



Original article

A study on the biodiversity of benthic invertebrates in the waters of Seogwipo, Jeju Island, Korea

In-Young Cho^a, Dong-Won Kang^a, Jisoon Kang^b, Hosung Hwang^b, Jeong-Hye Won^c, Woon Kee Paek^b, Su-Yuan Seo^{d,*}^a General Planning and Management Division, Planning Office for Marine Biodiversity Institute of Korea, Seochon-gun, South Korea^b Natural History Research Team, National Science Museum, Daejeon, Korea^c Resources Research Division, Planning Office for Marine Biodiversity Institute of Korea, Seochon-gun, Korea^d Ewha Womans University Natural History Museum, Seoul, Korea

ARTICLE INFO

Article history:

Received 21 January 2014

Received in revised form

11 February 2014

Accepted 13 February 2014

Available online 19 March 2014

Keywords:

Invertebrate

Jeju Island

Seogwipo

ABSTRACT

The biodiversity of benthic invertebrates in the intertidal and subtidal regions of Gapado, Beomseom, and Munseom islets was surveyed twice in May and September 2013 to study the state of biodiversity in Seogwipo, Jeju Island. As a result, a total of 77 species, 46 families, 25 orders, 14 classes, and nine phyla of benthic invertebrates were found. The species which were found, by taxon, consisted of the following: 26 species of Cnidaria (34%), 24 species of Mollusca (31%), seven species of Chordata (9%), six species of Arthropoda (8%), six species of Porifera (8%), five species of Echinodermata (7%), one species of Bryozoa (1%), one species of Annelida (1%), and one species of Ctenophora (1%).

Copyright © 2014, National Science Museum of Korea (NSMK) and Korea National Arboretum (KNA).

Production and hosting by ELSEVIER. All rights reserved.

Introduction

Jeju Island, Korea's southernmost island, is geographically affected by the Taiwan current; as a consequence, it becomes a place where temperate and subtropical creatures coexist, with a higher diversity of species and unique formation of biota (Song et al., 2009). In this regard, the waters near Seogwipo are included in the biosphere reserve designated by the United Nations Organization for Education, Science, and Culture. In particular, three islets named Munseom, Beomseom, and Seopseom, which serve as a natural breakwater in these waters, were designated as a core zone with more valuable structures of biota even in this biosphere

reserve. This area is the representative soft coral community and was designated Natural Monument No. 442 by the Cultural Heritage Administration. The adjacent waters around Munseom islet were designated as a marine sanctuary in November 2002 and have been managed in accordance with Article 25 of the Act on Conservation and Management of Marine Ecosystem, which has a higher academic value.

Although numerous studies have been conducted on the marine invertebrates in Seogwipo waters by taxon, no comprehensive research or reports on the entire group of marine invertebrates are available. Recently, the Jeju Special Self-governing Province published the 2012 Underwater Monitoring Project in Marine & Stream Areas of the Biosphere Reserve Report, which describes the biota and ecology research efforts undertaken in Seogwipo waters (Jeju Special Self-governing Province, 2013).

This study was conducted in the intertidal and subtidal regions of Gapado, Beomseom, and Munseom islets in Seogwipo waters as part of a joint survey with the National Biodiversity Institutions to investigate the biodiversity of benthic invertebrates in the area. The purpose of this study is to establish a list of benthic invertebrates found in Seogwipo area by comparing (and subsequently arranging) the list of species found in this study with those in previous studies.

* Corresponding author. Tel. +82 2 3277 3426.

E-mail address: syseo@ewha.ac.kr (S.-Y. Seo).

Peer review under responsibility of National Science Museum of Korea (NSMK) and Korea National Arboretum (KNA).

