Tidal flats tend to be extremely fertile due to high primary productivity by phytoplankton in the water and benthic microalgae on the surface sediment (Underwood & Kromkamp 1999). Although benthic animals must tolerate various physiological stresses such as extremely hot or cold temperatures, desiccation, exposure to fresh water when the tide is out, animals with high tolerance to these stresses could exploit the abundant food resources produced on the tidal flats. Therefore, unique benthic animals often occur in abundance on the tidal flats. However, the description of occurrence of the benthic animals remains still incomplete in Korea and Japan, partly due to the excessively large areas of study in relation to the limited number of researchers, and inaccessibility for the surveys (in particular on the soft mud flats). Nevertheless, the ecosystem of tidal flats is under the threat of destruction by reclamation, modification of shore, invasion of exotic species, etc., in many places (cf. Wada et al. 1996, Iwasaki et al. 2004, Sato & Koh 2004, Sato 2006). Above all, we need to know what kinds of species occur and how they are kept at the habitats on the tidal flats, in order at least to preserve these species and healthy ecosystem on the tidal flats.

As a social activity in “Korea and Japan Joint Symposium on Biology of Tidal Flats 2009” held in Sucheon, Jeollanam-do, the southern part of South Korea, 42 participants to the symposium joined the surveys with the purpose of making a list of macrobenthic fauna that occur on Suncheon Bay Tidal Flats with approximately 1,200 ha in total area between June 21 and 23, 2009. In this survey, sixteen species of bivalves, twenty species of gastropods, one species of chiton, fourteen species of polychaetes, eight species of crabs, and three species of other animals were collected, and identified by the participants. Among these sixty-one species, two species of macrobenthic invertebrate animals including gastropod, Ellobium chinense, and crab, Sesarmops intermedius, are listed in the latest Red List of the Ministry of Environment of the Republic of Korea, and eight species of them including five species of potamidid gastropods are listed in that of the Ministry of Environment, Japan. The results of this survey indicate that the ecosystem on the tidal flats in Suncheon Bay are still healthy, and preserved almost in their original conditions, due to the serious efforts of the people in Suncheon City and the municipal authorities.

**Key words:** macrobenthic fauna, mud flats, rocky shore, Suncheon Bay, tidal flats

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**Note**

**Concluding remarks on the joint survey of macrobenthic fauna on Suncheon Tidal Flats by the participants of “Korea and Japan Joint Symposium on Biology of Tidal Flats 2009”**

**JAE-SANG HONG**1,∗, JIN-WOO CHOI2 & HIROAKI TSUTSUMI3

1 Department of Oceanography, Inha University, Incheon 402—751, The Republic of Korea

2 Korean Ocean Research & Development Institute, Jangmok-Myon Geoje 656–830, The Republic of Korea

3 Faculty of Environmental and Symbiotic Sciences, Prefectural University of Kumamoto, Kumamoto 862–8502, Japan

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**Abstract:** As a social activity in “Korea and Japan Joint Symposium on Biology of Tidal Flats 2009” held in Sucheon, Jeollanam-do, the southern part of South Korea, most of the participants to the symposium joined the surveys with the purpose of making a list of macrobenthic fauna that occur on Suncheon Bay Tidal Flats with approximately 1,200 ha in total area between June 21 and 23, 2009. In this survey, sixteen species of bivalves, twenty species of gastropods, one species of chiton, fourteen species of polychaetes, eight species of crabs, and three species of other animals were collected, and identified by the participants. Among these sixty-one species, two species of macrobenthic invertebrate animals including gastropod, Ellobium chinense, and crab, Sesarmops intermedius, are listed in the latest Red List of the Ministry of Environment of the Republic of Korea, and eight species of them including five species of potamidid gastropods are listed in that of the Ministry of Environment, Japan. The results of this survey indicate that the ecosystem on the tidal flats in Suncheon Bay are still healthy, and preserved almost in their original conditions, due to the serious efforts of the people in Suncheon City and the municipal authorities.

