. calliantha* are 34–39 while *P. pseudodelicatissima* is at 36–43. Fibulae in 10 μm for *P. calliantha* are at 17–22 while *P. pseudodelicatissima* is at 20–25. Inner poroid sectors of *P. calliantha* are 7–10 with central poroid sector while *P. pseudodelictassima* has only two sectors.

Type locality of this species is in Ejby, Isefjorden, Sealand, Denmark (LUNDHOLM *et* *al.,* 2003). This is cosmopolitan (Skov *et al.* 1999, Lundholm *et al.,* 2003).

Pseudo-nitzschia delicatissima **(Cleve) Heiden**

Figs. 7, 16

Heiden and Kolbe, 1928.

Hasle *et al.,* 1996, pp. 147–149, Figs. 23–25, 70–75, Tables 1, 2, 7. Skov *et al.,* 1999, pp. 8–13, Figs. 9A-J. Stehr, *et al.,* 2002, p. 59, Figs. 3G and H. Cusack *et al.,* 2004, pp. 58–71, Pl. V.

Larsen and Nguyen, 2004, pp. 35–36, Pl. IV, Figs 2, 4, 8. Caroppo *et al.,* 2005, pp. 765, Fig. 3C. Kaczmarska *et al.,* 2005, p. 8, Figs. 14–23. Fehling *et al.,* 2006, pp. 95–97, Fig. B. Lundholm *et al.,* 2006, pp. 467–470, Figs. 1A-G, Table 4. Schnetzer *et al.,* 2007, pp. 377–378, Figs. 4c and d.

Synonym: *Nitzschia delicatissima* Cleve

Cleve 1897 b. p. 24.

Nitzschia actydrophila Hasle

Hasle, 1965, pp. 35–37, Pl. 2, Fig. 10, Pl. 15, Figs. 19–23, Pl. 16, Figs. 3–7.

Pseudo-nitzschia arenyesis Quijano-Scheggia, Garcés, Lundholm

Quijano-Scheggia *et al.*, 2009b, pp. 506–508, Figs. 30–34.

Morphological Description:

Cells in valve view are narrow and linear-lanceolate with straight cut tips while linear with straight cut ends in girdle view. A central interspace is present (Fig. 16a, arrowhead). There are two rows of poroids (Fig. 16b) and about 11–12 small poroids in every 1 μm. Interstriae in 10 μm are about 36–38; fibulae in 10 μm are about 23–25. Apical axis around 50–65 μm and transapical axis at 1.3–1.5 μm. Overlap of chains is within 1/7–1/10 of the cell's length.

Occurrence in Tokyo Bay:

This species was observed once on the months July, 2008 at temperature of 24.1℃ and salinity at 31.

Remarks:

P. delicatissima can be easily distinguished from *P. pseudodelicatissima, P. caciantha* and *P. calliantha* by having two rows of poroids instead of one as the other three species have. It is more linear than *P. caciantha* and has wider transapical axis compared to *P. pseudodelicatissima* and *P. calliantha.* Its ends seem cut-off when viewed under LM (Fig. 7).

The name *Pseudo-nitzschia arenyesis* Quijano-Scheggia, Garcés, Lundholm is considered here as a synonym of *P. delicatissima.* Diagnosis for this name compared with *P. delicatissima* stipulates that there is no difference morphologically between *P. delicatissima* and *P. arenysensis,* but in helix I of ITS2 rDNA (Quijano-Scheggia *et al.,* 2009b). Considering that ITS2 is not transcribed and its high intraspecific variability, make this a weak criterion for species determination. Other regions of DNA should be investigated and compared. Further studies should be made to find distinguishing morphological characteristics that separates *P. delicatissima* and *P. arenyesis.*

Type locality for *P. delicatissima* is not designated. This is widely distributed in arctic (Caroppo *et al.,* 2005; Skov *et al.,* 1999), temperate (Takano and Kuroki, 1977; Fraga *et al.,* 1998; Skov *et al.,* 1999; Cusack *et al.,* 2004; Kaczmarska *et al.,* 2005; Fehling *et al.,* 2006, Schnetzer *et al.,* 2007), and subtropical waters (Hasle, 1965; Skov *et al.,* 1999; Larsen and Nguyen, 2004).

Pseudo-nitzschia fraudulenta **(Cleve) Hasle**

Figs. 8, 17

Hasle *et al.,* 1996, pp. 144–146, Figs. 17–19, 57–61, Tables 1, 2, 6.

Stehr, *et al.,* 2002, p. 59, Figs. 3G and H. Cusack *et al.,* 2004, pp. 58–72, Pl. IV, Figs. a-f. Kaczmarska *et al.,* 2005, pp. 8–11, Figs. 14–23. Fehling *et al.,* 2006, pp. 97–98, Fig. C. Congrestri *et al.,* 2008, p. 201, Figs. 2a-f.

Synonym: *Nitzschia fraudulenta* P.T. Cleve

Cleve 1897a, p. 300, Fig. 11.

Hasle 1965, pp. 15–18, Pl.1, Figs. 2–3, Pl. 4, Figs. 8–10, Pl.6,

Figs. 5–10, Pl.8, Figs. 1 3. Takano and Kuroki, 1977, p. 43, Figs. 3, 14–18.

Pseudo-nitzschia seriata var. *fraudulenta* (P.T. Cleve) H. Peragallo

H. Peragallo in H&M Peragallo, 1900.

Morphological Description:
Cells in valve view are symmetric and spindle-shaped with straight cut tips. A central interspace is present (Fig. 17a, arrowhead). Two or a few times three rows of poroids and about 4.5–7 poroids with star-shaped membranes in every 1 μm are in striae (Fig. 17b). Interstriae in 10 μm are about 21–27; 19–25 fibulae in 10 μm. Apical axis is around 55–89 μm and 3.4–10 μm transapical axis.

Occurrence in Tokyo Bay:
This species was observed in May, June and July at temperatures of 18.8–24.1℃ and salinity at 31.

Remarks:
P. fraudulenta, like *P. delicatissima* has striae which consisted of two rows of poroids and valves with central insterspace. But it is very different from *P. delicatissima* because it is wider more lanceolate or spindle-shaped; more heavily silicified than the latter, and has larger pores with star-patterned inner poroids within each pore.

Type locality of this species is in Plymouth Harbour, England (HASLE *et al.,* 1996). Reports of its occurrence include Atlantic Moroccan waters, N. Atlantic; Skagerrak (HASLE, 1965), and temperate waters (TAKANO and KUROKI, 1977; RINES *et al.,* 2002; CUSACK *et al.,* 2004; KACZMARSKA *et al.,* 2005; FEHLING *et al.,* 2006; ALMANDOZ *et al.,* 2007).

***Pseudo-nitzschia galaxiae* LUNDHOLM and MOESTRUP**
Figs. 4, 18
LUNDHOLM and MOESTRUP, 2002, pp. 596–601, Figs. 1–22.
CERINO *et al.,* 2005, pp. 347–39, Figs. 1A-E, 2A-H.

Morphological Description:
Cells in valve view are lanceolate with rostrate apices. A central interspace is present (Fig. 18a, arrowhead). Rows of poroids are tiny, about 3–4 μm wide. Poroids are very tiny (Fig. 18c) and spread all over the valve. These are difficult to count. Interstriae in 10 μm is about 55–57 and fibulae in 10 μm is about 15–16 and barely seen in LM. This tiny cell has an apical axis of around 24–25 μm and 1.5–1.6 μm transapical axis. Chains of about 2–4 cells were observed in culture.

Occurrence in Tokyo Bay:
This species was observed once in May, 2009 at temperature of 18.8℃ and salinity at 31.

Remarks:
P. galaxiae is also a tiny species almost the same size as *P. americana* and *P. brasiliana.* Under the LM, it may be mistaken for *P. brasiliana* as it is also planktonic and form short chains. But it is very different from *P. americana* and *P. brasiliana* when viewed under the EM. *P. galaxiae* has a central interspace while the two other species do not have one. Its shape tapers to rostrate ends while the former two species are linear. *P. americana* and *P. brasiliana* have distinctly round poroids arranged in two rows. But *P. galaxiae* have very tiny poroids scattered all over the valve which are not arranged in rows.

Type locality for this species is in Off Tuxpam, Mexico (LUNDHOLM and MOESTRUP 2002). This is also found in Caribbean coast of Mexico off Tuxpam; Sydney, N.S.W. Australia; Bay of Naples, Italy (LUNDHOLM and MOESTRUP 2002; CERINO *et al.,* 2005).

***Pseudo-nitzschia multistriata* (TAKANO) TAKANO**
Figs. 9, 19
TAKANO, 1995, pp. 73–74. RHODES *et al.,* 1998, pp. 463–465, Figs. 1A-F. LARSEN and NGUYEN, 2004, pp. 41–43, Pl. VII, Figs. 1–4.
Synonym: *Nitzschia multistriata*
TAKANO, 1993, pp. 39–41, Figs. A-E, Table 1.

Morphological Description:
Cells at valve view are narrow, linear, tapering near the ends for a longer or shorter distance towards rounded apices. There is no central interspace. Two rows of poroids and about 9–12 poroids are found in 1 μm (Fig. 19c). Interstriae in 10 μm are about 40–42, and fibulae in 10 μm range from 24–29. Apical axis is around 47–53 μm and transapical axis at 2.3–3.2 μm. There are also two types of *P.*

multistriata encountered here as originally described: one with uniform striations and another with uneven striations (Figs. 24 a and b).

Occurrence in Tokyo Bay:

This species was observed in June, July, August, September and October at temperatures of 19.9–27.5℃ and salinity at 31–34.

Remarks:

P. multistriata may be distinguished by its curved ends or characteristic sigmoid shape when observed in girdle view under LM (Fig. 19). Valves of this species have striae which consisted of two rows of poroids similar to *P. fraudulenta* and *P. delicatissima.* Unlike these two species, *P. multistriata* has no central interspace.

Type locality for this species is in Fukuoka Bay, Japan (TAKANO, 1993). Reports of its distribution include China (QI *et al.* 1996), Gulf of Naples, Italy (SARNO and DAHLMANN, 2000), Japan, Korea, Malaysia, Vietnam (LARSEN and NGUYEN, 2004) and in Sea of Japan (ORLOVA *et al.,* 2008).

Pseudo-nitzschia multiseries **(HASLE) HASLE**
Figs. 10, 20
SKOV *et al.,* 1999, pp. 15–17, Figs. 11A, B, G, I.
STEHR, *et al.,* 2002, p. 58, Figs. 2 B and C.
KACZMARSKA *et al.,* 2005, pp. 11–12, Figs. 30–34.
Synonym: *Nitzschia pungens* f. *multiseries* G. R. HASLE 1965
HASLE, 1965, pp. 14–15, Pl. 2, Figs. 1–2, Pl.5, Figs. 10–12, Pl. 6, Fig.4, Pl. 7, Figs. 9–11.
TAKANO and KUROKI, 1977, p. 43, Figs. 2, 10, 12–13 vix 9, 11.
Pseudo-nitzschia pungens f. *multiseries* G.R. HASLE 1993
HASLE, 1993, p.39. VILLAC *et al.,* 1993, pp. 215–217, Figs. 1–2.

Morphological Description:

Cells are symmetric and linear-lanceolate in both the valve and girdle views. There is no central interspace. Apical axes are at 76–89 μm and transapical axis at 2.9–5.6 μm. Three (Fig. 20c) and up to six (not in photo) rows of poroids are found in a striae with about 5–6 poroids in every 1 μm (Fig. 20c). Interstriae in 10 μm are about 11–16, fibulae about 12–16 in 10 μm.

Occurrence in Tokyo Bay:

This species was observed in April, May, June, July, August and September at temperatures of 14.5–27.5℃ and salinity at 31–34.

Remarks:

P. multiseries was formerly called as *P. pungens* f. *multiseries* (HASLE, 1965). This is now considered as a separate species from *P. pungens* based on morphological, physiological and genetic data (HASLE, 1995). Morphological characteristics that separate *P. multiseries* from *P. pungens* are the different number of rows of poroids (HASLE, 1965). *P. multiseries* has three and as many as six rows of poroids especially near the border between valve face and mantle. *P. pungens* has three to four poroids in 1 μm while *P. multiseries* has four to six poroids in 1 μm.

Type locality of this species is in Drøbak, Oslofjord, Norway. Reports of its distribution are mainly in temperate waters (HASLE, 1965; SKOV *et al.,* 1999; TAKANO and KUROKI, 1977; KOTAKI *et al.,* 1996; ORLOVA *et al.,* 2008).

Pseudo-nitzschia pungens **(GRUNOW ex CLEVE) HASLE**
Figs. 11, 21
HASLE *et al.,* 1996, pp. 138–140, Figs. 3–6, 30–37, Table 1–3.
SKOV *et al.,* 1999, pp. 17–19, Figs. 11C-F, H.
STEHR, *et al.,* 2002, pp. 57–58, Figs. 2A and B.
CUSACK *et al.,* 2004, pp. 58–63, Pl. 1, Figs. a-j, Table 2. LARSEN and NGUYEN, 2004, pp. 43–45, Pl. VIII, Figs. 1–3.
CHEPURNOV *et al.,* 2005, pp. 382–383, Figs. 3, 4–6, Table 2. KACZMARSKA *et al.,* 2005, p. 16, Figs. 48–52.
Synonym: *Nitzschia pungens* Grunow ex P.T. CLEVE 1897b
HASLE, 1965, pp. 12–14, Pl. 1, Figs. 4–5, Pl. 5, Figs. 7–9, Pl. 6, Fig. 3, Pl. 7, Figs. 1–8.

Morphological Description:

Cells are symmetric and linear to lanceolate in both the valve and girdle views. Apical axis is around 70–92 μm and transapical axis at 2.9–

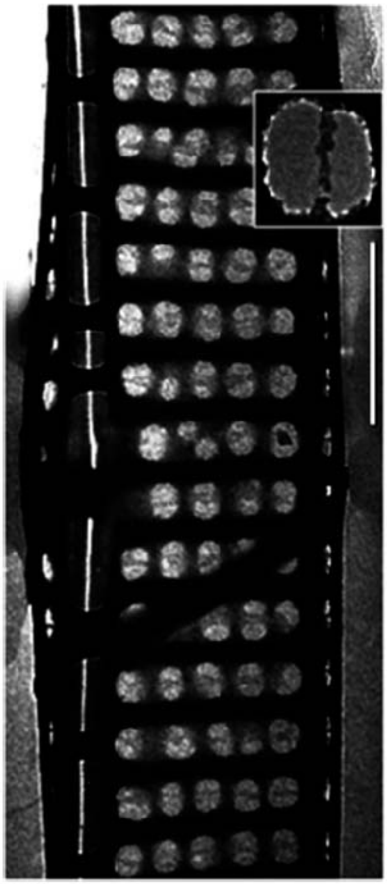


Fig. 22. TEM micrograph of a valve section of *P. pseudodelicatissima* showing pores and inner pore feature divided into two. Scale bar = 1 µm.

5 µm. No central interspace can be observed. Two rows of poroids are present (Fig. 21c) and about 3–5 poroids in every 1 µm are counted (fig. 21b) under the TEM. Interstriae in 10 µm are about 11–17; fibulae at 12–17. Overlap of chains is within 1/3–1/4 of the cell's length.

Occurrence in Tokyo Bay:

This species was observed in March, April, May, June, July, August and September at temperatures of 12.3–27.5℃ and salinity at 31–34.

Remarks:

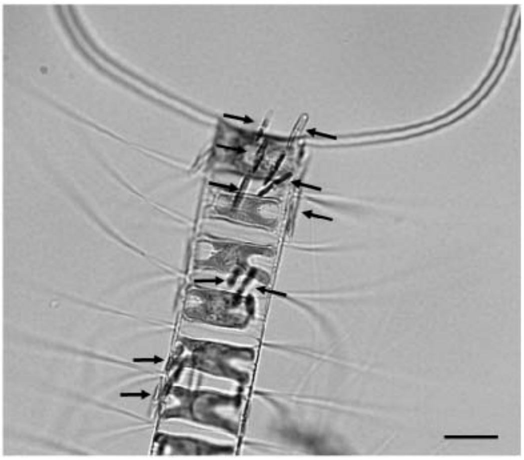


Fig. 23. LM micrograph of *P. americana* (shown by arrows) epiphytic to *Chaetoceros affinis*. Scale bar = 20 µm.

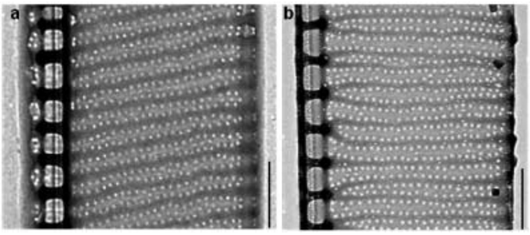


Fig. 24. TEM micrograph of *P. multistriata* (a) regular striations of interstriae, (b) irregular striations of interstriae. Scale bar = 1 µm.

P. pungens has larger pores and is the most heavily silicified based on sharpness of TEM micrographs among all Pseudo-nitzschia species in this study. The interstriae of this species are widely spaced as another species, *P. multiseries*. This, plus the resemblance with size and shape made these two species appear similar. The number of rows of poroids distinguishes *P. pungens* from *P. multiseries* (Figs. 20c, 21c). *P. pungens* has two rows of poroids that consisted of larger poroids while *P. multiseries* has three or more.

Type locality of this species is in Yeddo Bay (Tokyo Bay), Japan (Hasle, 1965). Hasle and Fryxell in 1995 reported this to be a cosmopolitan species. This was further supported by Casteleyn *et al.* (2008) who reported global distribution of one strain of *P. pungens*.

