Beach shell mollusks of Ise and Osaka Bays, southwestern Honshu, Japan

MERCY VERAR OPRECIO

In partial fulfillment of the requirements
for the degree of

Master of Science Education

Mie University
Graduate School of Education
Department of Earth Science

January 28, 2008

ADVISER:
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別紙様式第３

論　文　目　録

三重大学大学院教育学研究科

教科教育　専攻	理科教育　専　修	氏名	OPRECIO　MERCY　VERAR
論　文 (実技等の課題を含む)	題　目 **Beach shell mollusks of Ise and Osaka Bays, southwestern Honshu, Japan**		
添　付　資　料			

別紙様式第４

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ACKNOWLEDGMENTS

My sincerest thanks to my advisor Prof. Yutaka Honda for his patience with me during these past two years and critical reading of the manuscript. I also wish to thank Prof. Nobunari Ito and Taichiro Goto for their valuable comments and help. My heartfelt gratitude to the Soroptimist International of Mie for their financial support. I am indebted to Prof. Emeritus Nobutaka Ito for his trust and encouragement. My special thanks to Rodrigo Pechon for his help during my specimen collection and technical advices, to my family for their unfailing support and prayers, to all my friends for their understanding and concern and to all those who in one way or another had extended their help in the fulfillment of my purpose in coming to Japan. Above all I thank the Lord Almighty for the gift of strength and courage.

Beach shell mollusks of Ise and Osaka Bays, southwestern Honshu, Japan

Mercy Verar Oprecio

Abstract: Along with Tokyo Bay, Ise and Osaka Bays of southwestern Honshu are representative ones in Japan. I collected sand beach shells at five areas (Sambashi, Chiyozaki, Tsuzumigaura, Gotemba, and Gonushi) of the western coast of Ise Bay between May 2004 and April 2007; those at three areas (Nishikinohama, Hakotsukuri, and Tarui) of the southeastern coast of Osaka Bay between August 2006 and June 2007. A total of 81 species are identified at 13 localities of the western coast of Ise Bay, and 105 species at 10 localities of the southeastern coast of Osaka Bay. Six alien species are recognized: *Crepidula onyx* Sowerby, *Pomacea canaliculata* (Lamarck), *Perna viridis* (Linnaeus), *Xenostrobus securis* (Lamarck), *Meretrix petechialis* (Lamarck) and *Corbicula fluminea* (Müller).

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1. Introduction

Mollusks are important component of intertidal macrobenthic communities to measure environmental impacts because they are diverse and numerous. However, continuous alteration of habitat, over-harvesting, species introduction, pollution, and climate are the major causes of biodiversity loss and extinction of species (Edward-Stedman, 1997). In addition according to the U.S. Environmental Protection Agency (U.S EPA, 2006), exotic species or non-native species can have many negative impacts on the environment. They may cause increased predation and competition, disease, habitat destruction, genetic stock alterations, and even extinction. Several studies show that many benthic animals around Japanese coasts are threatened with extinction (Wada *et al.*, 1996 and Sato *et al.*, 2001). Ise and Osaka Bays (Figs. 1 and 2) are both relatively small and semi-enclosed marine environments. Ise Bay is surrounded by the Chubu industrial district (the cities of Nagoya, Yokkaichi, Toyohashi, Toyota, and so on). Its area is 1,738 km^2, with an average depth of 19.5 m (Fujiwara *et al.*, 2002). The mean residence time of bay water is 1.5 years (Saijo and Unoki, 1977).

Osaka Bay is located at the eastern end of the Seto Inland Sea, several large-scale land reclamation, industrialization and urbanization projects were undertaken in the coastal zone in the cities of Osaka and Kobe (Association for New Social Infrastructure of Osaka Bay, 1996). The bay is about 1,500 km^2 in area and is about 20 m in mean depth (Fujiwara, 1995). In Ise Bay mollusk species commonly found in 1960's such as, *Meretrix lusoria* (Röding), *Umbonium* (*Succhium*) *moniliferum* (Lamarck) and *Batillaria zonalis* (Bruguière) are proved to be endangered (Suzuki *et al*, 2006). Likewise most

commonly found species in Osaka Bay such as, *Ruditapes philippinarum* (Adams and Reeve), *Musculista senhausia* (Benson), *Crassostrea gigas* (Thunberg), *Littorina brevicula* (Philippi), and *Thais* (*Reishia*) *clavigera* (Küster) are observed in small number of occurrences.

Moreover, both bays are adjacent to urban areas which are relatively high risk to invasion of non-native species due to its numerous commercial trade ships on the coastal areas. In Japan most of the specimens of alien species were collected after 1980's in or around Seto Inland Sea and Tokyo Bay. Bivalves such as, *Perna viridis* (Linnaeus) was recorded between 1984-2002, *Mactra petechialis* (Lamarck) in 1992-1998, *Xenostrubos securis* (Lamarck) in 1980-2001 while the gastropods *Crepidula onyx* (Sowerby) was recorded in 1969-2002 (Kimura *et al*, 2004). *Corbicula fluminea* (Müller) is native to China and Taiwan, 1987 it was confirmed breeding in waterway of Okayama Prefecture and spread to Hyogo Prefecture and established into various parts of Kanto, Kyushu and Shikoku areas (Ministry of the Environment, Japan). A gastropod *Pomacea canaliculata* (Lamarck) was introduced into Japan in 1981. Damaged to rice was reported in 1984 and the species was designated as a quarantine pest by the Japanese Government (Wada, 1997) and thus an official list of recognized alien species in Japan including mollusks species was released by the Ministry of the Environment, Japan in October 27, 2004. Knowledge on the distribution of mollusks is very important for management of marine monitoring programs. In this paper a study was performed to compare the taxonomic composition of beach shell mollusks between sand beaches of Ise and Osaka Bays.

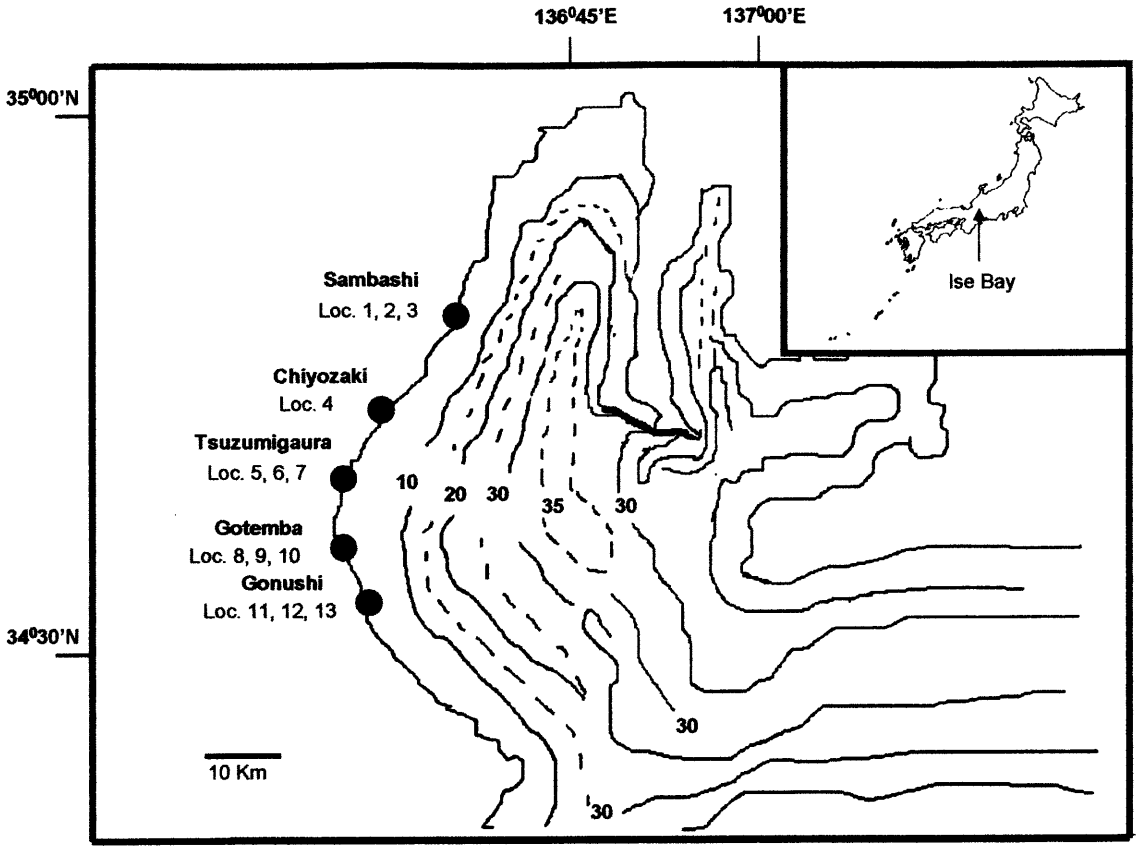


Fig. 1. Map of Ise Bay showing the sampling localities and water depths (in meters).

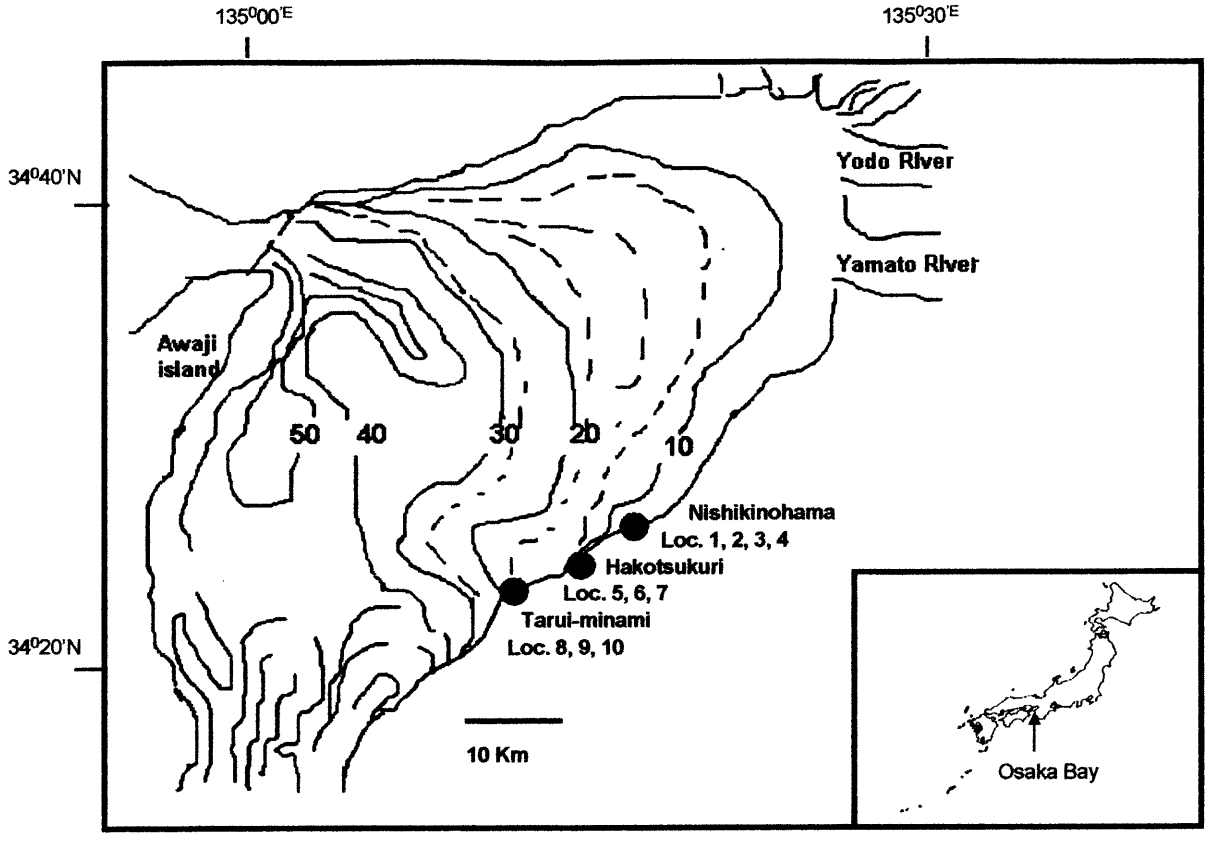


Fig. 2. Map of Osaka Bay showing the sampling localities and water depths (in meters).

2. Method of study

I collected sand beach shells at five areas (Sambashi, Chiyozaki, Tsuzumigaura, Gotemba, and Gonushi) of the western coast of Ise Bay between May 2004 and April 2007 (Fig. 3a-7b) giving a total of thirteen localities; those from three areas (Nishikinohama, Hakotsukuri and Tarui) of the southeastern coast of Osaka Bay between August 2006 and June 2007 (Fig. 8a-10b) totaling to ten localities. Specimens were collected at each locality from the quadrangle of 10 m^2 by randomly combing method along the shoreline (Fig. 11). The quadrat was plotted in the lower, middle and upper intertidal zones during the low tide. The total number of specimens in the quadrat was calculated. Specimens were dunked in a big bucket container with water overnight and individually took out from the water the following day. Small gastropods were put in a screen type bag, and dunked to a bucket of water and swing outside until it does not dripped anymore then tipped the contents into an old newspaper and leave them for two days. All individuals of a sample collected from each locality were identified and tabulated according to species (Tables 1, 2). Scientific and Japanese names were clarified based on Higo *et al.*, (1999). Shell measurement and visual microscopic observation were also done. A graph of cumulative number of species by locality was made to verify whether the samples in each sector were sufficient to established richness (Fig. 12A-B). Simpson's index of diversity was calculated to compare species diversity of both Ise and Osaka Bays (Tables 5a-b). Population density of beach shells per 10 m^2 was also estimated (Table 6). Specific composition of mollusks species by beach category were also determined to describe beach shell assemblages (Figs. 15a-16c.).