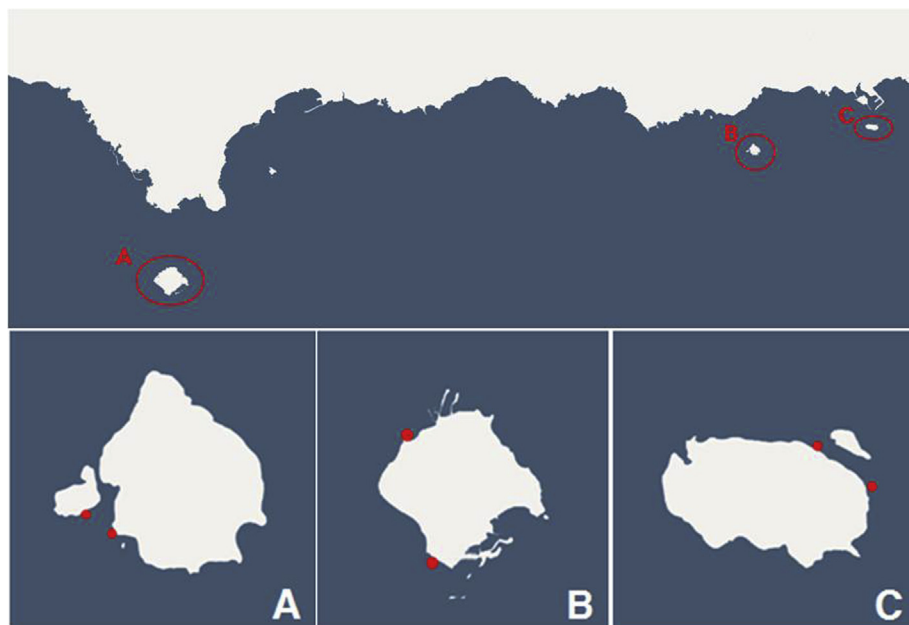


Fig. 1. Survey areas: (A) Gapado, (B) Beomseom, (C) Munseom (red dot: sampling sites).

Materials and methods

This survey was conducted twice, in May and September 2013, at a total of six sites around the Seogwipo region, including the islets of Gapado, Munseom, and Beomseom (Fig. 1). At each site, the researchers (using a chisel and tweezers) collected benthic invertebrates living in the intertidal zone. In the subtidal zone, surveys were performed by personnel in SCUBA gear who dove (up to a depth of 28 m) underwater at four sites around the islets of Munseom and Beomseom. The collected organisms were anesthetized for 4 to 5 hours by taxon, fixed in ethyl alcohol (70–100%) or formalin (5–10%) as necessary, and then transported to the sampling laboratory, where they were photographed and specimens were immersed. The researchers referred to Cnidaria (Song, 2004; Park, 2010), Echinodermata (Shin and Rho, 1996; Shin, 2010), Mollusca (Choi, 1992), and Arthropoda (Kim, 1973) and Ascidiacea (Rho, 1977), while looking at the taxonomy of the list of animals in Korea (Korean Society of Systemic Zoology, 1997) and WoRMS (World Register of Marine Species, 2014). In addition, they prepared a list of benthic invertebrates based on the reports that surveyed the same areas in Seogwipo (Jeju Special Self-governing Province 2013).

Results

The appearing species by taxon

This survey revealed nine phyla, 14 classes, 25 orders, 46 families, and 77 species of benthic invertebrates in total. The appearing species by taxon include: 26 species of Cnidaria (34%), 24 species of Mollusca (31%), seven species of Chordata (9%), six species of Arthropoda (8%), six species of Porifera (8%), five species of Echinodermata (7%), one species of Bryozoa (1%), one species of Annelida (1%), and one species of Ctenophora (1%). Overall, Cnidaria had the highest frequency of appearance (Fig. 2). The trend of regional appearing species revealed 23 species in the intertidal zone around Gapado Islet, where Mollusca had the highest frequency of appearance (61%). In the intertidal and subtidal zones around Beomseom Islet, a total of 51 species of invertebrates were found, of which Cnidaria had the highest frequency of appearance (35%). In the intertidal and subtidal zones of Munseom, 26 species

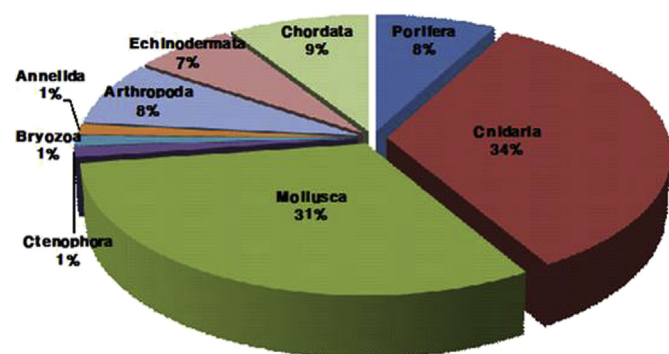


Fig. 2. Rate of taxonomic appearing species.

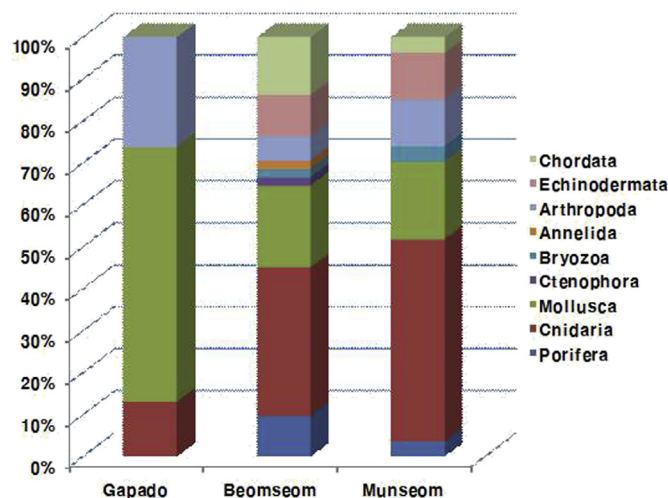


Fig. 3. Regional rate of taxonomic appearance.

