

Biodiversity of Marine Invertebrates on Rocky Shores of Dokdo, Korea

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Shi-Hyun Ryu, Kuem-Hee Jang, Eun-Hwa Choi, Sang-Ki Kim, Sung-Joon Song, Hyun-Jin Cho, Ju-Sun Ryu, Youn-Mi Kim, Jin Sagong, Jin-Hee Lee, Mi-Young Yeo, So-Yeong Bahn, Hae-Min Kim, Gil-Seong Lee, Don-Hwa Lee, Yeon-Sik Choo, Jae-Hong Pak, Jin-Soon Park, Jong-Seong Ryu, Jong-Seong Khim, and Ui-Wook Hwang (2012) Biodiversity of marine invertebrates on rocky shores of Dokdo, Korea. *Zoological Studies* 51(5): 710-726. Benthic fauna were collected from the intertidal rocky shores of Dokdo Is., Republic of Korea. Four qualitative surveys were performed at 9 stations between Aug. 2007 and June 2008. In total, 98 marine invertebrate species in 57 families were identified during the study period. Of these 98 species, 21 (> 20%) were newly recorded on Dokdo Is. shores including members of the Arthropoda ($n = 8$), Mollusca ($n = 4$), Annelida ($n = 4$), Echinodermata ($n = 2$), Porifera ($n = 1$), Cnidaria ($n = 1$), and Platyhelminthes ($n = 1$). By comparing related references, we identified that the 98 species found at Dokdo exist in mainland areas of both Korea and Japan. Topographical descriptions and ecological comments are given for each of the major species. Among the 7 phyla presented, the Mollusca and Arthropoda predominated, accounting for > 70%-100% of the total taxa at each station. A cluster analysis showed that the faunal composition and distribution of invertebrates considered by habitation types (attached, sessile, or mobile species) were possibly related to the topographical characteristics of each station. Altogether, 403 species (of 10 phyla and 172 families) from a combination of the present and previous studies indicate that the marine invertebrates inhabiting the rocky bottoms in the Dokdo ecosystem show high and dynamic biodiversity. <http://zoolstud.sinica.edu.tw/Journals/51.5/710.pdf>

Key words: Dokdo, Marine Invertebrates, Macrofauna, Far East, Biodiversity.

Dokdo consists of 2 large volcanic islands and 89 small islets and is located in the easternmost region of the Republic of Korea (Fig. 1). Dokdo is estimated to have been formed by volcanic activity during the Pliocene in the 3rd phase of the Cenozoic Era, between ~4.6 and 2.5 Mya (Shon and Park 1994). Because Dokdo is

an oceanic island which is far from the continent, it is thought to have distinctive marine biodiversity unlike continental islands. The sea around Dokdo is influenced by both the East Korean warm current that flows from the equator and the North Korean cold current that moves southwards from the polar regions, which explains why Dokdo is a

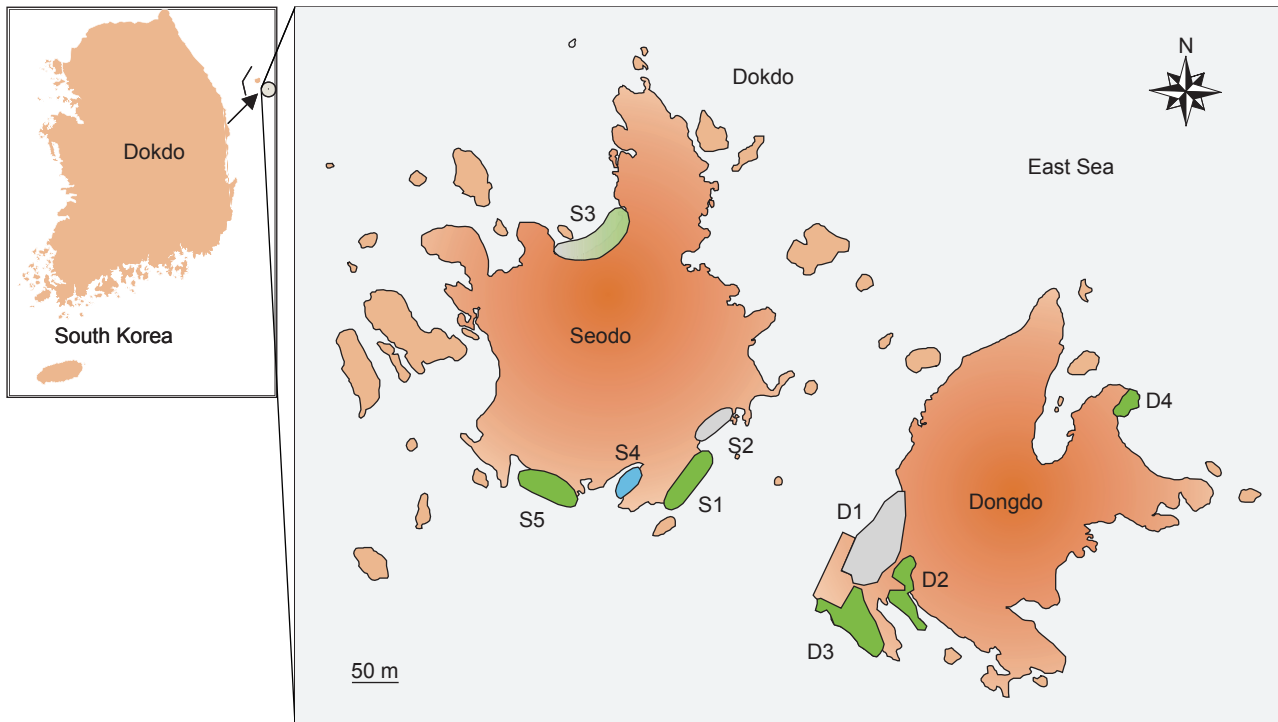
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boundary of water masses (Choi et al. 2002, Park et al. 2002). Consequently, this peculiar condition around Dokdo fosters the abundant diversity of marine invertebrates found there.

Moreover, topographic features of a myriad of small islets and rocks at Dokdo contribute to the relatively abundant distribution of marine macrofauna. Although marine biodiversity may be expected to be dynamic and abundant in the environment of Dokdo, previous studies were limited to specific group(s) of benthic fauna, and to our knowledge, no study to date has reported on the benthic community structure in detail. Since 1978, several studies reported the marine invertebrate fauna at Dokdo, but prior to the

present study (2007-2008) and another recent study (NFRDI 2009), most of them were limited to searching for specific group(s) of taxa (Park et al. 2002, DURIGJU 2004, Kim and Kim 2006, Lee and Seo 2006).

It is not easy for people to access Dokdo because it is remote from the mainland (> 200 km east of the Korean Peninsula) and also no one can stay more than 30 min on the island without extraordinary permission from the Cultural Heritage Administration of Korea. For these reasons, the biodiversity and ecosystem at Dokdo have been relatively well conserved compared to other islands that people can easily reach for leisure or collecting ocean organisms. MacArthur and Wilson (1967)



Vertical profiles for group stations reflecting

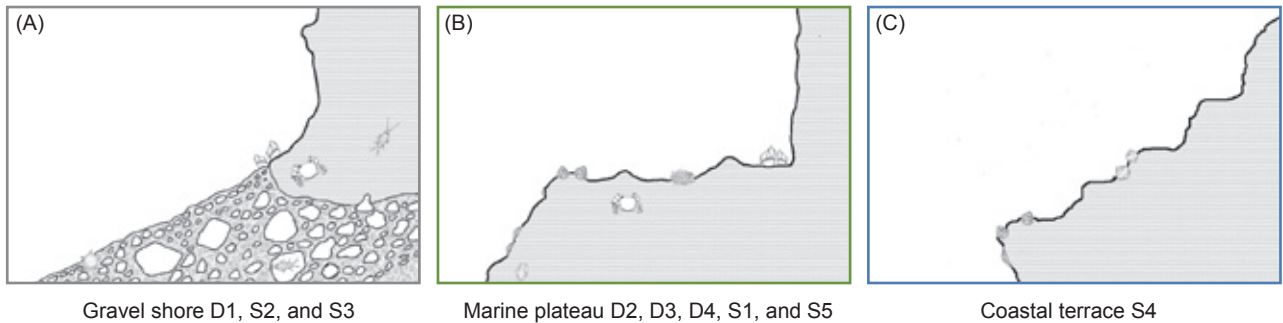


Fig. 1. Map showing the 9 sampling stations at Dokdo and their vertical profiles reflecting the topography. (A) Gravel shore for stations D1, S2, and S3, (B) marine plateau for stations D2, D3, D4, S1, and S5, and (C) coastal terrace for station S4.