***Pseudo-nitzschia pseudodelicatissima* (Hasle) Hasle**

Fig. 22

LUNDHOLM *et al.,* 2003, p. 801. Figs. 1A-G, Table 2. non HASLE *et al.,* 1996, pp. 149–150, Figs. 26–29, 76–81, Tables 1, 2, 8. non SKOV *et al.,* 1999, pp. 13–15, Figs. 10A-G. non CUSACK *et al.,* 2004, pp. 58–63, Pl. VI, Figs. a-f. non PHLIPS *et al.,* 2004, pp. 41–42, Fig. 2. non FEHLING *et al.,* 2006, pp. 95–97, Fig. C. KACZMARSKA *et al.,* 2005, pp. 12–16, Figs. non 35–38 vix 39 non 10–47.
Synonym: *Nitzschia pseudodelicatissima* G.R. HASLE 1976
TAKANO and KUROKI, 1977, p. 44, vix Figs. 21–25.
Nitzschia delicatula HASLE 1965
HASLE, 1965, pp. 37–40, Pl. 4, Figs. 4 –5, Pl. 16, Figs. 8–18, Pl. 17 Figs. 1–16 non 14–16.

Morphological Description:

There was only one broken valve of this cell observed during the sampling period. It is linear in shap. A central interspace is present for this species (not found in micrograph). Transapical axis was at 4.8 μm. Apical axis was not measured since an intact valve was not observed. A single row of poroids was found in striae and poroids in 1 μm is about 4–4.8, divided by a membrane into 2 sectors of inner poroids. Interstriae in 10 μm were calculated to about 30 and fibulae in 10 μm at 16.

Occurrence in Tokyo Bay:

This species was observed on July, 2009 at temperature of 24.5℃ and salinity at 31.

Remarks:

P. pseudodelicatissima is recently emended by LUNDHOLM *et al.* (2003). This species was split in three; *P. pseudodelicatissima, P. caciantha* and *P. calliantha* based on inner poroid features among others. This publication distinguished these three species mainly by sectors dividing each poroid wherein 7–10 in *P. calliantha,* 2 in *P. pseudodelicatissima* and 4–5 or 2–6 (AMATO *et al.,* 2007) in *P. caciantha* with no central perforated area. It was only *P. calliantha* which had a central perforated area surrounded by similar sized sectors inside its poroid. *P. pseudodelicatissima* at 50–140 μm in length, 1.5–3.4 μm in width, 30–46 interstriae and 14–26 fibulae per 10 μm (HASLE, 1965) was emended by LUNDHOLM *et al.* (2003) to 54–87 μm length, 0.9–1.6 μm width, 36–42 and 20–25 in 10 μm respectively.

Identification of *P. pseudodelicatissima* complex before and even after LUNDHOLM *et al.,* 2003 need to be restudied to ascertain proper identification of species. For example, Figs. 1–16 in HASLE (1965) identifications in HASLE *et al.* (1996), SKOV *et al.* (1999) and PHLIPS *et al.* (2004) based on inner poroid features are clearly *P. calliantha.* Figures in, FEHLING *et al.* (2006) CUSACK *et al.* (2004) and KACZMARSKA *et al.* (2005) have four sectors and thus could be *P. caciantha* or *P. mannii* (AMATO and MONTRESOR, 2008). Inner poroid features of figures in TAKANO and KUROKI (1977) are not visible.

Type locality for this genus is in Denmark Strait. Other reports of it occurrence are near Iceland off Costa Nova, Portugal and Napoli, Italy (LUNDHOLM *et al.,* 2003).

Discussion

During the survey conducted in April 2008 —August 2009 in Tokyo Bay, 11 species of *Pseudo-nitzschia* which were critically identified using TEM are yielded. This report of 11 species found in one bay is higher compared to reports in other bays *e.g.* eight, in Irish waters (CUSACK *et al.,* 2004) and Argentina (ALMANDOZ *et al.,* 2007) and seven in Bay of Fundy, Canada (KAKZMARSKA *et al.,* 2005). Further studies of *Pseudo-nitzschia* in this area, *e.g.*. ecological in nature should prove productive. Species previously reported to produce domoic Acid are the following: *P. calliantha* (LUNDHOLM *et al.,* 2003; BESIKTEPE *et al.,* 2008), *P. delicatissima* (SMITH *et al.,* 1991), *P. fraudulenta* (RHODES *et al.,* 1998), P. galaxiae (CERINO *et al.,* 2005), *P. multistriata* (SARNO and DAHLMAN, 2000; AMATO *et al.,* 2010), *P. multiseries* (BATES *et al.,*1989; KOTAKI *et al.,* 1996), *P. pungens* (RHODES *et al.,* 1996; TRAINER *et al.,* 1998). Most of toxic *P. pseudodelicatissima* have been found to be *P. calliantha* but there are still some unresolved toxic reports that attribute to this species (e.g. KACZMARSKA *et al.,* 2005).

Five species are reported for the first time here. These are the following: *P. americana, P.*

brasiliana, P. caciantha, P. calliantha and *P. galaxiae*. Morphometric characterizations of local populations and baseline data are provided herein for future investigations of toxic or newly discovered taxa. Methods are currently devised to aid species enumeration by LM to further ecological studies of *Pseudo-nitzschia* in the area.

Acknowledgments

We thank Mr. Kenichi Hasegawa of the Chiba Prefectural Fisheries Research Center for collection of water samples from several stations in Tokyo Bay. An anonymous reviewer is acknowledged for thorough evaluation of the manuscript. This study was partially supported by a grant-in-aid for Scientific Research to Y. Fukuyo (18255012) from Japan Society for the Promotion of Science (JSPS).

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Received: November 10, 2009
Accepted: February 23, 2010

La mer 48 : 17-32, 2010
Société franco-japonaise d'océanographie, Tokyo

根室市三里浜沖海況の季節変化　I. 水温構造

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Seasonal Variations of the oceanic condition off Sanrihama Beach, Nemuro I. Temperature structure

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Abstract: The Nemuro City Fisheries Research Institute installed bottom temperature measuring sensors off Sanrihama Beach, Nemuro, in order to know seasonal variations of environmental circumstance of Hanasaki crabs. We set 8 stations along a straight line extended offshore, and the observations were made from December 28, 2005 through May 13, 2009. Depths of stations are 5, 10, 15, 20, 30, 40, 50, and 60m. STD observations were made at the time of replacement of measuring systems or at that of exchange of data loggers. Though some of measuring systems were often lost due to severe storms or due to fishing activities, we could clarify peculiar seasonal variations of temperature structure in the sea under consideration. In "summer season" or in "winter seasons", temperature is basically vertically uniform at each station, except in surface thermocline, but temperature decreases toward offshore in "summer season" and increases toward offshore in "winter season". These horizontal temperature gradients are the same as those in the flow regions of the East Hokkaido Warm Current and of the Coastal Oyashio, respectively. The phases of "summer season" and "winter season" appear to advance by about 3 months than that of the East Hokkaido Warm Current or of the Coastal Oyashio, respectively. Besides, melted water of sea ice which originated from the Okhotsk Sea cannot produce very cold water (say below 0℃) in March or in April. These findings would give valuable suggestion for studies of the East Hokkaido Coastal Current.

Keywords : *Sanrihama, Nemuro City: Continuous measurement of bottom temperature: STD observation: Seasonal variation of temperature structure: The East Hokkaido Coastal Current*

1. はじめに

根室市水産研究所は、ロシアのサハニロ（SakhNIRO）との共同研究プロジェクト「ハナサキ・プロジェクト」の一環として、ハナサキガニの成体や幼生の動向と周辺環境の関係を調べるため、根室市太平洋岸の落石岬西の三里浜の試験操業地で水深5mから60mに至る8点の測点を設けて、2005年12月28日から2009年5月13日の間、周年にわたる底層水温の連続観測を行った。当海域をしばしば襲った嵐や、漁業活動によって計測装置が流失し、全測点での完全な同時観測はほとんどできなかったが、3年半に及ぶ測定結

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果から、この海域の海況の特異な季節変化特性を明らかにすることが出来た。この結果は今後のハナサキガニの生態研究の周辺環境資料として役立つものと考えられる。また、道東沿岸流（沿岸親潮と道東暖流）の水の起源や、その形成メカニズムの考察に対して重要な示唆を与えるものである。

2. 観測地点と観測機器、観測経過

水温測定の位置と、ハナサキガニ試験操業地付近の水深図を Fig. 1 に示す。観測点は、落石岬

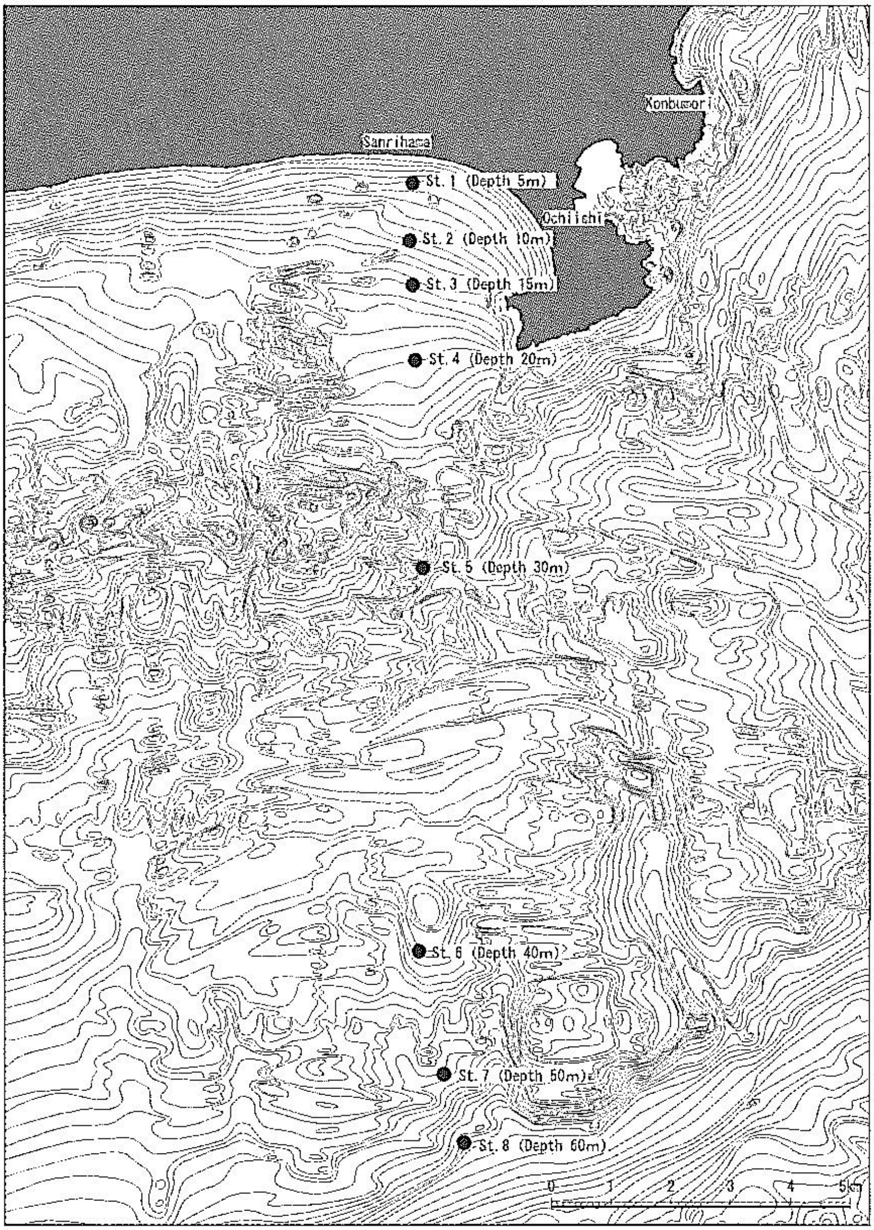

Fig. 1. Positions of the stations of bottom temperature measurement off Sanrihama Beach, Nemuro. The cape extending southward is Cape Ochiishi. Stations from St. 1 through St. 8 are set at depths of 5m, 10m, 15m, 20m, 30m, 40m, 50m, and 60m, respectively. Bottom contours are shown at interval of 1m. The horizontal scale is given at lower right corner.

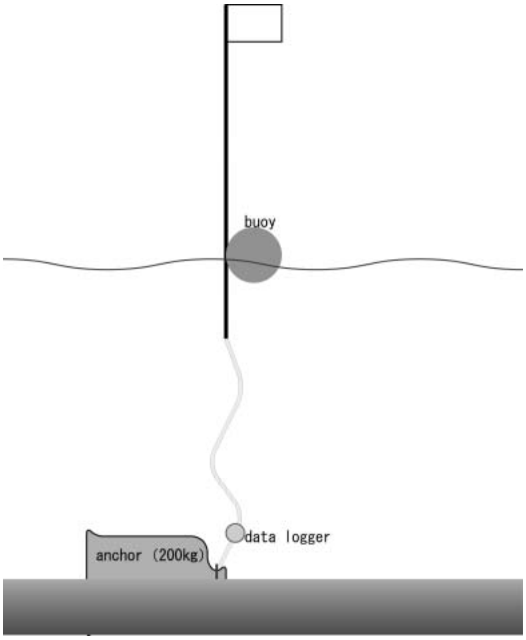

Fig. 2. Schematic view of the temperature measuring system. Temperature is measured about 50cm above the bottom.

西の三里浜から、ほぼ東経 145°29′E に沿って南に延びる線上に配置されている。一番岸よりの水深 5m のところに St. 1 が設けられ、St. 2 以下 St. 8 までの測点は、それぞれ水深 10m、15m、20m、30m、40m、50m、60m のところに設けられている。測点位置は最も岸よりの St. 1 が 43°10.9′N、145°29.6′E、最も沖の St. 8 が 43°02′N、145° 02′E である。この海域では西向流が卓越することが知られており、St. 1 から St. 4 までは落石岬による流れの影の部分にあり、St. 5 より沖の測点とは若干海況特性が異なっている。

用いた観測装置を模式的に Fig. 2 に示す。水温測定には温度センサーの付いた Onset Computer Cooperation Co. 製のデータロガー（UA-001-08 または TBI32-05-37）を用いた。温度センサーは海底から約 50cm の高さにある。測定は 2005 年 12 月 28 日から 2009 年 5 月 13 日まで実施した。最初、一年間の連続記録を一気に取ることを計画したが、2006 年 10 月 7 〜9 日に当地を襲った嵐のため、岸よりの 2 点（St.1 と St. 2）を除いて観測システムが流失し、測定記録も失われてしまった。2007 年からは、より太いロープを使うなど若干の改良を加えるとともに、データを頻繁に回収、再設置することにした。この作業等の際に、Alex Electronic Co.製の STD（ATS 200-PK）を用いて水温・塩分の鉛直プロファイルを測定した。しかし、その後も悪天候や、漁船の網に観測装置が引っかけられるなどの事故がしばしば発生した。データの取得状況を Fig. 3 に示すが、8 測点全てで同時計測ができたのは、2007 年 7 月 28 日から 12 月 1 日の期間のみであった。しかし、全期間について最低 2 測点での同時観測に成功している。データの取得状況から、St. 1 と St. 2 のみの観測が行われた 2005 年 12 月 28 日から 2006 年 12 月 7 日までを期間 I とし、St. 1 と St. 5 のみの観測が行われた 2006 年 12 月 7 日から 2007 年 7 月 26 日までを期間 II、St.

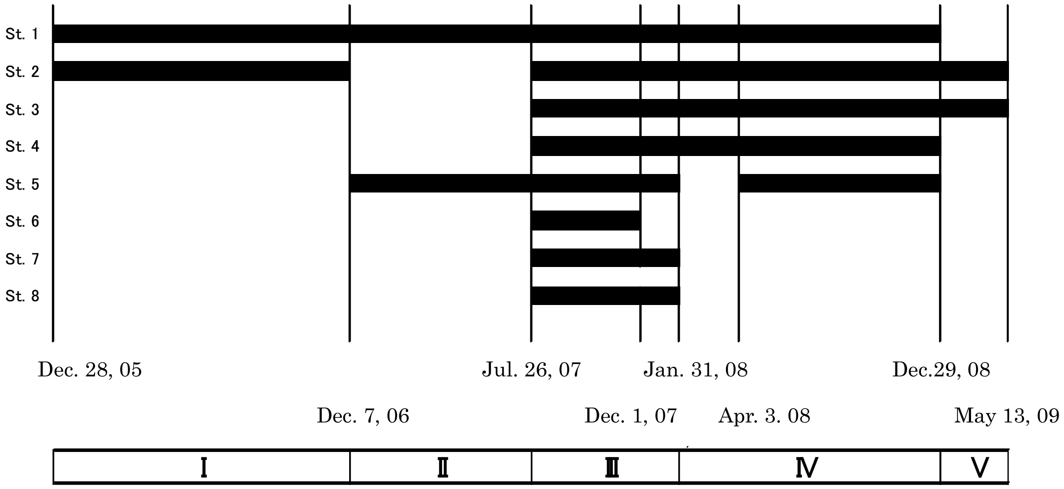

Fig. 3. Periods of data acquisition for each observation station. Roman numbers shown at the bottom of the figure indicate the periods from I to V, which are set in the text used for convenience sake.

