Journal of Asia-Pacific Biodiversity 7 (2014) e206–e212

Contents lists available at ScienceDirect

Journal of Asia-Pacific Biodiversity

journal homepage: http://www.elsevier.com/journals/journal-of-asia-pacific-biodiversity/2287-884x

Original article

Benthic invertebrate fauna in the islets of Namuseom and Bukhyeongjeseom off Busan

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ARTICLE INFO

Article history:
Received 18 March 2014
Received in revised form
25 March 2014
Accepted 31 March 2014
Available online 24 April 2014

Keywords:
Invertebrate fauna
Namuseom Islet
Bukhyeongjeseom Islet

ABSTRACT

This study was conducted to examine the benthic invertebrate fauna inhabiting in the subtidal zone in and around the islets of Namuseom and Bukhyeongjeseom off the coast of Busan by SCUBA diving in September 2013. As a consequence, it was confirmed that a total of 6 phyla, 14 classes, 20 orders, 46 families, and 73 species of zoobenthos inhabit in and around those islets. The total number of species surveyed by taxon during the study is 22 species of Arthropoda (30%), 20 species of Mollusca (27%), 15 species of Cnidaria (21%), 10 species of Echinodermata (14%), four species of Poridera (5%), and two species of Chordata.

Introduction

Busan is located in the southeastern part of the Korean peninsula bordering the sea in its south and includes 45 (un)inhabited islets (Busan, 2012). Korea Hydrographic and Oceanographic Administration (2010) attributed about 0.2 °C increased in water temperature off Busan waters in the past decade to the rise in the minimum water temperature during winter due to the increasingly stronger high-temperature and high-salt concentration Tsushima current. In addition, the administration published that judging from the increasing trend in the average water temperature in the southern coast, the thermal front distinguishing the waters off the south coast from Tsushima current becomes weaker making the Busan waters already an optimal marine environment for warm-sea fish and marine species. Such a climate change sees temperate and subtropical species appearing; accordingly the islets of Namuseom and Namhyeongjeseom were designated as a marine sanctuary in November 2013 pursuant to Article 25 of the Act on the Conservation and Management of Marine Ecosystem and have been properly managed, which are of high value in terms of research and science on subtropical fauna that increasingly go northwards.

The previous researches on the fauna in and around the uninhabited islets off Busan were conducted by the Ministry of Environment (2003) and the Busan Regional Maritime Affairs and Fisheries Office (2007), and most of them investigated those in the intertidal zones. Although the Ministry of Environment (2010) conducted a survey on Namuseom Islet, the survey was not accurate because it did not analyze the previous data for accurate examination and the Bukhyeongjeseom Islet was not investigated.

The purpose of this study is to compare the list of species found during the survey on the subtidal zone of the islets of Namuseom and Bukhyeongjeseom with the previous studies in order to identify the subtropical organisms that have moved northwards from their native habit, to identify species inhabit in the survey area as well as their compositional change.

Materials and methods

This study was conducted for two days from 27th and 28th September, 2013 in and around the islets of Namuseom and Bukhyeongjeseom in Saha-gu, Busan (Figure 1), in a way to survey benthic invertebrate fauna by SCUBA diving at each survey site the deepest at 23 m below sea level. The individuals collected were