pointed out that well-preserved environments should provide optimal habitats for diverse marine organisms. Considering this feature of Dokdo, its biodiversity should somewhat differ from the general feature of coastal marine biodiversity in terms of spatial (i.e., habitat-wise) variability of aquatic faunal assemblages (Mendonça et al. 2009, Tkachenko and Soong 2010). Access to Dokdo is limited due to bad weather conditions and the political context. Thus, there have been only a few ecological studies on the important islands of Dokdo to date, particularly on the biodiversity of marine organisms.

As a pioneering investigation of Dokdo's ecological and economic values, the 1st aim of the present study was to report the benthic fauna and provide an up-to-date scientific understanding of marine biodiversity of the Dokdo ecosystem. This study is one of the 1st systematic ecological surveys of marine invertebrates at Dokdo to our knowledge. Taxonomic descriptions and/or ecological comments on the benthic fauna found during the present study and previously reported taxa are summarized and integrated to evaluate the marine biodiversity of Dokdo's dynamic ecosystem. The review and data provided in the present study should provide a baseline for future faunal and/or ecological studies at Dokdo, Republic of Korea.

MATERIALS AND METHODS

Marine invertebrate sampling

Dokdo consists of 2 large islands (Dongdo and Seodo) and 89 adjacent small islets (Fig. 1).

The tidal range at Dokdo is approximately 0.4 m at maximum. Benthic invertebrates were sampled from the intertidal rocky zone at 9 stations (stns.) at Dongdo (stns. D1-D4) and Seodo (stns. S1-S5), in 4 surveys between Aug. 2007 and June 2008 (Table 1). For each survey, 8 h were spent collecting samples from the study area with a group of > 4 experts including 1 professor and at least 3 graduate students.

Although quantitative sampling was limited in the present study, we allocated a sampling time of 1 h/stn. throughout the series of 4 surveys. Given the differences in sampling date, time, and duration per survey and/or station, quantitative spatial comparisons of biodiversity between stations were minimized. Dominant species were only used to compare the assemblages of various stations. Sampling details including a site description and sampling scheme are summarized in table 1.

Marine invertebrate samples were additionally collected from the subtidal zones of stn. D1 at Dongdo and stn. S1 at Seodo by scuba diving, when accessible. Subtidal samplings were performed at a depth of < 2 m. Vertical profiles reflect the topographical characteristics of the survey stations represented by 3 types of habitats: gravel shore (Fig. 1A; stns. D1, S2, and S3), marine plateau (Fig. 1B; stns. D2, D3, D4, S1, and S5), and coastal terrace (Fig. 1C; stn. S4).

Sorting, identification, and cluster analysis

All faunal samples were fixed in the field with 100% ethanol and transferred to the laboratory for further processing. They were observed under a stereomicroscope (Leica M205C, Wetzlar, Germany) and sorted into major faunal groups.

Table 1. Sampling sites with detailed description and sampling dates for collecting Dokdo marine invertebrates in 2007-2008

Area	Sampling site				Sampling date				
	Station	Longitude	Latitude	Site description	No. of surveys	Aug. 2007	Oct. 2007	Apr. 2008	June 2008
Dongdo	D1	131°51'07"E	37°14'35"N	gravel shore	4	√	√	√	√
	D2	131°51'55"E	37°14'32"N	marine plateau	4	√	√	√	√
	D3	131°51'52"E	37°14'35"N	marine plateau	3		√	√	√
	D4	131°51'52"E	37°14'41"N	marine plateau	2	√	√		
Seodo	S1	131°51'49"E	37°14'35"N	marine plateau	3		√	√	√
	S2	131°51'05"E	37°14'22"N	gravel shore	4	√	√	√	√
	S3	131°51'05"E	37°14'20"N	gravel shore	2	√			√
	S4	131°51'03"E	37°14'19"N	coastal terrace	2			√	√
	S5	131°51'16"E	37°14'27"N	marine plateau	1			√	

After sorting, marine invertebrates were rinsed with distilled water and preserved in 70% ethanol or methanol. They were further identified to species level as far as possible under a stereomicroscope and light microscope (Leica DM2500).

The following monographs and/or taxonomic references were used for species identification: Porifera (Sim 1999); Mollusca (Choe 1992, Kwon et al. 1993, Takashi 2000, Min 2004); Polychaeta (Imajima and Higuchi 1975, Lee and Jae 1983, Lee and Paik 1986a b, Paik 1989, Lee and Jae 1983 1985, Lee 1984); Decapoda (Kim 1973, Kim and Kim 2001); Amphipoda (Jo 1989 1990, Barnard and Karaman 1991); and Echinodermata (Shin 1996). A clustering analysis based on the occurrence of invertebrate taxa at each station was done with squared Euclidean distances using SPSS vers. 19.0 software (SPSS, Chicago, IL, USA).

RESULTS

Faunal composition at Dokdo

During the sampling period at Dokdo, 98 species from 57 families in 7 phyla of marine invertebrates were identified (Tables 2, 3). Across 9 stations, Mollusca ($n = 45$ species) and Arthropoda ($n = 25$ species) collectively contributed about 70% of the total number of species found ($n = 98$ species). The next most frequently occurring marine invertebrate phyla in order were the Annelida (11 species), Echinodermata (11 species), Cnidaria (3 species), Porifera (2 species), and Platyhelminthes (1 species). Gastropoda (62%, 29 species) accounted for $> 1/2$ of the molluscan species (45 species), followed by the Bivalvia (10 species), Polyplacophora (5 species), and Cephalopoda (1 species).

Based on a combination of previously publi-

Table 2. Ninety-eight marine invertebrate species classified into 7 phyla from Dokdo, Korea, and the number of species of each phylum among the 9 stations. Numbers in parentheses indicate the proportion (%) of the number of species of each phylum out of the total number of marine invertebrate species identified at each station

Phylum	No. of species	Sampling site			
		D1	D2	D3	D4
Porifera	2	1 (1.82)	-	1 (2.27)	-
Cnidaria	3	1 (1.82)	1 (16.67)	2 (4.55)	-
Platyhelminthes	1	-	-	-	-
Mollusca	45	25 (45.45)	1 (16.67)	24 (54.55)	2 (28.57)
Annelida	11	7 (12.73)	-	-	-
Arthropoda	25	15 (27.27)	4 (66.67)	12 (27.27)	5 (71.43)
Echinodermata	11	6 (10.91)	-	5 (11.36)	-
Total	98	55 (100.00)	6 (100.00)	44 (100.00)	7 (100.00)

Phylum	No. of species	Sampling site				
		S1	S2	S3	S4	S5
Porifera	2	-	-	-	-	-
Cnidaria	3	1 (2.38)	-	-	-	-
Platyhelminthes	1	1 (2.38)	-	-	-	1 (3.03)
Mollusca	45	22 (52.38)	11 (68.75)	11 (73.33)	11 (64.71)	18 (54.55)
Annelida	11	3 (7.14)	-	-	-	3 (9.09)
Arthropoda	25	9 (21.43)	5 (31.25)	4 (26.67)	5 (29.41)	10 (30.30)
Echinodermata	11	6 (14.29)	-	-	1 (5.88)	1 (3.03)
Total	98	42 (100.00)	16 (100.00)	15 (100.00)	17 (100.00)	33 (100.00)

shed data and the present study (Fig. 2), 403 marine invertebrate species belonging to 10 phyla were recorded in Dokdo so far, among which 21 species were newly recorded in the present study (Appendix I): Porifera (1 species), Cnidaria (1 species), Platyhelminthes (1 species), Mollusca (4 species), Annelida (4 species), Arthropoda (8 species), and Echinodermata (2 species) (Table 3). All species recorded at Dokdo were compared to marine invertebrate species previously reported from both the Korean Peninsula and Japanese mainland. The results showed that all species recorded at Dokdo are known to exist in both the Korean Peninsula and Japanese mainland. Marine invertebrate species dominantly occurred, and newly recorded ones were described under the 7 invertebrate phyla as follows (as summarized in Table 4).