Table 1
Benthic invertebrates appearing around Gapado (I), Beomseom (II), and Munseom (III).

Scientific name & Korean name	This study (2013)			Previous study (2012)	
	I	II	III	II	III
Phylum Porifera 해면동물문					
Class Demospongiae 보통해면강					
Order Haplosclerida 단골해면목					
Family Calyspongiidae 예쁜이해면과					
<i>Calyspongia elegans</i> Thiele 예쁜이해면		+			+
<i>Calyspongia confederata</i> Ridley 보라예쁜이해면		+			+
<i>Calyspongia elongata</i> Lendenfeld 길쭉예쁜이해면					+
<i>Calyspongia differentiatia</i> Dendy 뿔예쁜이해면				+	
Family Chalinidae 보라해면과					
<i>Haliclona</i> sp. 보라해면류					+
Order Hadromerida 경해면목					
Family Suberitidae 코르크해면과					
<i>Suberites excellens</i> Thiele 코르크해면					+
Family Spirastrellidae 나선벌해면과					
<i>Spirastrella panis</i> Thiele 나선벌해면				+	
Order Poecilosclerida 다골해면목					
Family Myxillidae 끈적해면과					
<i>Myxilla</i> sp. 넓적끈적해면류		+			
Family Mycalidae 깃해면과					
<i>Mycale macginitiei</i> De Laubenfels 큰바늘뻘해면					+
Family Coelosphaeridae 강해면과					
<i>Lissodendoryx firma</i> (Lambe) 뇌산호끈적해면					+
<i>Myxilla rosacea</i> Lieberkuhn 장미끈적해면					+
Order Astrophorida 별해면목					
Family Geodiidae 조디아해면과					
<i>Erylus bahamensis</i> Pulitzer-Finali 바하마꼭지해면				+	
Order Lithistida 들해면목					
Family Theonellidae 꼬는해면과					
<i>Discodermia japonica</i> Döderlein 판가죽해면				+	
Order Halichondrida 해변해면목					
Family Halichondriidae 해변해면과					
<i>Halichondria okadai</i> Kadota 검정해변해면		+			
<i>Halichondria oshoro</i> Tanita 황록해변해면					+
<i>Hymeniacidon sinapium</i> De Laubenfels 주황해변해면			+		+
Family Axinellidae 축해면과					
<i>Axinella</i> sp. 축해면류		+			
Phylum Cnidaria 자포동물문					
Class Anthozoa 산호충강					
Order Alcyonacea 해게두목					
Family Alcyonidae 바다맨드라미과					
<i>Dendronephthya gigantea</i> Verrill 큰수지맨드라미		+	+		
<i>Dendronephthya putteri</i> Kükenthal 자색수지맨드라미*			+		
<i>Dendronephthya suenoni</i> Kükenthal 검붉은수지맨드라미*			+		
<i>Dendronephthya mollis</i> Kükenthal Kükenthal 연수지맨드라미*			+		
<i>Dendronephthya castanea</i> Kükenthal 밤수지맨드라미*		+	+		
<i>Scleronephthya gracillimum</i> Kükenthal 분홍바다맨드라미		+	+	+	+
<i>Umbellulifera spiculosa</i> Kükenthal 침해면맨드라미					+
Order Gorgonacea 해양목					
Family Melithaeidae 뿔산호과					
<i>Acabaria habereri</i> Kükenthal 바늘산호				+	
Family Parisididae 균형산호과					
<i>Parisis australis</i> Wright & Studer 호주균형산호				+	
Family Acanthogorgoniidae 가시산호과					
<i>Acalycigorgia inermis</i> Hedlund 민가시산호		+			
<i>Acalycigorgia radians</i> Kükenthal 방사민가시산호			+		
<i>Anthogorgia japonica</i> Studer 꽃가시산호		+	+		
Family Plexauridae 총산호과					
<i>Euplexaura crassa</i> Kükenthal 둔한진총산호		+			
<i>Bebryce</i> sp. 바보산호류			+		
<i>Calicogorgia granulosa</i> Kükenthal & Gorzawsky 둥근컵산호		+	+		
<i>Anthoplexaura dimorpha</i> Kükenthal 꽃총산호		+	+		
Order Actinaria 해변말미잘목					
Family Actiniidae 해변말미잘과					
<i>Actinia equina</i> Linnaeus 해변말미잘	+				
<i>Anthopleura japonica</i> Verrill 갈색꽃해변말미잘	+				
<i>Anthopleura kurogane</i> Uchida & Muramatsu 검정꽃해변말미잘	+				
Family Isanthidae 유사말미잘과					
<i>Parascyponis actinostoloides</i> Wassilieff 호리병말미잘		+			
Order Scleractinia 돌산호목					
Family Acroporidae 단풍산호과					
<i>Montipora trabeculata</i> Bernard 빛단풍돌산호		+		+	