Fig. 3a. Map showing the location of Sambashi beach, Yokkaichi City

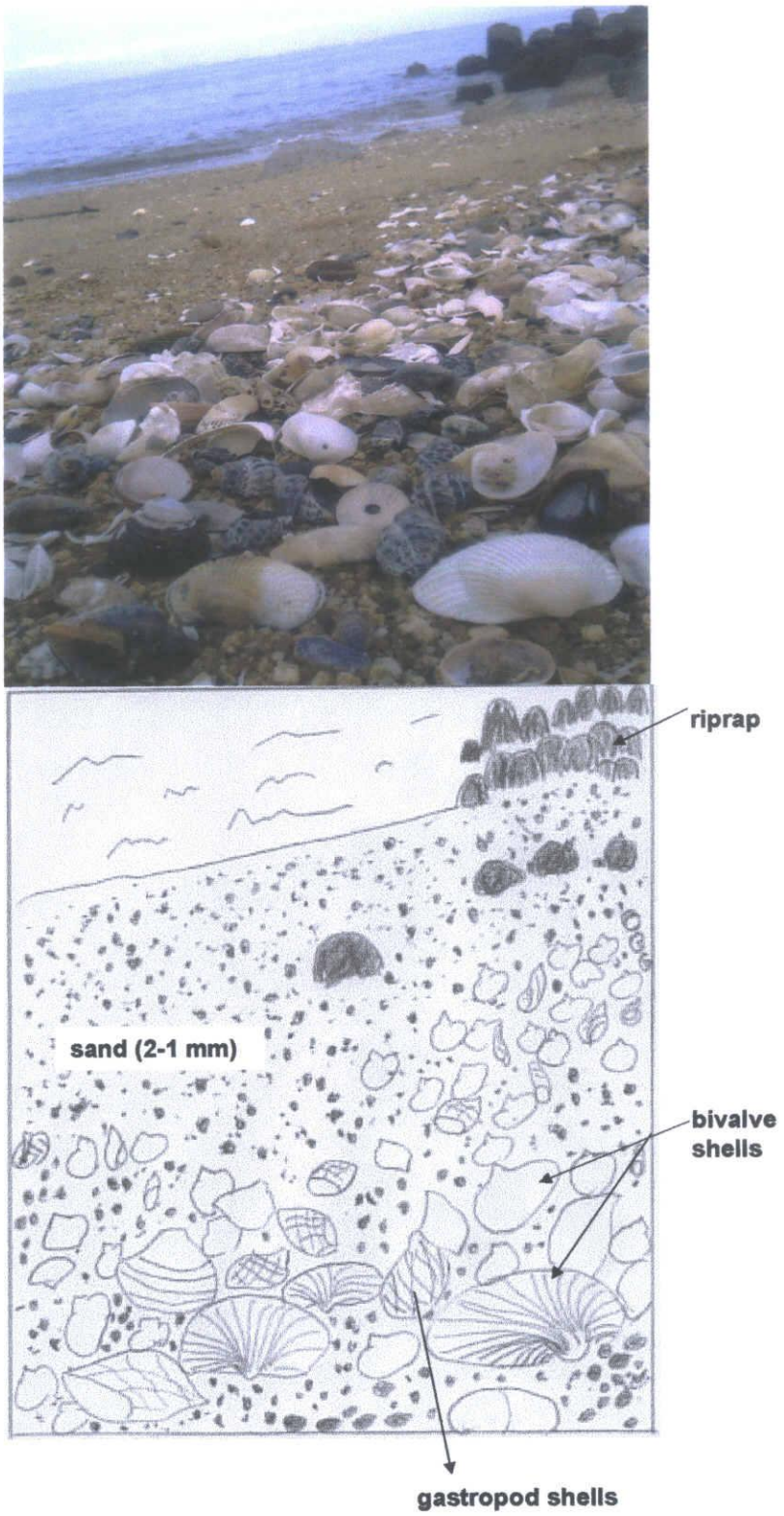


Fig. 3b. Occurrence of beach shells at Sambashi beach and sketch of the beach.

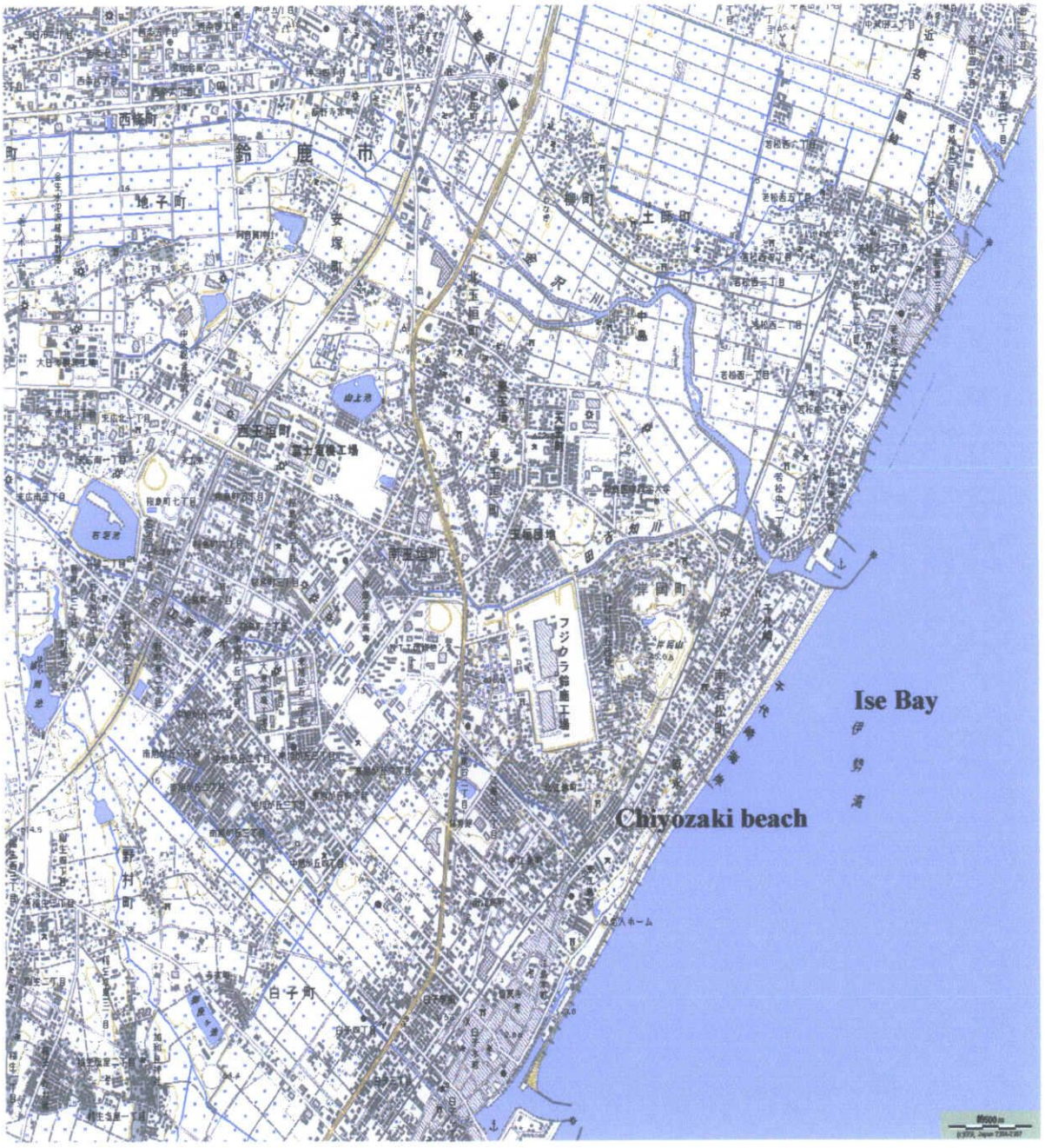
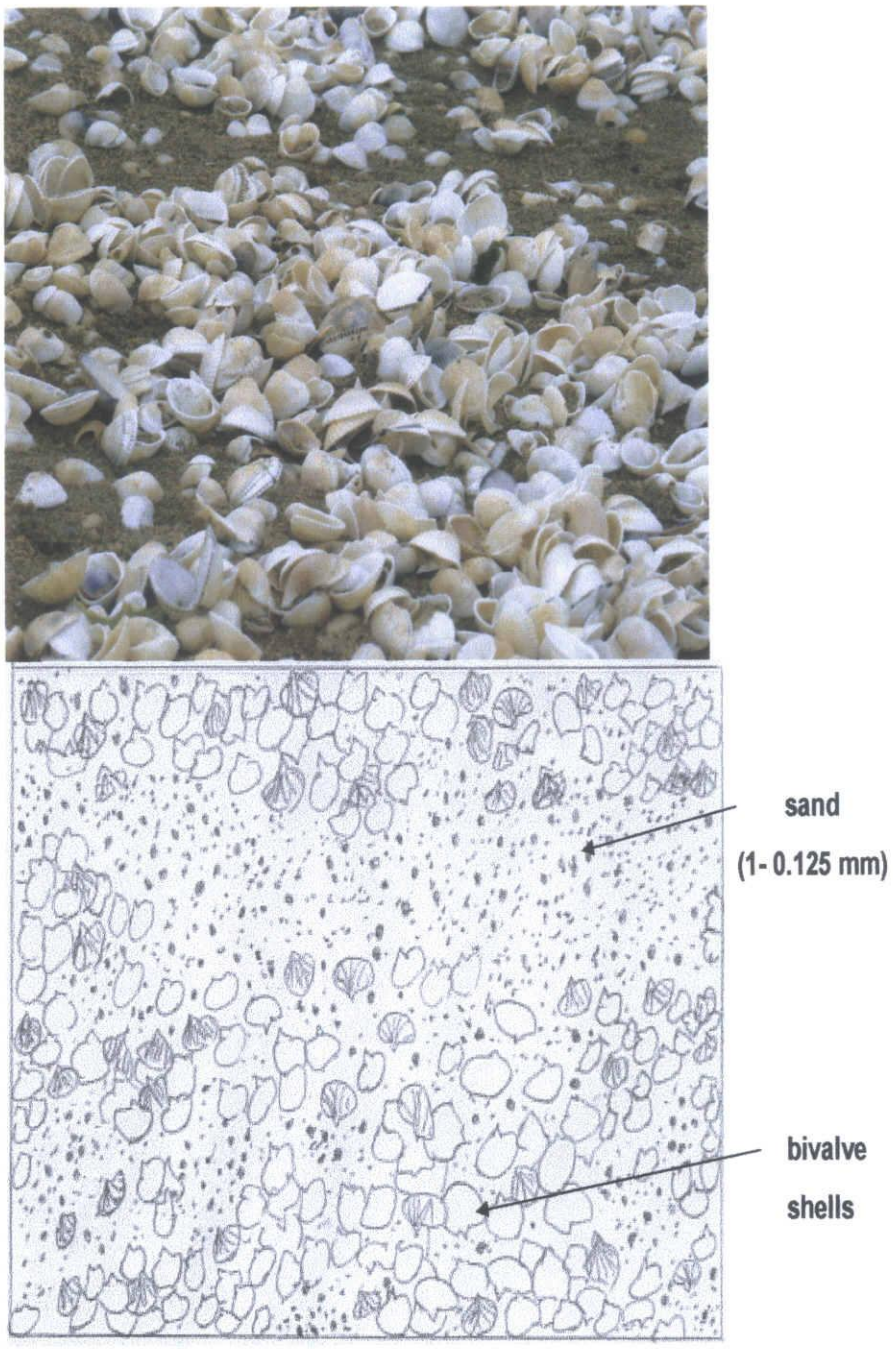


Fig. 4a. Map showing the location of Chiyozaki beach, Suzuka City.



Figs. 4b. Occurrences of beach shells at Chiyozaki beach and sketch of the beach.

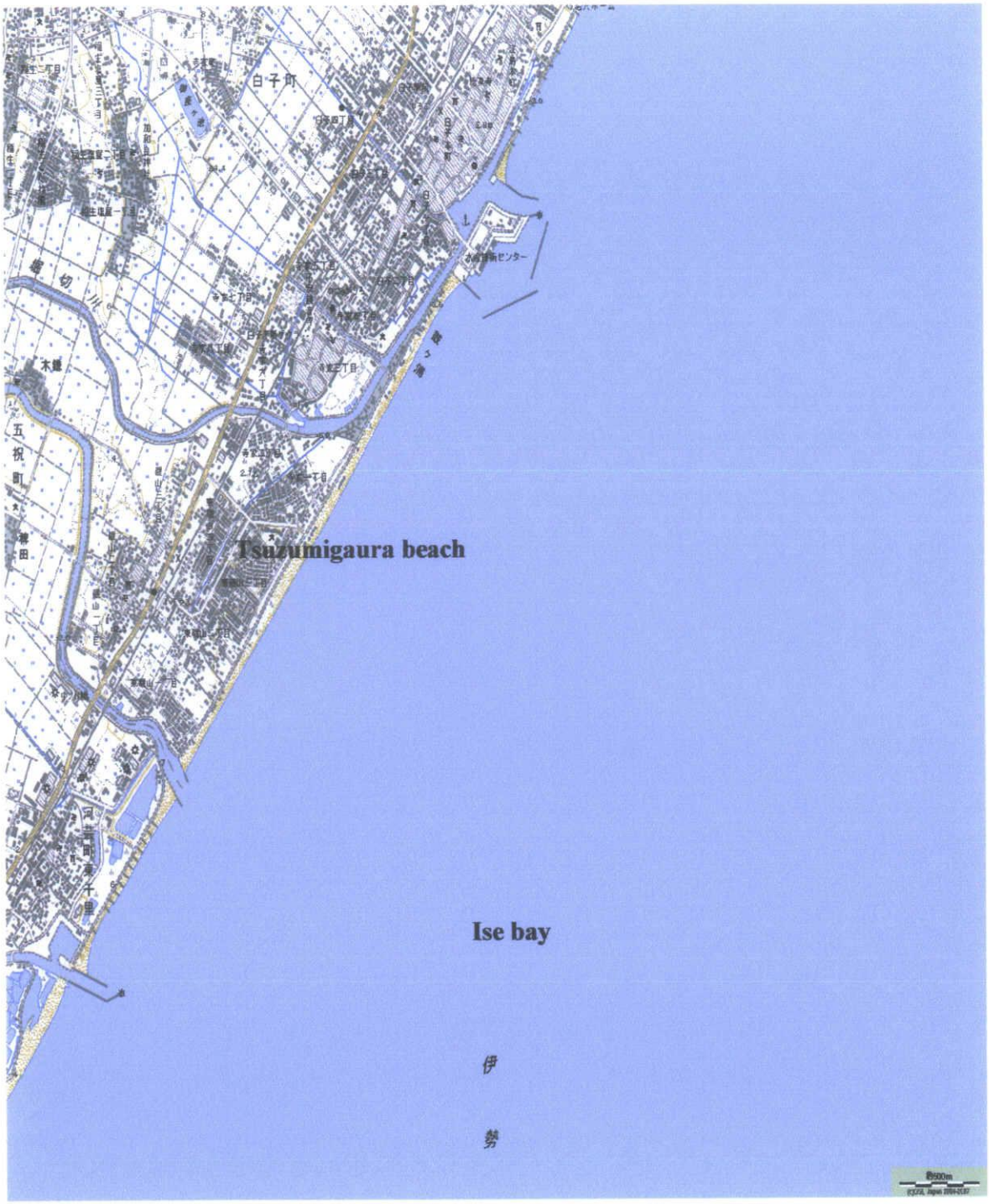


Fig. 5a. Map showing the location of Tsuzumigaura beach, Suzuka City.