Faunal occurrence and distribution at Dokdo

Dokdo consists of 2 large islands, Dongdo and Seodo. There were 4 sampling stations at Dongdo and 5 at Seodo. These 9 sampling stations were classified into 3 types of habitats according to their topographical features (Fig. 1). Between the 2 islands, the number of species found at Dongdo greatly differed among sampling stations from 6 species at stn. D2 to 55 species at stn. D1 (Table 2). Although the sampling stations were situated close to each other (Fig. 1), there

was a significant difference between the highest and lowest number of species observed at the 9 sampling stations. Numbers of species found at Seodo ranged 15-42 species, and the gap between the highest and the lowest number was rather small compared to that at Dongdo.

In this study, molluscs and arthropods were widely distributed at all stations, while poriferans and plathyhelminthes occurred at 2 sample stations, annelids at 3, cnidarians at 4, and echinoderms at 5. Among the major groups of marine invertebrates found at each station, molluscs were the most abundant at all sample stations except for stns. D2 and D4 where arthropods abundantly occurred.

We classified marine invertebrates into 2 habitation types, attached or mobile, and observed numbers of attached and mobile species at each station, which were classified into 3 types according to topography (Tables 4, 5). As a result, mobile species had higher numbers than attached species at 6 stations, except D3, D4, and S4. Especially at D1, S2, and S3, which were stations classified as having a gravel shore, the number of mobile species far exceeded that of attached species by > 34%. More attached species were found than mobile species only at 1 station, D3, classified as a marine plateau. At D4 and S4, numbers of attached and mobile species were almost equal with only 1 more attached species (Table 5).

Table 3. Numbers of species and families along each phylum of a total of 403 marine invertebrate species classified into 10 metazoan phyla reported from previous and the present studies at Dokdo, and the number of species newly recorded in the present study

Phylum	Marine invertebrates of Dokdo				
	Present study			Combination of previous and the present studies	
	Family	Species	New record	Family	Species
Porifera	2	2	1	11	19
Cnidaria	2	3	1	24	47
Ctenophora	-	-	-	1	1
Platyhelminthes	1	1	1	2	2
Nemertea	-	-	-	1	1
Bryozoa	-	-	-	3	4
Mollusca	22	45	4	59	147
Annelida	9	11	4	23	62
Arthropoda	14	25	8	35	98
Echinodermata	7	11	2	13	22
Total	57	98	21	172	403

-, not observed.

Table 4. (continued)

Species	Phylum ^a	Habitation type		Station								New record ^b		
		Attached species	Mobile species	D1	D3	S1	S5	S4	S2	S3	D4		D2	
<i>Ampithoe</i> sp.	Ar		∇	+										√
<i>Anachis misera</i>	Mo		∇			+								
<i>Anthopleura japonica</i>	Cn	▲			+									
<i>Aphelasterias japonica</i>	Ec		∇			+								
<i>Arabella iricolor</i>	An		∇				+							
<i>Arca boucardi</i>	Mo	▲				+								
<i>Asterina batheri</i>	Ec		∇			+								√
<i>Balanus trigonus</i>	Ar	▲			+									
<i>Cirriiformia cirratus</i>	An		∇	+										
<i>Collisella heroldi</i>	Mo	▲			+									√
<i>Crenomytilus grayanus</i>	Mo	▲							+					
<i>Cyclograpsus intermedius</i>	Ar		∇	+										
<i>Diopatra bilobata</i>	An		∇	+										√
<i>Disotolasterias nipon</i>	Ec		∇	+										
<i>Halichondria</i> sp.	Po	▲			+									√
<i>Haliclona</i> sp.	Po	▲		+										
<i>Haliotis discus</i>	Mo	▲		+										
<i>Holothuria monacaria</i>	Ec		∇			+								
<i>Homalopoma nocturnum</i>	Mo		∇						+					
<i>Hyale rubra</i>	Ar		∇	+										
<i>Idotea metallica</i>	Ar	▲							+					
<i>Irus macrophyllus</i>	Mo	▲					+							
<i>Lepas anatifera</i>	Ar		∇	+										√
<i>Lithophaga curta</i>	Mo	▲					+							
<i>Lumbrineris japonica</i>	An		∇	+										
<i>Monodonta labio confusa</i>	Mo		∇						+					√
<i>Mytilus edulis</i>	Mo	▲			+									
<i>Naineris lavigata</i>	An		∇	+										√
<i>Nassarius fraterculus</i>	Mo		∇	+										
<i>Nereis neoneanthes</i>	An		∇			+								
<i>Nereis pelagica</i>	An		∇			+								
<i>Notoacmea concinna fuscoviridis</i>	Mo	▲							+					√
<i>Notobryon wardi</i>	Mo		∇	+										
<i>Octopus vulgare</i>	Mo		∇		+									√
<i>Omphalius nigerrima</i>	Mo		∇						+					
<i>Ophiothrix exigua</i>	Ec		∇		+									
<i>Pagurus japonicus</i>	Ar		∇	+										
<i>Parhyalella</i> sp.	Ar		∇	+										√
<i>Petalomera wilsoni</i>	Ar		∇				+							
<i>Placiphorella stimpsoni</i>	Mo	▲		+										
<i>Platorchestia crassicornis</i>	Ar		∇		+									√
<i>Pomaulax japonicus</i>	Mo		∇	+										
<i>Porpita umbella</i>	Cn		∇	+										√
<i>Strongylocentrotus nudus</i>	Ec		∇	+										
<i>Synidotea laevidorsalis</i>	Ar	▲							+					
<i>Tristichotrochus unicus</i>	Mo		∇			+								
<i>Typosyllis</i> sp.	An		∇				+							
Total	98	38	60	55	44	42	33	17	16	15	7	6	21	

^aPo, Porifera; Cn, Cnidaria; Pl, Platyhelminthes; Mo, Mollusca; An, Annelida; Ar, Arthropoda; Ec, Echinodermata. ^bIndicates 21 marine invertebrate species newly recorded in this study.