1 から St. 8（一部 St. 6 の記録を欠く）までの観測が成功した 2007 年 7 月 26 日から 2008 年 1 月 30 日までを期間 III とする。さらに St. 1 から St. 5（一部 St. 5 記録を欠く）の記録の得られた 2008 年 1 月 30 日から 2008 年 12 月 29 日までを期間 IV、St. 2 と St. 3 のみの記録の得られた 2008 年 12 月 29 日から 2009 年 5 月 13 日までを期間 V と呼ぶことにする。これらの期間は Fig. 3 の下部に示してある。2008 年が閏年であるため、各年を全て 365 日と整えて、図の軸等の表記には、便宜上 2006 から 2008 年は各年の元日を 0 として、2009 年については 2008 年 12 月 31 日を 0 として、それから数えた日番号で表示する。（参考のため図の横軸下に月を示す。）

水温の記録間隔は 1 時間である。回収・再設置作業には約 2 時間を要する。この作業等のため欠測があった場合、3 時間までの欠測は、線形補間により内挿して連続記録にした。測定結果は、潮汐周期等の変動を除くため、各日について 0 時から 24 時までの 25 個のデータを平均して、各日の値として時系列を作成した。また、短周期変動を除去するため、さらに 15 日間の移動平均を求めて使用するが、日平均値が 1 日得られていない場合には、前後の日平均値の平均で代用して連続的な時系列を作成し、移動平均を行った。

STD 観測を実施した日を Table 1 に示す。この表の各欄には、日付（日番号）、期間番号（ローマ数字）が与えられている。水温・塩分は表面から 1m 間隔で海底近くまで観測されている。観測は底層水温の各観測点の近傍で実施したが、測点直上を避けて上記の各測点深度より、1〜2m 深めまで観測するように努めた。観測実施は 2007 年 5 月からであり、観測実施間隔は作業の都合から一定ではないが、ほぼ周年にわたる観測を行うことができた。

3. 各年の季節変化と基準季節変化

最も長期の連続観測が得られている水深 5m の St. 1 の記録を用いて、各年の季節変化を比較したのが Fig. 4 である。St. 1 の記録が利用できない 2008 年 12 月 29 日以降については、St. 2（水深 10m）の記録を代わりに用いた。日平均値の記録には、かなりの振幅の短周期変動が現れ季節変化の様相が分かりにくいので、この図では 15 日間の移動平均をかけたものを示している。各年の変動にはなおも比較的短周期の変動が残っているものの、かなりスムースな季節変動が得られている。

季節変化は各年とも、正弦曲線からかなりはずれている。3 月初め（日番号 30 付近）から 7 月末（日番号 210 付近）までの昇温期の水温上昇が直線的であるのに対して、9 月中旬（日番号 260 付近）からの下降期の曲線が、高温側に膨らむ形をしている。北海道沿岸には多くの地点で、沿岸水温の周年観測が行われており、観測結果は北海道栽培漁業振興公社から、「北海道沿岸漁場観測取りまとめ」として毎年公表されている。根室市周辺の太平洋側でも、歯舞（根室市）や厚岸、釧路に観測点があるが、これらの点での季節変化には、このような正弦波からの著しい歪みは認められない。恐らく、三里浜が外洋に開けており、外洋の条件に影響されやすく、海水の流動に伴う移流の効果が大きいことが原因であろう。年による変化は冬季水温の極小期と、夏季水温の極大期に大きく現れている。

各測点間の水温変動を比較するとき、振幅の大きな季節変動を除去しておくことが望ましい。各年について St. 1 の移動平均曲線からの差を用いることも考えたが、15 日の移動平均値に現れる短周期の変動の現れ方も見るためには、どの年に

Table 1. Dates of STD observations. Date, day number (in bracket), and period number (in Roman number) are given in each column in this order.

	2007	2008	2009
January		30 (29) III, IV	29 (29) V
February			26 (54) V
March			
April		3 (93), 30 (120) IV	
May	29 (147) II	28 (148) IV	
June		27 (178) IV	
July	28 (206) II, III	31 (211) IV	
August		28 (240) IV	
September		26 (269) IV	
October	1 (282) III	29 (302) IV	
November		26 (330) IV	
December	1 (334) III	29 (363) IV, V	

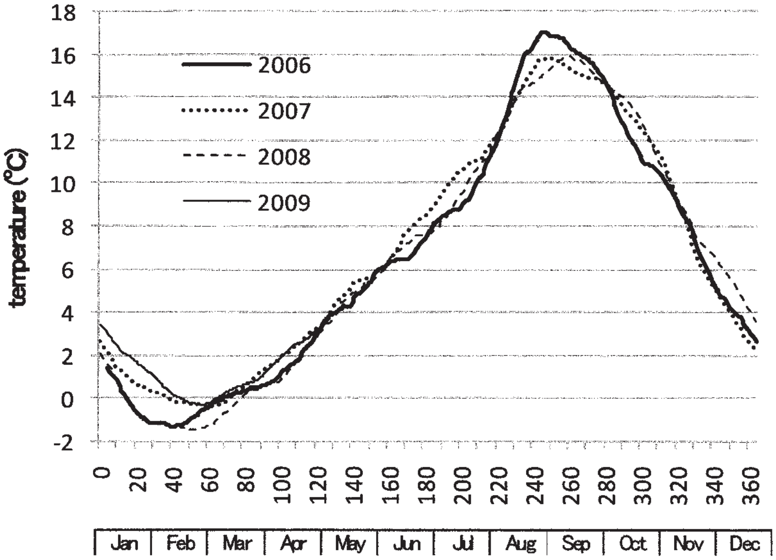

Fig. 4. Seasonal variations of the sea bottom temperature (15 days running mean) at St. 1, for 2006 (thick full line), for 2007 (dotted line), for 2008 (dashed line) and for 2009 (thin full line). The observation at St. 1 is not available after December 29, 2008, so the temperature values at St, 2 are used. The temperature (℃) is taken in ordinate, and the day number is taken in abscissa The day number is counted from January 1 for 2006 through 2008, and from Dec. 31, 2008 for 2009.

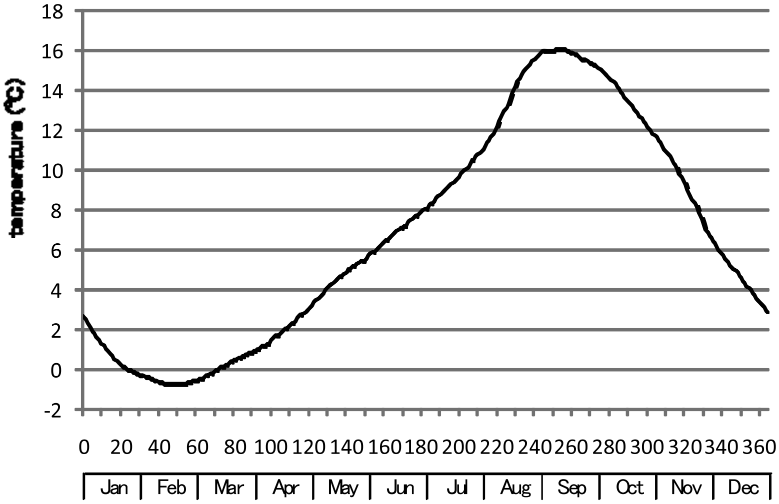

Fig. 5. Seasonal variation of the bottom temperature, which was obtained by averaging the variations at St. 1 over the period from 2005 to 2009. This curve is used as a reference curve in the following analysis.

ついても同じ基準を取ることが望ましい。そこで、Fig. 4 に示された各年の測定値を平均した季節変動を基準にすることとした。平均した季節変動を Fig. 5 に示す。正弦波からの外れはこの図にも良く現れている。平均した年数は少ないが、短周期の変動も Fig. 4 に比べて小さくなっている。

4. 各期間における底層水温変動特性

4-1.　期間 I および期間 II における水温変動

期間 I（2005 年 12 月 28 日から 2006 年 12 月 7 日）では St. 1（5m）と St. 2（10m）との 2 点、期間 II（2006 年 12 月 7 日から 2007 年 7 月 26 日）では St. 1（5m）と St. 5（30m）との 2 点しか観

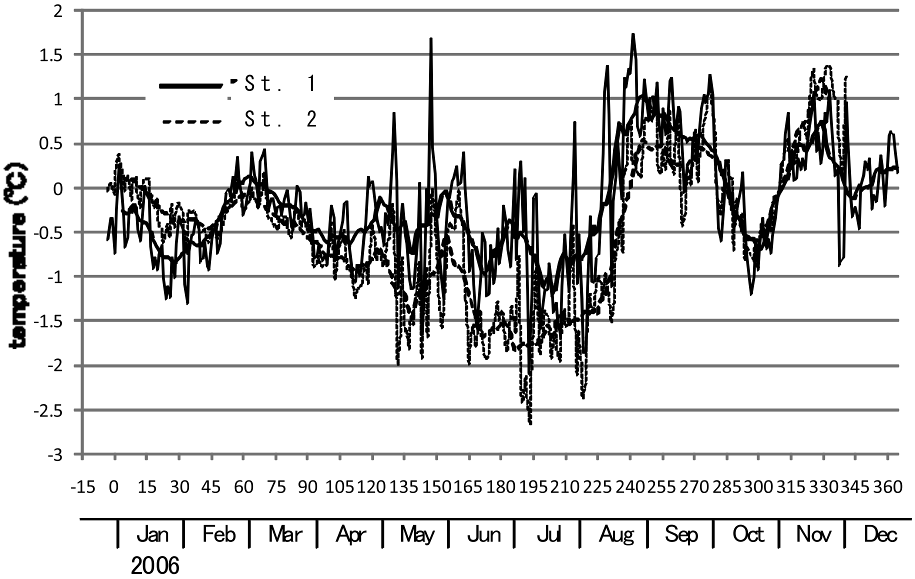

Fig. 6. Temporal variations of bottom temperature at St, 1 and St, 2 in the period I (from December 28, 2005 to December 7, 2006). Temperature values are shown as deviations from the reference curve shown in Fig. 5. Full lines indicate the temperature at St, 1 and dotted lines that at St. 2. Thin lines indicate the daily mean, and thick lines the 15 days running mean of the daily values. Temperature in ℃ is taken in ordinate, and the day number counted from January 1, 2006 is taken in abscissa.

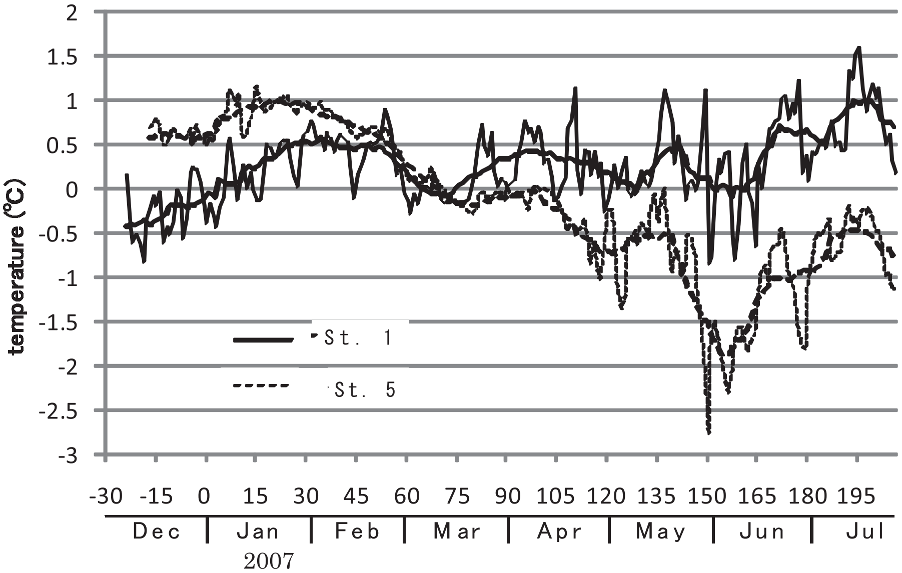

Fig. 7. Same as in Fig. 6 except for St. 1 (full lines) and St. 5 (dotted lines) in the period II (from December. 7 to July. 26, 2007). The day number is counted from January 1, 2007.

測されていない。それぞれの日平均観測値（細線）および15日間移動平均値（太線）について、基準季節変化（Fig. 5）からの偏差をFig. 6とFig. 7に示す。St. 1に対する曲線を実線で、St. 2ま

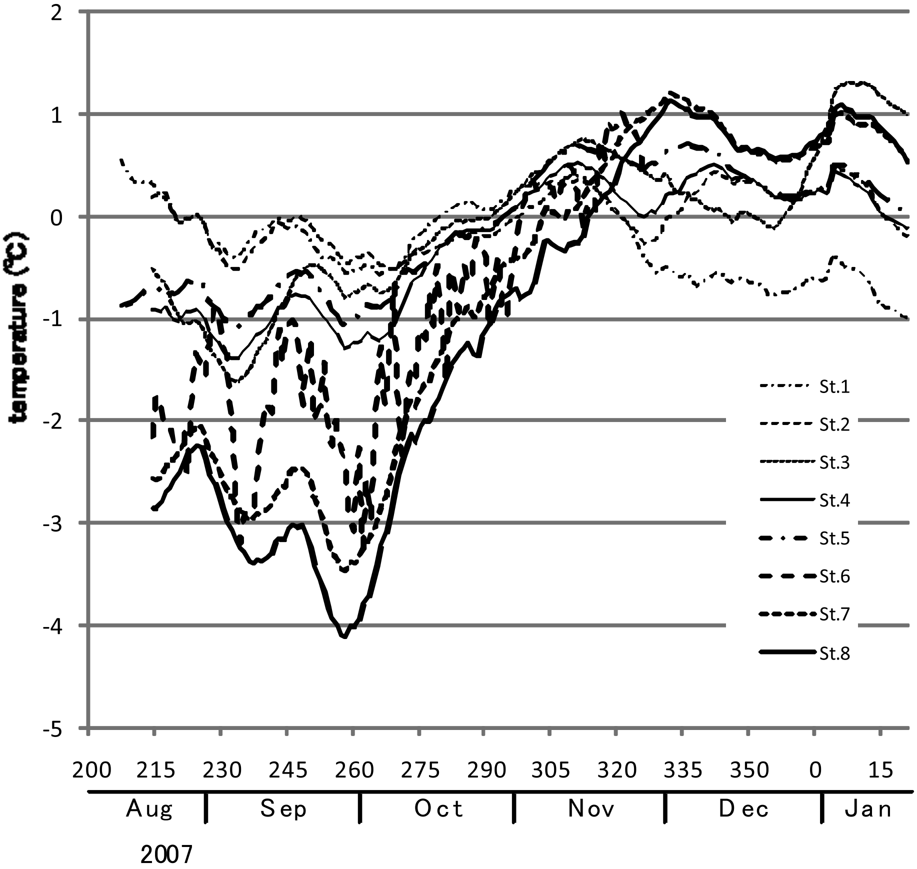

Fig. 8. Temporal variations of bottom temperature at St, 1 through St. 8 in the period III (from July 28, 2007 to January 30, 2008). Temperature values are shown as deviations from the reference curve shown in Fig. 5. Temperature in ℃ is taken in ordinate, and the day number counted from January 1, 2007 is taken in abscissa (it is reset to 0 on January 1, 2008). Thin curves indicate 4 inshore stations (dotted and dashed line is used for St. 1, dashed line for St. 2, dotted lines for St. 3 and full lines for St. 4). Thick curves indicates 4 offshore stations (dotted and dashed line for St. 5, dashed line for St. 6, dotted line for St. 7, and full lines for St. 8), respectively.

たはSt. 5に対する曲線を点線で示す。これらの図では、それぞれ、2006年1月1日、2007年1月1日を0とした日番号を横軸にとっている。水温差の値の範囲や、観測期間の違いから、両者の縦軸と横軸双方のスケールが違っていることに留意されたい。

Fig. 6とFig. 7の図の日平均値の曲線には、短周期の変動が見られる。しかし、St. 1とSt. 2、あるいはSt. 1とSt. 5を比べた時、短周期変動間にはほとんど相関は認められない。15日間移動平均した曲線にも若干のやや長い短周期変動が残っている。この変動については2地点間である程度の相関が認められるが、対応関係は明確とは言えない。季節変動に注目しているここでの議論では、15日移動平均値の変動を議論の対象とする。

期間I (Fig. 6) を見ると、15日移動平均が利用できる2006年1月5日（日番号4）から2月14日（日番号44）までの間はSt. 1の水温がSt. 2よりも低い。一方、2月26日（日番号56）から10月2日（日番号274）までの間はSt. 1の方が高い。その後、11月13日（日番号316）以降になると、再びSt. 1の水温の方が低くなる。この岸側の水温が低い傾向は、そのまま期間IIの初期にも引き継がれる。期間II (Fig. 7) では2007年3月9日（日番号67）までSt. 1の水温は沖側のSt. 5より低い。3月17日（日番号75）を過ぎると、St. 1の水温はSt. 5より高くなっ

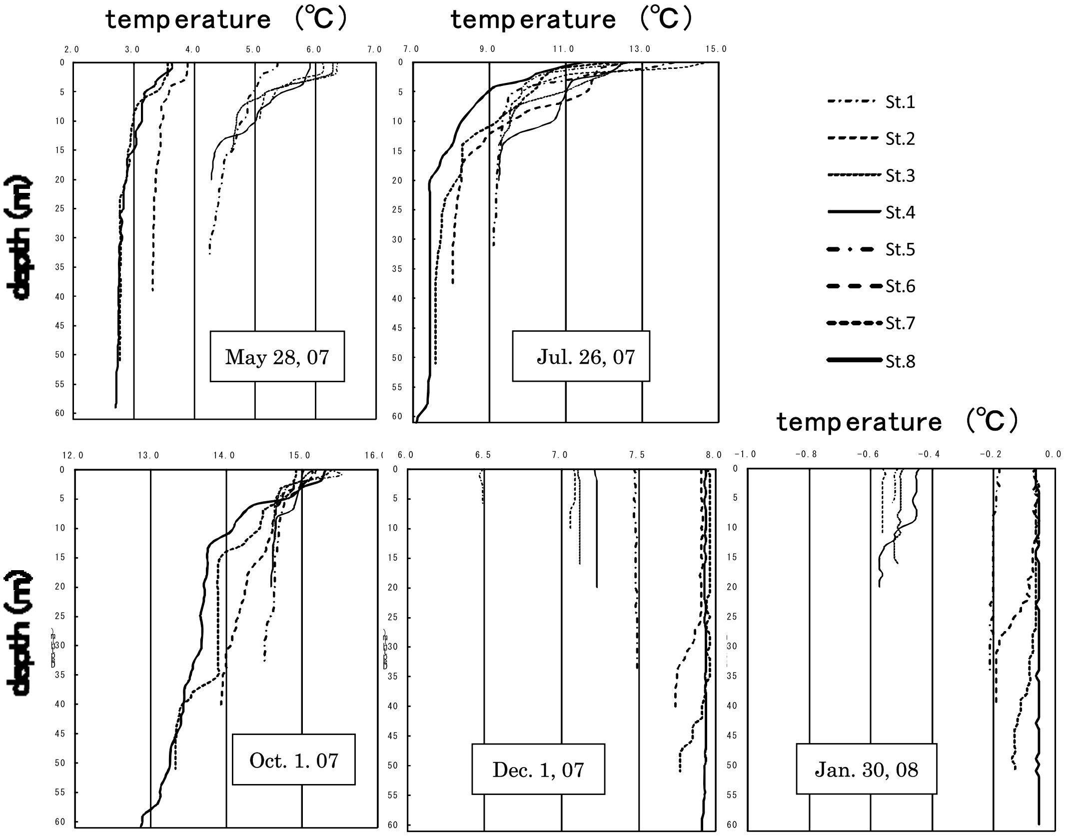

Fig. 9. Vertical temperature profiles measured with STD in the periods II (top figures) and III (bottom figures). Shown temperature range and interval of vertical lines are variable: range is from 2.0 to 7.0℃ and interval is 1.0℃ in top left figure (May 26, 2007), from 7.0 to 15.0 ℃ and 2.0℃ in top middle figure (Jul. 26, 2007), from 12.0 to 16.0℃ and 1.0℃ in bottom left figure (October 1, 2007), from 6.0 to 8.0℃ and 0.5℃ in middle bottom figure (June 31, 2008), and from −1.0 to 0.0℃ and 0.2℃ in bottom right figure (January 30, 2008), respectively. Depth range is from 0 to 61m for all figures. Thin curves indicate 4 inshore stations (dotted and dashed lines are used for St. 1, dashed lines for St. 2, dotted lines for St. 3 and full lines for St. 4). Thick curves indicate 4 offshore stations (dotted and dashed lines for St. 5, dashed lines for St. 6, dotted lines for St. 7, and full lines for St. 8), respectively.