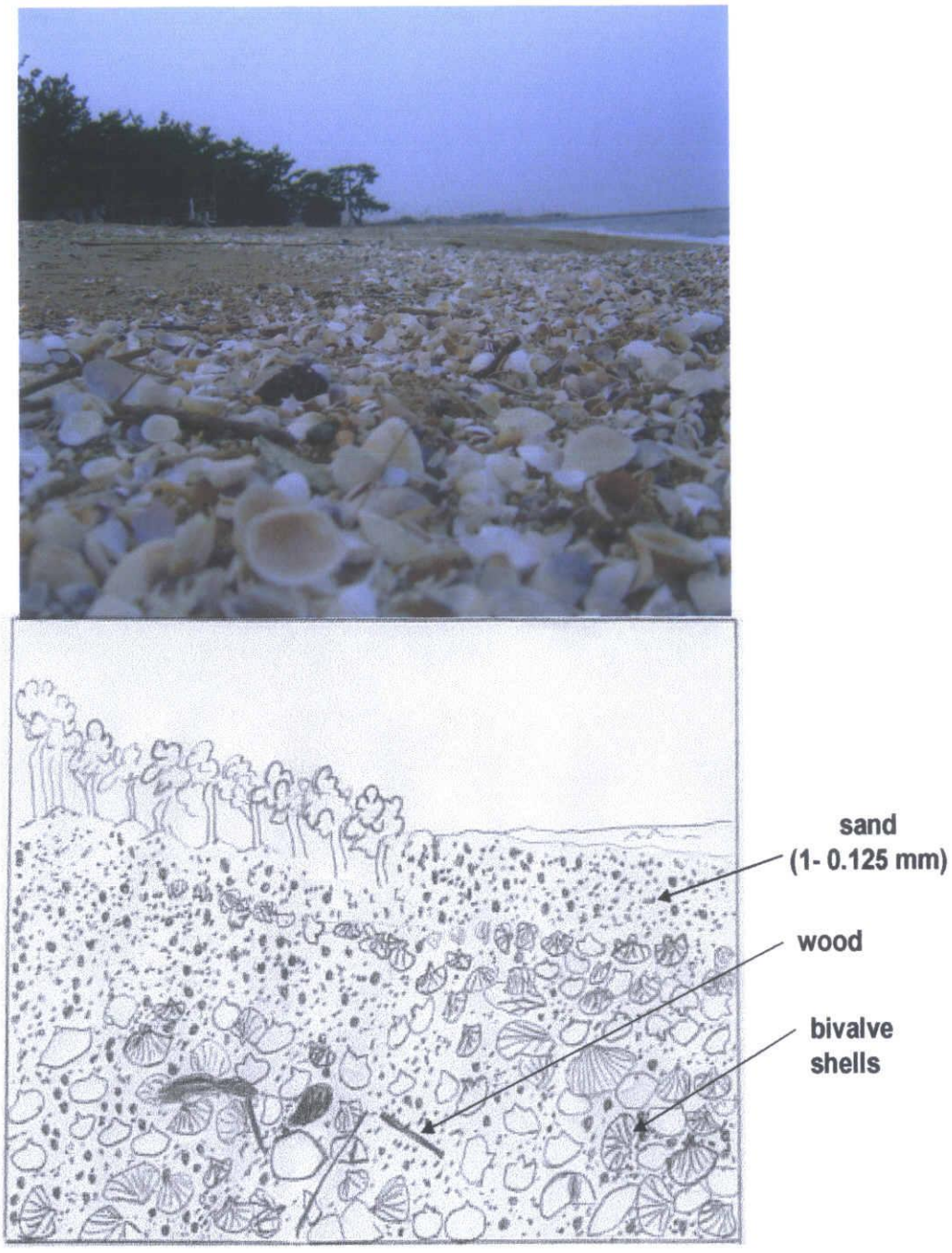


Fig. 5b. Occurrences of beach shells at Tsuzumigaura beach and sketch of the beach.

Fig. 6a. Map showing the location of Gotemba beach, Tsu City.

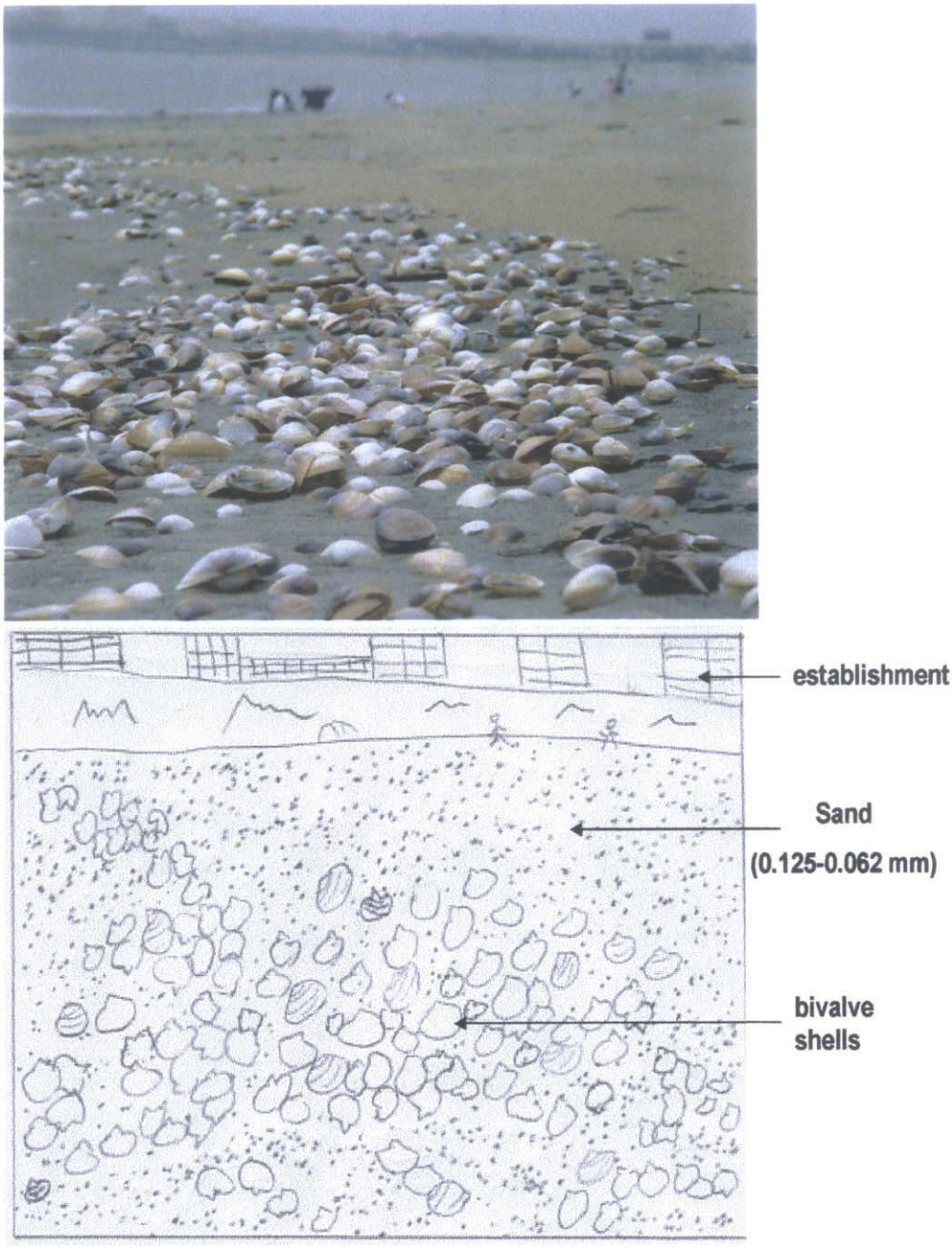


Fig. 6b. Occurrence of beach shells at Gotemba beach and sketch of the beach.

Fig. 7a. Map showing the location of Gonushi beach, Matsusaka City.

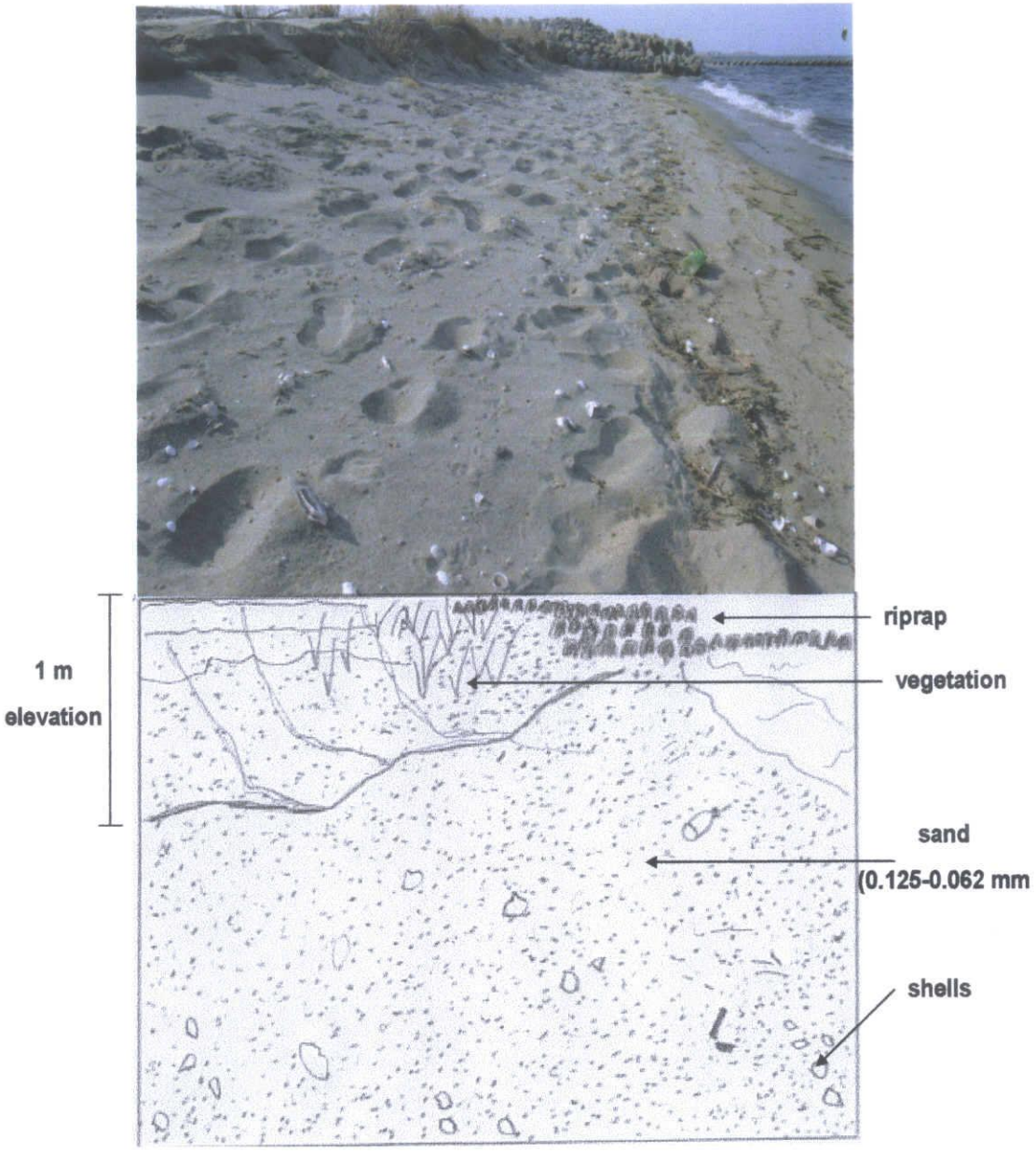


Fig. 7b. Occurrence of beach shells at Gonushi beach and sketch of the beach.