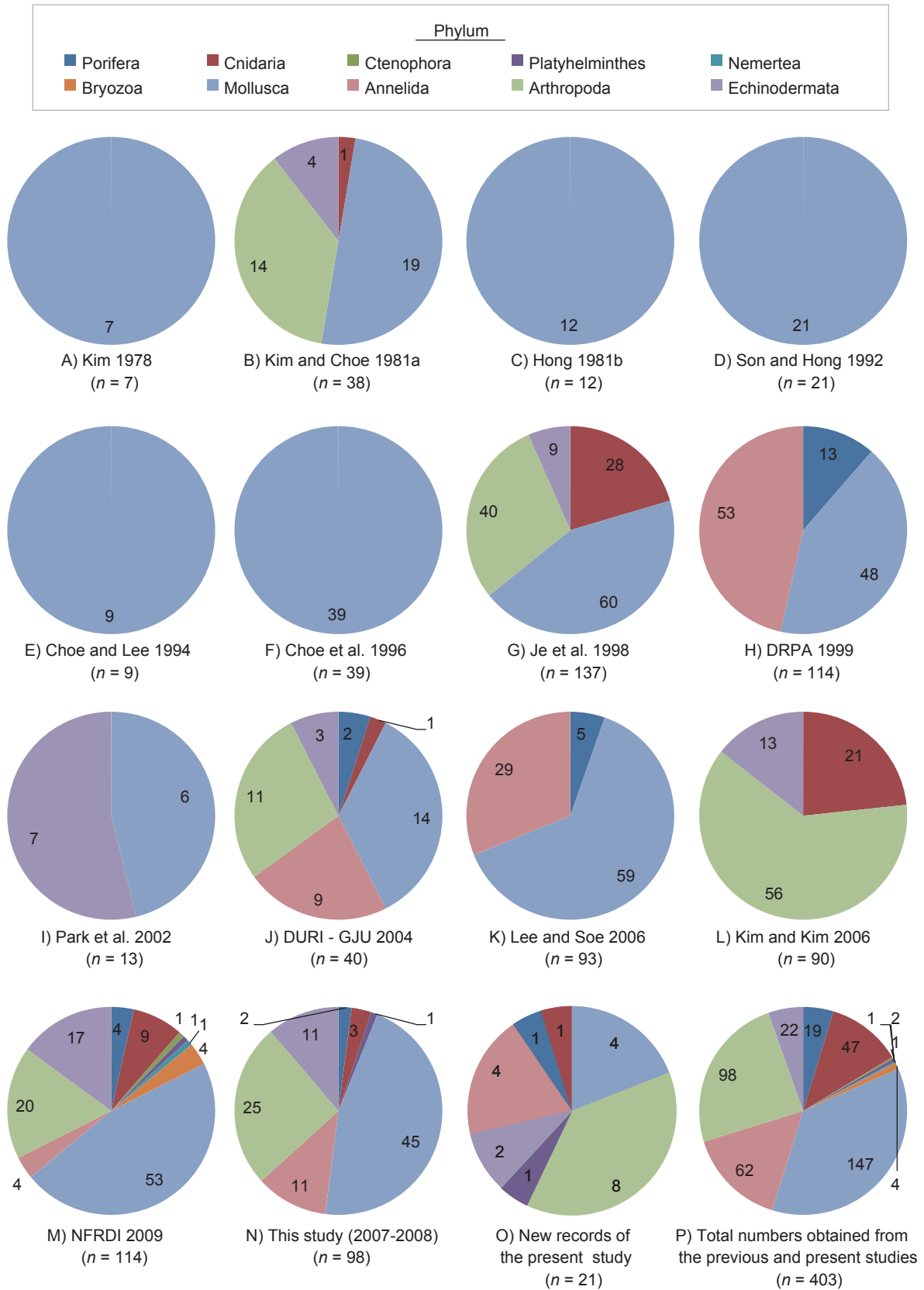


Fig. 2. Marine invertebrate taxa showing the faunal composition with the number of corresponding species at Dokdo from previous and the present studies.

Faunal biodiversity at Dokdo

To clearly evaluate the biodiversity of marine invertebrates at Dokdo, 2 quantitative analyses were performed: a cluster analysis and comparison of fauna. Absence/presence data were used in the cluster analysis in table 4. The cluster analysis of the sampling stations at Dokdo, based on the occurrence of invertebrate taxa at each station, produced 2 major groups (Fig. 3). Group A consisted of stns. D3, S1, and S5, which were classified together as marine plateau (Fig. 1B). In terms of diversity and abundance, molluscan species were the most conspicuous fauna at group A stations, followed by the Arthropoda. It is noteworthy that these plateaus are located on the open southern shore of Dokdo, indicating that the faunal composition was related to the physical and topographical characteristics of the sampling sites.

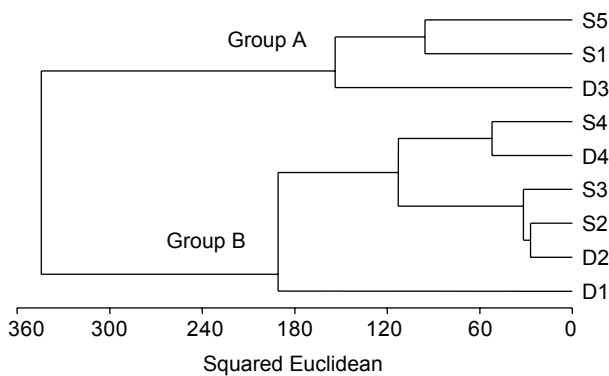


Fig. 3. Dendrogram obtained from the cluster analysis among the 9 sampling stations at Dokdo using the minimum variance method with squared Euclidian distances as the dissimilarity index.

Group B consisted of stns. D1, D2, D4, S2, S3, and S4, which include all of the other types of marine habitats at Dokdo. Station D1 seemed to be further separated from the other sites, reflecting somewhat-different faunal characteristics. In fact, stn. D1 showed the greatest marine invertebrate species diversity and abundance (6 phyla), while all the other stations in group B had a lower number of species and a simpler faunal composition (2 or 3 phyla only). Coastal terrace, old jetty, small creek, gravelly seashore, and sea arch were included in group B.

DISCUSSION

As a result of 4 qualitative surveys performed at 9 stations in the intertidal rocky shores of Dokdo from Aug. 2007 to June 2008, 98 marine invertebrate species belonging to 57 families and 7 phyla were identified (Tables 2, 4). Twenty-one species were sampled at Dokdo for the 1st time including 1 poriferan, 1 cnidarian, 1 plathyhelminth, 2 echinoderms, 4 annelids, 4 molluscs, and 8 arthropods. Since 2 decapod species *Pachytrapsus crassipes* and *Pagurus similis* were recorded from Dokdo for the 1st time by Kim (1960), many species from Dokdo have been discovered including 21 marine invertebrate species newly recorded in the present study (Table 3), for a total of 403 macroinvertebrate species (in 172 families and 10 phyla) to date (DURI-GJU 2004, Lee and Seo 2006, NFRDI 2009). Despite Dokdo being a small island with a total area of 187.554 m², there is a relatively high taxonomic richness of marine invertebrates there. In addition to intertidal

Table 5. Correlation between habitation types and topographic types examined for the 98 identified marine invertebrate species among 9 stations at Dokdo

	Station								
	D1	D2	D3	D4	S1	S2	S3	S4	S5
No. of species	55	6	44	7	42	16	15	17	33
Habitation Type									
Attached species (A)	15	2	25	4	19	4	5	9	14
Mobile species (M)	40	4	19	3	23	12	10	8	19
	A << M	A ≈ M	A > M	A ≈ M	A < M	A << M	A < M	A = M	A < M
Topographical type									
Gravel shore	√					√	√		
Coastal terrace								√	
Marine plateau		√	√	√	√				√

species, further additional investigations under different conditions of seawater depth will reveal more-diverse marine invertebrates at Dokdo.

Porifera

Two families and 2 species of *Halichondria* (demosponges) and *Haliclona* (swallow-water sponges) were found in the present study. Collectively, 11 families and 19 species of Porifera were reported at Dokdo (DRPA 1999, DURIGJU 2004, Lee and Seo 2006, NFRDI 2009; Table 3). *Halichondria* sp. has an irregular shape and was newly recorded in the present survey. It was commonly found on rocky shores of Dokdo, sometimes covering seaweed stalks, rocks, and shells.

Cnidaria

Two families and 3 species of *Anthopleura japonica* (sea anemone), *Actinia equina* (sea anemone), and *Porpita umbella* (jellyfish) were found in the present study. Previously, 24 families and 47 species of Cnidaria were reported from Dokdo (Kim and Choe 1981, Je et al. 1998, DURIGJU 2004, Kim and Kim 2006, NFRDI 2009; Table 3). The present study first records *Por. umbella* at Dokdo, only stn. at D1 (Table 4), although it was reported on the Yellow Sea coast early in 2002 (Park 2002).

Platyhelminthes

One species of *Planocera* belonging to the family Planoceridae was first recorded from Dokdo (stns. S1 and S5) in the present study (Table 4). Another platyhelminth species, *Notoplana humilis*, was previously observed at Dokdo (NFRDI 2009).