**Key words:** macrobenthic fauna, mud flats, rocky shore, Suncheon Bay, tidal flats

**Corresponding author:** Jae-Sang Hong; E-mail, jshong@inha.ac.kr
areas was muddy sand or sandy mud at Stn 1 to 3, and mud at 2)). The sediment type at the sampling stations in the off-shore among the pebbles or cobbles on the rocks (Fig. 2(d-1), 2(d-2)). In Area D, the sediment on the tidal flats was muddy sand placed by mud in the off-shore side on the tidal flats (Fig. 2(c-1), 2(c-2)). The sediment was re-covered by the reed and the halophytes. The sediment was re-
mud. In Area B (Fig. 2(b)), the sediment was mainly sandy marsh (Fig. 2(a)). The sediment of the reed marsh areas is mals from the wooden passageway constructed in the reed
in Suncheon. Macrophthalmus banzai Wada & Sakai was one of the most common crabs on the mud flats. This species was separated from
in the western side of the tidal flats using an air cushion vehi-
cle. Various animals were collected in the surveys, and their specimens were brought back to the laboratories of the participants for identification. Now, most of them are kept at the Ben-
minus. They all are endangered species registered as “Critically Endangered and Endangered (CR
in Table 2 shows a list of the macrobenthic animals that were collected at these sampling stations in this survey. Sixteen species of bivalves, twenty species of gastropods, one species of chiton, one species of brachiopod, one species of echino-
derm, fourteen species of polychaetes, and eight species of crabs were identified.
In Area A, various crabs including Helice tridens De Haan, Uca arcuata (De Haan) (Fig. 3(a)), Sesarmops intermedius (De Haan) (Fig. 3(b)), and Chiromantes dehaani (H. Milne Edwards) occurred densely in the reed marsh. S. intermedius is registered as one of “Threatened species II”, which is equiva-
lent to VU according to the Red Data Base category of IUCN (the International Union for Conservation of Nature) (The Ministry of Environment, Japan 2010), in the Red List of the Ministry of Environment, the Republic of Korea (The Ministry of Environment, the Republic of Korea 2005), and U. arcuata is one of “vulnerable (VU) species” in that of the Ministry of Environment, Japan (The Ministry of Environment, Japan 2010), respectively. The populations of U. arcuata recently de-
clined markedly on the major mud flats in western Japan (Wada et al. 1996). In the gap of the reed marsh, many muddy chimneys were built by Cleistostoma dilatatum (De Haan) (Fig. 3(c)). As infaunal animals in the mud, nereid polychaete, Tyllorrhynchus osawai (Izuka) predominated (Fig. 3(d)).
In Area B, four species of potamid gastropods (Cerithidea (C.) largillierti Philippi (Fig. 4(a)), Cerithidea (C.) ornata Sowerby (Fig. 4(b)), Cerithidea (C.) rhizophorum A. Adams (Fig. 4(c)), Cerithidea (Cerithideopsis) cingulata (Gmelin) (Fig. 4(d))) occurred commonly on the mud flats. In particular, C. (C.) largillierti occurred densely at three areas (Area B to D) on the tidal flats. They all are endangered species registered as “Critically Endangered and Endangered (CR+EN)”, “Criti-
cally Endangered and Endangered”, “Near Threatened (NT)”, and “Near Threatened”, respectively, by the Ministry of Envi-
ronment, Japan (The Ministry of Environment, Japan 2010). A bivalve, Tegillarca granosa (Linnaeus) (Fig. 4(e)), occurred as a dominant species in the mud, which is harvested as sea food in Suncheon. Macrophthalmus banzai Wada & Sakai was one of the most common crabs on the mud flats. This species was separated from Macrophthalmus japonica De Haan by Wada & Sakai (1989). One of the most distinct characteristics of this

![Image](image-url)
species is “banzai” form of claw waving (Fig. 4(f)). Wada (1991) collected this species on the mud flats in the west coast of Korea. The results of this survey added a new record of occurrence of this species on the mud flats from the southern part of South Korea. In the reed marsh, dense patches of assimineid gastropods were found commonly. Most of them were Pseudomphala latericea (H & A Adams) (Fig. 4(g)), but an undescribed species was included in the patches (Fig. 4(h)).