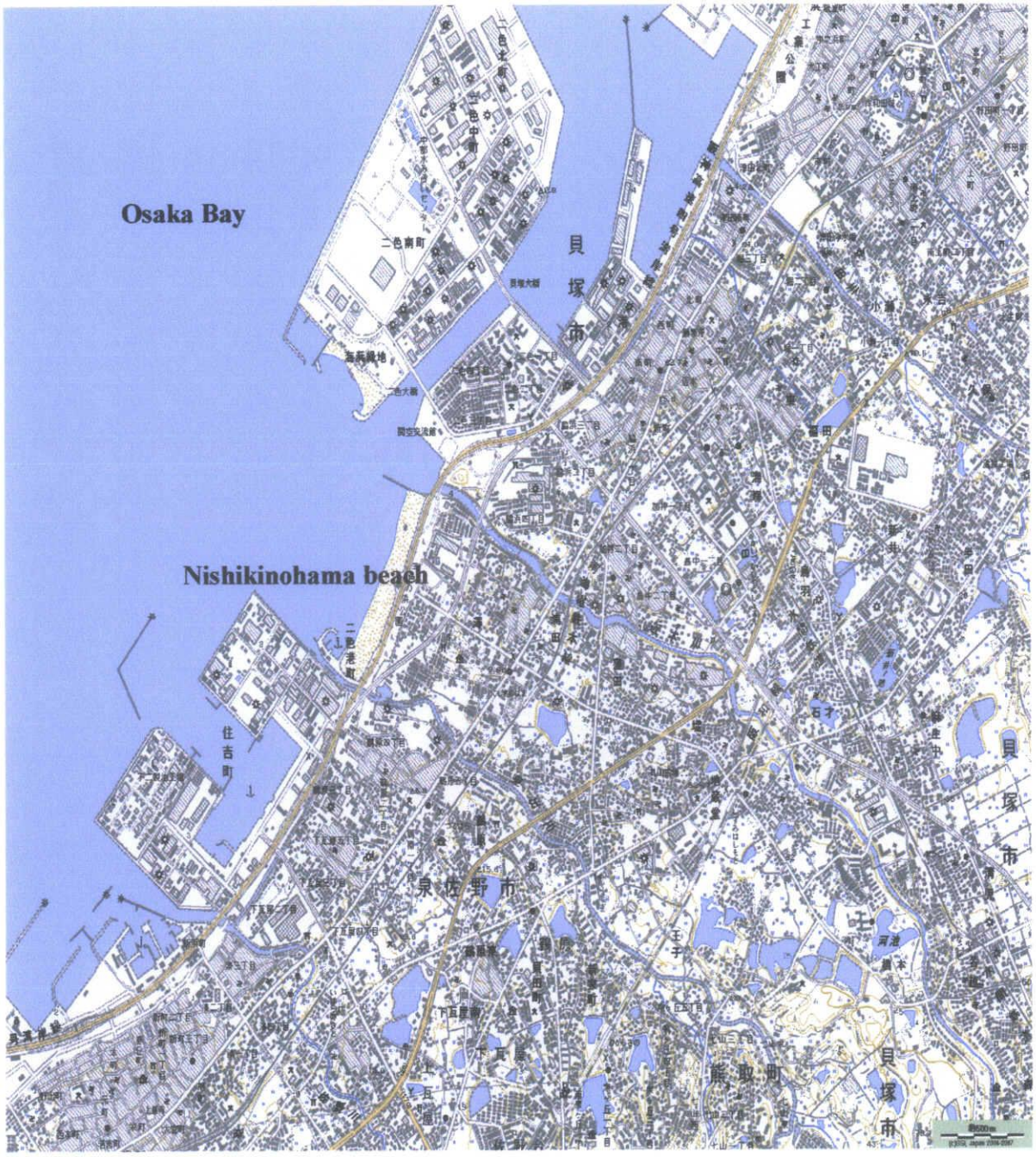


Fig. 8a. Map showing the location of Nishikinohama beach, Kaizuka City.

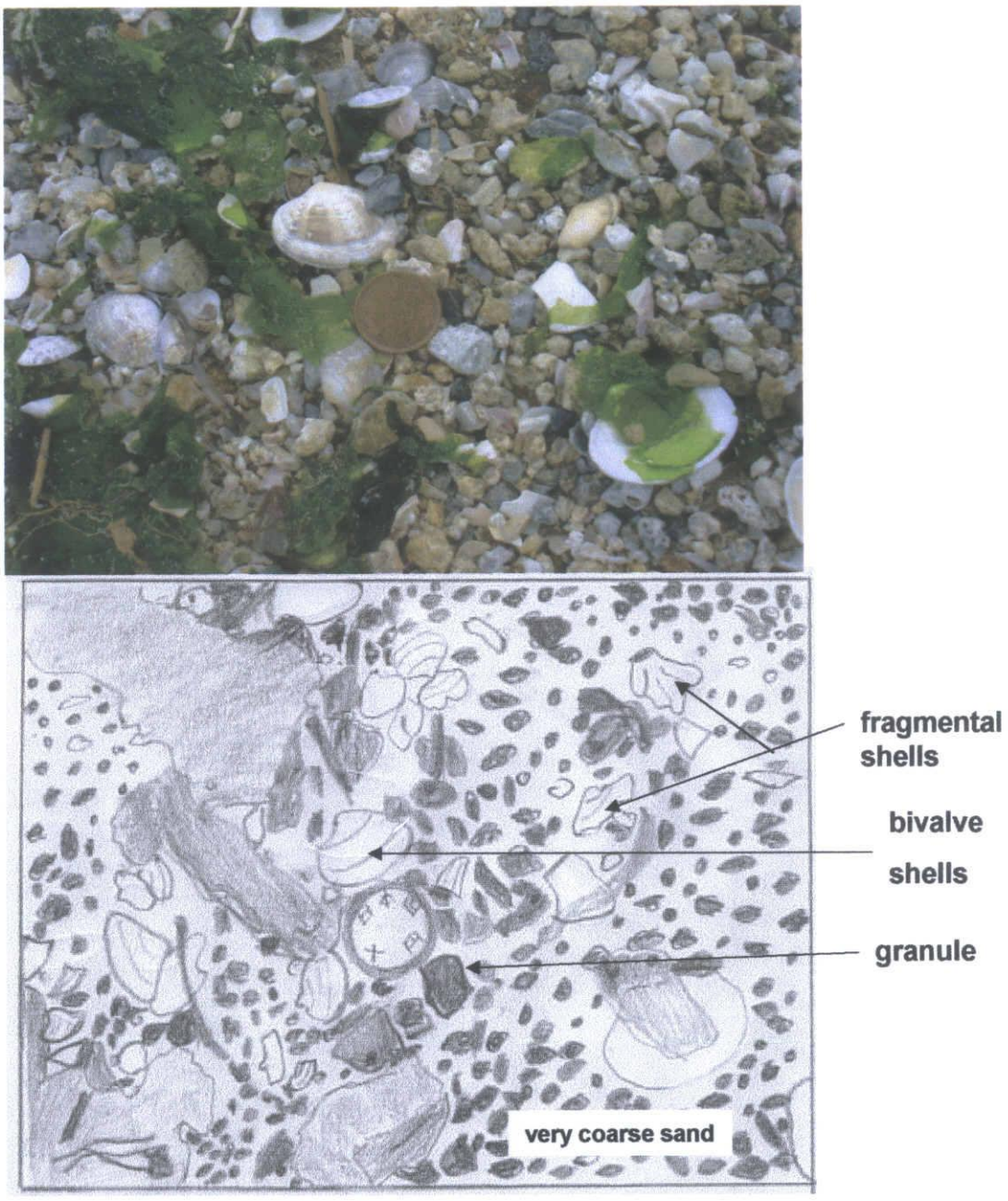


Fig. 8b. Occurrences of beach shells at Nishikinohama beach and sketch of the beach.

Fig. 9a. Map showing the location of Tarui-minami beach, Tarui City.

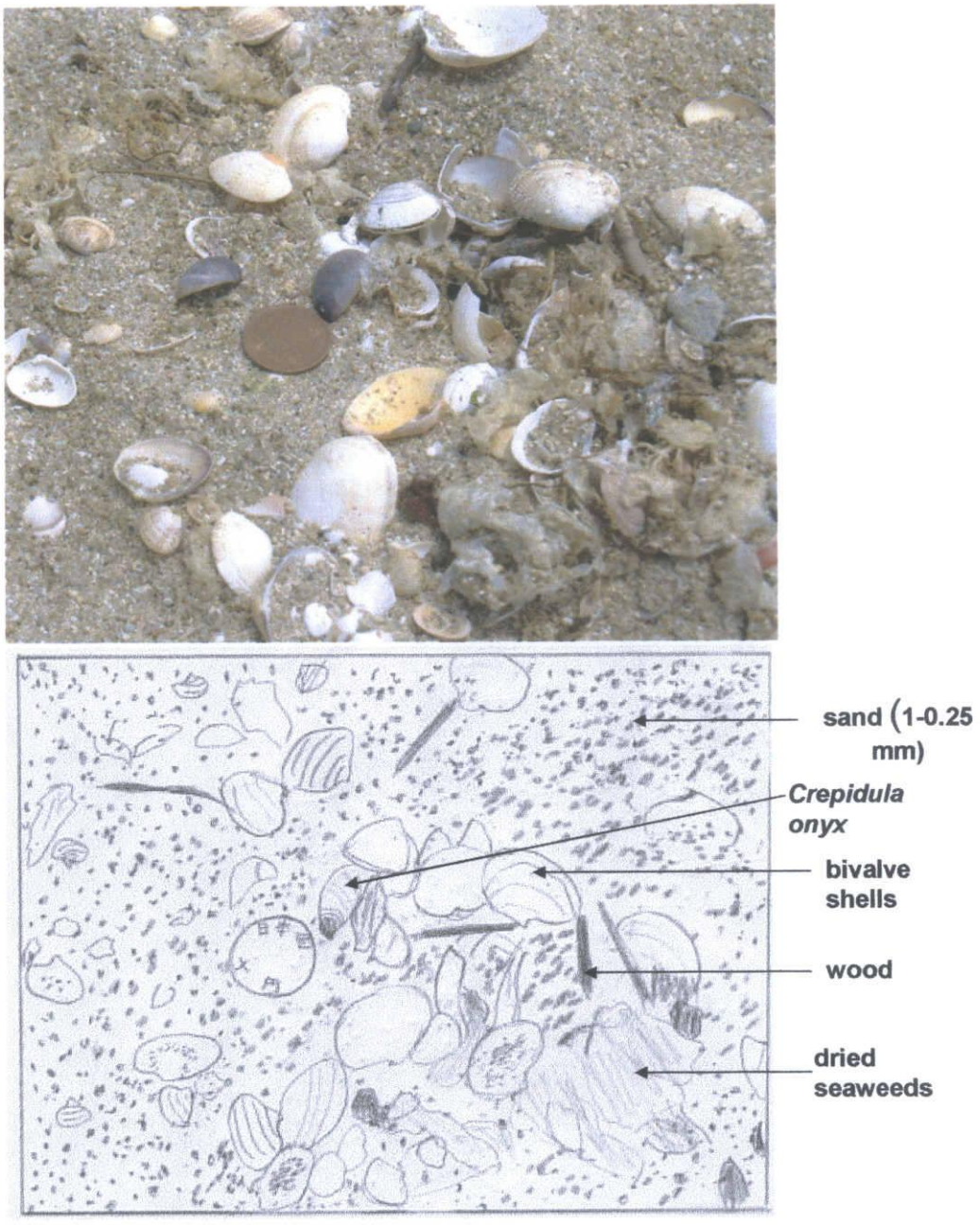


Fig. 9b. Occurrence of beach shells at Tarui-minami beach and sketch of the beach.

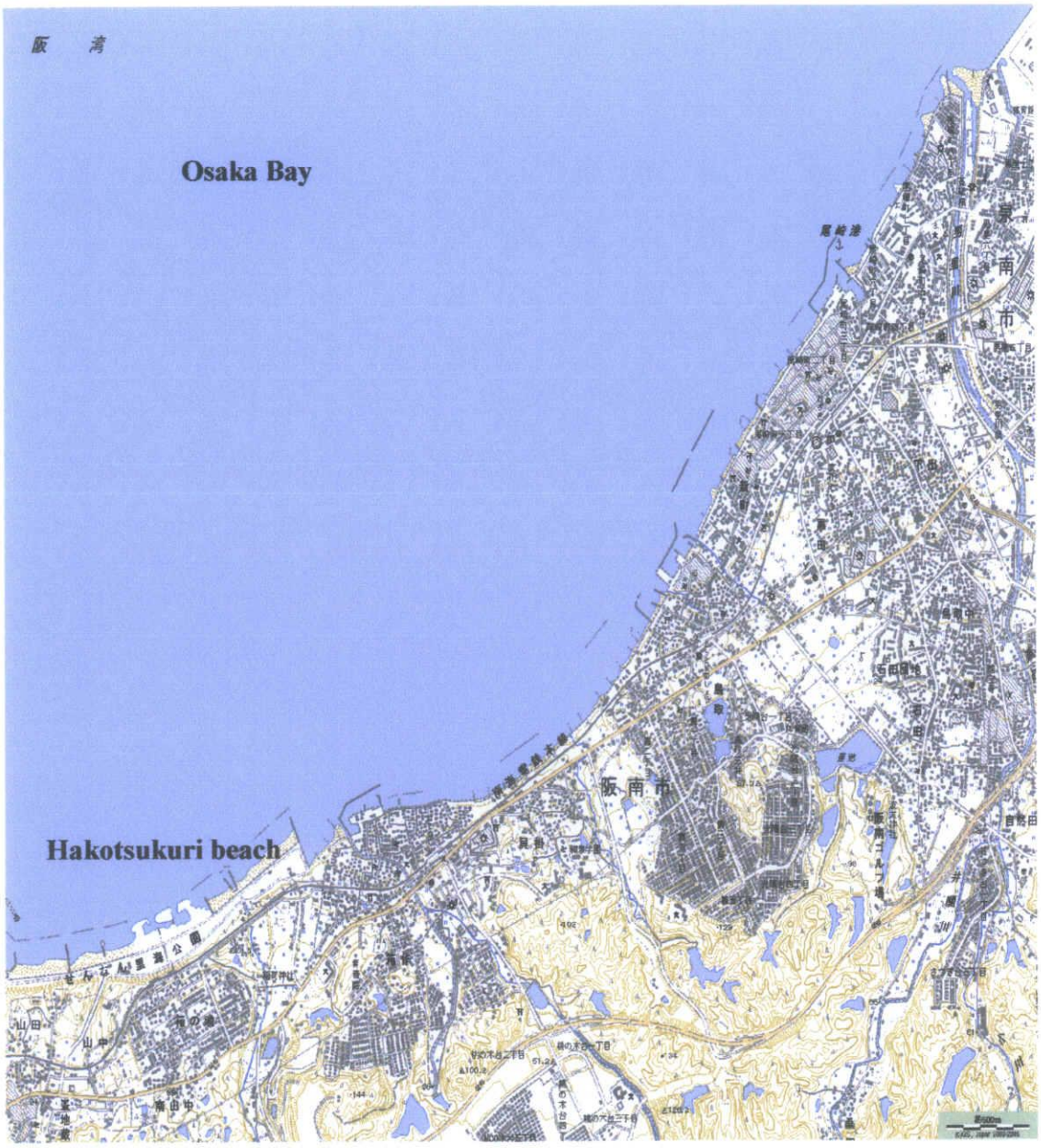


Fig. 10a. Map showing the location of Hakotsukuri beach, Sennan City.