Mollusca

This study noted 22 families and 45 species; previously, 59 families and 147 species of Mollusca were recorded at Dokdo (Kim 1978, Hong 1981, Kim and Choe 1981, Son and Hong 1992, Choe and Lee 1994, Choe et al. 1996, Je et al. 1998, DRPA 1999, Park et al. 2002, DURIGJU 2004, Lee and Seo 2006, NFRDI 2009; Table 3). The present study provides the 1st reports of the 3 molluscan species *Collisella heroldi*, *Notoacmea concinna fuscoviridis*, and *Monodonta labio confusa* at Dokdo. The class Gastropoda was dominant among the Mollusca with 13 families

and 29 species. Most of them were observed on gravel surfaces, among seaweeds, or between rocks, while limpets (families Patellidae and Acmaeidae) were observed adhering to rocks in the littoral zone. The most frequently occurring gastropod, *Granulittorina exigua*, was sampled from all 9 stations, being easily found in the splash zone. Two gastropod species (*Reishia bronni* and *R. clavigera*) were also frequently observed at seven of 9 stations. Species belonging to the class Polyplacophora, namely chitons, were also common at Dokdo: *Onithochiton hirasei* and *Acanthochitona circellata* were the most abundant. Out of 2 octopus species found in previous studies (DRPA 1999, Lee and Seo 2006, NFRDI 2009), only 1 (*Octopus vulgare*) was observed in the present study.

Annelida

Nine families and 11 species were found in the present study; previously, 23 families and 62 species of Annelida were recorded at Dokdo (DRPA 1999, DURIGJU 2004, Lee and Seo 2006, NFRDI 2009; Table 3). It is noteworthy that > 1/3 of the polychaete species found in the present study, viz. *Diopatra bilobata*, *Marphysa sanguine*, *Naineris lavigata*, and *Amphitrite oculata*, had not previously been reported from Dokdo. All of the newly recorded polychaete species were only found at stn. D1 (Table 4).

Arthropoda

Fourteen families and 25 species were found in the present study; previously, 35 families and 98 species were reported (Kim 1978, Kim and Choe 1981, Je et al. 1998, DURIGJU 2004, Kim and Kim 2006, NFRDI 2009; Table 3). Two arthropod species, *Pachygrapsus crassipes* and *Pollicipes mitella*, were observed at all 9 stations (Table 4). This study provides the 1st report of 8 Arthropoda species at Dokdo: *Achelia bituberculata*, *Ach. echinata sinensis*, *Ampithoe* sp., *Balanus improvisus*, *Lepas anatifera*, *L. anserifera*, *Parhyalella* sp., and *Platorchestia crassicornis*.

Echinodermata

Seven families and 11 species were found in the present study; previously, 13 families and 22 species of Echinodermata were reported from Dokdo (Kim and Choe 1981, Je et al. 1998, Park et al. 2002, DURIGJU 2004, Kim and Kim 2006,

NFRDI 2009; Table 3). This study provides the 1st report of 2 Echinodermata species, *Asterina batheri* (from stn. S1) and *Strongylocentrotus intermedius* (from stn. D1).

Among the species observed in the present study, molluscs and arthropods were widely distributed at Dokdo and were the most abundant with 45 (46.91%) and 25 species (25.51%), respectively (Table 2). The most dominant group of molluscs was gastropods with 29 species (29.59%). The high diversity of gastropods at Dokdo seems to be due to the existence of abundant rocks onto which gastropods can easily attach, as well as characteristics of the intertidal zones surveyed. Although a quantitative analysis was not planned for this study, the individual densities and abundances of the molluscan population were significantly higher than those of other groups. Since dominant molluscs are considered to be an important component of the macrobenthic fauna at Dokdo, detailed biological and ecological studies of molluscan species distributed at Dokdo need to be conducted.

Among the 9 sampling stations (Tables 2, 5), the station with the most abundant species diversity was stn. D1 with 55 species, while that with the lowest was stn. D2 with 6 species. Although these sampling stations are very close to each other, habitat conditions greatly differ. At stn. D1 where there is a gravel shore, abundant seaweeds were observed around the submerged rocks which are composed of volcanic tuff. It is likely that stn. D1 is not greatly influenced by wind and waves, compared to the other stations, because stn. D1 is located to the west of the wharf at Dongdo. In addition to this, the shallow water depth at stn. D1 made it easier to observe a number of species. Except for stn. D1, the 3 stations (D3, S1, and S5) where > 30 species were observed were topographically wide marine plateaus that provide stable habitats. On the other hand, at 2 stations (D2 and D4) where > 10 species were found, there is a marine plateau, but the topography is not stable due to heavy waves and strong winds. It is likely that such conditions make it hard for various organisms to live. Thus, it seems that the most important factor guaranteeing abundant species diversity of littoral marine invertebrates in this area is the availability of stable and safe habitats. At stns. D1, S2, and S3 that are topographically gravel shores, marine invertebrate species belonging to the mobile type were observed more frequently than the attached type (Fig. 1, Table 5). Among stns. D3, S1, and S5

that are topographically marine plateaus, at stn. D3, species of the attached type were observed more frequently than the mobile type, and at stns. S1 and S5, the ratios of attached and mobile types were similar to each other. Such a trend indicates that the habitation types were closely related to topographical characteristics of habitats, in terms of species occurrences and/or spatial distributions. The correlation between topography and species composition is more clearly presented in the cluster analysis of the sampled stations.

As shown in figure 3, 9 sampled stations were divided mainly into 2 groups, groups A (stns. D3, S1, and S5 which are a marine plateau) and B (stns. D2 and D4 which are a marine plateau; D1, S2, and S3 which are a gravel shore; and S4 which is a coastal terrace). All 3 stations of group A and only stn. D1 of group B showed higher species diversity than the others. Among the 4 stations with high species diversity, stns. D3, S1, and S5 (group A) showed topographic characteristics of a marine plateau, but the remaining stn. D1 (group B) showed characteristics of a gravel shore. In particular, it is noteworthy that all 3 stations of group A were topographically marine plateaus with high species diversity and are intriguingly located on the open southern shore of Dokdo. The results could be interpreted as the faunal composition and degree of species diversity tended to be closely related to the physical and topographical characteristics of the marine invertebrate habitats.

Certain species that occurred in this study are known as invasive species on other continents. The North American isopod, *Idotea metallica*, is a good example which invaded the German North Sea island of Helgoland in 1994 (Nehring 2002). This species can attach to drifting substrates such as driftwood and macroalgal fragments which provide a suitable habitat and food resource (Gutow and Franke 2003). However, this species is regarded as an indigenous species at Dokdo, as it was first recorded a century ago (Richardson 1909). Currently, all species found in the present study are considered to be native species.

The Dokdo marine ecosystem is still under investigation and needs further research especially on marine invertebrates. The difficulty in accessing the islands would be the 1st reason limiting in-depth faunal studies of the marine biodiversity at this time. Additional investigations under different conditions of sea depth and deep-sea diving around Dokdo would make it possible to observe more-diverse marine communities. Through further studies with marine organisms from Dokdo,

we plan to perform various molecular marker-based work in the fields of population genetics (Bahn et al. 2009), phylogenetics (Park et al. 2007, Hwang et al. 2009, Jang and Hwang 2009), and conservation biology (Ryu et al. 2010).