ている。すなわち、両年とも初冬期から厳冬期にかけて（以下では簡単のため「冬季」と呼ぶ）深い方、沖側の水温の方が高くなり、春先から秋にかけて（以下では「夏季」と呼ぶ）は深い方、沖側の水温の方が低くなる。

温度成層が発達する亜熱帯域であるならば、水温は深さとともに低下するのが普通である。高緯度では、深さと共に水温が降下しても、塩分鉛直分布の効果で安定化されることが起こりやすい。しかし、現在検討している三里浜沖の状況は、次に論じるSTD観測の結果が示すように、水温・塩分の鉛直構造が主役を演じてはいなかった。表1に示すように期間IIの期間中に、5月28日（日番号147）と7月26日（日番号176、期間IIの終わり）にSTD観測を実施している。この測定結果をふくめ、期間IIと期間IIIにおいて得られた水温の鉛直分布をFig. 9に示す。期間IIにとられたものが上段の2つである。この両観測は、St. 1の水温がSt. 5の水温より高い時期（「夏季」）にとられている。この両図ともに15m以浅に明瞭な水温躍層が現れている。したがって、水深の浅い方が高温であることには、水温躍層が寄与していることが考えられる。しかし、15mより深い躍層の下側では事情が異なる（St. 5の水深は30m）。そこでは等温層が発達しており水温の鉛直勾配は小さい。この等温層の各測点の水温を比

較すると、水温は沖に向かうほど低下する。すなわち、海底水温の沖方向への減少は、水温の鉛直勾配に起因するのではなく、主として水温の岸―沖方向の水平水温勾配に起因していることが示唆されている。

ただし、水温鉛直分布の曲線は、互いに交差する場合もあり、複数の測点の曲線がほとんど重なる場合ある。また、鉛直プロファイルは瞬間値であるのに対して、底層水温値は15日間の移動平均であるから、底層の水温記録と単純に比較することはできない。

4-2. 期間IIIにおける水温変動

期間III（2007年7月28日～2008年1月30日）では、2007年12月1日（日番号334）以降ではSt. 6の記録が得られていないが、ほぼ全8測点での水温記録が得られている。各測点の底層水温の変化を、基準季節変化（Fig. 5）からの偏差として示したのがFig. 8である。最も沖のSt. 8の海底水温（太い実線）に注目してみよう。その水温偏差値は11月11日（日番号314）に0となり、それ以前の期間では8点の中で最低の水温値を示しており、それ以後ではほぼ最高の水温値を示している。一方、St.1の水温値は、11月11日の前では最高値を示し、その後では最低値を示している。したがって、前節で述べた「夏季」で海底水温は沖に向かって低下する傾向は期間IIIにおいても明らかに認められる。ただ、St. 5の水温（太い一点破線）がSt.4の水温（細い実線）より高くなっていることに見られるように、水温は沖向きに単調に低下しているわけではない。この「夏季」の底層水温の変化特性は、次の4つの測

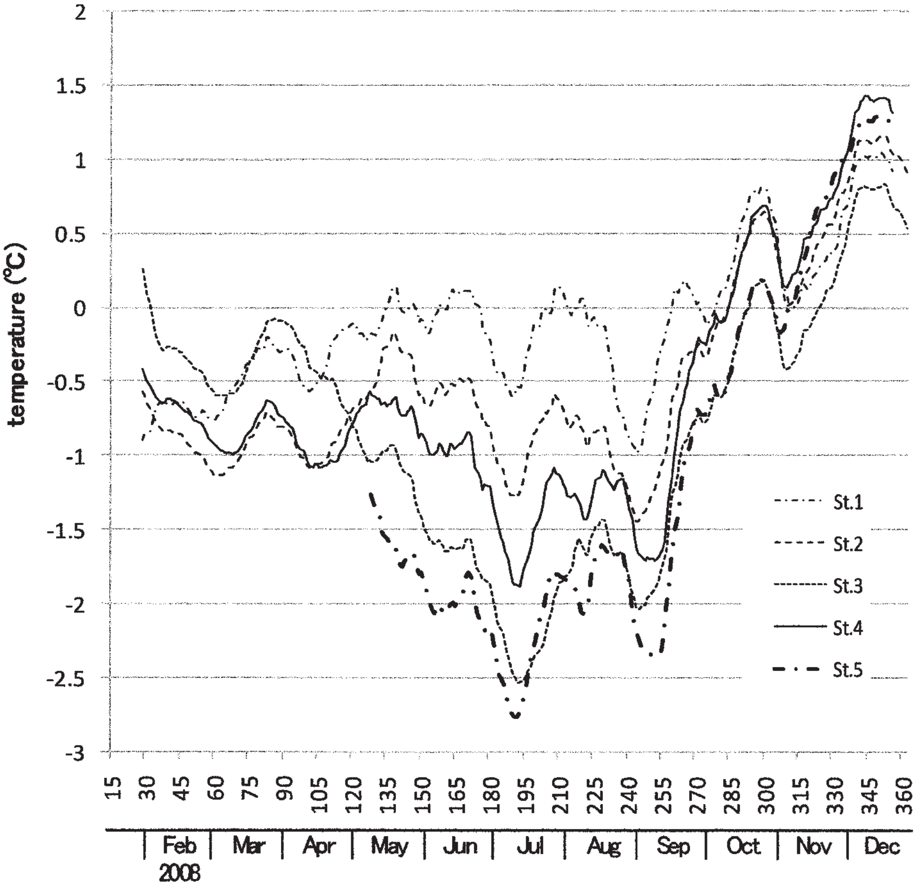

Fig. 10. Temporal variations of bottom temperature at St. 1 through St. 5 in the period IV (from January 30 to December 29, 2008). Temperature values are shown as deviations from the reference curve shown in Fig. 5. Thin dotted and dashed line is used for St. 1, thin dashed line for St. 2, thin dotted lines for St. 3 and thin full lines for St. 4, and thick dotted and dashed line for St. 5, Temperature in ℃ is taken in ordinate, and the day number counted from January 1, 2008 is taken in abscissa.

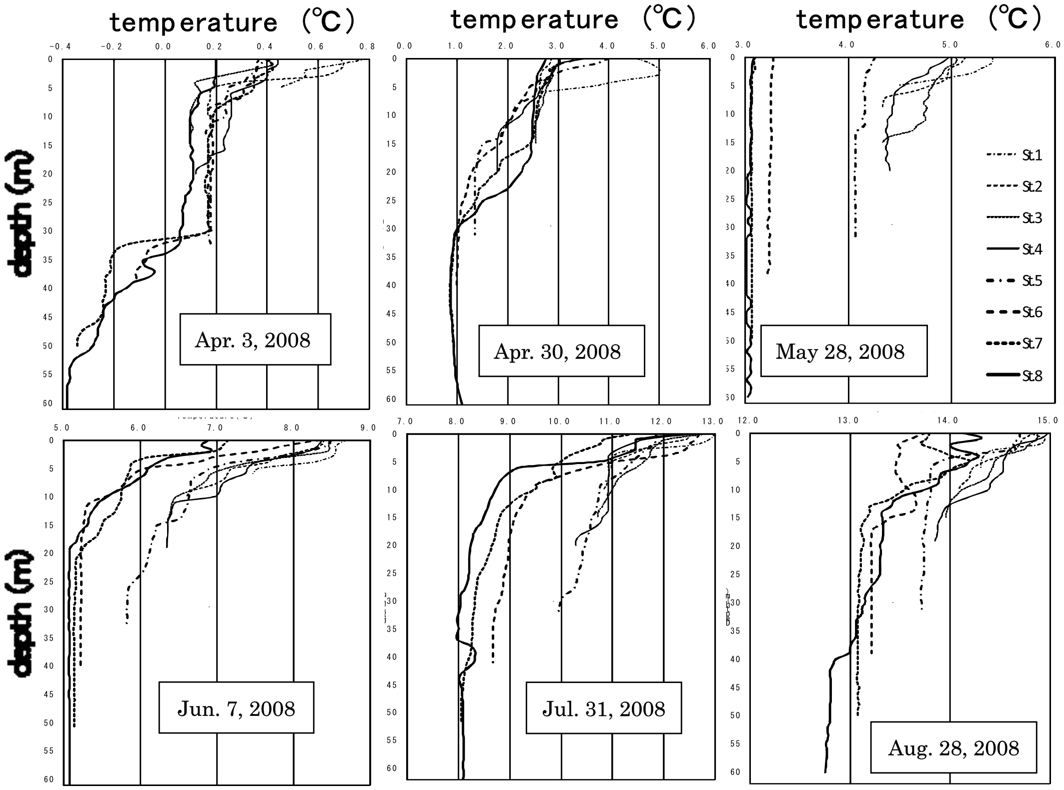

Fig. 11. Same as in Fig. 9, except for the period IV (April 3 to August 28, 2008). Temperature range is from −0.4 to 0.8℃ and interval of vertical lines is 0.2℃ in top left figure (April 3, 2008), from 0.0 to 6.0 ℃ and 1.0℃ in top middle figure (April 30, 2008), from 3.0 to 6.0℃ and 1.0℃ in top right figure (May 28, 2008), from 5.0 to 9.0℃ and 1.0℃ in left bottom figure (June 7, 2008), from 7.0 to 13.0℃ and 1.0℃ in bottom middle figure (July31, 2008), and from 12.0 to 15.0 ℃ and 1.0 in bottom right figure (August 28, 2008), respectively.

点グループ、(1) St. 1〜St. 2 、(2) St. 3〜St. 5、(3) St. 6 、(4) St. 7〜St. 8、に分けられる。Fig. 1の地形図から分かるように、St. 4より岸側は卓越する西向流に対して落石岬の影となる部分にあり、St. 5が境界で、St. 6〜St. 8はほとんど落石岬の影響を受けない地点と考えられる。複数の測点を含むグループ (1)、(2)、(4) のそれぞれのグループ内での水温差は非常に小さい。グループ (2) とグループ (4) との間の水温差は大きいが、その間のSt. 6 (グループ (3)) の水温は、短周期の振動に伴って (2) と (4) の水温の間を往復する形になっている。(2) と (4) の間に水温フロントが存在し、短周期の振動に伴って、このフロントがSt. 6の位置を繰り返して通過したものと考えられる。このようなグループ分けを行い、グループ内の小さな水温差を無視すると、水温は沖に向かってほぼ単調に低下している。11月11日 (日番号314) 以降については、St. 3の水温が12月後半から著しい高温を示すのを除けば、St. 7とSt. 8が高い水温を、中間のSt. 2〜St. 5が中位の水温を、最も岸よりのSt. 1が低い水温を示している。この場合も単調に水温が沖に向かって上昇しているわけではないが、グループ分けをして見ると、沖方向に水温が上昇するという「冬季」の特性を見てとれる。各測点における水温値偏差は1月に入ると低下を始め、期間IVの2月 (Fig. 10) になると全て負になり、そのまま次の「夏季」の状態につながってゆく。この年の「冬季」の終期は2月頃と厳冬期に起こっている。

STD観測は期間IIIの「夏季」においては、2007年7月26日と、2007年10月1日の2回行われている。7月26日については期間IIとIIIの境目で期間IIの章ですでに述べた。10月1日の結果はFig. 9下段左に示してあるが、39m以深でSt. 7とSt. 8のプロファイルが、20m以浅

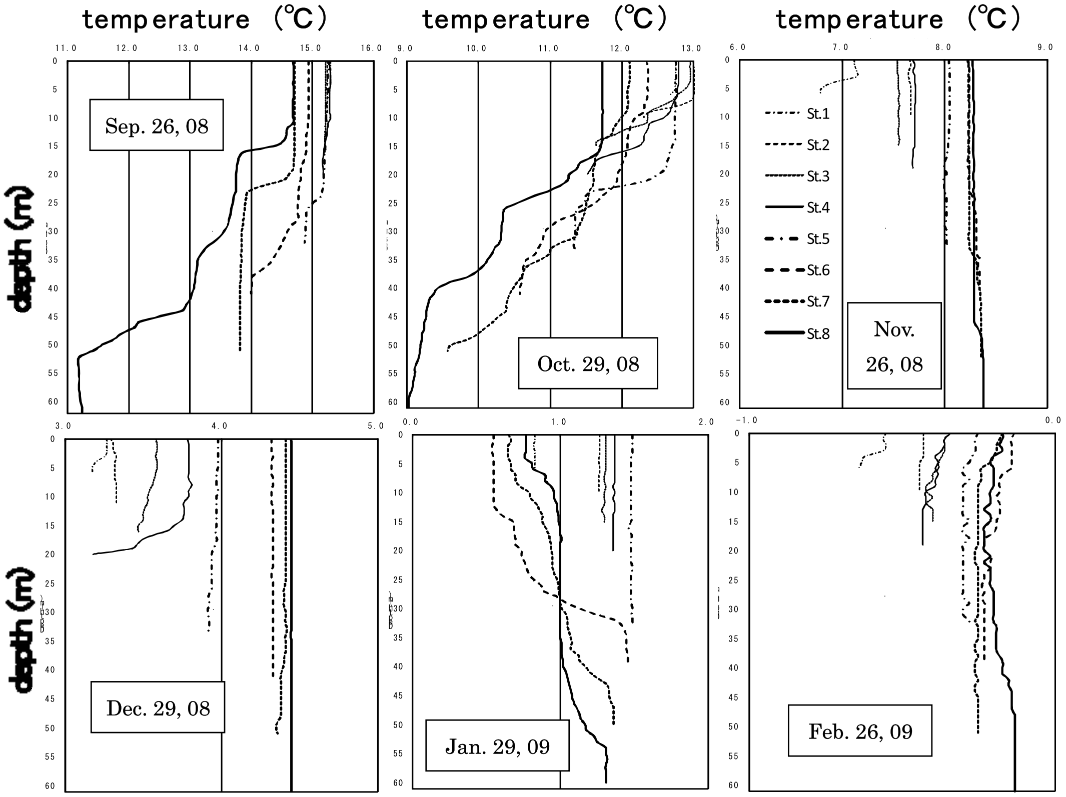

Fig. 12. Same as in Fig. 9, except for the period from September 26, 2008 to February 26, 2009 (period IV and period V). Temperature range is from 11.0 to 16.0℃ and interval of vertical lines is 1.0℃ in top left figure (September 26, 2008), from 9.0 to 13.0℃ and 1.0℃ in top middle figure (October 29, 2008), from 6.0 to 9.0 ℃ and 1.0℃ in top right figure (November 26, 2008), from 3.0 to 5.0℃ and 1.0℃ in left bottom figure (December 29, 2008), from 0.0 to 2.0℃ and 1.0℃ in bottom middle figure (January 29, 2009), and from 1−1.0 to 0.0℃ and 1.0℃ in bottom right figure (February 26, 2009), respectively.