(continued on next page)

Table 1 (continued)

Scientific name & Korean name	This study (2013)			Previous study (2012)	
	I	II	III	II	III
<i>Psammocora profundacella</i> Gardiner 그물코돌산호		+			
Family Politidae 구멍돌산호와					
<i>Alveopora japonica</i> Eguchi 거품돌산호		+			
Family Dendrophylliidae 나무돌산호와					
<i>Dendrophyllia arbuscular</i> van der Horst 관목나무돌산호		+			
<i>Tubastraea coccinea</i> Lesson 금빛나팔돌산호*		+		+	
Order Antipatharia 각산호목					
Family Antipathidae 해송과					
<i>Antipathes japonica</i> Brook 해송*		+			
<i>Antipathes lata</i> Silberfeld 긴가지해송		+			
Class Hydrozoa 히드라충강					
Order Thecatae 컵히드라충목					
Family Plumulariidae 깃히드라과					
<i>Plumularia setacea</i> (Linnaeus) 깃히드라		+	+	+	+
<i>Thecocarpus niger</i> Nutting 검정깃히드라		+	+		+
<i>Aglaophenia whiteleggei</i> Bale 흰깃히드라				+	
Family Sertulariidae 테히드라과					
<i>Sertularella quinquelaminata</i> Stechow 오컵테히드라				+	
Order Athecatae 민컵히드라충목					
Family Solanderiidae 산호불이히드라과					
<i>Solanderia secunda</i> (Indiva) 산호불이히드라					+
Phylum Ctenophora 유충동물문					
Class Nuda 무촉수강					
Order Beroida 오이빃해파리목					
Family Beroidae 오이빃해파리과					
<i>Beroe cucumis</i> Fabricius 오이빃해파리		+			
Phylum Mollusca 연체동물문					
Class Gastropoda 복족강					
Order Nudibranchia 나새목					
Family Chromodorididae 갯민숭달팽이과					
<i>Chromodoris orientalis</i> Rudman 흰갯민숭달팽이		+	+		
<i>Chromodoris tintoria</i> (Rüppell & Leuckart) 망사갯민숭달팽이		+			
<i>Hypselodoris festiva</i> (Angas) 파랑갯민숭달팽이		+	+		
<i>Ceratosoma tenue</i> Abraham 꼬리갯민숭달팽이		+			
Family Dorididae 갑옷갯민숭달팽이과					
<i>Platydorid tabulata</i> (Abraham) 노랑납작갯민숭달팽이		+			
Family Phyllidiidae 흑갯민숭이과					
<i>Phyllidia ocellata</i> Cuvier 흑고리갯민숭이		+			
<i>Phyllidia babai</i> Brunckhorst 검은고리갯민숭이		+			
Order Neogastropoda 신복족목					
Family Muricidae 뿔소라과					
<i>Reishia clavigera</i> (Küster) 대수리	+				
<i>Bedequina birileffi</i> (Lischke) 입주름뿔고둥					+
<i>Ceratostoma fourmieri</i> (Crosse) 세뿔고둥					+
<i>Ergalatax contracta</i> (Reeve) 탑뿔고둥				+	+
<i>Lataxiena fimbriata</i> (Hinds) 잔가시뿔고둥				+	
<i>Reishia bronni</i> (Dunker) 두드럭고둥				+	
Family Buccinidae 물레고둥과					
<i>Japeuthria ferrea</i> (Reeve) 타래고둥	+				
Family Columbellidae 무늬과					
<i>Anachis misera</i> (G. B. Sowerby I) 보살고둥					+
<i>Columbelopsis mindorensis</i> Reeve 흰띠줄무늬무늬					+
<i>Columbelopsis yabei</i> (Nomura) 꼭지세로줄무늬보살무늬무늬					+
<i>Metanachis marquesa</i> (Gaskoin) 갈색띠줄무늬무늬					+
<i>Mitrella bella</i> Reeve 고운띠무늬					+
<i>Mitrella bicincta</i> (Gould) 보리무늬				+	+
<i>Mitrella tenuis tenuis</i> (Gaskoin) 날씬이보리무늬				+	+
<i>Pyrene flava</i> (Bruguière) 고운점무늬무늬				+	+
<i>Pyrene testudinaria tylerae</i> (Griffith & Pidgeon) 무늬				+	+
<i>Euplica versicolor</i> (Sowerby) 무늬무늬				+	
Family Nassariidae 줄발무늬고둥과					
<i>Nassarius fraterculus</i> (Dunker) 검은줄발무늬고둥					+
Family Turridae 단풍고둥과					
<i>Hemicythara octangulata</i> (Dunker) 갈색띠흰연청이고둥				+	
Order Mesogastropoda 중복족목					
Family Potamododae 갯고둥과					
<i>Batillaria cumingii</i> (Crosse) 땡가리	+				
Family Littorinidae 총알고둥과					
<i>Neritrema sitkana</i> (Philippi) 큰총알고둥	+				
Family Cerithiidae 짜부락고둥과					
<i>Bittium alutaceum</i> Gould 얼룩덜룩갈고둥					+
Family Calyptraeidae 배고둥과					
<i>Crepidula gravispinosus</i> Kuroda & Habe 침배고둥					+