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Appendix I. List of a total of 403 marine invertebrate species (172 families, 64 orders, 17 classes, 10 phyla) reported from Dokdo, Republic of Korea as of June 2010

Phylum Porifera	<i>Eudendrium tenellum</i>	Family Dendrophylliidae
Class Demospongia	<i>Eudendrium</i> sp. 1	<i>Rhizopsammia minuta</i>
Order Homosclerophorida	<i>Eudendrium</i> sp. 2	<i>mutsuensis</i>
Family Plakinidae	Family Tubulariidae	Order Antipatharia
<i>Oscarella lobularis</i>	<i>Tubularia mesembryanthemum</i>	Family Antipathidae
Order Astrophorida	Order Thecarae	<i>Antipathes lata</i>
Family Stellettidae	Family Haleciidae	<i>Antipathes</i> sp.
<i>Stelletta</i> sp.	<i>Halecium delicatum</i>	Order Ceriantharia
Family Geodiidae	Family Lafoeidae	Family Cerianthidae
<i>Geodia</i> sp.	<i>Filellum serratum</i>	<i>Cerianthus filiformis</i>
Order Hadromerida	<i>Lafoea fruticosa</i>	Order Corallimorpharia
Family Chondrosiidae	Family Campanulariidae	Family Corallimorphidae
<i>Chondrilla</i> sp.	<i>Eucalix paradoxus</i>	<i>Corynactis viridis</i>
Order Dictyoceratida	<i>Orthophyxis platycarpa</i>	Family Corallimorphidae
Family Irciniidae	<i>Obelia geniculata</i>	<i>Corynactis</i> sp.
<i>Ircinia</i> sp.	Family Sertulariidae	
Order Haplosclerida	<i>Sertularella sagamina</i>	Phylum Ctenophora
Family Haliclonaidae	<i>Sertularella miurensis</i>	Class Tentaculata
<i>Haliclona permollis</i>	<i>Sertularella levigata</i>	Order Cydippida
<i>Haliclona</i> sp. ^a	Family Plumulariidae	Family Lampeidae
Family Callyspongiidae	<i>Plumularia filicaulia japonica</i>	<i>Lampea pancernia</i>
<i>Callyspongia confoederata</i>	<i>Aglaophenia whiteleggei</i>	
<i>Ceraochalina differentiata</i>	Order Siphonophora	Phylum Platyhelminthes
Order Petrosiida	Family Porpitidae	Class Turbellaria
Family Perosiidae	<i>Porpita umbella</i> ^{a,b}	Order Polycladida
<i>Petrosia corticata</i>	Class Anthozoa	Family Notoplanidae
<i>Petrosia</i> sp. 1	Order Stolonifera	<i>Notoplana humilis</i>
<i>Petrosia</i> sp. 2	Family Cornulariidae	Family Planoceridae
Order Poecilosclerida	<i>Clavularia racemosa</i>	<i>Planocera</i> sp. ^{a,b}
Family Myxillidae	<i>Clavularia mikade</i>	
<i>Myxilla incrustans</i>	<i>Cornularia komaii</i>	Phylum Nemertea
<i>Myxilla setoensis</i>	Order Gorgonacea	Class Nemertini
<i>Myxilla</i> sp.	Family Plexauridae	Order Hoplonemertini
Order Halichondrida	<i>Eupleaura</i> sp.	Family Lineidae
Family Halichondriidae	<i>Eupleaura</i> sp. 1	<i>Lineus fuscoviridis</i>
<i>Halichondria oshoro</i>	Family Melithaeidae	
<i>Halichondria panicea</i>	<i>Acabaria</i> sp.	Phylum Bryozoa
<i>Halichondria</i> sp. ^{a, b}	<i>Acabaria</i> sp. 1	Class Gymnolaemata
Family Hymeniacionidae	<i>Acabaria bicolor</i>	Order Cheilostomata
<i>Hymeniacion sinapium</i>	<i>Melithaea flabellifera</i>	Family Cabereidae
	Order Alcyonacea	<i>Tricellaria occidentalis</i>
Phylum Cnidaria	Family Alcyoniidae	Family Watersiporidae
Class Hydrozoa	<i>Bellonella rubra</i>	<i>Watersipora subovoidea</i>
Order Athecatae	<i>Bellonella rigida</i>	Family Phidoloporidae
Family Corymorphidae	<i>Bellonella</i> sp.	<i>Iodictyum deliciosum</i>
<i>Fukaurahydra</i> sp.	Order Actiniaria	<i>Flustra</i> sp.
<i>Fukaurahydra anthoformis</i>	Family Actiniidae	
Family Corynidae	<i>Actinia equina</i> ^a	Phylum Mollusca
<i>Coryne pusilla</i>	<i>Anthopleura japonica</i> ^a	Class Polyplacophora
Family Solanderiidae	<i>Anthopleura</i> sp.	Order Neoloricata
<i>Soladeria misakinensis</i>	<i>Epiactis japonica</i>	Family Ischnochitonidae
<i>Solanderiidae</i> sp.	Family Haliplanellidae	<i>Lepidozona coreanica</i>
Family Bougainvilliidae	<i>Haliplanella lucia</i>	<i>Ischnochiton comptus</i>
<i>Rhizorhagium</i> sp.	Order Scleractinia	<i>Ischnochiton</i> sp.
Family Eudendriidae	Family Caryophyllidae	<i>Ischnochiton boninensis</i>
<i>Eudendrium capillare</i>	<i>Caryophyllia japonica</i>	<i>Ischnochiton hakodadensis</i>

Appendix I. (continued)