で St. 4 と St. 5 のプロファイルが、それぞれ重なっているが、沖方向に水温が減少する傾向は明瞭に認められる。

「冬季」の時期にも 2007 年 12 月 1 日（日番号 334）および 2008 年 1 月 30 日（日番号 29）の 2 回の STD 観測が行われている。観測された水温鉛直プロファイルを Fig. 9 下段中と下段右にそれぞれ示す。「冬季」の水温プロファイルは、各測点において等温層が「夏季」よりも発達している。この等温層部分あるいは St. 6、St. 7、St. 8 では等温層より下の部分で、水温が沖に向かって上昇する傾向が明瞭に見られ、「冬季」の底層水温が沖に向かって上昇することの原因が、水温の水平勾配に起因することを示している。

4-3.　期間 IV における水温変動

期間 IV（2008 年 1 月 30 日～12 月 29 日）では、初めの 4 月 3 日までの St. 5 を除き、ほぼ St. 1～St. 5 までの記録が得られている。各観測点での、海底水温の基準季節変化（Fig. 5）からの差をプロットしたのが、Fig. 10 である。St. 5 において 15 日移動平均値が利用できるのは 5 月 8 日（日番号 128）以降である。

期間 IV における St.3 における底層水温の変化は他の測点の変化に比べて特異である。4 月中頃（日番号 105）までは、St. 1 の水温とほぼ同じ値を示しているが、その後水温はどんどん降下していき、以降は St. 5 の水温に近い低い値で推移していく。その原因は分からないが、全体の特性を見るとき、4 月中旬以降に異常に低い水温値を示す St. 3 の水温は考慮しないでおく。

期間 III の終わり頃から各測点の水温が低下しているが、期間 IV に入って、2 月 1 日（日番号 32）には、観測されている 4 測点全てで水温偏差

は負になっている。4月中頃までの部分で水温は沖に向かうほど降下する「夏季」の状態になっていたと考えられる。ただ、4月のSTD観測によると、30m水深に非常にシャープな水温躍層が見られており、少なくとも4月において、岸よりの4測点のデータから「夏季」の状態にあったと結論することは困難である。この現象については後に6章で論ずる。

St. 5の値が利用できる4月25日（日番号115）から9月末（日番号270）の期間では、異常なSt. 3を除き、St. 1からSt. 5まで水温は沖向きに単調に低下する典型的な「夏型」が現れている。それ以後も、St. 4とSt. 5の水温を比較してみると10月末（日番号300前後）までSt. 5の水温の方が低く「夏季」の特性が認められる。それ以後ではSt. 4とSt. 5の水温カーブは、ほとんど重なってしまうが、他の岸側の3点の水温よりは明らかに高く、「冬季」の特性が見られる。この年の「夏季」から「冬季」への移行は、10月下旬頃に起こったと考えられる。

期間IVとそれに続く期間Vにおいて、2008年4月3日から2009年2月26日までの約1年間の間にほぼ1ヶ月の間隔で12回のSTD観測を実施することができた（Table 1）。その結果をFig. 11とFig. 12に示す。Fig. 11の上段左の4月3日の水温プロファイルには明確なステップ構造が現れており、上段中央の4月30日のプロファイルにもその影響が残っている。このステップ構造については6章で改めて論じる。2008年5月28日（Fig. 11上段右）から、10月29日（Fig. 12上段中）までが、「夏季」の状態の時にとられたものであり、2008年11月26日（Fig. 12上段右）から2009年2月26日（Fig. 12下段右）までが「冬季」にとられたものである。STD観測は、全測点で実施されているので、海底水温が得られなかったSt. 6から沖の情報も得られている。「夏季」と「冬季」の全ての水温プロファイルに、等温層の発達が見られる。この部分に注目すると、「夏季」では測点が沖に向かうほど水温が低下し、「冬季」では上昇する傾向がみとめられる。

5月28日のSt. 3、St. 2のプロファイルを見ると底層に沿って低温水が侵入してきている。このため、底層近くでSt. 3、St. 2のプロファイルはSt. 4のそれと交わっている。このような現象が、水温の沖向きの低下が単調に起こらない原因の1つであろう。

4-4.　期間Vにおける水温変動

期間V（2008年12月29日〜2009年5月13日）ではSt. 2とSt. 3の記録しか得られていない。両測点での海底水温の基準季節変化（Fig. 5）からの偏差値の変動をFig. 13に示す。この図では、2008年2月5日以降の期間IVの変化も含めてある。時期Vの少なくとも2009年2月頃までは、他の年であれば、「冬季」に当たる期間であるが、全期間にわたって、沖合のSt. 3の方が低温になっている。この傾向は、2008年の期間IVの「夏季」の状態がそのまま続いているように見える。

しかし、STD観測の結果を見ると、先に述べたように2009年11月26日（Fig. 12 上段右）には「冬季」の水温構造になっていた。2008年11月26日ではSt. 2の水温プロファイルは、St. 3とSt. 4のプロファイルの間にあり、Fig. 13に示された沖側のSt. 3の水温が低かったことと整合性をもってはいる。しかし、2008年12月29日（Fig. 12 下段左）と2009年2月26日（Fig. 12 段右）では、プロファイルの等温層の水温は沖に向かって上昇しており、沖側の方の水温が高い「冬季」の特性を示している。2009年1月29日の観測結果（Fig. 12 下段中）は特異であり、St. 6、St. 7、St. 8の3つのプロファイルは約30mの深さで互いに交差している。この3測点で交差点より上では水温は沖向きに上昇しており、下では沖向きに低下している。これは上層では「冬季」の型であるが、下層では「夏季」の型を示していることになる。また、St. 1〜St. 5までのグループは、その中で見る限り沖向きに水温が上昇しているが、より沖側の3点の水温よりも著しく高い。いわば、「夏季」の特性と、「冬季」の特性が入り混じった形になっている。このようにSTD観測で得られた水温構造は非常に変動している。これに対して、底層水温2測点の関係は長期にわたって維持されている。期間Vにおいては底層水温の変動特性と、STD観測の結果とを結び付けるのは困難である。しかし、期間VにおけるSTD観測の結果は、2009年1月29日の複雑な構造を除外すると、11月以降、他の年と同様に、「冬季」の状態にあったことを示している。

5. 得られた結果の総括と沖合海況との関連

5-1.　水温の沖向きの水平勾配

三里浜沖の水深60m以下の極沿岸域の海況の季節変化を調べてきたが、その特徴の1つに、表層の季節水温躍層の部分を除くと、季節を問わず等温層が発達していることがあげられる。この等温層の水温は沖に向かって降下していく時期と、上昇していく時期があり、ここでは前者を「夏季」、後者を「冬季」と定義した。

三里浜を含む道東沿岸域の沖側には、道東沿岸

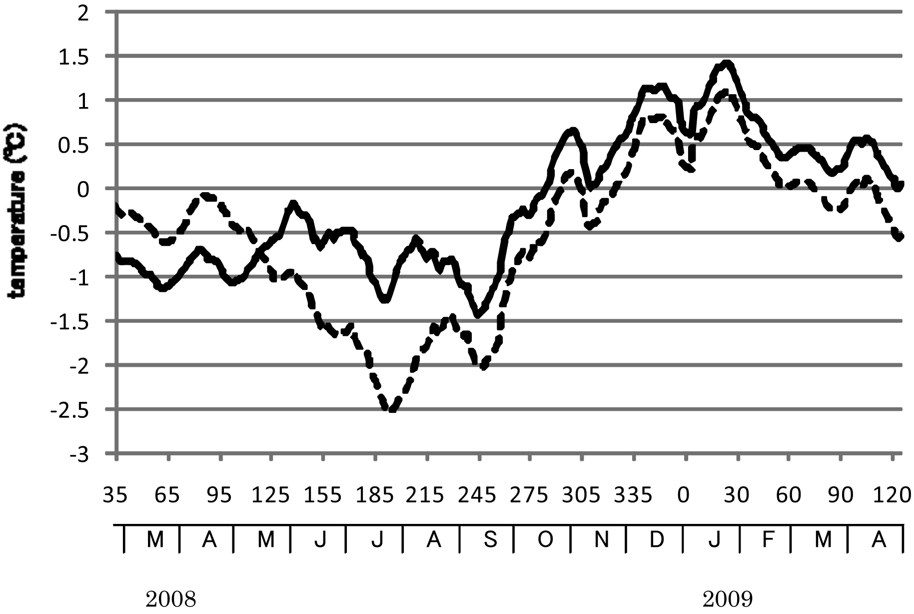

Fig. 13. Temporal variations of bottom temperature at St, 2 and St. 3 in period V (from December 29, 2008 to May 13, 2009). Variations at these points in period IV is also shown after February 5. Temperature values are shown as deviations from the reference curve shown in Fig. 5. Full lines indicate the temperature at St, 2, and dotted lines that at St. 3. Temperature in ℃ is taken in ordinate, and the day number counted from December 31, 2008 is taken in abscissa.

流（沿岸親潮・道東暖流）が流れており、冬季には低温・低塩分の水（沿岸親潮）が、夏季には高温・高塩分の水（道東暖流）が、岸に沿う形で南西方向に流れている。その出現状況の季節変化については永田ら（2009a）が、その水塊の季節変化については永田ら（2009b）が詳しく検討している。永田ら（2009a）は、水塊の季節変化を調べるのに、50m 深の水温・塩分を調べることを推奨している。この論文で扱っているのは極沿岸部ではあるが、最も沖の観測点 St. 8 の水深は 60m に達しており、沖合の流れとの関連をある程度は考察できるであろう。道東暖流の内部では、水温は沖向きに降下しており、沿岸親潮の内部では水温は沖向きに上昇している。「夏季」の沖向きの水温勾配は道東暖流のそれに連続する形になっており、「冬季」の水温勾配は沿岸親潮のそれに連続する形になっている。これまでの議論で、春後半から夏の期間を「夏季」、秋後半から冬の期間を「冬季」と呼んできたのは、夏を中心に現れる道東暖流と、冬を中心に現れる沿岸親潮を意識したためでもある。

5-2.　「冬季」・「夏季」の出現時期と沿岸親潮・道東暖流の出現時期

永田ら（2009a, 2009b）は、釧路水産実験場の 2 か月おきの観測資料を用いて、2 月～6 月が沿岸親潮の時期であり、8～12 月が道東暖流の時期であることを示している。また、沿岸親潮に関しては、1 月には発生していると一般に考えられている。

4 章の議論をもとに、「冬季」・「夏季」それぞれの各年でのおよその生起・消滅の時期をまとめたのが Table 2 である。4 章で論じてきたように、「夏季」から「冬季」へ、あるいは「冬季」から「夏季」への遷移の仕方は、年によって多様である。しかし、上述の各期間についての議論の中で考察したように、「冬季」、「夏季」の始まりと終わりのおよその時期を決めることができる。Table 2 では「冬季」、「夏季」の始期と終期を月の上旬、中旬、下旬あるいは何月頃という形で示してある。（この表で 2007 年秋から 2008 年に至る欄で、「夏季」の始まりを 1 月下旬としているが、4 月に、「冬季」とも「夏季」ともつかない構造が見られたので、その後を夏季の始まりと見れば、5 月中旬が始まりとすることもできる。ここでは 1 月末にすでに「夏季」的な構造が現れた

Table 2. Starting time and ending time of “winter season” and of “summer season”.

	“winter season”		“summer season”	
	srart	end	srart	end
2005～6		middle of February	late February	early November
2006～7	middle of November	early March	middle of March	middle of November
2007～8	late October	early February	end of January	around November
2008～9		early February		

ことを重視している。）

Table 2は「冬季」は11月頃に始まり2月頃に終わり、「夏季」は2～3月頃に始まり、11月頃に終わることを示している。この「冬季」・「夏季」の出現時期と、上に述べた沿岸親潮・道東暖流の出現時期との間にはかなりのずれがあり、沿岸親潮の始まりを1月とすると「冬季」の始まりは2か月程度ほど先行し、「道東暖流」の始まりを6月とすると「夏季」の始まりは4か月ほど先行していることになる。ただし、2か月、4か月といっても、その決定の精度は高いとはとても言えない。ここでは、「冬季」・「夏季」の出現時期は親潮・道東暖流の出現時期より早く、位相のずれは約3か月であると一応結論しておく。

5-3.　測点間に見られる位相差

岸―沖方向の位相の遅れは、三里浜沖の測点間にも見られる。例えば、Fig. 7において、2007年2月から3月に「冬季」から「夏季」に移る時期、St. 1とSt. 5の水温偏差値は互いに平行する形で減少するが、偏差値が0になるのは岸側のSt.1の方が早い。Fig. 8の10から11月、Fig. 10の9から10月の「夏季」の終末期に、各測点の水温偏差の曲線は平行する形で上昇するが、これらの曲線が0を切る時間は岸よりの測点の方がは早く、沖の測点はど遅くなっており、岸に近づくほど位相が先行している。

季節変動を含めた2007年の生の水温変化をSt. 5～St. 8までの沖合4測点について、Fig. 14に太線で示す。上から下にSt. 5、St. 6、St. 7、St. 8の順に示すが、各図に比較のためSt. 1の水温変化を細線で示してある。St. 5では年間を通して観測が行われており、5月の初め頃から8月の初めごろまで、水温はSt. 1に比べて水温が低く、「夏季」の状態が生じていたことが分かる。St. 6以下では「夏季」の始まり部分の観測値は得られていないが、沖の測点ほど水温値が低下していく様子が見られる。「夏季」の終わりの時期に注目すると、測点の深さが増大するほど遅れる傾向が認められる。最も沖のSt. 8では11月になっても、僅かであるがSt. 1よりも低い水温値が認められる。

このような、測点間で生じる岸近くほど位相が先行するという現象は、「冬季」・「夏季」の出現時期が親潮・道東暖流の出現時期より約3か月先行することを直接説明するものではないが、関連する現象として興味あるところである。

5-4.　沿岸親潮水の起源について

従来から沿岸親潮は、その水の低温・低塩分性からその起源をオホーツク海の海氷の融解水に求める見解がある（例えば、大谷、1971）。その根底には、沿岸親潮を涵養するに十分な量の一定の水塊特性を持つ低温・低塩分水が、海氷の融解で作り出されることを前提としており、そのような水がオホーツク海から流出してくると考えている。しかし、均質な水が流出してきたとすると、三里浜の極沿岸域まで水温の水平勾配を持つような構造を作り出すことは考えにくい。

永田（2009）は道東海域を30分メッシュの領域にわけ、過去のデータからそれぞれの領域における水温の季節変化を調べている。42° N線沿いに東方へ並ぶ5つの領域AI、AII、AIII、AIV、AVの季節変化を比べると、2～3月の沿岸親潮期の最低水温は東に進むほど高くなる傾向を示す。また、8・10月の道東暖流期の水温は東に進むほど低くなる傾向を示す。この水温の東西勾配の特性が、東西に圧縮された形で道東沿岸域にもたらされるとすると、道東沿岸流の構造を説明できる。今後さらにアリューシャン列島南岸沿いの海況を調べる必要があると考えられる。池田実（私信）はDNAの解析から、知床半島の東西に住むハナサキガニは異なったグループに属していることを示し、この2つのグループは数万年前に分離されたことを示している。三里浜で見出された、極沿岸域においても沖向きの水温勾配が存在するいう特性も、根室水道等から流氷の溶融水が直接この海域に流入してくると言う考えを否定していると考えられる。最近、根室水道が浅く、幅も狭いため、沿岸親潮水が、オホーツク海の水の直接的な流入によって形成されることに対して、否定的な見解が示されるようになってきている。特にOguma et al.（2008）は、化学物質の分析から、同様の結論を得ている。次に述べる2008

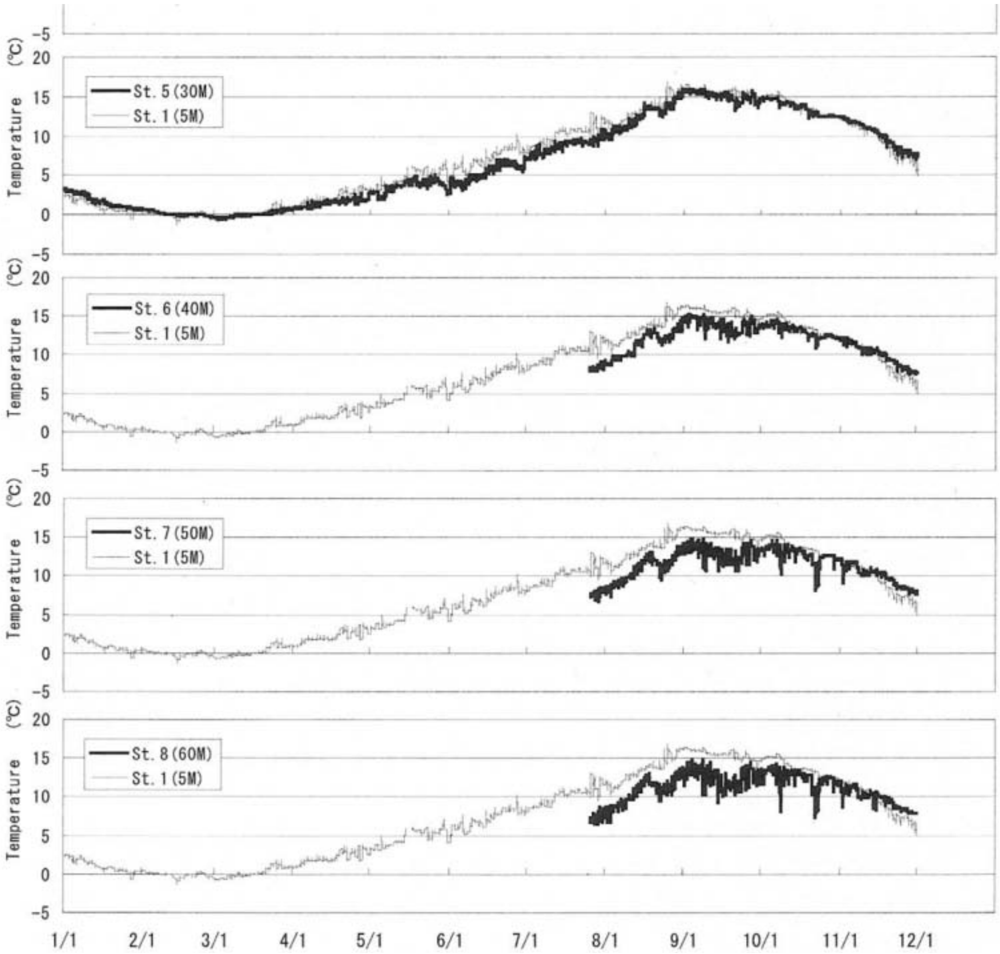

Fig. 14. Variations of bottom temperature measured at St. 5 through St. 8 (from top to bottom) in 2008. Thin curve drown in each figure shows temperature variation at St. 1.