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

http://dx.doi.org/10.1016/j.japb.2014.03.009

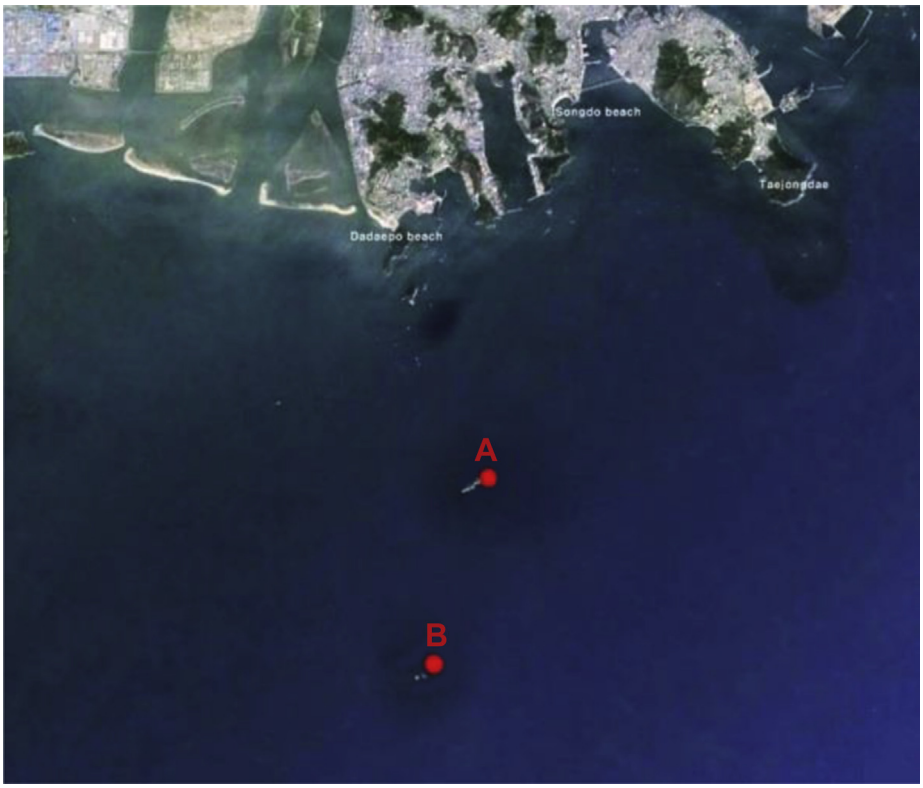

Figure 1. Study areas of Islets of Namuseom (A) and Bukhyeongjeseom (B).

subject to anesthesia for 4 to 5 hours depending on each taxon and then, if required, fixed in 70–100% ethyl alcohol or 5–10% formalin before being carried to the specimen preparation lab for photography and immersion specimen. The identification and arrangement of country name referred to: Rho (1977) for Poridera; Song (2004) and Park (2010) for cnidarians; Shin and Rho (1996) and Shin (2010) for Echinodermata; Paik (1989) for Annelida; Choi (1992) for Mollusca; and Kim (1973) for Arthropoda while the classification complied with the system set the forth in the Korean Society of Systematic Zoology (1997) and the World Register of Marine Species (WoRMS, 2014).

Result

List of the species in Islets of Namuseom and Bukhyeongjeseom

This survey found a total of 6 phyla, 14 classes, 26 orders, 48 families, and 73 species of zoobenthos. The total number of species surveyed by taxon during the study is: 22 species of Arthropoda (30%), 20 species of Mollusca (27%), 15 species of Cnidaria (21%), 10 species of Echinodermata (14%), 4 species of Poridera (5%), and 2 species of Chordata, indicating the largest appearance of Arthropoda.

Phylum Porifera
Class Demospongiae
Order Haplosclerida
Family Callyspongiidae
Callyspongia confoederata (sensu Ridley, 1884)
Order Hadromerida
Family Clionaidae
Cliona celata Grant, 1826
Order Astrophoridae
Family Stelletidae
Caminus awashimensis Tanita, 1969
Order Poecilosclerida
Family Myxillidae
Myxilla sp.
Phylum Cnidaria
Class Anthozoa
Order Alcyonacea
Family Alcyoniidae
Bellonella rubra Brudin, 1896
Dendronephthya sp.
Order Gorgonacea
Family Melithaeidae
Melithaea flabellifera flabellifera Kükenthal, 1909
Acabaria tenuis Kükenthal, 1908
Acabaria undulata Kükenthal, 1908
Acabaria sp1.
Acabaria sp2.
Family Acanthogorgiidae
Acanthogorgia inermis (Hedlund, 1890)
Acanthogorgia radians Kükenthal & Gorzawsky, 1908
Family Plexauridae
Euplexaura recta (Nutting, 1910) *
Order Pennatulacea
Family Virgulariidae
Virgularia gustaviana (Herklots, 1863)
Order Actiniaria
Family Actiniidae
Actinia sp.
Aulactinia coccinea (Verrill, 1866)
Family Nemanthidae
Nemanthus nitidus Wassilieff, 1908 **