Table 1 (continued)

Scientific name & Korean name	This study (2013)			Previous study (2012)	
	I	II	III	II	III
Family Cypraeidae 개오지과					
<i>Purpuradusta gracilis japonica</i> Schilder 점박이개오지				+	+
Family Triviidae 흰구슬개오지과					
<i>Trivia pellucidula</i> (Gaskoin) 가는줄흰구슬개오지					+
Order Archaeogastropoda 원시복족목					
Family Patellidae 삿갓조개과					
<i>Cellana nigrolineata</i> (Reeve) 흑색배말	+				
Family Fissurellidae 구멍삿갓조개과					
<i>Emarginella incisura</i> (A. Adams) 언청이삿갓조개					+
<i>Elegidion quadriradiatus</i> (Reeve) 주름구멍삿갓조개				+	
Family Stomatellidae 넓은입고둥과					
<i>Stomatolina rubra</i> (Lamarck) 넓은입고둥					+
Family Trochidae 밭고둥과					
<i>Omphalius pfeifferi carpenteri</i> (Dunker) 팽이고둥	+				
<i>Chlorostoma xanthostigma</i> A. Adams 명주고둥	+				
<i>Monodonta perplexa</i> Pilsbry 갯장각시고둥	+				
<i>Monodonta australis</i> Lamarck 남방울타리고둥	+				
<i>Cantharidus callichroa bisbalteatus</i> Pilsbry 두줄얼룩고둥					+
Family Neritidae 갈고둥과					
<i>Heminerita japonica</i> (Dunker) 갈고둥	+	+	+		
Family Phasianellidae 유리고둥과					
<i>Phasianella modesta</i> Gould 유리고둥				+	
Family Turbinidae 소라과					
<i>Turbo cornutus</i> Lightfoot 소라			+		
<i>Astrarium haematuragum</i> (Menke) 바퀴고둥					+
Order Sorbeoconcha 흠강목					
Family Triphoridae 띠줄고둥과					
<i>Viriola tricineta</i> (Dunker) 띠줄고둥					+
Order Thecosomata 유각익족목					
Family Cavoliniidae 거북고둥과					
<i>Diacavolinia angulosa</i> (Gray) 연갈색세모거북고둥				+	
Order Aplysiomorpha 군소목					
Family Aplysiidae 군소과					
<i>Aplysia kurodai</i> Baba 군소		+			
Class Polyplacophora 다판강					
Order Neoloricata 신킨부목					
Family Acanthochitonidae 가시군부과					
<i>Acanthopleura japonica</i> (Lischke) 군부	+				
<i>Acanthochitona achates</i> (Gould) 촌털군부	+				
Family Cryptoplacidae 털군부과					
<i>Cryptoplax japonica</i> Pilsbry 벌레군부	+				
Class Bivalvia 이매패강					
Order Mytiloida 홍합목					
Family Mytilidae 홍합과					
<i>Septifer virgatus</i> (Wiegmann) 굵은줄격판담치	+	+	+		
<i>Lithophaga curta</i> (Lischke) 애기돌맏조개				+	+
<i>Septifer keenae</i> Nomura 격판담치				+	
<i>Modiolus auriculatus</i> (Krauss) 깃털담치					+
<i>Modiolus agripetus</i> (Iredale) 개적구				+	
Order Arcoida 돌조개목					
Family Arcidae 돌조개과					
<i>Arca avellana</i> 돌조개				+	+
<i>Barbatia stearnsi</i> (Pilsbry) 꼬마돌조개					+
<i>Barbatia decussata</i> (G. B. Sowerby I) 촌살줄돌조개					+
<i>Barbatia virescens</i> (Reeve) 복털조개					+
<i>Nipponarca bistricata</i> (Dunker) 두줄돌조개					+
Order Pterioidea 익각목					
Family Isognomonidae 말다래조개과					
<i>Isognomon ephippium</i> (Linnaeus) 부리말다래조개				+	+
Family Anomiidae 잠쟁이과					
<i>Monia umbonata</i> (Gould) 둥근잠쟁이					+
Family Ostreidae 굴과					
<i>Dendostrea crenulifera</i> (Sowerby) 옆주름덩굴굴				+	+
<i>Ostrea circumpicta</i> Pilsbry 태생굴				+	+
Family Glyphaeidae 주름굴과					
<i>Hytissa hyotis</i> (Linnaeus) 종국굴				+	
Family Pteriidae 진주조개과					
<i>Pinctada fucata</i> (Gould) 주홍진주조개				+	
<i>Pteria breviaata</i> (Dunker) 산호살이조개				+	
Family Spondyliidae 국화조개과					
<i>Spondylus butleri</i> Reeve 가시국화조개				+	
Family Limidae 외투조개과					