年4月3日に観測された事象も、海氷の溶融水が沿岸親潮を作り出せないことを示唆している。

6. オホーツク海起源の海氷の溶解水

2008年の3月、オホーツク海の流氷が大量に根室海峡を通って太平洋に流出してきて、釧路周辺の海岸におびただしい流氷が着岸した。このような流出は数年に1度くらいしか起こらない現象である。三里浜沖の観測域にも、3月3日に多量の流氷が回遊してきて、沖側の4つの観測点（St. 5からSt. 8）の底層水温測定システムが流失した。2008年4月3日に復旧作業を行い、その際にSTD観測を行っている。その時の水温プロファイルはFig. 11の上段左に示すが、30m水深付近に非常にシャープな水温躍層が認められる。この水温躍層はシャープな塩分躍層をともなっており、最も躍層が発達しているSt. 7では、31m深では水温0.08℃、塩分32.25であるのに対して、32m深では、水温−0.11℃、塩分32.41と急変している。この躍層から表層10mの季節躍層季節躍層底部の間には水温0.1〜0.2℃、塩分が32.2前後の等温・塩分層が見られる。この層の水は、その低い塩分値から考え、太平洋に流出した海氷の溶融水と推定される。躍層の下側では、St. 6とSt. 8の水温プロファイルがほぼ重なりあっており、St. 7の水温値がこれより低温側にある。したがって、「冬季」的な状態であったのか「夏季」的状態であったたのかの判定できない。しかし、流氷の溶融水の影響を受けていないと考えられる下層の水温が、流氷の溶融水よりも低温であることは注目すべきであり、少なくとも3〜4月においては、溶融水はそれほど低温の水を作りえ

ないこと示している。1例だけでは結論を得られないが、沿岸親潮の水が流氷の溶融水ではありえないことを示唆していると考えられる。

4月30日に観測された水温プロファイル（Fig. 11 上段右）では30m以浅に温度躍層が認められる。これは、溶融水による躍層の名残である可能性が高い。そうだとしても、4月3日に見られた流氷溶融水層が4月30日にはほとんど消滅していることになる。したがって、流氷溶融水から作られた層の寿命は高々1月と短いものであったと推定される。量的にも流氷溶融水が沿岸親潮を形成するとは考え難い。

7. おわりに

この論文では、8地点に設置した海底水温計測装置による水温の連続測定の結果と、STD観測の結果を報告した。ハナサキガニが生息する三里浜沖の環境水温の周年的な変化特性を明確にすることを目的に行われたものである。ここでは水温構造の季節変化に焦点をあて、塩分構造・密度構造の検討は次の論文で扱う。3年間の成果は、初期の目的を十分果たすものであると考える。この結果は、ハナサキガニの生態・行動の研究に十分な指針を与えうるものと確信している。さらに、ここで見出された三里浜沖に現れる特異な季節変化特性、「夏季」および「冬季」の水温鉛直プロファイルには表層を除き等温層が発達していること、この等温層の水温は、「夏季」では沖に向かって水温が低下し、「冬季」では沖に向かって水温が上昇すること、そうしてこれらの水温の水平勾配は、沖合を流れる道東沿岸流（沿岸親潮と道東暖流）の特性にそのままつながっていると考えられること等の知見は、重要な成果と考える。また、「夏季」・「冬季」の発生時期は、沿岸親潮・道東暖流の発生時期に約3か月先行する。極沿岸水域内でも、「夏季」・「冬季」の現象は、岸近くが先行し、沖方向に遅れるという位相差が認められる。また、流氷の溶融水はそれほど低温（0℃以下）にならないことが示唆された。これらの知見は、道東沿岸流の起源水を求める研究に貴重な示唆を与えるものと考えられる。

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受付　2009年8月1日
受理　2010年2月24日

La mer 48 : 33-45, 2010
Société franco-japonaise d'océanographie, Tokyo

Marking of tiger shrimp *Penaeus monodon* (Fabricius) juveniles: Comparison among inexpensive tagging options

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Abstract: Three low-cost marking methods (staining with food color, uropod trimming, and T-bar tagging) were tested on 2-mo old juvenile tiger shrimps *Penaeus monodon* with 8.42 ± 0.1 mm mean carapace length (CL) for 8 weeks. Together with an unmarked control group, marker retention and effects on shrimp's survival and growth were monitored. There was no significant difference in specific CL growth rates among treatments ($p>0.05$). Survival was not significantly different among staining (60%), uropod trimming (51%), and control (58%) throughout the experiment, but T-bar tagging showed significantly lower survival from week 6 until 8 (33%) ($p<0.05$). Marker retention was significantly highest for T-bar tags (100%) at the end of 8 weeks, followed by uropod trimming at 65%, while staining was already 0% from week 3. Food color stains are poor shrimp markers because of weak retention. T-bar tags are not effective markers despite having excellent tag retention because of low shrimp survival after 6 weeks. Uropod trimming is a more practical option given that shrimps showed comparable survival with the control group and marker distinction through unique uropod regrowth was relatively high. Further work on modifications on these methods is needed to increase efficiency while maintaining lower cost. This study is viewed to have practical applications for community-based shrimp stock enhancement monitoring.

Keywords: *molting, shrimp tagging, stock enhancement, tag retention*

1. Introduction

World capture fisheries is seen to have become static in the recent years and signs of decline have been reported in some countries (FAO-FIES, 2008; FAO, 2009). In the Philippines, artisanal fish capture production quality and quantity have declined in the past years from various fishing grounds (MINES *et al.*, 1986; LIM *et al.*, 1995; KATON *et al.*, 1998; EVASCO, 2000; FERNANDEZ *et al.*, 2000; PALMA *et al.*, 2002; NEDA, 2005). Specifically for example, the Batan Estuary in the northern Panay Island in central Philippines was known for abundant wild shrimps, including the highly-priced tiger shrimp *Penaeus monodon,* but decreasing catch in the recent decades has become very evident (ALTAMIRANO, 2007; ALTAMIRANO and KUROKURA, 2008). The steady loss and overexploitation of local fishery resources directly affects the livelihood of the already poor fishers.

Shrimp restocking can be an effective tool in enhancing wild stocks (DAVENPORT *et al.*, 1999; WANG *et al.*, 2006) and, at the same time, in alleviating poverty among subsistence fishers through a direct increase in shrimp catches (ALTAMIRANO and KUROKURA, 2008). While the practice of fish stock enhancement has been done since the 1960s, crustacean stock enhancement programs especially for shrimps, have been limited (BELL *et al.*, 2005). For example, shrimp restocking projects were implemented for *Penaeus japonicus* in Japan (HAMASAKI

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Table 1. Some studies on different marking and tagging methods for crustaceans.

Species[1]	Marker or Tag	Setup (Duration)	Size (mm CL)	Survival (%)	Retention (%)	Reference
Neocaridina denticulate (S)	Laboratory	Trypan blue/red	15-30 BL[2]			Niwa *et al*., 1998
Penaeus monodon (S)	Tank (5-6 mo)	Streamer	15	31-35	100	Benzie *et al*., 1995
			18	37-70	100	
	Pond (5-6 mo)	Streamer	15	30-44		
			18	44-59		
P. esculentus (S)	Tank (~2 mo)	Streamer	12-19	~80		Hill and Wassenberg, 1985
P. plebejus (S)	Pond (2 mo)	Streamer	17-27	35-48		Montgomery and Gray, 1991
P. monodon (S)	Tank (2 mo)	Streamer	16-18	90		Primavera and Caballero, 1992
			18-21	47		
P. esculenlus (S)	Tank (2-3 mo)	Streamer	12-17	75-90		Wassenberg and Kerr, 1990
			15-20	90-93		
P. merguiensis(S)	Tank (2-3 mo)	Streamer	11-17	85-100		
Munida rugosa (L)	Tank (2 mo)	Streamer	<27 to >32	29	100	Claverie and Smith, 2007
		T-bar tags		52	100	
		V.I. Elastomer		95	100	
Macrobrachium rosenbergii (S)	Tank (2.5 mo)	V.I. Elastomer	0.01 BW[3]	100	79	Brown *et al*., 2003
		V.I. Alpha	<5.5 BW[3]	~99	60	
Jesus verreauxi (S)	Tank (37 mo)	T-anchor, dart	90-104	43-51	78-82	Montgomery and Brett, 1996
		Uropod trim		47	77	
Homarus gammarus (L)	Trays (3 molts)	Micro wire	5-8	82	97	Linnane and Mercer, 1998
			12-16	97	97	
		V.I. Elastomer	5-8	68	100	
			12-16	97	100	
		Rostrum cut	5-8	80	0	
			12-16	99	0	
		Branding	12-16	57	0	
			16-19	90	0	
		Streamer	16-19	97	100	
P. vannamei (S)	Tanks (3 mo)	V.I. Elastomer	<3.92BW[3]	99-100	91-93	Godin *et al*., 1996
			21-47BW[3]	100	93	
Litopenaeus vannamei (S)	Tank (~2 mo)	V.I. Alpha	2.7 BW[3]	81-92	92-98	Arce *et al*., 2003
			21.5 BW[3]	68-74	80-83	
	Pond (~4 mo)		2.7 BW[3]	90-93	93-97	
			21.5 BW[3]	80-88	83-85	
Callinectes sapidus (C)	Lab (1.5 mo)	V.I. Elastomer	6-25	~58-60	~81-84	Davis *et al*., 2004
		Micro wire	6-25	~47-60	~92-93	
Litopenaeus setiferus (S)	Tank (1 mo)	Micro wire	30-90 BL[2]	81-100	95-100	Kneib and Huggler, 2001
Litopenaeus vannamei (S)	Lab (4 mo)	Uropod cut	13-16	~98	0	Leano and Liao, 2006
			28-29	~63	~88	
		Uropod trim	13-16	~99	~91	
			28-29	~53	100	
Penaeus japonicus (S)	Lab (~2.5 mo)	Uropod cut	21-73 BL[2]	92	96	Miyajima *et al*., 1999
	Sea (12 mo)	Uropod cut	35-75 BL[2]		2.4[4]	

1 (S) =shrimps, (L) =lobster, (C) =crab; 2 BL=Body Length (mm) ; 3BW=Body Weight (g) ; 4 recaptured

and KITADA, 2006), *Penaeus chinensis* in China (WANG *et al*., 2006), *Penaeus monodon* in Taiwan (SU and LIAO, 1999) and Sri Lanka (DAVENPORT *et al*., 1999), and *Penaeus esculentus* in Australia (LONERAGAN *et al*., 2006). Although various methods and technology have been applied, the problems in monitoring still remain to be a challenge, even for a financially-capable community.

To evaluate the success or failure of shrimp restocking initiatives, an efficient method of marking shrimps is important in sorting recaptured stocks from wild catch. The main challenge for shrimp tagging is the difficulty imposed by molting. A number of marking options for shrimps have been tested and improved since the late 1950s, to include various modes of staining, internal or external tags, and cutting of body parts (NEAL, 1969; FARMER, 1981). Table 1 summarizes some of the studies on marking and tagging of crustaceans, especially shrimps. Most of these studies use sub-adults and larger juveniles, requiring longer pre-release culture that increases cost. On the other hand, other mass shrimp restocking programs use post-larvae shrimps that cannot be marked because of their very small size. Therefore, shrimps that are to be released should be big enough to be tagged but should not require long culture periods. In this study, juvenile shrimps of about 10 mm CL or about 60 days old were marked.

The main concern in choosing a marking method or tag is its efficiency in terms of retention and minimal effects on the commodity's growth, movement and survival. It has been recommended that visual implant elastomers (VIE) and micro wire tags are the more viable options for crustaceans (GODIN *et al.*, 1996; LINNANE and MERCER, 1998; DAVIS *et al.*, 2004); however, the main limitation for these tags is the cost required for its use. Except those involving ablation of body parts, majority of shrimp marking and tagging studies use specialized branded materials that are expensive.

In addition, stock-enhancement programs are also viewed to have better efficiency when implemented and managed by its direct beneficiaries — the local communities (GARAWAY *et al.*, 2006). Although community-based stock enhancement may have positive prospects, its implementation is mostly restricted financially. Therefore, for local stock enhancement programs, the availability and cost of tags and methods are also very important considerations.

In this study, we attempted to use and compare low-cost and readily available options for tagging and marking small juvenile shrimps *P. monodon*. Instead of specialized stains, we opted to use ordinary natural food color (McCormick and Company, Inc., Maryland) that has also been described in some reports and applied to stain other taxa like nematodes (THIES *et al.*, 2002). Ordinary plastic T-bar tags (Bano'k, Japan), commonly used in tagging clothing merchandise, were also tested as a possible substitute for streamer tags and specialized T-bar tags (Hallprint Pty Ltd., Australia). Uropod trimming, discussed by various authors (MIYAJIMA *et al.*, 1999; TOYOTA *et al.*, 2003; LEANO and LIAO, 2006), was also tested because it involves no additional costs for materials.

2. Materials and Methods

This experiment was a part of a series of studies on the stock enhancement of tiger shrimp *Penaeus monodon* in the Batan Estuary, Aklan, Philippines led by the Laboratory of Global Fisheries Science, the University of Tokyo, Japan. This study was conducted at the Brackishwater Aquaculture Station of the College of Fisheries and Marine Science (CFMS), Aklan State University, New Washington, Aklan, Philippines.

2.1. Set-up and monitoring

Hatchery-bred tiger shrimp *P. monodon* porstlarvae (PL15) were acquired (approx. 1000 pcs) from a local hatchery (wild broodstock were sourced locally). These were reared until 2 mo old in hapa nets inside an open pond with half-opened gates to allow regular water change from a nearby creek. In a separate experiment, 2-month old juveniles were observed to be the optimal age of shrimps for release in the immediate local water conditions of the Batan Estuary. At this age, the study showed that *P. monodon* juveniles have a carapace length of about 8-10 mm. From the reared stocks, shrimp juveniles measuring 8.42 ± 0.1 (s.e.) mm mean carapace length (CL) and weighing 3.4 ± 0.02 (s.e.) mg mean body weight (BW) were used in the experiment. A total of 12 aquaria (140 L) were prepared with washed fine sand as substrate (2 cm deep) then filled with filtered water (120 L) from the same rearing pond and creek. Water from each aquarium was drained by 10% daily using a siphon tube. Water was refilled through individual distribution pipes connected to a central holding tank where the filtered source water was collected daily, aided by a submersible electric pump. Constant aeration was supplied using airstones powered by an electric blower. There were three replicate aquaria for each marking treatment, namely: staining, uropod trimming, and T-bar tagging. Another three aquaria were designated as unmarked control replicates. These 12 aquaria were placed adjacent to a wide window in the laboratory to allow natural diel cycles, arranged in one row and alternating among treatments.

Prior to the actual experiment, tagging trials were done as practice runs for each tagging method to achieve minimal time in marking and to reduce stress of shrimps while out of the water. In the final run, twenty shrimp juveniles were tagged/marked accordingly (as described below) and placed in each aquarium for a day to acclimate. The same number was also stocked untagged in each control aquaria. Few dead shrimps, as a possible result of tagging shock or acclimation after about 24 h was noted as immediate mortality and removed. Those that survived were further randomly reduced to 15 individuals per aquarium as the final number used in this study for the next 8 weeks. Visual observations were carried out daily. Monitoring for growth was conducted weekly in terms of carapace length measured with a digital caliper, and wet body weight using a digital top loading scale (0.01 g sensitivity). Shrimp's survival and mortality were assessed from weekly total count. Examination of marker retention and/or visibility was also done every week. The experiment lasted for 8 weeks, from 20 April to 15 June, 2008.

Finely chopped fish meat was provided as feed daily (1800 H) *ad libitum*. Uneaten food and unwanted particulates in the aquaria were siphoned-out daily during every water change. Water quality data (salinity, temperature, DO, pH) were monitored daily (0900–1000 H) using a Horiba UX-21 multi-parameter probe. A data logger (ACT-HR, Alec Electronics, Japan) was also used to monitor a detailed (10 min interval) trend in salinity and temperature.

2.2. Staining

Biological staining has been used to mark shrimps since the 1950s (MENZEL, 1955; NEAL, 1969) and has evolved into using some expensive patented materials. In this experiment, however, the cost of staining agent must be affordable and locally available. Hence, the common natural food color (MCCORMICK) was tested. Using a small (6.35 mm) sterile tuberculin syringe and a 30-gauge needle, a small amount (about 0.01 ml) of red food color was injected ventrally through the articular membrane of the shrimp between the 1st and 2nd abdominal segments. Stained shrimps were placed in a holding pan with aeration for about 20 min. Stains spread beneath the exoskeleton and mostly accumulate in the gills. Only those that appeared stable and survived the initial shock of staining were replaced in each aquarium (20 shrimps aquarium^{-1}) for a day of acclimation. Then, only the final number of 15 individuals was retained per aquarium for monitoring throughout the experiment.

2.3. Uropod trimming

Trimming of shrimp's uropod was chosen rather than complete removal of uropod. Trimmed uropod usually creates unique regrowths after molting that can be used as a marking indicator (LEANO and LIAO, 2006). Trimming was done using a pair of small fine-tip surgical scissors. Half of the left outer uropod was cut, adapting the methods described by TOYOTA *et al.* (2003) and LEANO and LIAO (2006). Trimmed shrimps were placed in an aerated collection pan for a few minutes before replacing in their respective aquarium. After given about 24 h to stabilize and acclimate, the number of individuals in each aquarium was reduced to 15, setting day zero of the experiment. Observations and monitoring proceeded as described above.

2.4. T-bar tagging

Physically-attached tags have been extensively used for stock enhancement monitoring purposes and a number of these have been utilized for tagging crustaceans, including shrimps (NEAL, 1969; HOWE and HOYT, 1982; HILL and WASSENBERG, 1985; TEBOUL, 1993;

Linnane and Mercer, 1998; Arce *et al.*, 2003; Brown *et al.*, 2003; Claverie and Smith, 2007). Most of these special tags however, require considerable capital to acquire, making it impractical for low-budget studies. In this experiment, ordinary T-bar tags, commonly used in clothing's price label, were used. The plastic T-bar tags were about 0.3 mm thick and 11 mm long, giving enough room for shrimp's growth until marketable size. Specifically, the Bano'k 303XL T-bar injector gun was chosen because of its thin and long injector needle. This injector gun drives the T-bar tags from a set of cartridges.