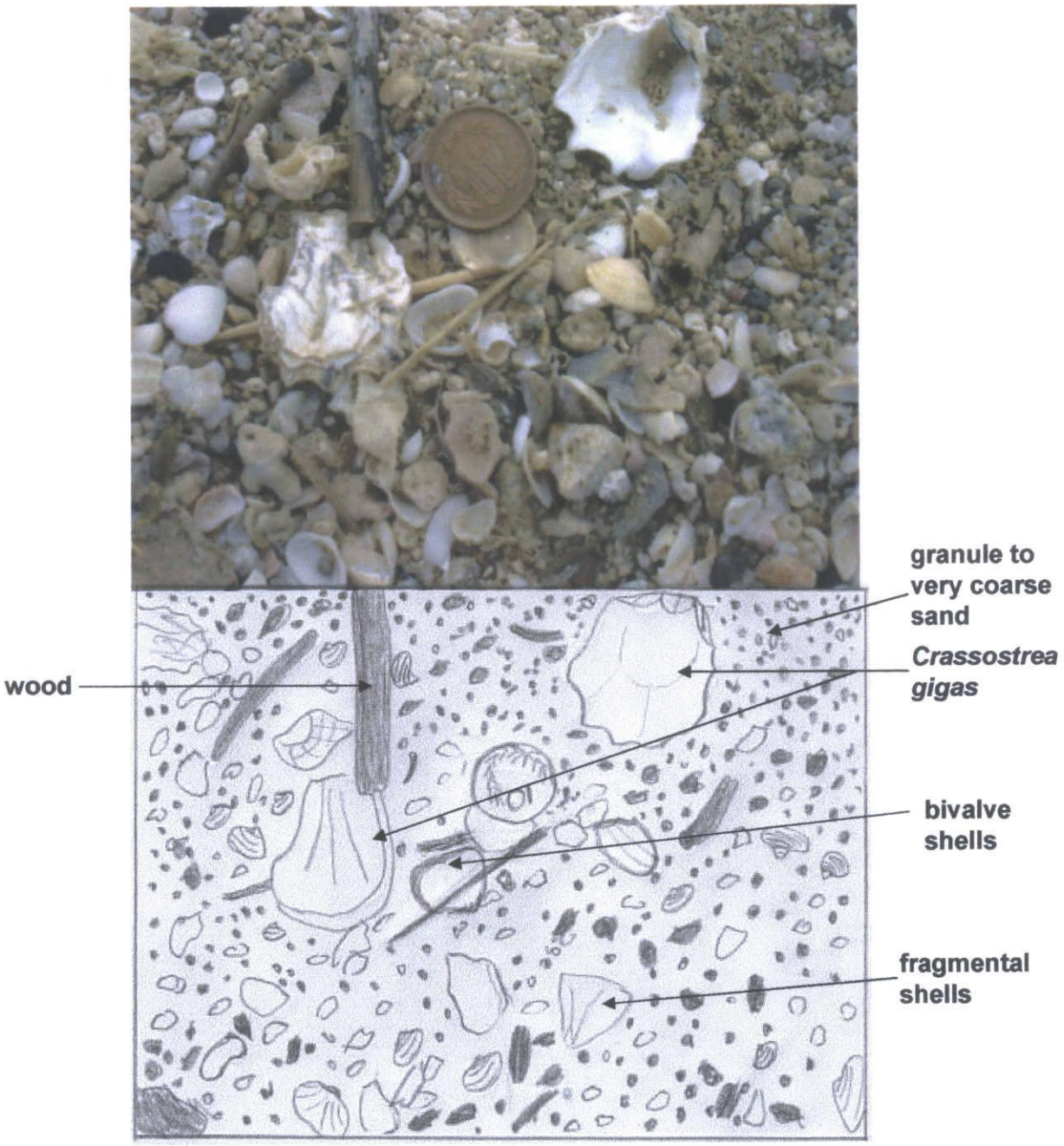


Fig. 10b. Occurrence of beach shells at Hakotsukuri beach and sketch of the beach.

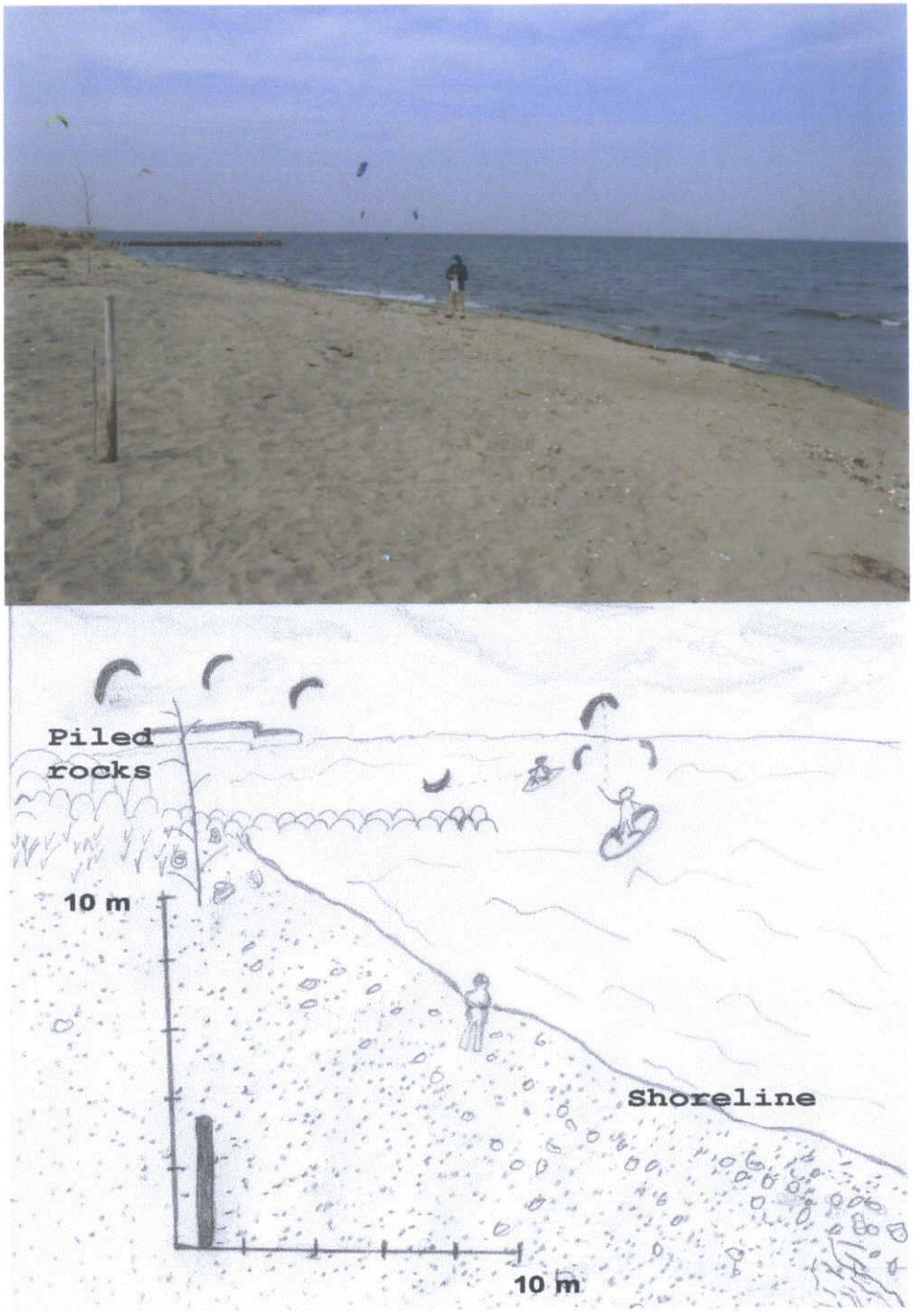
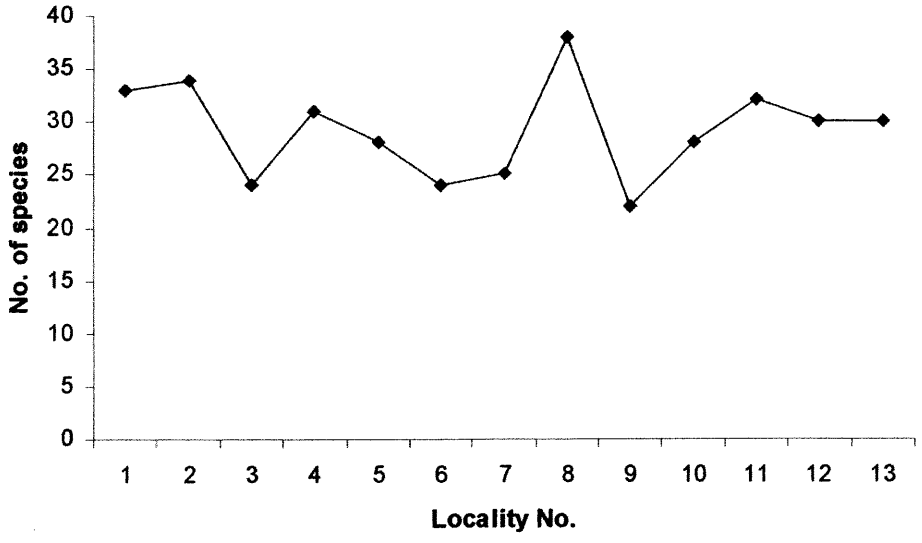


Fig. 11. Gonushi beach and sketch of the sand beach showing the shoreline and quadrat (10 m^2) plotted in the seashore.

A



B

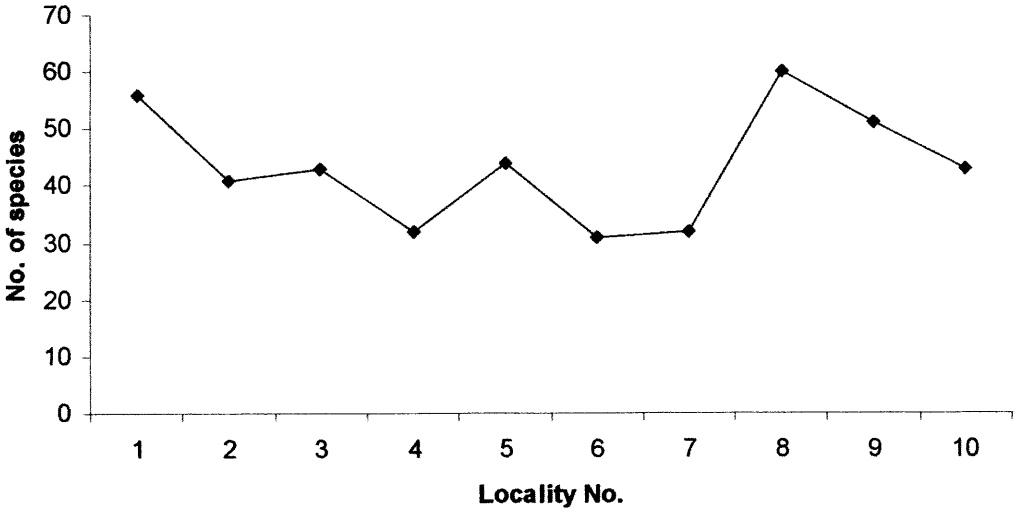


Fig. 12A-B. Species-Area Curve of beach shells of Ise Bay and Osaka Bay.

3. Results and Discussion

3.1 Species diversity of Ise and Osaka beach shells

I collected approximately fourteen thousands individuals from thirteen localities of Ise Bay. Ten localities of Osaka Bay represent an approximate of seven thousands individuals (Tables 1 and 2). In Ise Bay there were 29 species among 24 genera of gastropods and 52 species among 37 genera of bivalves. Whereas, Osaka Bay is composed of 56 species among 53 genera of gastropods and 48 species among 43 genera of bivalves and one species of scaphopod (Table 3). Percentage composition at class level is shown in Fig.14, where the total number of species (81) in Ise Bay consists of 64 % bivalves and 36 % gastropods whereas, in Osaka Bay the total number of species (105) is composed of 55 % gastropods, 44 % bivalves and 1 % scaphopod. The most abundant beach shell mollusk in Ise Bay are mactrids species such as *Mactra* (*Mactra*) *veneriformis* Reeve, 17 % and *M.* (*Mactra*) *chinensis* Philippi 5%; arcids species, such as *Scapharca inaequivalvis* (Bruguière) 16%, *Ruditapes philippinarum* (Adams and Reeve) 15%, *R. bruguieri* (Hanley) 6%, and *Scapharca sativa* (Bernard) 5%. *Crassostrea gigas* (Thunberg) and *Crepidula onyx* Sowerby are 10 %, *Mytilus trossulus* Gould and *Donax semigranosus* (Dunker) are consist of 4 and 2 % respectively of the total number of individuals collected (Table 4a-b). However, both the mactrids and arcids species represent a large number of fresh-dead juvenile specimens in mud at Gonushi beach in September 2004. Batilliriids, e.g. *Batillaria cumingii* (Crosse), and nassariids, *Hima festiva* (Sowerby and Powys) are the abundant gastropods found near riprap of rocks.

On the other hand, the most abundant mollusks in Osaka Bay are the venerids species, such as, *R. bruguieri* (Hanley), *R. philippinarum* (Adams and Reeve), and small arcids such as, *Striarca symmetrica* (Reeve), *Didimacar tenebrica* (Reeve), *S. sativa* (Lischke), *Nipponarca bistigata* (Dunker), *S. inaequivalvis* (Bruguière) which are made up of 25, 21, 8, 7, 6, 4 and 2 % respectively. In addition, *Cardita leana* Dunker is three percent and *M. trossulus* Gould with one percent. However, specimens from Osaka Bay are very small and old dead shells (Fig. 13A-B) indicating limited or no production. Some specimens show erosion of shells particularly in gastropod species, such as *Thais* (*Thais*) *clavigera* (Küster), *Cantharus cecillei* (Philippi), *Glossaulax didyma didyma* (Röding), and *B. zonalis* (Bruguière). On comparison, specimens from Ise Bay are mostly comparatively large and are fresh-dead shells except certain species at Sambashi beach, such as *M. chinensis* Philippi, *Atrina* (*Servatrina*) *pectinata* (Linnaeus), *Umbonium* (*Succhium*) *moniliferum* (Lamarck) and *Meretrix lusoria* (Röding).