(continued on next page)

Table 1 (continued)

Scientific name & Korean name	This study (2013)			Previous study (2012)	
	I	II	III	II	III
<i>Ctenoides lamyi</i> (Smith) 빗개가리비				+	
Order Veneroida 백합목					
Family Ungulinidae 둘사리조개과					
<i>Diplodonta gouldi</i> Yokoyama 황갈색돌살이조개					+
Family Chamidae 굴아재비과					
<i>Chama fragum</i> Reeve 굴아재비				+	+
<i>Chama limbula</i> Lamarck 보라굴아재비					+
<i>Chama japonica</i> Lamarck 햇빛굴아재비					+
<i>Chama dunkeri</i> Lischke 맨드라미굴아재비				+	
<i>Pseudochama retroversa</i> (Lischke) 보라원돌이굴아재비				+	+
Family Carditidae 주름방사촉조개과					
<i>Cardita leana</i> Dunker 주름방사촉조개					+
Family Veneridae 백합과					
<i>Irus macrophyllus</i> (Deshayes) 굵은주름입조개					+
<i>Irus mitis</i> (Deshayes) 주름입조개					+
Order Myoida 우럭목					
Family Gastrochaenidae 구멍뿔이조개과					
<i>Gastrochaena cuneiformis</i> Spengler 구멍뿔이조개					+
Phylum Annelida 환형동물문					
Class Polychaeta 다모강					
Order Phyllodocida 부채발갯지렁이목					
Family Nereidae 참갯지렁이과					
<i>Neanthes japonica</i> (Izuka) 참갯지렁이					+
Family Polynoidae 비늘갯지렁이과					
<i>Halosydna brevisetosa</i> Kinberg 짧은마름비늘갯지렁이					+
Order Eunicida 털갯지렁이목					
Family Eunicidae 털갯지렁이과					
<i>Eunice antennata</i> (Savigny in Lamarck) 고리털갯지렁이				+	+
<i>Lysidice collaris</i> Grube 노란숨털갯지렁이				+	+
Order Sabellida 꽃갯지렁이목					
Family Sabellidae 꽃갯지렁이과					
<i>Sabellastarte</i> sp. 꽃갯지렁이류		+			
Phylum Arthropoda 절지동물문					
Class Maxillopoda 소악강					
Order Thoracica 완충목					
Family Tetracitidae 사각따개비과					
<i>Tetracita japonica</i> (Pilsbry) 검은큰따개비	+	+	+		
Family Scalpellidae 거북손과					
<i>Pollicipes mitella</i> (Linnaeus) 거북손	+	+	+		
Class Malacostraca 연갑강					
Order Decapoda 십각목					
Family Grapsidae 바위게과		+	+		
<i>Cyclograpsus intermedius</i> Ortmann 비단게	+				
<i>Hemigrapsus sanguineus</i> (De Haan) 무늬발게	+				
<i>Pachygrapsus crassipes</i> Randall 바위게	+				
Family Xanthidae 부채게과					
<i>Leptodius exaratus</i> (H. Milne Edwards) 부채게				+	+
<i>Actaea semblatae</i> Guinot 움부채게				+	
<i>Macromedaeus distinguendus</i> (De Haan) 꽃부채게				+	
Family Majidae 물맞이게 과					
<i>Pugettia intermedia</i> Sakai 중간뿔물맞이게					+
<i>Pugettia quadridens quadridens</i> (De Haan) 뿔물맞이게					+
Family Paguridae 집게과					
<i>Pagurus</i> sp. 집게류	+				
FamilyAlpheidae 딱충새우과					
<i>Alpheus lobidens</i> De Haan 갯가딱충새우					+
<i>Synalpheus neomeris</i> (De Man) 큰발톱세이마뿔딱충새우				+	+
Order Amphipoda 단각목					
Family Amphithoidae 참열새우과					
<i>Amphithoe</i> sp. 참열새우류				+	+
Family Galatheididae 새우불이과					
<i>Galathea orientalis</i> Stimpson 새우불이				+	+
Phylum Bryozoa 태형동물문					
Class Gymnolaemata 나후강					
Order Cheilostomata 순구목					
Family Phidoloporidae 연구멍이끼벌레과					
<i>Iodictyum axillare</i> (Ortmann) 빨간망이끼벌레		+	+		
<i>Phidolopora pacifica</i> (Robertson) 태양연구멍이끼벌레				+	
Family Membraniporidae 막이끼벌레과					
<i>Membranipora tuberculata</i> (Bosc) 관막이끼벌레				+	+
Family Bugulidae 다발이끼벌레과					
<i>Bugula subglobosa</i> Harmer 꽃다발이끼벌레				+	+
Family Cabereidae 카베레이끼벌레과					