Family Mopaliidae	<i>Batillus cornutus</i> ^a	<i>Placida cremoniana</i>
<i>Placiphorella stimptus</i> ^a	<i>Turbo</i> cf. <i>excellens</i>	Family Elysiidae
Family Chitonidae	<i>Marmarostoma stenogyrum</i>	<i>Elysia abei</i>
<i>Chiton kurodaia</i> ^a	<i>Pomaulax japonicus</i> ^a	<i>Elysia flavomacula</i>
<i>Chiton tectiformis</i>	<i>Homalopoma amussitatum</i>	Order Aplysiomorpha
<i>Liolophura japonica</i> ^a	<i>Neocollonia pilula</i>	Family Aplysiidae
<i>Onithochiton hirasei</i> ^a	<i>Homalopona nocturnum</i> ^a	<i>Aplysia kurodai</i> ^a
Family Acanthochitonidae	Family Phasianellidae	<i>Aplysia parvula</i>
<i>Acanthochiton achates</i>	<i>Hiloa megastoma</i>	<i>Aplysia oculifera</i>
<i>Acanthochiton circellata</i> ^a	Order Mesogastropoda	<i>Aplysia sagamiana</i>
<i>Acanthochitona defilippi</i>	Family Littorinidae	Order Pleurobranchomorpha
Family Cryptoplacidae	<i>Littorina brevicula</i>	Family Pleurobranchidae
<i>Cryptoplax japonica</i>	<i>Granulilittorina exigua</i> ^a	<i>Pleurobranchaea japonica</i>
Class Gastropoda	<i>Littorina mandschurica</i>	<i>Bethellina citrina</i>
Order Archaeogastropoda	<i>Alectrion</i> cf. <i>glans nipponensis</i>	Order Nudibranchia
Family Haliotidae	Family Litiopidae	Family Goniodorididae
<i>Nordotis discus</i> ^a	<i>Styliferina goniochila</i>	<i>Hopkinsia hiroi</i>
<i>Nordotis gigantea</i>	Family Vermetidae	Family Chromodorididae
<i>Sulculus diversicolor</i>	<i>Dendropoma maximum</i>	<i>Chromodoris aureopurpurea</i>
<i>supertexta</i>	<i>Serpulornis imbricatus</i> ^a	<i>Chromodoris orientalis</i>
Family Fissurellidae	Family Hipponicidae	<i>Chromodoris tinctoria</i>
<i>Tugali decussata</i>	<i>Amalthea conica</i>	<i>Hypselodoris festiva</i>
Family Patellidae	Family Capulidae	Family Aldisidae
<i>Cellana grata</i> ^a	<i>Capulus dilatatus</i>	<i>Aldisa cooperi</i>
<i>Cellana nigrolineata</i>	Family Calyptraeidae	Family Tritoniidae
<i>Cellana toreuma</i> ^a	<i>Crepidula onyx</i>	<i>Tritonia festiva</i>
Family Acmaeidae	<i>Bostrycapulus gravispinosus</i>	Family Arminidae
<i>Chiazacmea pygmaea</i>	Family Lamellariidae	<i>Dermatobranchus otome</i>
<i>Patelloida saccharina lanx</i>	<i>Larmellaria kiiensis</i>	Family Scyllaeidae
<i>Collisella dorsuosa</i> ^a	Family Cypraeidae	<i>Notobryon wardi</i> ^a
<i>Collisella heroldi</i> ^{a,b}	<i>Palmadusta gracilis</i>	Family Facelinidae
<i>Collisella langfordi</i>	Family Ovulidae	<i>Hermisenda crassicornis</i>
<i>Notoacmea gloriosa</i>	<i>Primovula rhodia</i>	<i>Sakuraeolis modesta</i>
<i>Notoacmea shrenckii</i> ^a	Order Hypsogastropoda	Family Aeolidiidae
<i>Notoacmea concinna</i>	Family Triphoridae	<i>Protaeolidiella atra</i>
<i>fuscoviridis</i> ^{a,b}	<i>Iniforis</i> sp.	Family Fionidae
Family Trochidae	<i>Mastonia</i> sp.	<i>Fiona pinnata</i>
<i>Chlorostoma argyrostoma</i>	Order Neogastropoda	Order Basommatophora
<i>lischkei</i> ^a	Family Muricidae	Family Siphonariidae
<i>Chlorostoma argyrostoma</i>	<i>Reishia bronni</i> ^a	<i>Anthosiphonaria sirius</i> ^a
<i>turbinatum</i> ^a	<i>Reishia clavigera</i> ^a	<i>Sacculosiphonaria japonica</i> ^a
<i>Chlorostoma xanthostigma</i>	<i>Ergalatax contractus</i>	Class Bivalvia
<i>Omphalius pfeifferi carpenteri</i> ^a	<i>Reishia luteostoma</i> ^a	Order Arcoida
<i>Omphalius rusticus</i>	Family Columbelloidae	Family Arcidae
<i>Omphalius nigerrima</i> ^a	<i>Mitrella bicincta</i>	<i>Arca avellana</i>
<i>Cantharidus callichroa</i>	<i>Anachis misera</i> ^a	<i>Arca boucardi</i> ^a
<i>Cantharidus jessoensis</i>	Family Nassariidae	Family Parallelodontidae
<i>Cantharidus callichroa</i>	<i>Nassarius fraterculus</i> ^a	<i>Porterius dalli</i>
<i>bisbalteatus</i>	Family Buccinidae	Order Mytiloidea
<i>Fossarina picta</i>	<i>Enzinopsis menkeana</i>	Family Mytilidae
<i>Tristichotrochus haliarchus</i>	<i>Kelletia lischkei</i>	<i>Crenomytilus grayanus</i> ^a
<i>Tristichotrochus simodense</i>	<i>Pollia subrubiginosus</i>	<i>Musculus cupreus</i>
<i>Tristichotrochus unicus</i> ^a	<i>Cantharus cecillei</i>	<i>Mytilus coruscus</i> ^a
<i>Monodonta neritoides</i> ^a	Order Cephalaspidea	<i>Mytilus edulis</i> ^a
<i>Monodonta perplexa</i> ^a	Family Haminoeidae	<i>Hormomya mutabilis</i>
<i>Monodonta labio confusa</i> ^{a,b}	<i>Haloa japonica</i>	<i>Lithophaga curta</i> ^a
<i>Calliostoma unicum</i>	Order Sacoglossa	<i>Modiolus modiolus difficilis</i>
Family Turbinidae	Family Hermaeidae	<i>Modiolus philippinarum</i>

Appendix I. (continued)

<i>Modiolus auriculatus</i>	Family Glyceridae	Family Cirratulidae
<i>Septifer bilocularis</i>	<i>Hemipodus yenourensis</i>	<i>Acrocirrus validus</i>
<i>Septifer virgatus</i>	<i>Glycera chirori</i>	<i>Cirriformia tentaculata</i>
Order Pterioida	Family Hesionidae	<i>Cirriformia cirratus</i> ^a
Family Propeamussiidae	<i>Hesione reticulata</i>	<i>Dodecaceria comcharum</i>
<i>Chlamys irregularis</i>	Family Syllidae	Order Opheliida
Family Spondylidae	<i>Autolytus tsugarus</i>	Family Opheliidae
<i>Spondylus varius</i>	<i>Typosyllis hyalina</i>	<i>Polyopthalmus pictus</i>
<i>Spondylus butleri</i> ^a	<i>Typosyllis adamanteus</i>	Family Scalibregmidae
Family Limidae	<i>kurilensis</i>	<i>Oncoscolex pacificus borealis</i>
<i>Limaria hirasei</i>	<i>Typosyllis variegata</i> ^a	Order Capitellida
Family Glyphaeidae	<i>Trypanosyllis zebra</i>	Family Capitellidae
<i>Neopycodonte musashiana</i>	<i>Trypanosyllis taeniaformis</i>	<i>Notomastus latericeus</i>
Family Ostreidae	<i>Trypanosyllis gemmipara</i>	<i>Capitella capitata</i>
<i>Ostera</i> sp.	<i>Odontasyllis undecimdongta</i>	Family Maldanidae
<i>Ostrea circumpecta</i> ^a	<i>Syllis gracilis</i>	<i>Axiothella quadrimaculata</i>
<i>Crassostrea echinata</i> ^a	<i>Syllis spongiphila</i>	Order Terebellida
<i>Crassostrea gigas</i> ^a	Family Nereidae	Family Terebellidae
<i>Crassostrea nippona</i>	<i>Nereis surugaense</i>	<i>Amphitrite oculata</i> ^{a,b}
Order Veneroidea	<i>Nereis neoneanthes</i> ^a	<i>Thelepus japonicus</i>
Family Chamidae	<i>Nereis multignatha</i>	<i>Loimia medusa</i>
<i>Chama fragum</i>	<i>Nereis zonata</i>	Order Sabellida
<i>Chama japonica</i>	<i>Nereis pelagica</i> ^a	Family Sabellidae
<i>Chama dunkeri</i>	<i>Neanthes caudata</i>	<i>Chone teres</i>
<i>Chama limbula</i>	<i>Platynereis dumerilii</i>	<i>Euchone alicaudata</i>
<i>Pseudochama refroversa</i>	<i>Perinereis cultrifera floridana</i>	<i>Myxicola infundibulum</i>
<i>Amphichama argentata</i>	Family Polynoidae	Family Serpulidae
Family Lasaeidae	<i>Halosydna brevisetosa</i>	<i>Serpula watsoni</i>
<i>Lasaea undulata</i>	<i>Lepidonotus squamatus</i>	<i>Ditrupa arietina</i>
Family Kelliidae	Family Chrysopetalidae	<i>Dexiospira foraminosus</i>
<i>Kellia lischkei</i>	<i>Chrysopetalum occidentale</i>	<i>Filograna</i> sp.
Family Carditidae	Order Amphinomida	<i>Leodora argutus</i>
<i>Cardita leana</i>	Family Amphinomidae	<i>Salmacina dysteri</i>
Family Tellinidae	<i>Amphinome rostrata</i>	<i>Protula tubularia</i>
<i>Macoma incongrua</i>	Family Euprosinidae	Phylum Arthropoda
Family Veneridae	<i>Euprosine superba</i>	Class Pycnogonida
<i>Irus macrophyllus</i> ^a	Order Eunicida	Order Pantopoda
<i>Irus mitis</i>	Family Onuphidae	Family Ammotheidae
Order Myoidea	<i>Diopatra bilobata</i> ^{a,b}	<i>Ammothea hilgendorffi</i> ^a
Family Gastrochinidae	Family Eunicidae	<i>Achelia echinata sinensis</i> ^{a,b}
<i>Gastrochaena</i> sp.	<i>Lysidice collaris</i>	<i>Achelia bituberculata</i> ^{a,b}
Family Hiattellidae	<i>Eunice antennata</i> ^a	<i>Tanystylum scrutator</i>
<i>Hiattella orientalis</i>	<i>Eunice mucronata</i>	<i>Tanystylum ulreungum</i>
Order Pholadomyoidea	<i>Marphysa sanguinea</i> ^{a,b}	Class Crustacea
Family Lyonsiidae	Family Lumbrineridae	Order Thoracica
<i>Agriodesma naricula</i>	<i>Lumbrineris bifurcata</i>	Family Scalpellidae
Class Cephalopoda	<i>Lumbrineris japonica</i> ^a	<i>Pollicipes mitella</i> ^a
Order Octopoda	Family Arabellidae	Family Lepadidae
Family Octopodidae	<i>Arabella iricolor</i> ^a	<i>Lepas anatifera</i> ^{a,b}
<i>Octopus vulgare</i> ^a	Order Orbiniidae	<i>Lepas anserifera</i> ^{a,b}
<i>Octopus dofleini</i>	Family Orbiniidae	Family Chthamalidae
Phylum Annelida	<i>Naineris lavigata</i> ^{a,b}	<i>Octomeris sulcata</i>
Class Polychaeta	<i>Orbiniidae</i> sp.	<i>Chthamalus challengerii</i> ^a
Order Phyllodocida	Order Spionida	Family Tetracitidae
Family Phyllodocidae	Family Spionidae	<i>Tetracita japonica</i> ^a
<i>Eulalia viridis</i>	<i>Prionospio krusadensis</i>	Family Archaeobalanidae
<i>Genetyllis castanea</i>	<i>Laonice cirrata</i>	<i>Acasta dofleini</i>
	Order Cirratulida	