In Area C, dense patches of bivalve, Glauconome chinensis, were found in the sandy sediment at the shore (Fig. 5(a)). Numerous holes appeared in the sediment in Fig. 2(c-1), created by the respiration activities of this species. The sediment on the tidal flats tended to become muddy on the offshore side. A small thread-like capitellid polychaete, Heteromastus sp. (Fig. 5(b)), was one of the dominant species in the muddy sand. In the mud, brachiopod, Lingula anatina (Lamarck) was common (Fig. 5(c)). On the shells of some specimens, an ectosymbiotic bivalve, Koreamya arcuata (A. Adams), attached (Fig. 5(c)) (Hong et al. 2007). This species was found from the coasts of Yellow Sea (Lützen et al. 2009), but no records were reported around the southern coasts in South Korea (personal communication from Torii H & Sato S). Since the distribution of this species concentrates on South Korea and Philippines (Hong et al. 2007, Lützen et al. 2009), the occurrence in Sun-
Table 2. The list of the macrobenthic animals collected in the joint surveys in Suncheon Bay Tidal Flats. Threatened species II: category of endangered species in the Red List of the Ministry of Environment, the Republic of Korea. CR+EN (Critically Endangered and Endangered), NT (Near Threatened), and VU (Vulnerable) are categories of endangered species in the Red List of the Ministry of Environment, Japan.