A number of tagging locations have been used for physical tags, such as a dorso-ventral insertion of T-bar tags between the cephalothrax and 1st abdominal segment for squat lobsters *M. rugosa* (Claverie and Smith, 2007), and horizontal tagging of streamer tags between abdominal segments on *P. monodon* (Benzie *et al.*, 1995) primarily to minimize difficulty of shedding exuviae during molting. However, the present study adapted the methods for streamer tags on *P. monodon* by Wassenberg and Kerr (1990) and Primavera and Caballero (1992) where the tag was inserted laterally through the left side of the middle of the 2nd abdominal segment, exiting and of the body. This tagging location provided the least resistance for movement of the shrimps. Wassenberg and Kerr (1990) also found that this location has the fastest wound healing effect. The T-bar tag was injected through the guide needle with a single squeeze of the injector gun, carefully avoiding further tissue damage, and was slowly removed after the tag was locked in place. Same as the other treatments, T-bar tagged shrimps were held in aerated pans before replacing in the aquaria. The final number of 15 individuals was maintained a day after tagging and monitored throughout the experiment.

2.5. Data analysis

Water quality data (water pH, DO, temperature and salinity) were subjected to two-way analysis of variance (ANOVA) with marking treatment and measurement week as fixed factors.

Initial and weekly growth parameters in terms of CL and BW, as well as total count of surviving shrimps, were recorded to determine growth and survival rates, respectively. Weekly specific growth rates (SGR) were computed for CL and BW using the formula adapted from Ye *et al.* (2009):

$$\mathrm{SGR}\ (\%\ \mathrm{d}^{-1}) = 100 \times (\ln x_t - \ln xi)\ /\ d\ ,$$

where SGR is Specific Growth Rate for CL ($\%\mathrm{CL\ d}^{-1}$) or BW ($\%\mathrm{BW\ d}^{-1}$), xi is initial measurement for CL or BW, x_t= measurement for CL or BW at a given time t, and d = number of days between measurements. A similar measure for SGR was also used by Primavera and Caballero (1992) to present CL and BW growth rates of *P. monodon* marked with streamers tags.

Survival was represented as a percentage of remaining shrimps from the initial 15 individuals during each weekly monitoring. Marker retention and visibility was examined and recorded as a percentage from among the surviving shrimps per monitoring week.

Data were initially tested for normality using the Shapiro-Wilk test, and for homoscedasticity using Levene's test. Percentage data were further transformed to arcsine prior analyses to improve homogeneity of variances (Zar, 1999). Then, data analysis proceeded with ANOVA. When significant differences were detected, further analyses with Tukey's Honestly Significant Difference (HSD) multiple comparison tests were performed. Comparisons were made to determine differences among treatments and control on the survival and growth of shrimps, as well as on the tag retention. Significance was established at $p<0.05$. Statistical analyses were performed with SPSS statistical software version 14 (SPSS Inc., Chicago, IL).

3. Results

3.1. Water condition

Water pH, dissolved oxygen (DO), salinity and temperature were constantly monitored and showed no significant differences among treatments on every monitoring week (two-way ANOVA, treatment* week, $p>0.05$). Average measurements (mean ± s.d.) of these are as follows: pH, 7.77±0.89; DO, 3.83±0.66 mg

L^{-1}; salinity, 18.80 ± 1.77; and temperature, 26.96 ± 2.59 ℃. Since aeration was sustained and water exchange was maintained, DO was relatively stable throughout the experiment, as well as pH. Some fluctuations in temperature and salinity were recorded by the data logger especially during the sustained rains in May but no drastic changes occurred that may have affected the shrimps.

3.2. Shrimp's growth

Specific growth rates in terms of % CL d^{-1} showed no significant differences among treatments and control within the 8-week period (ANOVA, $p>0.05$) (Fig. 1).

The trend in CL changes between monitoring weeks suggests two molting stages within 8 weeks (Fig. 1). Results confirmed rapid molting and growth within the first 2 weeks after marking, reaching an overall average CL change of 0.75 ± 0.03 %CL d^{-1} after week 1 and 1.29 ± 0.14 %CL d^{-1} on week 2. Observations also indicated that about 75% of the experimental shrimps molted within these first two weeks. On week 3, zero growth rate was recorded which was significantly lower (ANOVA, Tukey's HSD, $p<0.05$) than the previous week indicative of intermolt period (Fig. 1). After week 3, an increasing growth rate was again manifested until week 6 (0.69 ± 0.11 %CL d^{-1}), highlighting the second molt stage. Although less pronounced and statistically not significant (ANOVA, Tukey's HSD, $p>0.05$), another carapace rigidity stage followed on week 7 as denoted by another zero average specific growth rate (Fig. 1). A slight increase ini-

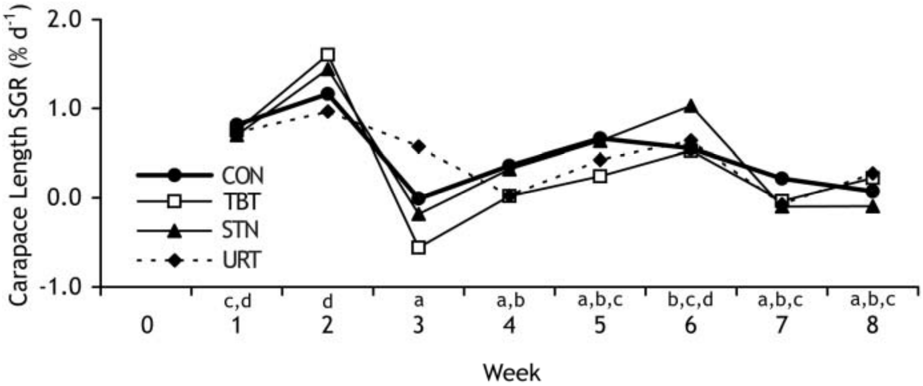

Fig. 1. Specific growth rates (SGR) in terms of carapace length (%CL d^{-1}) of 2-mo old *Penaeus monodon* juveniles marked through staining (STN), T-bar tagging (TBT), and uropod trimming (URT) together with untagged control (CON) within 8 weeks. Molting periods are shown, terminating during the carapace rigidity stages (zero growth) at weeks 3, then week 7. Similar superscripts among weeks are not significantly different (ANOVA, $p>0.05$). Also, values among marking methods were not found to be significantly different.

Table 2. Specific growth rate (SGR) in terms of BW (mean ± s.e., %BW d^{-1}) of 2-mo old *Penaeus monodon* juveniles marked through staining (STN), T-bar tagging (TBT), and uropod trimming (URT), including untagged control (CON) within 8 weeks.

Week	CON	STN	URT	TBT
1	3.45 ± 0.38	3.72 ± 0.73	3.57 ± 0.34	3.14 ± 0.52
2	1.80 ± 0.24	0.58 ± 0.45*	3.41 ± 0.26	1.43 ± 0.22
3	2.75 ± 0.35	2.28 ± 0.29	1.44 ± 0.22	2.07 ± 0.38
4	1.48 ± 0.27	0.58 ± 0.49	2.23 ± 0.72	2.50 ± 0.28
5	1.37 ± 0.30	0.82 ± 1.12	0.35 ± 0.57	1.01 ± 0.68
6	0.42 ± 0.46	−0.51 ± 0.73	1.17 ± 0.92	1.50 ± 0.18
7	0.73 ± 0.46	−0.79 ± 1.00	0.83 ± 0.33	−0.49 ± 0.45
8	0.75 ± 0.33	1.02 ± 0.47	−0.08 ± 1.04	0.82 ± 0.23

* significant difference ($p<0.05$) from among treatments on the same week.

tiated again on week 8 (0.12 ± 0.08 %CL d^{-1}) that may have been the start of the 3rd molting cycle.

Specific growth rates in terms of %BW d^{-1} showed a generally decreasing trend, from an overall mean of 3.47 ± 0.12 %BW d^{-1} during the first week to only 0.63 ± 0.24 %BW d^{-1} during the last week (Table 2). Generally, no significant differences in BW-SGR were found among treatments and control throughout the study period, except only for staining at week 2.

3.3. Shrimp's survival

The small initial size (mean CL±s.e., 8.42 ± 0.1 mm; mean BW±s.e., 3.4 ± 0.02 mg) of shrimp juveniles was a challenge for tagging. As a result, high immediate mortality was observed especially for staining and T-bar tagging during the practice runs as a direct effect of mishandling. However, tagging efficiency greatly increased after familiarization of the tagging procedure. During the actual experiment, immediate mortality (<1 hr after marking) was very low even for T-bar tagging (1 to 3 individuals).

Survival steadily declined and was not significantly different (ANOVA, $p>0.05$) among treatments up to week 5 (control, 84%; staining, 73%; uropod trimming, 71%) (Fig. 2). Although similarly not significantly different from other treatments, T-bar tagging showed a lower survival of 67% after 5 weeks. The decrease in survival continued with similar trend until week 8 for control (58%), staining (60%), and uropod trimming (51%). However, T-bar tagging showed significantly lower (ANOVA, Tukey's HSD, $p<0.05$) survival rates of shrimps from week 6 (47%) until week 8 (33%).

3.4. Marker retention

Marker retention from survived shrimps was significantly highest (ANOVA, Tukey's HSD, $P<0.05$) up to the last week for T-bar tags, where 100% were retained throughout the 8-week experiment (Fig. 3). However, visibility of trimmed uropods steadily declined until 65% at the end of 8 weeks, while only 14% of stained shrimps were identified as having been marked after the first week and none showed signs of staining from week 3.

For uropod trimming, marker retention was determined through abnormal regrowth of the trimmed portion (Fig. 4). The decline in marker visibility for this method was caused by normal regeneration of uropods after molting on some shrimps. In weeks 2 and 3, after the first molt, 88% of the survived shrimps (14 out of 15 individuals) showed identifiable abnormal uropod regrowths; while from week 4 until week 7 (after the second molt), only 75% of the 10 surviving shrimps from each aquarium retained abnormal uropod regrowth. Lastly, at week 8, only 65% were recognizable as having had a trimmed uropod. For this method, it is important that the observer be properly trained to differentiate an untrimmed

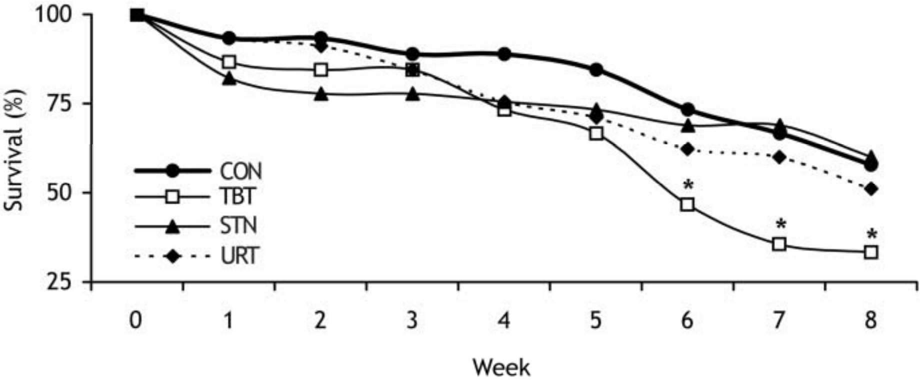

Fig. 2. Survival (%) of *Penaeus monodon* juveniles marked through staining (STN), T-bar tagging (TBT), and uropod trimming (URT), including untagged control (CON) within 8 weeks. Asterisks (*) denote significant difference from among other treatments in the same monitoring week (ANOVA, $p<0.05$).

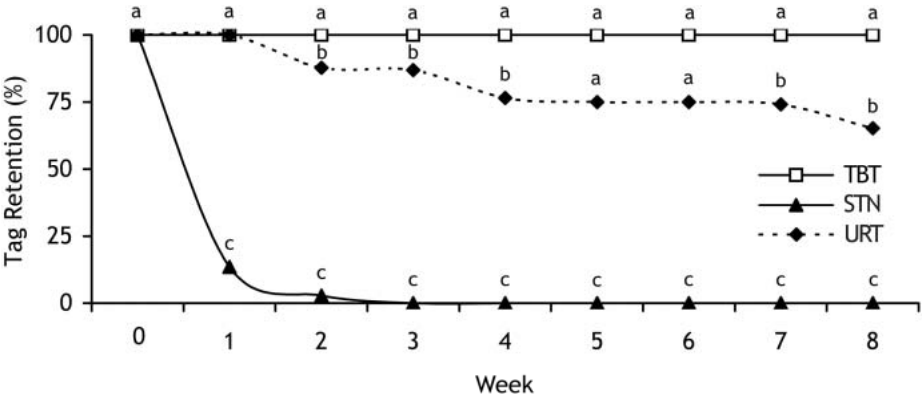

Fig. 3. Tag retention/visibility (%) from survived *Penaeus monodon* juveniles marked through staining (STN), T-bar tagging (TBT), and uropod trimming (URT), including untagged control (CON) within 8 weeks of laboratory experiment. Similar superscripts denote no significant difference among treatments in the same monitoring week (ANOVA, $p>0.05$).

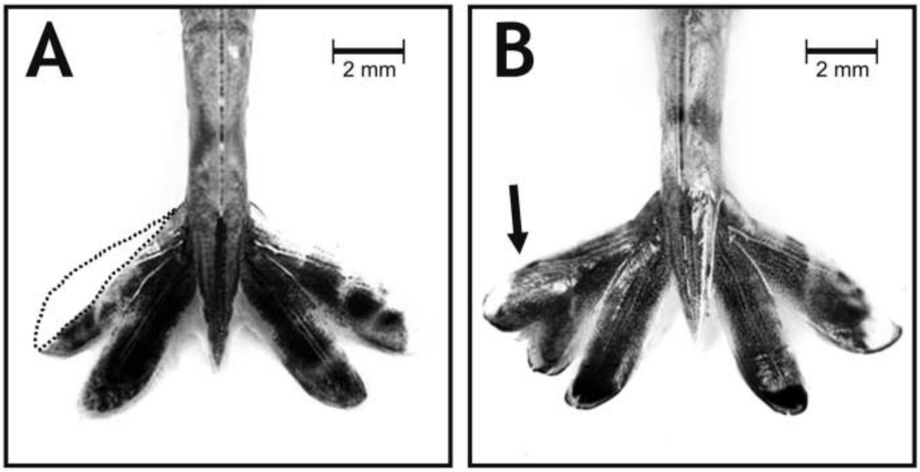

Fig. 4. (A) *P. monodon* juvenile marked by uropod trimming (trimmed portion represented by dotted line). (B) After molting, abnormal regrowth from the trimmed uropod can be observed (arrow).

normal uropod and that of the regenerated uropod and that careful scrutiny is necessary during monitoring.

On the other hand, staining showed very significantly lower (ANOVA, Tukey's HSD, P<0.01) marker retention rate than the other methods even on the first week where only 14% of survivors were able to retain the red food color stain, mostly in the gills. At week 2, only 3% were observed to have a tinge of red in their body. Then, from week 3 onwards, no identifiable stain marks were observable from the experimental subjects.

4. Discussion

Although some studies already recommended the use of more expensive visual implant elastomers (VIE) and micro wire tags for crustaceans (GODIN *et al.*, 1996; LINNANE and MERCER, 1998; DAVIS *et al.*, 2004; LEBATA *et al.*, 2009), the current study on the other hand, evaluated the utility of more economical options for marking shrimps. Three marking categories were tested in this experiment: staining, tagging with physical tags, and ablation of body parts. The use of common food color as a staining agent and tagging with ordinary plastic T-bar tags have never been mentioned in published literature, especially for small shrimp juveniles.

Various stains such as trypan blue (Hartman-Leddon Company, Philadelphia) and similar others have been injected to accumulate in the gills of shrimps such as *Neocaridina denticula* (NIWA *et al.*, 1998). Literature search of current studies on shrimp marking by staining returned no results. In a review by NEAL (1969), he mentioned that stains appeared to have less utility as these tend to fade after a few days although, in some cases, it can last for about a week. The results in the current study also confirmed this observation. Only 14% of shrimps retained their stain after one week and were completely faded starting the third week. However, stains have practical applications for laboratory studies of a few days. The current experiment also showed that even ordinary food color can have the same short-term effectiveness as that of more expensive stains although a direct comparative experiment is needed to really prove this. In addition, proper staining with natural food color seemed to have very minimal effect on shrimp survival and growth, where current results for staining were not significantly different from the control group (Figs. 1, 2).

Physical cutting or modifying body parts such as rostrum ablation in lobsters were tested by LINNANE and MERCER (1998) but complete regeneration was only as short as three molts. Trimming of uropods in shrimps, however, showed higher retention rates since molting often resulted in distinct abnormal growths from cut or trimmed uropod in *Litopenaeus vannamei and Penaeus japonicus* (MIYAJIMA *et al.*, 1999; TOYOTA *et al.*, 2003; LEANO and LIAO, 2006). Similar results were found in the present study for *P. monodon* juveniles. Abnormal regrowths were noted, often characterized by a branched protruding extension from the trimmed uropod (Fig. 4). The first molt and regeneration was observed within 1 week after trimming which was similar with that of *L. vannamei* (LEANO and LIAO, 2006). Aside from unique regrowth, MIYAJIMA *et al.* (1999) also mentioned noticeable differences on coloration of the regenerated uropod of bigger (around 60 mm BL) *P. japonicus* but this was not clearly observed in our samples, probably because of relatively smaller sizes. Survival of shrimps for this method was high, reaching 98% for juvenile *L. vannamei* after 4 mo (LEANO and LIAO, 2006). In the present study, survival for uropod trimming (51%) was not significantly different from the control group (58%) after the 8-week experiment. This suggests that the relatively low survival rate may be attributed to external factors such as water quality and natural mortality, rather than a direct effect of the marking method. One noticeable immediate effect of uropod trimming on shrimps was the initial difficulty in swimming. Shrimps were observed to swim sideways because of the unbalanced trimmed uropods. However, after a few hours, some were able to correct their balance and swim upright. It is therefore recommended to allow the uropod-trimmed shrimps to stabilize for a few hours or days before actual release in the open to minimize possible susceptibility from predation.