Table 1 (continued)

Scientific name & Korean name	This study (2013)			Previous study (2012)	
	I	II	III	II	III
<i>Scrupocellaria diadema</i> Busk 가시이끼벌레					+
Family Steginoporellidae 단추이끼벌레과					
<i>Labioporella sinuosa</i> Osburn 굽은입술이끼벌레					+
Family Celleporariidae 섬유이끼벌레과					
<i>Celleporaria aperta</i> (Hincks) 구멍섬유이끼벌레				+	
Family Smittinidae 입이끼벌레과					
<i>Smittina torques</i> Powell 목걸이입이끼벌레					+
Phylum Sipunculida 성구동물문					
Class Phascolosomatidea 등족수벌벌레강					
Order Phascolosomatiformes 등족수벌벌레목					
Family Phascolosomatidae 등족수벌벌레과					
<i>Phascolosoma scolops</i> (Selenka) 상어껍질벌벌레				+	+
Phylum Echinodermata 극피동물문					
Class Stellerioidea 불가사리강					
Order Phanerozonia 현대목					
Family Linckiidae 선불가사리과					
<i>Certanaroda semiregularis</i> (Müller & Troschel) 빨강불가사리		+	+		+
<i>Ophidiaster cribrarius</i> Lütken 긴팔불가사리		+			
Order Myophiurida 폐사미목					
Family Ophiidermatidae 가죽거미불가사리과					
<i>Ophiarachnella gorgonia</i> (Müller & Troschel) 뱀거미불가사리		+	+	+	
Class Echinoidea 성게강					
Order Echinoida 성게목					
Family Echinometridae 만두성게과					
<i>Anthocidaris crassispina</i> (A. Agassiz) 보라성게		+	+		
Order Clypeasteroida 연잎성게목					
Family Clypeasteridae 연잎성게과					
<i>Clypeaster japonicus</i> Döderlein 방패연잎성게		+			
Family Strongylocentrotidae 둥근성게과					
<i>Hemicentrotus pulcherrimus</i> (A. Agassiz) 말뚝성게				+	
Phylum Chordata 척삭동물문					
Class Ascidiacea 해초강					
Order Pleurogona 축성해초목					
Family Pyuridae 멍게과					
<i>Herdmania momus</i> (Savigny) 분홍멍게		+	+	+	+
Family Botryllidae 판멍게과					
<i>Botryllus</i> sp. 판멍게류		+			
Family Styelidae 미더덕과					
<i>Styela</i> sp. 미더덕류		+			
<i>Polyzoa</i> sp. 폴라조아류		+			
Order Enterogona 내성해초목					
Family Chionidae 유령멍게과					
<i>Ciona intestinalis</i> (Linnaeus) 유령멍게		+			
Family Polycitoridae 곤봉멍게과					
<i>Clacelina</i> sp. 곤봉멍게류		+			
Family Didemnidae 흰덩이멍게과					
<i>Didemnum</i> sp. 흰덩이멍게류		+			
Family Rhodosomatidae 안창멍게과					
<i>Chelyosoma dofleini</i> Hartmeyer 거북등안창멍게					+

*Marine protected species.

were recorded, of which Cnidaria also had the highest frequency of appearance (48%) (Fig. 3).

List of regional appearing species

A better understanding of the appearing species at each site required comparing and analyzing the appearing species reported in the 2012 Underwater Monitoring Project in Marine & Stream Areas of the Biosphere Reserve Report (hereinafter referred to as the “2012 Report”), with those found in this survey (Jeju Special Self-governing Province, 2013).

Both surveys revealed a total of 173 species of benthic invertebrates around the islets of Gapado, Beomseom, and Munseom. In our survey, the appearing taxonomic number at each sampling station showed 23 species around Gapado, 51 species around Beomseom, and 27 species around Munseom, suggesting that the area around Beomseom had the highest biodiversity. The 2012 Report stated 55 species appearing around Beomseom and 74

species around Munseom, showing a different aspect from this survey (Jeju Special Self-governing Province 2013). The 2012 Report indicated the higher rate of appearing species of Mollusca, Porifera, and Arthropoda (Jeju Special Self-governing Province 2013). In contrast, this survey showed a higher rate of appearing species of Cnidaria and also observed Ctenophora such as *Beroe cucumis* Fabricius, which was not found in the previous survey (Table 1, Fig. 4).