| Family               | Species name                          | Korean name          | Japanese name          | Sampling location | Red List, the Ministry of Environment |
|----------------------|---------------------------------------|----------------------|------------------------|-------------------|---------------------------------------|
| **Bivalvia**         |                                       |                      |                        |                   |                                       |
| Mytilidae            | Musculista senhousia (Benson, 1842)   | Jongmit              | Hototogisugai          | Stn A, Stn B      | CR+EN (Korea), NT (Japan)              |
| Mytilidae            | Mytilus galloprovincialis (Lamarck, 1819) | Jijunghaedamchi     | Murasakiigai           |                   |                                        |
| Mytilidae            | Semicythera viridis (Reeve, 1844)     | Boktoeljogae         | Kariganegeai           |                   |                                        |
| Arcidae              | Scapharca kogashimensis (Tokunaga, 1906) | Sarubougai           |                        |                   | CR+EN (Japan), NT (Japan)              |
| Arcidae              | Tegillarca granosa (Linnaeus, 1758)   | Komak                | Hanagumori             |                   |                                        |
| Noetiidae            | Sphaeroma galactodes (Benson, 1842)   | Sasagemimiegai       |                        |                   |                                        |
| Trapezidae           | Trapezium (Neantrapezium) sanatum (Reeve, 1843) | Dolgobuji           | Unenshiromyagai        |                   | CR+EN (Japan), NT (Japan)              |
| **Gastropoda**       |                                       |                      |                        |                   |                                       |
| Batillariidae        | Batillaria cumingi (Crosse, 1862)     | Daenggari            | Hossuminina            |                   |                                       |
| Batillariidae        | Batillaria multiformis (Lischke, 1869) | Gaeedogung           | Umunna                  |                   | NT (Japan)                            |
| Potamididae          | Cerithidea (Cerithidea) langilberti (Philippi, 1846) | Geomjeongbiturigodung | Kurohenatari           |                   | CR+EN (Japan)                         |
| Potamididae          | Cerithidea (Cerithidea) ornata Sowerby, 1855 | Eolubbiturigodung   | Shimahenatari          |                   | CR+EN (Japan)                         |
| Potamididae          | Cerithidea (Cerithidea) rhizophoratum A. Adams, 1855 | Dongdzi             | Futohenatari           |                   | NT (Japan)                            |
| Potamididae          | Cerithidea (Cerithidea) ocellata Gmelin, 1791 | Biturigodung        | Henatari                |                   | NT (Japan)                            |
| Potamididae          | Cerithidea (Cerithidea) dajdahimensis Martin, 1899 | Gaetbiturigodung    | Kawai                    |                   | VU (Japan)                            |
| Litueridae           | Lituaria (Lituaria) brevicula (Philippi, 1844) | Garimatjogae        |                        |                   |                                        |
| Littorinidae         | Liturina (Liturina) brevicula (Philippi, 1844) | Chongalgodung       | Tamakibi                 |                   |                                        |
| Stenothyridae        | Stenothyra sp.                        |                      |                        |                   |                                        |
| Assimineidae         | Pseudomphala latericea (H. & A. Adams, 1864) | Palgangkusworeong   | Hirokawazanshou          |                   |                                        |
| Assimineidae         | Pseudomphala sp.                      |                      | Gatazanhou               |                   |                                        |
| Naticidae            | Eunargsa fortunei (Reeve, 1855)       | Gaeitoomgogai        | Akanshi                  |                   |                                        |
| Muricidae            | Kajana venosa (Valenciennes, 1846)    | Pipalgodung          |                        |                   |                                        |
| Muricidae            | Thais (Reishia) clavigera (Küster, 1860) | Daesuri            | Ibonshi                  |                   |                                        |
| Columbellidae        | Columbellus hilla (Reeve, 1859)       | Goowonimireuk        | Marutensumatsumushii     |                   |                                        |
| Nassaridae           | Nassariz (Zebra) starna (Philippi, 1851) | Togkudam             |                        |                   |                                        |
| Bullectidae          | Bullecta exustata (Philippi, 1848)    | Minhaegi            | Hinagino                 |                   |                                        |
| Ellobidae            | Ellobium chunense (Pfeiffer, 1955)    | Daechugwigodung      |                        |                   |                                        |
| Amphiobidae          | Lactiforis takii (Kuroda, 1928)       |                        |                        |                   |                                        |
| **Polyplacophora**   |                                       |                      |                        |                   |                                        |
| Acanthochitonidae    | Acanthochiton defilippi (Tapparone-Canebr, 1874) | Teolganbui         | Kehadahiearaagi         |                   |                                        |
| **Brachiopoda**      |                                       |                      |                        |                   |                                        |
| Lingulidae           | Lingula anatina (Lamarck, 1801)       | Gaetmat              | Midorsihamisengai      |                   |                                        |
| Family               | Species name                  | Korean name      | Japanese name | Red List, the Ministry of Environment |
|---------------------|-------------------------------|-----------------|---------------|--------------------------------------|
| Echinodermata       |                              |                 |               |                                      |
| Temnopleuridae      | Temnopleurus toreumaticus     | Bunjiseongge    | Sanshouuni    |                                      |
| Polychaeta          |                               |                 |               |                                      |
| Nereidae            | Paraleonnates uschakovi       | Hanippaechangaecheongi | Arikawakawagokai |                                      |
|                     | Helista japonica             | Chamaecheongi   |               |                                      |
|                     | Tyrochthys osawaiz (Izuka, 1903) | Sikkamaechongi | Irome         |                                      |
|                     | Persieres albidistrius       | Aogokai         |               |                                      |
|                     | Glycera nicobarica Grube, 1866 | Chirori         |               |                                      |
|                     | Sigambo tentaculata (Treadwell, 1941) | Hanakakagigokai |               |                                      |
| Lumbrineridae       | Scoletoma heterogoda (Marenzeller, 1879) | Kindarisongetgaechongi | Niagashiumisome |                                      |
| Eunicidae           | Marphysa sanguinea (Montagu, 1815) | Basiteolgaechongi | Iwamushi      |                                      |
| Oruphidae           | Diopatra zoomaiz (Izuka 1907) | Teolbogaechongi | Sogokai isome | 1, 4                                  |
| Captellidae         | Heteromastus sp.              |                 |               |                                      |
| Spionidae           | Psamodysyndon koensis (Southern, 1921) |                 |               |                                      |
| Magelonidae         | Megelona japonica Okada 1937 | Yangsogaecheongi | Morotogokai   | 4                                     |
| Pectinidae          | Lagis bocki (Hesse, 1917)    | Ipbigaechongi   | Unissagomushi | 1                                     |
| Terebellidae        | Lorna sp.                     |                 |               |                                      |
| Arthropoda          |                              |                 |               |                                      |
| Camptandridae       | Cleistostoma dilatatum (De Haan, 1833) | Sessanggae      | Arikewagokai  |                                      |
| Ocypodidae          | Uca areata (De Haan, 1833)   | Nonggae         | Shionakai     |                                      |
| Macrophthalmidae    | Macrophthalmus harai Wada & Sakai, 1989 | Chilgae        |               |                                      |
| Macrophthalmidae    | Macrophthalmus japonica De Haan, 1835 | Banggae        | Ashiharamoisi |                                      |
| Varunidae           | Helice trilens De Haan, 1835 |                 |               |                                      |
| Sesarmidae          | Parasesarma insfectus Shen, 1940 | Bulgeunhalsaagakae | Yubakakenkeigani |                                      |
|                     | Sesarmops intermedius (De Haan, 1835) | Bulgeunbalmaenhonggakae | Benkeigani |                                      |
|                     | Chiromantes dehaani (H. Milne Edwards, 1853) | Malonggae | Kurobenkeigani |                                      |
Cheon Bay seems very important from the point of view of biogeography and biodiversity of the macrobenthic animals in South Korea (personal communication from Torii H & Sato S). In the mud, several species of mollusks including gastropods, *C. (C.) largillierti*, *Lactiforis takii* (Kuroda) (Fig. 5(d)), *Nassarius (Zeuxis) sinarus* (Philippi) (Fig. 5(e)), and a bivalve, *Moerella iridescens* (Benson) (Fig. 5(f)), represented also the macrobenthic communities. *L. takii* is relatively abundant, but it is registered as “CR/H11001 EN” in the Red List of the Ministry of Environment, Japan (The Ministry of Environment, Japan 2010).