In Ise Bay bivalves outnumbered gastropods species but in Osaka Bay gastropods are the dominant species. According to Sietz (2006), in marine habitat bivalves are dominant benthic organism that can comprise of over 50% of biomass and are indicative of benthic production. It becomes apparent that Osaka Bay has a lower benthic production in spite of having high species diversity. Moreover, infaunal suspension-feeding bivalves, *M.* (*Mactra*) *veneriformis* (Reeve), *M.* (*Mactra*) *chinensis* Philippi and *R. philippinarum* (Adams and Reeve), *R. bruguiere* (Hanley), *Crassotrea gigas* (Thunberg), *Donax* (*Chion*) *semigranosus* (Dunker), *M. trossulus* Gould and sedentary bivalves, *S. inaequivalvis* (Bruguière), *S. sativa* (Bernard) were found as the dominant species in Ise Bay.

Similar results for the occurrences of bivalves were obtained in the previous study in Honda (1997) (HP, http://www.cc.mie-u.ac.jp/~lz00102/cosmos.htm). However, of these species *R. philippinarum* (Adams and Reeve) was most dominant species. In recent investigation from the 5 sandy beaches of Ise Bay *M.* (*Mactra*) *veneriformis* (Reeve) has found to be the most abundant species. Three infaunal suspension-feeding bivalves, *R. philippinarum* (Adams and Reeve), *M.* (*Mactra*) *chinensis* Philippi and *M.* (*Mactra*) *veneriformis* (Reeve) are widely distributed in tidal flats and shallow waters in Japan (Habe and Kosuge, 1996), including Tokyo Bay (Furota, 1997). The life history and ecological aspects of the former two species are well reported (Sakurai *et al.*, 1996 and Kakino, 1996) because of their commercial importance. But their occurrences in Osaka Bay have declined tremendously in the past years.

Table 1. Occurrences of beach shells of the western coast of Ise Bay. Locs. 1, 2, 3 (Sambashi area); 4 (Chiyozaki beach); 5, 6, 7 (Tsuzumigaura area); 8, 9, 10 (Gotemba area); 11, 12, 13 (Gonushi area). Numerals indicate number of individuals collected.

Species		Dates and Localities													
		2004.8.4	2004.9.30	2005.2.27	2007.4.22	2004.7.30	2004.9.16	2005.2.25	2004.4.22	2004.9.25	2005.2.17	2004.5.14.2	2004.9.2	2006.2.10	
		1	2	3	4	5	6	7	8	9	10	11	12	13	Totals
Gastropods															
Trochidae	*Umbonium (Succhium) moniliferum* (Lamarck)	0	0	0	0	0	0	0	5	4	7	0	3	1	20
	Monodonta labio form *confusa* Tapparone-Canefri	0	0	0	1	0	0	0	0	0	0	0	0	0	1
Turbinidae	*Turbo (Batillus) cornutus* Lightfoot	0	0	0	0	0	0	0	0	0	0	1	0	0	1
Siliquariidae	*Tenagodus (Agathirses) cumingii* (Mörch)	0	0	1	1	0	0	0	0	0	0	1	0	0	3
Batillariidae	*Batillaria multiformis* (Lischke)	0	0	0	0	0	0	1	0	0	0	27	13	0	41
	B. cumingii (Crosse)	25	0	0	0	0	0	0	0	0	1	199	21	16	262
Littorinidae	*Lacuna (Haloconcha) reflexa* (Dall)	0	0	0	0	0	0	0	0	0	0	0	0	1	1
	Littorina (Littorina) brevicula (Philippi)	11	5	0	0	0	1	4	1	0	0	3	0	0	25
Calyptreidae	*Crepidula onyx* Sowerby*	32	18	0	196	59	38	58	43	0	0	14	16	0	474
Vermetidae	*Serpolurbis xenophorus* Habe	0	0	0	1	0	0	0	0	0	0	0	0	0	1
Naticidae	*Cryptonatica hirasei* (Pilsbry)	1	0	0	2	0	0	0	0	1	0	0	0	0	4
	Euspira fortunei (Reeve)**	0	0	0	2	0	0	0	1	0	0	13	16	6	38
	Natica spadicea (Gmelin)	0	1	0	0	0	0	0	0	0	1	0	0	0	2
	Glossaulax didyma didyma (Röding)	0	3	2	9	0	2	4	12	8	0	5	0	0	45
Epitoniidae	*Epitonium (Papyriscala) clementium* Grateloup	0	0	0	0	0	0	0	0	0	0	0	0	2	2
	E.. (Hirtoscala) castum (A. Adams)	0	0	0	0	0	0	0	0	0	0	0	0	1	1
Muricidae	*Thais (Reishia) clavigera* (Küster)	13	85	6	5	1	1	8	4	0	0	1	0	0	124
	T. (Reishia) bronni (Dunker)	9	2	1	1	0	0	0	2	0	0	1	2	1	19
	Rapana venosa venosa (Valenciennes)	0	2	4	2	12	2	2	13	4	0	4	0	1	46
Nassariidae	*Hima festiva* (Sowerby and Powys)	62	43	3	10	0	8	21	15	4	1	59	9	7	242
	H. fuscolineata (E.A Smith)	0	0	0	0	0	0	0	6	0	0	0	0	0	6
Buccinidae	*Babylonia japonica* (Reeve)	0	0	0	0	0	0	0	0	0	1	0	0	0	1
	Siphonalia modificata (Reeve)	0	0	0	0	1	0	0	0	0	0	0	0	0	1
Cancellariidae	*Cancellaria (Sydaphera) spengleria* Deshayes	0	2	0	0	0	0	0	0	0	2	0	0	0	4
Haminoeidae	*Haloa nigropunctata* (Pease)	0	0	0	0	0	0	0	0	0	0	0	0	2	2
Siphonariidae	*Siphonaria (Sacculosiphonaria) japonica* (Donovan)	0	0	0	0	0	0	0	1	0	0	1	0	0	2
	S. lacintosa (Linnaeus)	0	0	0	0	0	0	0	0	0	0	1	0	0	1
bradybaenidae	*Euhadra senckenbergiana* (Kobelt)	0	0	0	0	0	0	0	0	1	0	0	0	0	1
Ampullariidae	*Pomacea canaliculata* (Lamarck)*	0	0	0	0	0	0	0	0	0	0	0	1	1	2
Bivalves															
Arcidae	*Barbatia (Savignyarca) virescens* (Reeve)	1	0	0	0	0	0	0	0	0	0	0	0	0	1
	Tegillarca granosa (Linnaeus)	0	0	0	0	0	0	0	1	0	0	0	0	0	1
	Scapharca inaequivalvis (Bruguière)	154	186	96	625	129	125	256	523	11	13	0	0	3	2121
	S. broughtonii (Schrenck)	0	0	0	0	0	0	0	1	0	0	0	0	0	1
	S. sativa (Bernard)	84	160	36	0	61	93	65	126	8	0	1	0	4	638
	S. satowi (Dunker)	2	3	0	0	1	0	0	1	1	17	0	0	0	25
Mytilidae	*Musculista japonicus* (Dunker)	1	2	0	97	0	0	0	0	0	0	0	0	0	100
	M. senhausia (Benson)	0	13	0	175	4	0	0	0	0	2	16	5	2	217
	Mytilus trossulus Gould	69	9	6	115	89	1	5	2	2	0	21	29	2	350
	Perna viridis (Linnaeus)*	0	0	0	2	0	0	0	0	0	0	0	0	0	2
	Xenostrobus securis (Lamarck)*	0	0	0	0	0	0	0	0	0	0	1	0	0	1

Table 1. (Continued).

Pinnidae	*Atrina (Servatrina) pectinata* (Linnaeus)	1	0	2	0	0	0	0	1	0	0	2	0	2	8
Pectinidae	*Pecten (Notovola) excavatus* (Anton)	2	0	0	0	1	0	0	0	0	0	0	0	0	3
	Chlamys (Mimachlamys) nobilis (Reeve)	0	0	0	0	0	0	0	0	0	0	1	0	0	1
	Mizuhopecten yessoensis (Jay)	2	0	0	0	0	0	0	0	0	0	0	0	0	2
Anomiidae	*Anomia cheniensis* Philippi	6	3	6	3	40	12	1	1	0	0	0	0	0	72
Ostreidae	*Crassostrea gigas* (Thunberg)	48	52	18	5	0	2	0	21	0	7	112	551	530	1346
	C. nippona (Seki)	0	0	0	2	0	0	0	0	0	0	0	0	0	2
	Hyotissa hyotis (Linnaeus)	3	0	0	0	0	0	0	2	0	0	0	0	0	5
	Ostrea denselamellosa Lischke	3	0	0	0	1	0	0	0	0	0	0	0	0	4
Lucinidae	*Pillucina (Pillucina) pisidium* (Dunker)	0	0	0	0	0	0	1	0	0	0	0	0	0	1
Cardiidae	*Fulvia mutica* (Reeve)	0	2	1	4	3	0	0	17	4	5	0	0	0	36
Mactridae	*Mactra (Mactra) chinensis* Philippi	0	14	63	96	129	36	12	208	13	96	10	13	29	719
	M. (Mactra) venetiformis Reeve	86	34	31	202	130	106	73	599	156	175	50	632	12	2286
	M. (Mactra) nipponica Kuroda and Habe	0	1	0	2	1	3	7	0	22	5	0	9	3	53
Donacidae	*Donax (Chion) semigranosus* (Dunker)	0	0	0	0	0	0	0	0	156	141	0	0	0	297
Tellinidae	*Nitidotellina hokkaidoensis* (Dunker)	10	6	0	0	8	0	2	2	18	1	0	0	0	47
	Macoma tokyoensis Makiyama	0	3	4	7	1	3	0	0	0	1	0	0	0	19
Psammobiidae	*Nutallia japonica* (Jay)	0	0	0	0	1	1	1	8	4	2	93	66	62	238
	N. ezonis (Kuroda and Habe)	21	0	0	0	0	0	0	2	0	0	1	2	2	28
	Psammotaea virescens (Deshayes)	1	0	0	0	0	0	0	0	0	0	10	9	2	22
	P. minor (Deshayes)	0	0	0	0	2	0	0	1	0	0	0	33	10	46
	Soletellina diphos (Linnaeus)	0	0	1	0	0	0	0	2	0	0	0	0	0	3
Solecurtidae	*Solecurtus divaricatus* (Lischke)	0	1	0	0	0	0	0	1	0	1	0	0	0	3
Solenidae	*Solen strictus* Gould	1	1	1	3	0	0	46	21	0	5	0	6	39	123
	S. grandis Dunker	0	0	16	0	14	1	63	34	2	52	0	7	45	234
Corbiculidae	*Corbicula japonica* Prime	38	8	1	0	0	1	5	2	0	1	2	2	0	60
	C. fluminea (Müller)*	0	3	0	0	2	1	1	1	0	1	0	0	0	9
Trapezidae	*Trapezium (Neotrapezium) liratum* (Reeve)	0	0	0	0	2	0	0	0	0	1	0	0	0	3
	T. sublaevigatum (Lamarck)	2	0	0	0	0	0	0	0	0	0	0	0	0	2
Veneridae	*Protothaca euglypta* (Sowerby)	0	0	0	1	0	0	1	0	0	0	0	0	0	2
	Ruditapes bruguieri (Hanley)	41	12	2	14	23	5	3	29	3	5	323	215	76	751
	R. philippinarum (Adams and Reeve)	129	152	9	13	96	53	57	189	0	15	670	406	250	2039
	Paphia (Neotapes) undulata (Born)	6	10	0	11	9	3	0	0	0	0	9	8	2	58
	Saxidomus purpurata (Sowerby)	0	0	0	3	0	0	0	4	2	0	0	0	0	9
	Phacosoma japonicus (Reeve)	0	7	5	0	33	72	0	33	3	4	3	11	6	177
	Dostnella corrugata (Reeve)	1	0	0	0	0	0	0	0	0	0	0	0	0	1
	Gomphina (Macridiscus) veneformis (Lamarck)	0	2	0	0	0	0	0	0	0	0	0	0	2	4
	Meretrix lusoria (Röding)	1	1	0	0	0	0	0	0	0	0	4	4	1	11
	M. petechialis (Lamarck)*	0	0	0	0	0	0	0	0	0	0	2	2	1	5
	M. lamarckii Deshayes	0	0	0	0	0	0	0	0	0	0	1	0	1	2
Myidae	*Mya (Arenomya) arenaria oonogai* Makiyama	1	2	1	3	4	2	1	9	4	11	0	1	0	39
	Totals	867	848	316	1613	857	572	698	1944	431	574	1662	2092	1125	13, 599

* Exotic or non-native species in Japan

** Native but introduced intentionally or unintentionally from abroad (Kimura *et. al.* 2004)

Table 2. Occurrences of beach shells of the southeastern coast of Osaka Bay. Locs. 1, 2, 3, 4 (Nishikinohama area); 5, 6, 7 (Tarui area); 8, 9, 10 (Hakotsukuri area). Numerals indicate number of individuals collected.