Through-the-body external markers were widely used, especially the streamer tags, noting that larger shrimps have lower short-term or immediate mortality rate than smaller juveniles (HILL and WASSENBERG, 1985; WASSENBERG and KERR, 1990; MONTGOMERY and GRAY, 1991; PRIMAVERA and CABALLERO, 1992; BENZIE *et al.*, 1995). Anchor tags or T-bar tags are smaller; hence, short-term mortality was significantly lower than streamer tags as used in squat lobster *Munida rugosa* (CLAVERIE and SMITH, 2007) and *Jesus verreauxi* (MONTGOMERY and BRETT, 1996). The main advantages of external tags are high retention rates and ease in tag detection. In the present study, observations for marker retention and/or visibility were easiest for T-bar tags because of the externally protruding plastic were easy to spot. Marker retention for this method was 100% from the survived shrimps in the present study. This high retention (100%) of the similar T-bar or T-anchor tags was also true for *M. rugosa* after 2 mo (CLAVERIE and SMITH, 2007), while 78–82% was retained for shrimp *J. verreauxi* after a long-term study of 37 mo (MONTGOMERY and BRETT, 1996).

One concern in having tags inserted through the body is the negative effect during molting. LINNANE and MERCER (1998) observed that cast exoskeleton frequently became entangled on the streamer tags during molting of *Homarus gammarus* and that tagged shrimps needed more flicks to discard old exoskeleton on *P. esculentus* (BENZIE *et al.*, 1995). However, this effect seems to be only minimal. BENZIE *et al.* (1995) also showed that time to complete molting was not affected, while molting and general growth rate was also not significantly different between streamer-tagged and untagged shrimps (HILL and WASSENBERG, 1985; BROWN *et al.*, 2003). The same observations were also noted in the present study for *P. monodon* juveniles, where exuviae sometimes get entwined with the T-bar tag; however, growth rates and intermolt periods were still not significantly different than the control group or other marking methods (Fig. 1, Table 2.). *P. monodon* has been known to molt at an average of every 5 days during post-larval stage and about every 14 days for sub-adults (KIBRIA, 1993). For this reason, longer studies and actual release experiments employing through-the-body markers like T-bar tags may eventually have adverse effects on survival after these multiple moltings. As shown in the current study, the main drawback in using T-bar tags was in the survival of shrimps. A significantly lower survival (47%) was recorded for T-bar tagging after 6 weeks compared with other treatments (62–73%) (Fig. 2). This lower survival was estimated to roughly coincide with the second molting of the shrimps at about 6 weeks although no further confirmation was conducted. Other studies using a specialized T-bar or T-anchor tags produced the same results, such as for *M. rugosa* with 52% survival after 2 mo (CLAVERIE and SMITH, 2007), and *J. verreauxi* with 43–51% after 37 mo (MONTGOMERY and BRETT, 1996). These high mortalities, especially after a month or so can be the effects of delayed infection and some studies applying antibiotics did not seem to have any major advantage (NEAL, 1969). WASSENBERG and KERR (1990) also observed that wounds inflicted by the inserted tags and its constant movement hinders the quick healing of the injuries and thereby increasing the chances for irritation and infection. High mortalities were also recorded during tagging of smaller shrimps (>10 mm CL) in our experiment during the practice tagging runs. During the actual experiment; however, survival rates were comparable with the control group in the first 5 weeks. For *P. monodon,* the minimum size of juveniles for T-bar tagging was established to be about 9–10 mm CL in this study but smaller shrimps where also successfully tagged. WASSENBERG and KERR (1990) even estimated a higher critical size limit for streamer tags for *P. esculentus* (18 mm CL) and *P. merguiensis* (17 mm CL). This means that T-bar tags, streamer tags, and similar through-the-body tags may only be practically used on larger juveniles or sub-adults unless significant modifications on the tag size or applicator device can be developed. However, T-bar tags have practical applications for restocking studies in smaller areas that expect full recapture within a month or so.

Although the present study was done in a laboratory, natural water conditions were attempted to be simulated. Hence, only creek water was used with no other treatments made aside from filtration. In effect, changes in natural water conditions were also manifested in the aquaria through daily water exchanges. Water condition is also an important factor that affects shrimps growth and survival. At 30℃, JACKSON and WANG (1998) showed that *P. monodon* can grow double in weight than that at 20℃ within 180 d. Abrupt changes in salinity also affects mortality although younger prawns (< 40 days post-metamorphosis) can tolerate short acclimation periods of 6 h to 3 days and can survive in low salinity water better than older animals (CAWTHORNE *et al.*, 1983). Some fluctuations in both temperature and salinity were observed during the study but these were still within tolerable ranges and were not observed to have drastic effects on the shrimps. Dissolved oxygen was also far from the lethal level of 0.9 mg L^{-1} (ALLAN and MAGUIRE, 1991), as this was maintained at about 4 mg L^{-1} with aeration. Other biological and chemical factors may also have affected the growth and natural mortality of the shrimps in this study. However, limited by resources, no measurements were done on these aspects. Nevertheless, all treatments were subjected to the same water condition, hence, comparisons among marking treatments and control can still be done, negating other external causes.

Generally, results in the present study showed comparable outcomes with those made with conventional yet more expensive tagging materials, as discussed above. Of course, direct comparisons among different studies cannot be accurately made because of differences in laboratory setup, shrimp's initial age and size, stocking density and water condition. It is interesting to see that shrimp marking activities do not necessarily need proprietary tags and sophisticated equipment to implement. In terms of cost, the most expensive equipment used in our experiment was perhaps the Bano'k 303XL injector gun, purchased for about US$25. Of course, a similar local brand would have even cost less. Other materials like food color and syringe for staining, T-bar cartridges, and small scissors for uropod trimming can be easily and cheaply acquired.

5. Conclusion

Staining is not an effective marker for shrimps because marker retention only lasts for a few days or at most a week or two, limiting its use for very short-term studies. Externally visible tags like T-bar tags have very high retention rates but there is a significant decline on shrimps' survival after about 6 weeks. This maybe used for studies requiring high marker retention but also only limited for about a month. For initial restocking trials in the current site, the Batan Estuary, this method can be applied because tag distinction is fairly easy even for untrained local fishers. Also with the current status of fishing pressure in this small area (ALTAMIRANO, 2007), recapture of released stocks can be expected to be in the order of a few weeks only. On the other hand, the more practical method may as well be the trimming of uropods as this provides both good retention and survival of shrimps even for longer tagging experiments. However, more study is recommended on finer modifications of these methods for applications on specific restocking sites to primarily increase efficiency but with equal consideration on cost of materials and methods for community-based stock enhancement programs.

Acknowledgement

The present work was supported by grants-in-aid for International Scientific Research from the Japan Society for the Promotion of Science (No. 19255013). Our gratitude is extended to the faculty and staff of the College of Fisheries and Marine Sciences (CFMS), Aklan State University (ASU) in New Washington, Aklan, for the assistance in the conduct of the experiment, especially to Abegaile D. Saturnino, Marvin T. Villanueva, Anna Mae N. Mola, Jackelou B. Dua, and Vicente B. Pastrana. We also wish to thank Dr. Danilo E. Abayon, CFMS Executive Director, and Dean Eduardo B. Pastrana for granting permission to utilize some facilities and laboratory space in their aquaculture station in Dumlog, New Washington, Aklan. Insights and comments from Dr. Ma. Junemie Hazel Lebata-Ramos of SEAFDEC-AQD, and the three anonymous reviewers of this paper are also much appreciated.

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Received: November 2, 2009
Accepted: February 25, 2010

La mer 48 : 47, 2010
Société franco-japonaise d'océanographie, Tokyo

資　料

第48巻第1号掲載欧文論文の和文要旨

Leni G. Yap-DEJETO[1&2], 大村卓朗[1], 長濱幸生[1], 福代康夫[1]：東京湾で採集された11種の *Pseudo-nitzschia*

2008年4月から2009年8月の期間に，東京湾で得られたサンプルについて，光学顕微鏡および透過型電子顕微鏡を用いて形体観察をおこなった。その結果，東京湾からこれまでに報告の無い5種（*Pseudo-nitzschia americana,* P. *brasiliana, P. caciantha, P. callantha,* P. *galaxiae*）を含む11種（残りの6種：*P. delicatissima, P. fraudulenta, P. multistriata, P. multiseries, P. pseudodelicatissima, P. pungens*）が観察された。

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ジョン・P・アルタミラノ、黒倉　寿：ウシエビ *Penaeus monodon*（Fabricius）稚エビの標識法―安価な標識法の比較

コストのかからないエビ類の標識法として，染色，尾肢の一部切除，T-barタイプのタグについて検討した。実験には2ケ月令のウシエビ，*Penaeus monodon*（頭胸甲長8.42±0.10）を用い，無標識の対照群を含めて，各種の標識法で標識した個体を8週間飼育した。頭胸甲長の成長には，対照群を含めて，各処理間で有意な違いは見られなかった。染色処理群（60%），尾肢一部切除群（51%），対象群（58%）の間には，生存率の違いも見られなかったが，T-barタグ群の生残率は有意に劣っていた（33%）。標識の保持率はT-barタグ群で極めて高く（100%），これに尾肢一部切除群（65%）でつづいていた。しかし，染色群の標識保持率は実験開始後3週間で0%となった。以上のことから，染色法は標識保持時間が短く長期にわたる標識としては使えないこと。T-barタグは標識保持率は高いものの生残に強い影響を与え，標識方法として不適切なことが明らかになった。尾肢の一部切除は再生した尾肢が特有の形態となるため，比較的識別性が高く，生残率も対照群と大きく異ならないことから，現実的に利用可能な標識法である物と考えられた。今後，費用がからない形でこの方法を改善し，生残率・保持時間をさらに高めていく事が必要である。本研究は，途上国において地域レベルで資源添加を行いその結果を追跡していくことを可能にするために行われた研究である。

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La mer 48 : 48-49, 2010
Société franco-japonaise d'océanographie, Tokyo

学 会 記 事

1. 2010－2011年度評議員（24名）選出

荒川久幸　有元貴文　石丸　隆　磯田　豊　今脇資郎
神田譲太　北出裕二郎　小池勲夫　小松輝久
河野　博　斎藤誠一　関根義彦　千手智晴　田中祐志
寺崎　誠　中田英昭　長島秀樹　森永　勤　門谷　茂
柳　哲雄　八木宏樹　山口征矢　山崎秀勝　吉田次郎
内田　裕*　小池康之*　鈴木秀和*　溝端浩平*
（*は会長推薦）

2. 2010－2011年度会長選出

会長　今脇資郎会員

3. 2010年度役員・学会賞委員

会　長：今脇資郎
副会長：森永　勤　小松輝久
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　　　　（研究）石丸　隆　鈴木秀和，（渉外）小池康之，
　　　　（広報）溝端浩平　内田　裕
監　事：長島秀樹　小池　隆
編集委員長：吉田次郎
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　　　　　　和泉　充　門谷　茂　神田穣太
　　　　　　石丸　隆　田中祐志　市川　香

4. 2010年５月17日（月）日仏会館会議室において2010年度第１回幹事会が開かれた。

審議事項

１）2010・2011年度の体制について

24名の評議員，会長の選出，幹事の依頼，賞推薦委員の選出について，資料に基づいて論議した。研究担当幹事として鈴木秀和会員（東京海洋大学）を加えることで了承された。なお，新体制については，評議員会で承認を得る必要がある。

２）Kobe2010について

・「Techno-Ocean 2010」（TO2010）の，日仏海洋学会関係の世話人は，引き続き，河野幹事が務める。Kobe2010の中の「第14回日仏海洋学シンポジウム第１部」の世話人は小松副会長が務め，創立50周年記念式典・講演の世話人は森永副会長が務めることとした。「Kobe2010実行委員会」の副委員長は，八木前副会長に代って小松副会長が務めることとした。

・TO2010の基調講演者をHenocque氏とすることが了承され，小池幹事が連絡をとることとした。「第14回日仏海洋学シンポジウム第1部」の基調講演者をBailly氏と柳哲雄氏とすることが了承され，Bailly氏には小池幹事が，柳氏には小松副会長が連絡をとることとした。創立50周年記念講演者をSempere氏とすることが了承され，小松副会長が連絡をとることとした。

・「第14回日仏海洋学シンポジウム第1部」の内容を検討するために，日仏合同組織・科学委員会を設置する。日本側の主査は小松副会長が務める。詳細はフランス側の意向を聞きながら企画することで了承された。投稿論文の審査は当委員会が担当し，必要に応じて「Kobe2010実行委員会」の総務担当委員に審査を依頼する。

・Kobe2010の，TO2010でのセッション・タイトルおよび会場の看板について論議した結果，フランス語表記にすることとし，表記案を小松副会長が考えることとした。

・記念式典での祝辞をお願いする方について論議した。その結果，Ceccaldi氏には今脇会長が，日仏会館には小池幹事が，フランス大使には小松副会長が連絡することとした。なお，感謝状の贈呈に関しては森永副会長が担当することとした。また，祝辞の言語について，母国語がフランス語の方には，日本語訳を作成・配布しフランス語で祝辞を，それ以外の方には英語で祝辞をいただくこととした。

・名誉会員や元会長の方々の招待については，荒川幹事が担当することとした。

・助成・寄附については森永副会長が，日仏学者交流事業については小松副会長が，引き続き折衝を行うこととした。

３）「第14回日仏海洋学シンポジウム第２部」について

「第14回日仏海洋学シンポジウム第２部」を2010年10月19日（火）午後３時～５時30分の予定で日仏会館において開催することとした。世話人は小松副会長が務める。

４）2010年度の評議員会・総会などについて

今年度の評議員会・総会・賞贈呈・受賞記念講演を，上記シンポジウムの直前に，2010年10月19日（火）午後１時～２時30分の予定で日仏会館において開催することとした。世話人は荒川幹事が務める。

５）2009年度の決算および2010年度の予算について

2009年度の決算案および監査報告がなされ，了承された。また，2010年度の予算案が示され，若干の修正を

行った上で了承された。なお，会費の自動引落しの可能性を調べることとした。

6）「うみ」創立50周年記念号の編集について

記念号に，学会の50年間の活動を記録した「50年の歩み（仮称）」を掲載する方向で作業を進めることとした。海洋学・水産学分野での日仏間の交流，今回で14回となる日仏海洋学シンポジウムの歴史，日仏交換学者の記録，歴代賞受賞者一覧その他を資料とし，小池幹事・森永副会長・小松副会長が中心となって執筆する。

7）第13回日仏海洋学シンポジウムの報告について

2008年10月にマルセイユとパリで開催された第13回日仏海洋学シンポジウムの報告書を，7月末を目処に完成させることとなった。

8）学会ホームページなどの充実について

学会の活動としてホームページの充実は極めて重要であることを確認した。「うみ」掲載論文のpdfファイルを（発刊から一定期間後に）ホームページに載せることに関連して，コピーライトの問題点などを内田幹事が検討することとした。「うみ」掲載論文を国立情報学研究所のCiNii（NII論文情報ナビゲータ）に集録してもらえるかどうかを，吉田編集委員長が調査することとした。また，会員への電子メールによる連絡を促進するために，会員のメールアドレスの情報を集めることにした。

9）学会のフランス語名について

現在の学会のフランス語名が，フランスの仏日海洋学会とまったく同じであることの問題点が指摘され，同学会と区別するために，最後に「, Tokyo」を付ける案が検討された。この件は，引き続き検討することにした。

10）追悼記事について

2009年に逝去された，宇野寛元会長の追悼記事を小池幹事の担当で，また森田良美名誉会員のそれを神田幹事の担当で，それぞれ「うみ」に掲載することとした。

5. 新入会員

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溝端浩平	東京海洋大学 〒108-8478　東京都港区港南4-5-8

6. 退会（逝去者含む）

長谷川一幸，有本真依子，森田良美

7. 住所変更

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8. 寄贈図書および資料

農工研ニュース（農村工学研究所）；No.63, 64, 65
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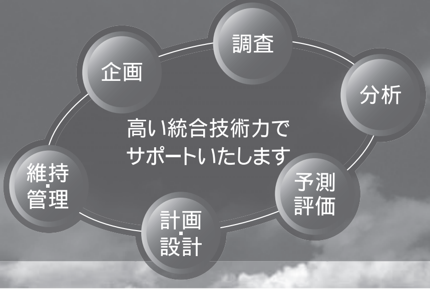


フクジュソウ【植物調査】


信濃川やすらぎ堤(新潟県)【親水型堤防護岸設計】


せせらぎの道(神奈川県)【景観道路計画・設計】


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クマタカ(絶滅危惧種)【猛禽類調査】

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「ハイブリッド抽出」によって生まれた、天然・無添加無着色マグロ魚油カプセル

まぐろの輝き ツナミン

栄養成分(6粒中あたり)

DHA　435mg
EPA　106mg
ビタミンD　2.33μg (栄養機能食品)
ビタミンE　0.43mg

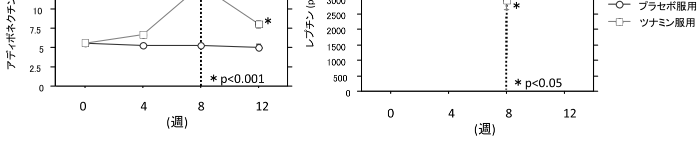
内容量79.2g (440mg/粒、内容300mg/粒 × 180粒)
標準小売価格　6,300円 (送料・税込)

ハイブリッド抽出法 (特開2009-051959)

「ハイブリッド抽出」は低温で圧力を調整しながら数段階抽出を行う製法です。従来の精製で失われるビタミン類を保持し、かつ非常に酸化しにくい魚油を抽出できます。トランス脂肪酸は一切生成されません。

アディポサイトカイン改善作用 (特願2009-274638)

関西大学福永准教授の協力のもと、ツナミン摂取群とプラセボ摂取群各17人の計34人を対象に二重盲検試験を実施し検証しました。1日3回（1回2錠）、1日計6錠、8週間服用を継続させ、その後は服用を中止しました。



ツナミンを服用することにより、脂肪細胞から分泌される善玉物質『アディポネクチン』を増加させ、悪玉物質『レプチン』を減少させる効果があります。これらアディポサイトカインの増減と同時に、血圧降下作用、中性脂肪低下作用、コレステロール低下作用も確認されています。

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日仏海洋学会入会申込書

（正会員・学生会員）

	年度より入会	年　　月　　日申込
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