*N. (Z.) sinarus* originally occurs in the southern coast of China between Qingdao and Hong Kong, but was introduced to Japan recently with imported clams from China such as *Tapes (Ruditapes) philippinarum*, *Mereptrix petechialis* (Lamarck), and *Sinonovacula constricta* (Lamarck). This species was found first in the innermost areas of Ariake Bay, Kyushu, in 2000, and in the coast of Okayama Prefecture facing to the Seto Inland Sea in 2002 (Tamaki et al 2002, Iwasaki et al 2004). Therefore, it is likely that this species was introduced also to Suncheon Bay by human activities from China.

In Area D, various bivalves and gastropods attached on the rock surface (*Mytilus galloprovincialis* Lamarck, *Thais (Reishia) clavigera* (Küster)), occurred in the cracks of the rocks or under the pebbles or cobbles (*Barbatia (Savignyvarca) virescens* (Reeve), *Trapezium (Neotrapezium) liratum* (Reeve), *Littorina (L.) brevula* (Philippi), *Rapana venosa* (Valenciennes)) or inhabited in the coarse sands among the pebbles or cobbles (*T. (R.) philippinarum*) on the rock shore. *Ellobium chinense* (Pfeiffer) (Fig. 6(a)) inhabited the reed marsh on the shore. On the mud flats, bivalves (*T. granosa*, *Scapharca kagoshimensis* (Tokunaga), *Sinonovacula constricta* (Fig. 6(b)), *Cyclina sinensis* (Gmelin)), gastropods (*Batillaria cumingi* (Crosse)(Fig. 6(b), *B. multiformis* (Lischke)(Fig. 6(c), *Cerithidea (Cerithideopsilla) djadjariensis* (Martin) (Fig. 6(d)), *C. (C.) largillieri, N. (Z.) sinarus*) occurred commonly. Among these mollusks, *E. chinense* is registered as “Threatened species II” by the Ministry of Environment of the Republic of Korea, and *B. multiformis, C. (Cerithideopsilla) djadjariensis, C. (C.) largillieri* are registered as endangered species by the Ministry of Environment, Japan (NT, VU, CR+EN, respectively). In the mud, we found also the dense patches of nereid polychaete, *Hediste japonica* (Izuka) (Fig. 6(d)) (cf. Sato & Sattmann 2009).