Appendix I. (continued)

Family Balanidae	Order Decapoda	<i>Pilumnus minutus</i>
<i>Balanus trigonus</i> ^a	Family Rhynchocinetidae	<i>Palapedia integra</i>
<i>Balanus improvisus</i> ^{a,b}	<i>Rhynchocinetes uritai</i>	<i>Leptodius exaratus</i>
<i>Megabalanus rosa</i> ^a	Family Alpheidae	Family Grapsidae
<i>Megabalanus volcano</i>	<i>Alpheus</i> sp.	<i>Pachygrapsus crassipes</i> ^a
Order Siphonostomatoidea	<i>Alpheus</i> sp. 1	<i>Hemigrapsus sanguineus</i> ^a
Family Caligidae	<i>Synalpheus tumidomanus</i>	<i>Cyclograpsus intermedius</i> ^a
<i>Lepeophtheirus semicossoyphi</i>	<i>Salmonus gracilipes</i>	<i>Gaetice depressus</i>
Order Tanaidacea	Family Hippolytidae	<i>Hemigrapsus penicillatus</i>
Family Tanaidae	<i>Heptacarpus rectirostris</i>	
<i>Tanai cavolinii</i>	Family Pandalidae	Phylum Echinodermata
Order Isopoda	<i>Pandalus</i> sp.	Class Stelleridae
Family Sphaeromatidae	Family Diogenidae	Order Valvatida
<i>Holotelson tuberculatus</i>	<i>Paguristes ortmanni</i>	Family Goniasteridae
<i>Dynoides brevispina</i>	Family Lithodidae	<i>Certonardoa semiregularis</i>
<i>Dynoides spinipodus</i>	<i>Oedignathus inermis</i>	Order Spinulosa
<i>Dynoides dentisinus</i>	Family Paguridae	Family Asterinidae
Family Idoteidae	<i>Pagurus japonicus</i> ^a	<i>Asterina pectinifera</i> ^a
<i>Cleantiella isopus</i>	<i>Pagurus similis</i> ^a	<i>Asterina batheri</i> ^{a,b}
<i>Idotea ochotensis</i>	<i>Pagurus lanuginosus</i> ^a	Family Echiniasteridae
<i>Idotea metallica</i> ^a	<i>Pagurus pectinatus</i>	<i>Henricia nipponica</i> ^a
<i>Synidotea laevidorsalis</i> ^a	<i>Pagurus</i> sp.	Family Solasteridae
<i>Synidotea</i> sp.	<i>Pagurus pilosipes</i>	<i>Solaster dawsoni</i>
<i>Synidotea hikigawaensis</i>	<i>Pagurus exiguus</i>	Order Forcipulata
<i>Synidotea</i> sp.	<i>Pagurus imaii</i>	Family Asteriidae
Family Janiridae	<i>Pagurus angustus</i>	<i>Asterias amurensis</i>
<i>Janiropsis longiantennata</i>	<i>Pagurus nigrivittatus</i>	<i>Distolasterias nipon</i> ^a
Family Ligiidae	<i>Pagurus rubrior</i>	<i>Plazaster borealis</i>
<i>Ligia exotica</i> ^a	<i>Pagurus constans</i>	<i>Aphelasterias japonica</i> ^a
Order Amphipoda	Family Galatheididae	<i>Coscinasterias acutispina</i>
Family Gammaridae	<i>Galathea orientalis</i>	Order Myophurida
<i>Elasmopus japonicus</i>	Family Porcellanidae	Family Ophiotrichidae
Family Hyalidae	<i>Pisidia serratifrons</i>	<i>Ophiarachnella gorgonia</i>
<i>Hyale schmidti</i>	<i>Petrolisthes japonicus</i>	Family Ophiotrichidae
<i>Hyale rubra</i> ^a	<i>Pachycheles stevensii</i>	<i>Ophiothrix exigua</i> ^a
<i>Hyale punctata</i>	Family Dromiidae	Family Ophionereididae
<i>Parhyale</i> sp.	<i>Petalomera wilsoni</i> ^a	<i>Ophioneresis eurybrachioplax</i>
<i>Allorchestes</i> sp.	<i>Petalomera</i> sp.	Family Ophiuridae
Family Talitridae	Family Majidae	<i>Ophioplocus japonicus</i>
<i>Platorchestia crassicornis</i> ^{a,b}	<i>Pugettia quadridens</i>	Class Echinoidea
Family Ischyroceridae	<i>quadridens</i>	Order Echinoidea
<i>Jassa falcata</i>	<i>Pisoides bidentatus</i>	Family Stroglyocentrotidae
Family Ampithoidae	<i>Pugettia quadridens intermedia</i>	<i>Hemicentrotus pulcherrimus</i> ^a
<i>Ampithoe brevipalma</i>	Family Hymenosomatidae	<i>Pseudocentrotus depressus</i>
<i>Ampithoe lacertosa</i>	<i>Rhynchoplax messor</i>	<i>Strongylocentrotus nudus</i> ^a
<i>Ampithoe valida shimizuensis</i>	<i>Halicarcinus orientalis</i>	<i>Strongylocentrotus</i>
<i>Ampithoe</i> sp. ^{a,b}	Family Portunidae	<i>intermedius</i> ^{a,b}
<i>Parhyalella</i> sp. ^{a,b}	<i>Thalamita sima</i>	Family Echinometridae
Family Podoceridae	<i>Liocarcinus</i> sp.	<i>Anthodiaris crassispina</i> ^a
<i>Podocerus inconspicuus</i>	Family Xanthidae	Class Holothuroidea
Family Caprellidae	<i>Actaea semblatae</i>	Order Aspidochirotrida
<i>Caprella penantis</i>	<i>Macromedaeus distinguendus</i>	Family Stichopodidae
<i>Caprella verrucosa</i>	<i>Gaillardiellus orientalis</i>	<i>Stichopus japonicus</i>
<i>Caprella brevirostris</i>	<i>Heteropilumnus ciliatus</i>	Family Holothuriidae
<i>Caprella acanthogaster</i>	<i>Actumnus elegans</i>	<i>Holothuria monacaria</i> ^a
<i>Caprella danielewskii</i>	<i>Cycloxanthops truncatus</i>	<i>Holothuria pardalis</i>

^a Ninety-eight marine invertebrate species observed in the present study.^b Twenty-one newly recorded species of 98 marine invertebrate species observed in the present study.