In particular, this survey confirmed that six corals of the marine protected species designated by the Ministry of Oceans and Fisheries live in the subtidal zones around Munseom and Beomseom; they include *Dendronephthya putteri* Kükenthal, *D. suensoni* Kükenthal, *D. mollis* Kükenthal Kükenthal, *D. castanea* Kükenthal, *Tubastraea coccinea* Lesson, and *Antipathes japonica* Brook.

Discussion

The fauna of benthic invertebrates in Seogwipo was surveyed twice, in May and September 2013, as part of a joint survey with



Fig. 4. Major benthic invertebrates found in Gapado, Beomseom, and Munseom.

the National Biodiversity Institutions. Among the survey areas, the islets of Beomseom and Munseom were designated and protected as Natural Monument No. 442 “Jeju coastal soft coral community”; thus, efforts were made to ensure that the survey will be conducted in a manner that would not harm or disrupt the local ecosystem.

Although it was not mentioned in the 2012 Report, this survey additionally observed Cnidaria, Ctenophora, and Chordata in the study areas (Jeju Special Self-governing Province 2013). Because Seogwipo has a biological significance, there have been numerous surveys and studies conducted on a variety of taxa. However, there is a lack of comprehensive surveys and reports across the entire region of Seogwipo; thus, we expect this survey to serve as a basis for such a comprehensive survey in the future. According to records, benthic invertebrates appearing around Jeju waters are estimated to comprise more than 1600 species including marine plants (Choi 1993; Lee and Bu, 1993; Song et al., 2009); furthermore, it is projected that more than 2000 species live in this area if one includes vertebrates such as fish. The 173 species recorded in this survey were observed at six sites in three regions, the scope of which is narrow and limited but still significant because a variety of taxonomic marine benthic invertebrates were surveyed even in such a small domain, suggesting the richness of the biodiversity in these areas. It is necessary to systematically survey the biodiversity in Seogwipo region by continuously conducting surveys in Seogwipo waters in the future. If an additional survey is to be conducted in the subtidal zone of Gapado Islet, and other islets of Seogwipo including Seopseom, Saeseom, and Jigwido, the biodiversity of benthic invertebrates across Seogwipo will be systematically arranged. The survey was an opportunity to confirm a variety of fauna including the marine protected species living around Beomseom

and Munseom, implying that it is necessary to continuously observe and protect the waters around Seogwipo.

Acknowledgments

This work was supported by the National Research Foundation of Korea (NRF) grant funded by Ministry of Science, ICT, & Future Planning (MSIP) (NRF-2008-2004707).

References

- Choi BL. 1992. *Illustrated Encyclopedia of Fauna & Flora of Korea: Molluscs II*, vol. 33. Seoul: Ministry of Education.
- Choi BL. 1993. Marine fauna on Jeju Island. *Biol Sci Symp* 14:28–90.
- Jeju Special Self-governing Province. 2013. 2012 Underwater Monitoring Project in Marine & Stream Areas of the Biosphere Reserve. Final Report; 2013.
- Kim HS. 1973. *Illustrated encyclopedia of fauna & flora of Korea: Anomura, Brachyura*, vol. 14. Seoul: Ministry of Education.
- Korean Society of Systemic Zoology. 1997. *List of animals in Korea (excluding insects)*. Seoul: Academy Press.
- Lee IG, Bu SM. 1993. Marine flora on Jeju Island: focusing on marine plants. *Biol Sci Symp* 14:132–149.
- Park JH. 2010. *Invertebrate Fauna of Korea: No. 1 Thecates*, vol. 4. Incheon: National Institute of Biological Resources.
- Rho BJ. 1977. *Illustrated Encyclopedia of Fauna & Flora of Korea: Porifera, Hydrozoa and Ascidiacea*, vol. 20. Seoul: Ministry of Education.
- Shin S. 2010. *Invertebrate fauna of Korea: No. 1 Sea stars*, vol. 32. Incheon: National Institute of Biological Resources.
- Shin S, Rho BJ. 1996. *Illustrated encyclopedia of fauna & flora of Korea: Echinodermata*, vol. 36. Ministry of Education.
- Song JI. 2004. *Illustrated encyclopedia of fauna & flora of Korea: Anthozoa*, vol. 39. Seoul: Ministry of Education.
- Song JI, Seo SY, Hwang SJ, et al. 2009. Report on the “Jeju yeonanyeonsanho gullakji (Soft coral group off the coast of Jeju)” Natural Monuments 442. Jeju Special Self-Governing Province Seogwipo-si.
- World register of marine species. 2014. WoRMS Editorial Board. Available from: <http://www.marinespecies.org> (accessed 15 January 2014).