Order Antipatharia
Family Antipathidae
Antipathes japonica Brook *
Class Hydrozoa
Order Thecatae
Family Plumulariidae
Plumulariidae sp.
Phylum Mollusca
Class Polyplacophora
Order Neoloricata
Family Chitonidae
Onithochiton hirasei Pilsbry, 1901
Class Gastropoda
Order Archaeogastropoda
Family Haliotidae
Nordotis discus (Reeve, 1846)
Family Acmaeidae
Acmaea (*Niveotectura*) *pallida* (Gould, 1859)
Family Trochidae
Omphalius rusticus (Gmelin, 1791)
Omphalius pfeifferi (Dunker, 1882)
Calliostoma unicum (Dunker, 1860)
Stomatolina rubra (Lamarck, 1822)
Family Turbinidae
Turbo cornutus Lightfoot, 1786
Order Mesogastropoda
Family Vermetidae
Serpulorbis imbricatus (Dunker, 1860)
Family Calyptraeidae
Crepidula onyx (Reeve, 1859)
Order Neogastropoda
Family Muricidae
Reishia bronni (Dunker, 1860)
Ceratostoma burnetti (Adams & Reeve, 1848)
Family Buccinidae
Kelletia lischkei Kuroda, 1938
Family Fasciolariidae
Fusinus perplexus (A. Adams, 1863)
Fusinus ferrugineus Kuroda & Habe, 1961
Fusinus longicaudus (Lamarck, 1801)
Family Conidae
Conus lischkeanus Weinkauff, 1875
Class Bivalvia
Order Mytiloida
Family Mytilidae
Mytilus edulis Linnaeus, 1758
Mytilus coruscus Gould, 1861
Class Cephalopoda
Order Octopoda
Family Octopodidae
Octopus dofleini (Wülker, 1910)
Phylum Arthropoda
Class Maxillopoda
Order Thorcica
Family Balanidae
Balanus trigonus Darwin, 1854
Megabalanus rosa (Pilsbry, 1916)
Class Pycnogonida
Order Pantopoda
Family Ammotheidae Dohrn, 1881
Ammothridae sp.
Class Malacostraca
Order Decapoda
Family Hippolytidae
Lebbeus comanthi Hayashi & Okuno, 1997
Lysmata vittata (Stimpson, 1860)
Family Galatheidae
Galathea orientalis Stimpson, 1858
Family Porcellanidae
Pisidia serratifrons (Stimpson, 1858)
Family Diogenidae
Areopaguristes nigroapiculus (Komai, 2009)
Paguristes ortmanni Miyake, 1978
Family Paguridae
Pagurus japonicus (Stimpson, 1858)
Pagurus nigrivittatus Komai, 2003
Pagurus proximus Komai, 2000
Pagurus rubrior Komai, 2003
Family Pilumnidae
Harrovia japonica Balss, 1921
Heteropilumnus ciliatus (stimpson, 1858)
Pilumnus minutus De Haan, 1835
Family Xanthidae
Actaea semblatae Guinot, 1976
Cycloxanthops truncatus (De Haan, 1837)
Microcassiope orientalis Takeda & Miyake, 1969
Medaeops granulosus (haswell, 1882)
Family Portunidae
Liocarcinus corrugatus (Pennant, 1777)
Family Epialtidae
Hyastenus elongatus Ortmann, 1893
Phylum Echinodermata
Class Crinoidae
Order Comantulida
Family Comasteridae
Comasteridae sp. **
Class Stelleroidea
Order Phanerozonia
Family Astropectinidae
Astropecten polyacanthus Müller et Troschel, 1842
Family Linckiidae
Certonardoa semiregularis (Muller & Troschel 1842)
Order Spinulosida
Family Asterinidae
Asterina pectinifera Müller et Troschel, 1842
Order Perrier
Family Asteriidae
Coscinasterias acutispina (Stimpson, 1857)
Asterias amurensis Lütken, 1871
Order Myophiurida
Family Ophiodermatidae
Ophiactis savignyi Müller & Troschel 1842
Class Echinoidea
Order Echinoida
Family Temnopleuridae
Temnopleurus harwicki (Gray, 1855)
Family Strongylocentrotidae
Hemicentrotus pulcherrimus (A. Agassiz, 1863)
Family Echinometridae
Anthocidaris crassispina (A. Agassiz, 1863)
Phylum Chordata
Class Ascidiacea
Order Stolidobranchia
Family Pyuridae
Halocynthia roretzi (Drasche, 1884)
Family Styelidae
Styela sp.

(*Threatened marine organism necessary of protection; ** subtropical organism)

Table 1
Benthic Organisms Appearing in and around Namuseom (I), Bukhyeongjeseom (II), and Namhyeongjeseom (III) Islets.