At the offshore stations, two bivalves, *Theora fragilis* (A Adams) (Fig. 6(e)) and *Potamocorbula* sp. (Fig. 6(f)), and a gastropod, *Stenothyra* sp. (Fig. 6(g)) were most abundant in the macrobenthic communities. *Stenothyra* sp. has been found in...
Fig. 4. Benthic animals collected in Area B. (a) to (d) four species of potamid gastropods, *Cerithidea* (*Cerithidea*) *largillierti* (27 mm in shell length), *C. (C.)* *ornate* (37 mm in shell length), *C. (C.)* *rhizophoratrum* (31 mm in shell length), *C. (C.)* *cingulata* (22 mm in shell length), (e) edible arcid bivalve, *Tegillarca granosa*, (f) “banzai” form of claw waving by *Macrophthalmus banzai*, (g) assimineid gastropod, *Pseudomphala latericea* (9 mm in shell length), (h) undescribed species of *Pseudomphala* (5.2 mm in shell length).

Fig. 5. Benthic animals collected in Area C. (a) bivalve, *Glauconome chinensis*, (b) small thread-like capitellid polychaete, *Heteromastus* sp., (c) brachiopod, *Lingula anatine*, and ectosymbiotic bivalve, *Koreamya arcuata*, on the shells of *Lingula anatine* (indicated by an arrow), (d) amphiborid gastropod, *Lactiforis takii*, 5.3 mm in shell length, (e) nassariid gastropod, *Nassarius (Zeuxis) sinarus*, 20 mm in shell length, (f) tellinid bivalve, *Moerella iridescens*. 
Ariake Bay, Kyushu, Japan, since 2000 (Tamaki et al. 2002, Fukuda 2004). Although this species has not been described as a species formally, it was collected at three different localities in the western coast of Korea. The results of this survey added another locality of this species in Suncheon Bay. It is likely that this species was introduced from Korea to Ariake Bay, Kyushu, Japan, through the import of edible clams (Fukuda 2004). Eight species of polychaetes were collected at these six stations. The largest species was *Diopatra sugokai* Izuka (Fig. 6(h)), and several small infaunal species including *Sigambra tentaculata* (Treadwell) and *Psudopolydora kempi* (Southern) were abundant.

The results of this survey indicate that the ecosystem on the tidal flats are still healthy in Suncheon Bay. The macrobenthic community consists of various mollusks and other taxa including two and eight endangered species registered in Korea and Japan, respectively, while the molluscan community declined drastically in Ariake Bay in Japan, where approximately 40% of Japanese tidal flats are concentrated, in the 1980s to 1990s (Kikuchi 2000, Tsutsumi 2006). In Korea, the registration of endangered species has been done by two different governmental acts, Wildlife Protection Act 2004, by the Ministry of Environment (The Ministry of Environment, the Republic of Korea 2005, 2009), and, Marine Ecosystems Protection and Management Act 2006, by the Ministry of Land, Transport and Maritime Affairs (The Ministry of Land, Transport, and Maritime Affairs, the Republic of Korea 2007). In the latest Red List of these two acts, only four species of marine invertebrates, crabs (*Chasmagnathus convexus* de Haan and *S. intermedius*), and gastropods (*E. chinense* and *Clithon retropectus* von Martens), are registered as threatened species from the coastal wetlands, and many species are treated as “DD (data deficient)” yet. The occurrence of two “Threatened species II” on Suncheon Tidal Flats seems to demonstrate how the tidal flats with approximately 1,200 ha in area are preserved almost in their original conditions due to the serious efforts of the people in Suncheon City and the municipal authorities.

In this paper, we have described the minimum species of macrobenthic animals that we could identify precisely. Fukuda H, Sato S, Sato M, and us conducted an additional benthic faunal survey on the tidal flats in Suncheon Bay in April 2010, collected further various macrobenthic animals including several species of endangered species in Japan, and found dense patches of nereid polychaetes such as *H. japonica* and *T. osawai* in the muddy sediment under the reed marsh widely on the tidal flats. It is very likely that various other species also occur on the tidal flats in Suncheon Bay. Further efforts will be made to describe all the members of the macrobenthic community, and understand their roles in the community on the bay.

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