Taxon	Species	Dates and Localities										
		2005.8.20	2005.8.20	2005.8.21	2006.4.20	2007.5.22	2007.6.1	2007.6.1	2005.8.21	2007.4.21	2007.4.21	
		1	2	3	4	5	6	7	8	9	10	Totals
Gastropods												
Lottidae	*Patelloida pygmaea pygmaea* (Dunker)	1	0	1	0	0	0	0	0	0	0	2
	Lottia kogamogai Sasaki and Okutani	0	0	1	0	0	0	0	0	0	0	1
Fissurelidae	*Diodora mus* (Reeve)	0	0	0	0	0	0	0	1	1	0	2
Trochidae	*Chlorostoma turbinatum* A. Adams	24	16	2	0	0	1	1	0	3	2	49
	Trochus stellatus Gmelin	1	0	0	0	0	0	0	0	0	0	1
	Eurytrochus affinis cognatus (Pilsbry)	0	0	1	0	0	0	0	1	0	0	2
	Monodonta labio confusa Tapparone-Canefri	1	0	0	0	0	0	0	0	0	0	1
	Cantharidus japonicus (A. Adams)	0	0	2	0	1	0	0	0	0	0	3
	Komaitrochus pulcher Kuroda and Taki	0	0	0	0	0	0	0	2	0	0	2
	Akoya akoya (Kuroda)	0	0	1	1	0	0	0	1	0	0	3
	Umbonium (Succhium) moniliferum (Lamarck)	0	0	0	1	0	3	2	0	0	0	6
Turbinidae	*Liotina semiclathratula* (Shrenck)	0	0	0	2	2	0	0	5	10	0	19
Neretidae	*Nerita (Heminerita) japonica* (Dunker)	0	0	0	0	0	0	0	1	0	0	1
Cerethiidae	*Bittium (Stylidium) batillarium* (Kuroda and Habe)	0	1	0	0	0	0	0	2	0	0	3
Planaxidae	*Angiola zonata* (Gould)	0	5	0	0	6	2	0	7	5	8	33
siliquariidae	*Tenagodus (Tenagodus) cumingii* (Mörch)	1	2	1	1	2	3	2	5	1	3	21
Batillariidae	*Batillaria zonalis* (Bruguière)	0	0	0	0	1	0	0	0	0	3	4
Littorinidae	*Littorina (Littorina) brevicula* (Philippi)	2	0	1	0	0	0	0	2	1	0	6
Capulidae	*Capulus badius* (Dunker)	0	0	0	0	3	0	0	21	16	7	47
	Crepidula onyx Sowerby*	13	28	25	13	12	35	10	20	23	14	193
Vermitidae	*Serpolurbis xenophorus* (Habe)	0	0	0	0	0	0	0	0	1	0	1
Cypraeidae	*Purpuradusta (Purpuradusta) gracilis* Gaskoin	1	0	0	0	0	0	0	0	0	0	1
Triviidae	*Proterato (Sulcerato) callosa* (Adams and Reeve)	0	0	0	0	3	0	0	19	13	8	43
Velutinidae	*Limneria bulla* (Habe)	0	1	2	0	2	0	0	6	0	0	11
Naticidae	*Sigatica bathyraphe* (Pilsbry)	1	1	0	0	0	0	0	0	0	0	2
	Glossaulax didyma didyma (Röding)	2	2	1	4	2	2	1	2	3	1	20
	Tanea tosaensis (Kuroda)	1	1	0	0	0	0	0	3	9	3	17
	Eunaticina papilla (Gmelin)	0	0	0	1	0	1	0	0	0	0	2
Cerithiopsidae	*Cerithiopsis spongicola* Habe	2	2	0	0	0	0	0	2	1	0	7
	Notoseila morishimai Habe	0	0	0	1	0	0	0	0	0	2	3
	Furukawaia fukuiensis Kuroda and Habe	1	0	0	0	0	0	0	0	0	0	1
	Triphora tristoma (Blainville)	0	0	0	0	0	0	0	0	0	2	2
Epitoniidae	*Gyroscala (Pomiscala) perplexa* (Pease)	0	0	0	0	0	0	0	1	0	0	1

Table 2. (Continued).

Muricidae	*Thais (Reishia) clavigera* (Küster)	4	6	3	0	0	0	0	1	1	0	15
	T. (Reishia) bronni (Dunker)	1	2	1	0	0	0	0	0	0	0	4
	Rapana venosa venosa (Valenciennes)	0	0	1	0	0	0	0	1	1	2	5
	Ceratostoma inornatum (Récluz)	1	0	0	0	0	0	1	0	1	0	3
	Bedeva brileffi (Lischke)	1	0	0	0	0	0	1	0	1	0	3
Columbellidae	*Mitrella bicinta* Gould	1	5	1	0	3	0	9	10	9	9	47
Nassaridae	*Hima festiva* (Sowerby and Powys)	8	9	10	0	3	3	0	4	4	10	51
	H. fuscolineata (E.A. Smith)	0	4	0	0	0	1	0	4	0	1	10
Buccinidae	*Catharus cecillei* (Philippi)	1	0	1	0	0	0	0	2	6	7	17
	Phos (Phos) naucrators (Watson)	0	0	0	0	0	0	0	3	0	0	3
	P. (Phos) laeve (Habe)	0	0	0	0	0	0	0	1	0	0	1
	Siphonalia modificata (Reeve)	1	2	2	1	1	0	0	1	0	0	8
	Pollia subrubiginosus (Smith)	0	0	0	0	0	0	0	1	0	0	1
Fasciolariidae	*Latirus kandai* (Kuroda)	0	0	1	0	2	0	0	1	2	1	7
Costellariidae	*Vexillum* sp	1	0	0	0	0	0	0	0	0	0	1
Turridae	*Clathromangelia coffea* (Kuroda)	0	0	0	0	0	0	0	3	0	0	3
	Horaiclavus (Cytharoclavus) stenocyma (Kuroda and Oyama)	0	0	0	0	1	0	0	0	0	2	3
Pyramidellidae	*Orinella puchella* (A. Adams)	0	0	0	0	0	0	0	2	0	0	2
	Odetta tenpei (Nomura)	0	0	0	0	6	0	0	4	2	0	12
	Monotygma eximia (Lischke)	0	0	0	0	0	0	0	1	0	0	1
	Amathina tricarinata (Linnaeus)	0	0	0	0	0	0	0	1	0	0	1
	Ptycheultmella misella (Yokoyama)	0	0	0	0	2	0	0	1	0	0	3
Ampulariidae	*Pomacea conaliculata* (Lamarck)*	0	0	0	0	0	2	0	0	0	0	2
Scaphopod												
	Fissidentalium (Fissidentalium) lima (Kuroda and Habe)	0	0	0	0	0	0	0	1	1	0	0
Bivalves												
Arcidae	*Arca bourcardi* (Jousseaume)	4	2	3	1	2	1	6	19	11	18	67
	Barbatia (Savignyarca) virescens (Reeve)	0	0	0	0	1	0	0	0	0	3	4
	Nipponarca bistrigata (Dunker)	10	15	12	1	6	1	15	72	81	37	250
	Scapharca inaequivalves (Bruguière)	19	39	60	12	0	14	4	10	1	0	159
	S. sativa (Lischke)	72	226	43	23	0	5	5	15	10	3	402
	Tegillarca granosa (Linnaeus)	1	0	0	0	1	0	1	0	1	3	7
	Didimacar tenebrica (Reeve)	8	10	16	7	52	0	0	128	173	67	461
	Striarca symmetrica (Reeve)	11	8	13	29	23	1	9	159	164	102	519
Glycymeridae	*Glycemeris (Glycemeris) aspersa* (Adams and Reeve)	0	0	0	0	0	0	3	1	0	0	4
Mytilidae	*Mytilus trossulus* Gould	20	10	17	5	2	6	5	18	9	4	96
	Xenostrobus securis (Lamarck)*	0	0	1	1	0	0	0	0	0	0	2
	Musculista senhausia (Benson)	8	5	18	1	0	10	21	1	2	0	66

Table 2. (Continued).

Limidae	*Lima vulgatula* Yokoyama	1	0	0	0	0	0	0	0	0	0	1
	L. vulgaris Link	1	0	0	0	0	0	0	0	0	0	1
	Ctenoides ales (Finley)	2	0	0	0	1	0	0	0	0	0	3
Pectinidae	*Chlamys* (*Veprichlamys*) *empressae* Kuroda and Habe	4	0	0	1	0	1	4	12	8	0	30
Spondylidae	*Spondylus* (*Spondylus*) *longitudinalis* (Lamarck)	1	0	1	1	0	1	0	0	1	1	6
Anomiidae	*Anomia cheniensis* (Philippi)	9	3	1	1	2	3	7	14	1	5	46
Plicatulidae	*Plicatula simplex* Gould	1	1	0	1	0	1	1	5	2	0	12
Dimyidae	*Dimya filipina* Bartsch	1	1	2	3	3	0	2	4	5	5	26
Osteridae	*Crassostrea gigas* (Thunberg)	7	8	12	7	1	3	18	9	0	7	72
	Parahyotissa inermis (Sowerby)	3	0	0	0	13	0	0	0	11	21	48
	Ostrea denselamellosa Lischke	2	0	0	0	0	0	0	0	1	0	3
Lucinidae	*Epikodakia delicatula* (Pilsbry)	1	0	0	0	0	0	1	1	0	1	4
	Bellucina civica (Yokoyama)	0	0	0	0	0	0	1	0	0	1	2
	Pillucina (*Sydlorina*) *yamakawai* (Yokoyama)	0	0	0	0	0	0	2	0	0	1	3
	Wallucina striata (Tokunaga)	0	0	0	0	0	0	0	6	4	0	10
Ungulinidae	*Felaniella sowerbyi* (Kuroda and Habe)	1	0	0	0	0	0	0	0	0	0	1
Carditidae	*Megacardita ferruginosa* (Adams and Reeve)	5	1	0	0	2	0	0	7	7	4	26
	Cardita leana Dunker	8	7	3	6	6	0	8	66	21	39	164
	Pleuromeris pygmaea (Kuroda and Habe)	0	0	0	1	1	0	0	6	8	2	18
Chamidae	*Chama japonica* (Lamarck)	0	0	0	0	3	0	2	6	6	14	31
Crassatellidae	*Nipponocrassatella adamsi* (Kobelt)	7	2	2	3	2	1	1	14	2	2	36
	Indocrasatella oblongata (Yokoyama)	4	4	1	0	3	0	0	6	10	16	44
Psammobiidae	*Nutallia olivacea* (Jay)	0	0	0	0	0	0	0	0	2	0	2
Mactridae	*Mactra* (*Mactra*) *chinensis* Philippi	2	52	19	3	0	3	2	4	0	0	85
	M. (*Mactra*) *veneriformis* Reeve	8	3	6	0	0	0	0	0	0	0	17
	M. nipponica (Kuroda and Habe)	2	2	0	0	0	0	0	0	0	0	4
Corbiculidae	*Corbicula japonica* (Prime)	1	0	1	0	0	0	1	3	1	1	8
Veneridae	*Globivenus toreuma* (Gould)	1	1	0	0	0	0	0	0	0	0	2
	Ruditapes philippinarum (Adams and Reeve)	430	365	136	68	36	157	115	35	21	67	1430
	R. bruguieri (Hanley)	161	410	105	56	31	520	345	44	10	3	1685
	Paphia (*Neotapes*) *undulata* (Born)	0	0	0	12	1	3	1	0	2	4	23
	Saxidomus purpurata (Sowerby)	0	0	2	0	0	0	0	0	0	0	2
	Phacosoma japonicus (Reeve)	2	1	0	3	2	2	0	0	1	0	11
	Cyclosunetta concinna (Dunker)	1	3	2	0	0	1	0	5	0	0	12
Corbulidae	*Anisocorbula venusta* (Gould)	0	3	3	0	2	2	0	9	5	12	36
	Solidicorbula erythroden (Lamarck)	1	0	0	0	2	0	0	0	0	0	3
	Totals	890	1269	537	271	250	789	607	822	696	528	6,657

* Exotic or non-native species in Japan

3.2 Comparison of frequency and distribution

Osaka Bay has the highest species diversity (105) but lower Simpson's Index (7.7) which is also a reflective of a lower frequency of beach shells. Ise Bay has species diversity of 81 with higher Simpson's Index (10.3) which indicates higher frequency of beach shells (Tables 5a-b). Furthermore, each locality in Ise Bay contained 1,046 individuals on average (SD=590) whereas, each locality in Osaka Bay has 666 individuals on average (SD=302).

3.3 Alien or non-native species

Alien species recognized to be established in Japan such as, *Crepidula onyx* (Sowerby), *Pomacea canaliculata* (Lamarck), and *Xenostrobus securis* (Lamarck) were found mostly fresh dead in both bays. Other three alien species of Ise Bay such as, *Meretrix petechialis* (Lamarck), *Corbicula fluminea* (Müller), and *Perna viridis* (Linnaeus), have also obtained as fresh dead shells. Both bays are adjacent to urban areas with relatively high risk to invasion of native species due to its numerous commercial trade ships on the coastal areas. Results of this investigation show that Ise Bay has more number of alien species than that of Osaka Bay, but their frequency in both bays are only from 1-3 individuals except for *C. onyx* (Sowerby), which was the eighth and seventh most abundant species in Ise and Osaka Bays respectively. However, this study requires more extensive research to catalogue the existence of alien species in Ise and Osaka bays.

3.4 Molluscan assemblages in the sand beaches of Ise Bay.

3.4.1 *Scapharca-Ruditapes-Mactra-Crassostrea* assemblage

This assemblage is characterized by dominant occurrence of *Scapharca inaequivalvis* (bruguière), *S. sativa* (Bernard), *Ruditapes philippinarum* (Adams and Reeve), *Mactra* (*Mactra*) *veneriformis* Reeve and *Crassostrea gigas* (Thunberg) recognized in Sambashi area at Locs. 1, 2, 3 (Fig. 15a). Numerous old dead specimens of this assemblage were obtained on 2-1 mm sand beach (Fig. 3a-b) in the upper intertidal zone of this area in association with *Hima festiva* (Sowerby and Powys), and *Thais* (*Reishia*) *clavigera* (Küster), corbiculids, psammobids, and solenids. Batillirids species such as, *Batillaria cumingii* (Crosse) were found in the eroding groins constructed perpendicular to the shore made up of rocks. However, fresh dead shells of mactrids, venerids, and mytillids were gathered in the lower and middle intertidal zones. Abundant occurrence of alien species such as, *C. onyx* Sowerby and few fresh dead shells of *Corbicula fluminea* (Müller) were also obtained.

3.4.2 *Scapharca-Mactra-Crepidula-Musculista* assemblage

This assemblage occurs in the coarse to fine sand of Chiyozaki beach (Fig. 4a-b) *Scapharca inaequivalvis* (Bruguière) is the leading species with sporadic occurrence of *Mactra* (*Mactra*) *veniformis* (Reeve), *Crepidula onyx* Sowerby, *Musculista senhausia* (Benson) and *Musculista japonicus* (Dunker). *Hima festiva* (Sowerby and Powys), *Mytilus trossulus* Gould, *Mactra* (*Mactra*) *chinensis* Philippi, and venerids species such as, *Ruditapes bruguieri* (Hanley) *Paphia undulata* (Born) were obtained from the middle

to lower intertidal zone(Loc. 4 and Fig. 15b) . Almost all specimens are fresh dead shells including an alien species of *Perna viridis* (Linnaeus).