taxon	Scientific name	This study (2013)		Previous study (2010)	
		I	II	I	III
Porifera	*Callyspongia confoederata*		+		
	Cliona celata	+			
	Caminus awashimensis		+		
	Myxilla sp.		+		
Cnidaria	*Bellonella rubra*	+	+		
	Dendronephthya sp.		+		
	Dendronephthya castanea				+
	Melithaea flabellifera	+	+		
	Acabaria tenuis		+		
	Acabaria undulata	+	+		
	Acabaria sp1.		+		
	Acabaria sp2.		+		
	Acalycigorgia radians		+		
	Euplexaura recta		+		+
	Virgularia gustaviana	+			
	Actinia sp.		+		
	Aulactinia coccinea		+		
	Nemanthus nitidus		+		
	Antipathes japonica		+		+
	Plumulariidae sp.	+			
Annelida	*Anaitides* sp.				+
	Arabella iricola			+	+
	Chrysopetalum occidentale				+
	Eunice antennata			+	+
	Halosydna brevisetosa			+	
	Halosydnopsis pilosa				+
	Harmothoinae sp.			+	+
	Hydroides ezoensis			+	
	Lepidonotus squamatus				+
	Nereis multignatha				+
	Nereis neoneanthes				+
	Nereis pelagica			+	
	Platynereis bicanaliculata			+	+
	Polyopthalmus pictus			+	+
	Syllidae sp.			+	+
	Terebellidae sp.			+	
Mollusca	*Anomia chinensis*			+	
	Arca boucardi			+	
	Cardita leana				+
	Chlamys squamata				+
	Crassostrea nipponica				+
	Irus irus			+	
	Kellia porculus			+	
	Lithophaga curta			+	+
	Modiolus agripetus			+	+
	Musculus cupreus				+
	Musculus viridulus				+
	Mytilus edulis	+			
	Mytilus coruscus		+		
	Onithochiton hirasei	+			
	Cryptoplax japonica				+
	Mopalia retifera				+
	Placiphorella stimpsoni			+	
	Rhyssoplax kurodai			+	
	Nordotis discus	+			
	Acmaea (Niveotectura) pallida	+		+	
	Anachis miser miser			+	
	Bedeva birileffi			+	
	Omphalius rusticus	+		+	
	Omphalius pfeifferi	+		+	
	Calliostoma unicum	+	+		+
	Cantharidus japonicus			+	
	Cantharidus jessoensis			+	+
	Stomatolina rubra		+		
	Turbo cornutus	+		+	
	Serpulorbis imbricatus	+			
	Reishia bronni	+		+	+
	Ceratostoma burnetti	+	+	+	+
	Crepidula gravispinosus			+	
	Crepidula onyx	+	+	+	+
	Ergalatax contracta contracta			+	+
	Charonia sauliae			+	+

(*continued on next page*)

Table 1 (*continued*)

taxon	Scientific name	This study (2013)		Previous study (2010)	
		I	II	I	III
	Hipponix conica			+	
	Homalopoma amussitatum				+
	Homalopoma nocturnum				+
	Homalopoma sangarense			+	
	Lirularia iridescens			+	
	Mitrella bicincta			+	+
	Pleurotomitrella pleurotomoides			+	
	Pyrene testudinaria tylerae				+
	Tugali decussata				+
	Tylotiella burnupi				+
	Zafra mitriformis				+
	Kelletia lischkei		+		
	Fusinus perplexus	+			
	Fusinus ferrugineus	+			
	Fusinus longicaudus	+			
	Conus lischkeanus		+		
	Octopus dofleini		+		
Arthropoda	Amphipoda spp.			+	+
	Caprella sp.			+	+
	Balanus trigonus	+	+	+	
	Megabalanus rosa		+		
	Ammothridae sp.	+		+	+
	Lebbeus comanthi	+			
	Lysmata vittata	+			
	Synalpheus tumidomanus				+
	Galathea orientalis	+			
	Munida japonica				+
	Pachycheles stevensii				+
	Pisidia serratifrons	+			+
	Areopaguristes nigroapiculus	+			
	Paguristes ortmanni	+		+	
	Pagurus japonicus	+			
	Pagurus nigrivittatus	+			
	Pagurus proximus	+		+	
	Pagurus rubrior	+			
	Actaea semblatae	+			+
	Atergatis floridus				+
	Cycloxanthops truncatus	+			
	Harrovia elegans				+
	Harrovia japonica	+			
	Heteropilumnus ciliatus	+			
	Hyastenus elongatus		+		
	Liocarcinus corrugatus		+		
	Macromedaeus distinguendus				+
	Medaeops granulosus	+			
	Microcassiope orientalis	+			
	Pilumnus minutus	+			+
	Pinnotheres pholadis			+	
	Pugettia quadridens			+	
	Cymodoce japonica			+	
	Dynoides dentisinus			+	+
	Holotelson tuberculatus			+	+
	Joeropsis lobata				+
	Janira sp.				+
	Gonodactylus chiragra				+
	Anatanais normani			+	
Echinodermata	Comasteridae sp.		+		
	Astropecten polyacanthus	+			
	Certonardoa semiregularis		+		
	Asterina pectinifera	+		+	
	Coscinasterias acutispina		+		
	Asterias amurensis	+			
	Ophiactis savignyi		+	+	+
	Temnopleurus harwicki	+			
	Hemicentrotus pulcherrimus	+		+	
	Strongylocentrotus nudus				+
	Anthocidaris crassispina	+			
Nemertina	*Lineus fuscoviridis*				+
Sipunculida	*Phascolosoma scolops*			+	+
Chordata	*Halocythia roretzi*	+	+		
	Styela sp.	+	+		

List of the species by region

Understanding the species appearing at each survey point and their changes compared to the past species required comparatively analyzing the appearing species described in the 2010 Baseline Survey on Marine Ecosystem (Eastern Part of the South Sea) by the Ministry of Environment with those in this study; and also comparatively analyzing those found in Namhyeongjeseom Islet with a similar environment due to no previous studies on the fauna in the subtidal zone of Bukhyeongjeseom Islet (Table 1). The trend of the species appearing in each region showed that 48 species (66%) surveyed on Namuseom Islet, among which Arthropoda amounted to 19 species (40%) indicating the greatest appearance while 35 species (48%) were surveyed on Bukhyeongjeseom Islet, among which Cnidaria amounted to 13 species (37%) indicating the highest appearance. 8 species (10%) of zoobenthos commonly appeared on both survey islets. The list of fauna in the subtidal zone reported in the 2010 Baseline Survey on Marine Ecosystem (Eastern Part of the South Sea) conducted by the Ministry of Environment did not include Cnidaria and Poridera, only mentioning such threatened species in the sector of landscape as *Antipathes japonica*, *Euplexaura recta, Dendronephthya castanea*, and *Charonia sauliae*.

This survey confirmed that those threatened marine organisms inhabit in the subtidal zone of Bukhyeongjeseom Islet such as *Antipathes japonica* and *Euplexaura recta*.

Discussion

This study surveyed the benthic fauna in and around the islets of Namuseom and Bukhyeongjeseom in Busan by SCUBA diving in September 2013, which was conducted before the designation of those regions as a marine sanctuary in November 2013 in accordance with Article 25 of the Act on the Conservation and Management of Marine Ecosystem and in a way to survey within the areas with higher benthic fauna informed by a local guide to the extent not to cause habitat disturbance to the threatened marine species (Figure 2).

This survey additionally observed a variety of subtropical species including Poridera and Cnidaria that had yet to be found in the 2010 Baseline Survey on Marine Ecosystem (Eastern Part of the South Sea) conducted by the Ministry of Environment, and particularly confirmed that much more sponges and cnidarians inhabit on Bukhyeongjeseom Islet located at the southerly latitude. The islets of Namuseom and Bukhyeongjeseom off coast of Busan are under a subtropical climate (Korea Hydrographic and Oceanographic Administration, 2010; Ministry of Land, Transport and Maritime Affairs, 2011) and of higher biological importance; though, there has been no survey and/or research on the entire or a variety of taxon as well as a lack of the comprehensive surveys including Bukhyeongjeseom Islet, this survey is expected to pave the way for the future studies. In particular, subtropical sponges

Figure 2. Macro benthic invertebrates in and around the islets of Namuseom and Bukhyeongjeseom.

and cnidarians were observed during this survey that have been no appearance in the past and known to inhabit in and around Jejudo Island, definitely indicating the change in fauna and the northward movement of subtropical organisms attributable to the increasingly higher sea surface temperature and hopefully useful in examining the northward movement of such subtropical organisms up to the East Sea including the islets of Dokdo and Ulleungdo in line with the subsequent continuation of monitoring. The Ministry of Environment (2010) surveyed 1,846 species appearing in the eastern part of the South Sea, among which 54 species in Namuseom Islet and 61 species in Namhyeongjeseom Islet while this survey found out a total of 73 species at both survey sites: which was attributed to the listing of a total of 144 species, the list of which is expected to be useful in understanding the subsequent continuation of surveys in and around those two survey sites and further the change in marine fauna as well as the community structure in the subtropical areas in Busan. Furthermore, since this survey found a variety of fauna including the threatened marine species that inhabit in and around the islets of Namuseom and Bukhyeongjeseom, it is implied and suggested that the continuous observation and protection be needed in the waters including those islets in Busan.

Acknowledgments

This work was supported by the National Research Foundation of Korea (NRF) grant funded by Ministry of Science, ICT & Future Planning (MSIP) (2013M3A9A5047052).

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