3.4.3 *Scapharca-Mactra-Ruditapes-Crepidula* assemblage

In Tsuzumigaura area (Locs. 5, 6, 7 and Fig. 15c) arcids and mactrids were the most abundantly encountered species in the coarse to fine sand beach (Fig. 5a-b). *Scapharca inaequivalvis* (Bruguière) and *Mactra* (*Mactra*) *veneriformis* Reeve with other leading species, *Scapharca sativa* (Bernard), *Ruditapes philippinarum* (Adams and Reeve) and *Crepidula onyx* Sowerby, *Phacosoma japonicus* (Reeve) were mostly collected at upper to middle intertidal zones. Whereas fresh dead shells of *Mytillus trossulus* Gould, *Solen grandis* Dunker, and *Anomia chinensis* Philippi, were collected in the lower intertidal zone including *Corbicula fluminea* (Müller).

3.4.4 *Mactra-Scapharca-Donax-Ruditapes* assemblage

This assemblage was recognized at Gotemba beach (Locs. 8, 9, 10 and Fig. 15d), *Mactra* (*Mactra*) *veneriformis* Reeve, *Scapharca inaequivalvis* (Bruguière), *Ruditapes philippinarum* (Adams and Reeve) were the predominant species collected from the fine sand grained of the beach (Fig. 6a-b) at upper and middle parts. However, fresh dead shells of *Donax* (*Chion*) *semigranosus* (Dunker), in association with *Solen grandis* Dunker were collected at locality 10 or lower intertidal area. A specimen of *Tegillarca granosa* (Linnaeus) and *Babylonia japonica* (Reeve) were also recorded. These species were considered extinct and endangered species respectively of the Japanese marine water.

3.4.5 *Ruditapes-crassostrea-Mactra-Batillaria* assemblage

In Gonushi beach (Locs. 11, 12, 13 and Fig. 15e) the most abundant genera are *Ruditapes-Crassostrea-Mactra*. However, *Ruditapes* is represented mainly by fresh dead young juveniles shells collected from the fine to very fine sand of the beach (Fig. 7a-b), except for the batilliriids where large concentration occurs at eroding groins constructed perpendicular to the shore which extend out into the water. Erosion of landfill areas was observed. Other dominant species found near the shore are *Nutallia japonica* (Jay), *Hima festiva* ((Sowerby and Powys), *Mytilus trossulus* Gould, *Solen grandis* Dunker. Psammobiids and mytilids were mostly found attached to torn out fishing nets. Live specimen of non-native gastropod, *Pomacea canaliculata* (Lamarck) was collected and fresh dead specimens of *Meretrix petechialis* (Lamarck) and old shell of *Xenostrobus secures* (Lamarck). The presence of live *Pomacea canaliculata* is probably supported by large area of rice field in adjacent area of the beach.

3.5 Molluscan assemblages in the sand beaches of Osaka Bay

3.5.1 *Ruditapes-Scapharca-Mactra-Crepidula* assemblage

This assemblage is predominantly composed of *Ruditapes bruguieri* (Hanley), *Scapharca inaequivalvis* (Bruguière), *Mactra* (*Mactra*) *chinensis* Philippi, and *Crepidula onyx* Sowerby in association with *Striarca symmetrica* (Reeve), *Mytilus trossulus* Gould, *Chlorostoma turbinatum* A. Adams, and *Didimacar tenebrica* (Reeve) collected in Nishikinohama area (Locs. 1, 2, 3, 4 and Fig. 16a). The beach materials are mixture of

very coarse sand, fragmental shells and numerous decaying seaweeds (Fig. 8a-b). Old and small shells of arcids were mostly collected at the upper area with *Chlorostoma turbinatum* A. Adams, which are found fresh dead specimen. Among non-native species, *C. onyx* Sowerby is the most established with few occurrence of *Xenostrobus securis* (Lamarck).

3.5.2 *Ruditapes- Didimacar-Crepidula-Striarca* assemblage

This assemblage was identified in Tarui beach (Locs. 5, 6, 7 and Fig. 16b), *Ruditapes bruguieri* (Hanley) and *R. philippinarum* (Adams and Reeve) are widely distributed in association with *Didimacar tenebrica* (Reeve), *Striarca symmetrica* (Reeve), and *Crepidula onyx* Sowerby, species collected at the coarse sand with mixture of wood pieces, fragmented shells and seaweeds nearshore (Fig. 9a-b). Specimens of alien species such as *C. onyx* Sowerby, were numerously found which accounted for the third abundant species and few occurrences of small shells of *Pomacea canaliculata* (Lamarck). *P. canaliculata* is known as rice pest but there are no rice field and other vegetation in the surrounding area.

3.5.3 *Striarca-Didimacar-Nipponarca-Cardita* assemblage

Hokotsukuri beach (Locs. 8, 9, 10 and Fig. 16c) material is mainly made up of biogenically derived sediments. The most abundant occurring species were small arcids and carditids such as *Striarca symmetrica* (Reeve), *Didimacar tenebrica* (Reeve), *Nipponarca bistrigata* (Dunker), and *Cardita leana* Dunker, mixed with the very coarse sand to granule, fragmented shells, wood, dried seaweeds and animal skeleton materials of the sea shore (Fig. 10a-b). Very small shells of gastropods such *Proterato* (*Sulcerato*)

callosa (Adams and Reeve), *Mitrella bicinta* Gould, and *Angiola zonata* (Gould) were also found at the upper area of the shore. Both shells of bivalves and gastropods do not show sign of production because most of them were old dead shell specimens. However, *Crepidula onyx* Sowerby is the most established gastropod species.

3.6 Systematic notes on some important species

Phylum Mollusca

Class Gastropoda

Family Batillariidae Thiele

Genus *Batillaria* Benson

Batillaria cumingii (Crosse, 1862)

Plate 1, Figs 13-15

Occurrences: Ise Bay (Locs. 1, 10-13)

Japanese name: Hoso-umi-nina

Description: Shell is turreted, with many whorls and alternating white to light brown spiral ribs.

Shell length: 3 cm.

Habitat: offshore tidal flats, in mud among rocks.

Distribution: Sakhalin and southwards, Japan Sea, Korea, China, Primoriye region (Japan Sea coast of Russia).

Family Calyptraeidae Lamarck

Genus *Crepidula* Lamarck

Crepidula onyx Sowerby, 1824

Plate 1, Figs. 23 a-b

Occurrences: Ise Bay, Locs. 1-2, 6-8, 11; Osaka Bay (Locs. 1-10).

Synonym: *C. cerithicola* C.B. Adams; *C. lirata* Reeve; *C. fornicata* Habe and Maze

Japanese name: Shima-meno-funegai

Description: Oval-shaped shell, surface is smooth with brownish irregular stripes. Periostracum is porcellaneous white.

Shell length: 3.5 cm.

Habitat: intertidal to 20 m. on abalones, *Rapana, Pecten etc.*

Distribution: Fukushima Prefecture (northeastern Honshu), Izu islands, Tokyo Bay, Seto Inland Sea; Kyushu (Ariake Inland Sea) Japan Sea (Shimane Prefecture).

Note: introduced from north America into central Tokyo Bay and spread from 1968 onwards (Ekawa, 1985). It is usually confused with *C. fornicata*, Habe and Maze (1970) reported *C. fornicata* introduced into Tokyo Bay, Japan, in 1968. In fact it was *C. onyx* which subsequently has extensively spread along the southern coast of Japan (Huang *et al.* 1983).

Family Nassariidae Iredale

Subfamily Nassariininae Iredale

Genus *Hima* Leach in Gray

Hima festiva Powis Sowerby and Powys, 1835

Plate 1, Figs. 5-7

Occurrences: Ise Bay (Locs. 1-4, 6-11, 13); Osaka Bay (Locs. 1-3, 5, 6, 8-10)

Synonym: *Reticunassa festiva* Powys in Okutani, 2000; *Nassa nodata* Hinds *Lirata* Dunker; *Nassarius* (*Hinia*) *prefestivus* Macneil.

Japanese name: Ara-mushiro

Description: Axial ribs white intersected by broad dark spiral grooves creating nodules. Outer lip thickened with denticles.

Shell length: 1.5 cm.

Habitat: intertidal in bays, coarse sand and stones.

Distribution: southern Hokkaido and southwards, Japan Sea (Oga Peninsula); Korea, China, Philippines

Family Ampullariidae

Genus *Pomacea* Perry

Pomacea canaliculata (Lamarck, 1822)

Plate 1 , Figs. 27-28

Occurrences: Ise Bay (Loc. 12 and 13); Osaka Bay (Loc. 9).

Synonym: *Ampullaria canaliculata* Lamarck

Japanese name: Sukumiringo-gai

Description: Globular shell and shell color is brownish and greenish, with spiral banding patterns around the whorls.

Shell length: 3.5 cm

Habitat: tidal flats, mud.

Distribution: The snails are distributed in southern Japan, and northern distribution is limited by the low temperature in winter.

Note: originated in south America and widely established to southeast asia, Indonesia, south Korea and Hawaii. Introduced from Taiwan into Nagasaki and Wakayama Prefectures for food in 1981, and it was specified as harmful species in 1984. (Yusa *et al.*, 1999)

Class Bivalvia

Order Arcoida Stoliczka

Superfamily Arcoidea Lamarck

Family Arcidae Lamarck

Genus *Arca* Linnaeus

Arca boucardi Jousseaume, 1894

Plate 5, Fig. 16

Occurrences: Osaka Bay (Locs. 1-10)

Synonym: *A. kobeltiana* Pilsbry; *A. rectangularis* Tokunaga; *A. Miyatensis* Oyama; *A. miuraensis* Noda

Japanese name: Koberuto-fune-gai

Description: Shell quadrate, thick, solid and well-inflated. Ligamental area very wide. Byssal gape at central part of ventral margin. Outer surface ornamented by fine radial riblets and concentric lamellae. Ligamental area broad with many lines in chevron-pattern. Internal surface dark brown. Byssal gape broad. Periostracum dark brown and thick.

Shell length: 4 cm,

Shell height: 1.5 cm

Habitat: intertidal to 50 m. , attached by byssus to rocks and stones.

Distribution: southern Hokkaido and southwards, Japan Sea, East China Sea; Korea, Philippines, Yellow Sea, south China Sea, China.

Genus *Nipponarca* Habe

Nipponarca bistrigata Dunker, 1866

Plate 5, Fig. 42

Occurrences: Osaka Bay (Locs. 1-10)

Synonym: *Arca obtuse duplicostata* Kira; *Hawaiarca miikensis* Noda

Japanese name: Hime-egai

Description: Shell small, antero-posteriorly elongated trapezoidal, thick and solid. Outer surface ornamented by about 28 bifurcated, strong, radial ribs with irregular nodules.

Shell length: 2.9 cm.

Shell height: 1.3 cm

Habitat: intertidal to 50 m. , sandy and mud gravel.

Distribution: Boso Peninsula and southwards, East China Sea; South China Sea, Yellow Sea, Bo-hai to western Pacific.

Subfamily Anadarinae Reinhart

Genus *Scapharca* Gray

Scapharca inaequivalvis (Bruguière, 1789)

Plate 2 and 5, Figs. 28 and 44

Occurrences: Ise Bay (Locs. 1-13); Osaka Bay (Locs. 1-5)

Synonym: *Arca refusens* Reeve; *A. disparilis* Reeve; *A. Hispida* Philippi; *S. penangena* Jousseaume.

Japanese name: Kuichigai-sarubo-gai

Description: Shell well-inflated, thick and solid. Left valve larger than right. Ribs of right valve with nodules but ribs of left valve smooth.

Shell length: 6 cm.

Shell height: 5.4 cm.

Habitat: subtidal to 20 m. , sand and mud.

Distribution: Boso Peninsula and southwards; East China Sea; South China Sea, Philippines, Hainan (China), Indo- Pacific.

Scapharca satowi Dunker, 1882

Plate 30, Fig. 29

Occurrences: Ise Bay (Loc. 1, 3-4, 7-8, 10)

Synonym: *Arca nipponensis* Pilsbry

Japanese name: Sato-gai; Maru-sarubo

Description: Shell well-inflated, ligamental area wide. Outer surface ornamented by about 38 nearly smooth ribs.

Shell length: 6.5 cm.

Shell height: 5.4 cm.

Habitat: subtidal to 20 m. , sand and mud.

Distribution: northeastern Honshu (Iwate Prefecture) and southwards, Japan Sea (Noto Peninsula), East China Sea; Korea, south China Sea.

Scapharca sativa Bernard *et al.*, 1993

Plate 2 and 5, Figs. 27 and 43

Occurrences: Ise Bay (Locs. 1-13; Osaka Bay (Locs. 1-4, 6-10)

Synonym: *Arca subcrenata* Lischke; *S. kagoshimensis* Tokunaga and *S. subcrenata* in Okutani, 2000.

Japanese name: Sarubo-gai

Description: Shell quadrate, well-inflated, thick and solid. Outer surface ornamented by about 32 ribs.

Shell length: 5 cm.

Shell height: 3.6 cm.

Habitat: intertidal to 20 m. , sandy mud.

Distribution: northeastern Honshu (Otsuchi Bay, Iwate Prefecture) and southwards, Seto Inland Sea, Japan Sea (northern Niigata Prefecture), western Kyushu (Ariake Inland Sea), East China Sea; Yellow Sea, south China Sea, Bo-hai, China, western Pacific.

Genus *Tegillarca* Iredale

Tegillarca granosa Linnaeus, 1758

Plate 2 and 5, Figs. 21 and 5

Occurrences: Ise Bay (Loc. 1); Osaka Bay (Locs. 1, 5-7)

Synonym: *Arca aculeate* Bruguière; *A. corbicula* Gmelin; *A. zanzibarensis* Nyst; *A. oblonga* Philippi; *Anadara bisenensis* Schrenck and Reinhart; *Tegillarca granosa bessalis* Iredale; *T. obesa* Kotaka; *Anadara granosa kamakuraensis* Noda.

Japanese name: Hagai

Description: Shell ovate, well inflated, thick and solid. Outer surfaceornamented by about 20 ribs with distantly spaced nodules.

Shell length: 4.3 cm.

Shell height: 2.6 cm.

Habitat: intertidal to 10 m., mud.

Distribution: Mikawa Bay (Aichi Prefecture), Ise Bay, Seto Inland Sea, southern Shikoku (Urado Bay), western Kyushu (Omura Bay; Ariake Inland Sea); southeast Asia, Indo western-Pacific.

Family Noetiidae Stewart

Subfamily Striarciinae Macneil

Genus *Striarca* Conrad

Striarca symmetrica Reeve, 1844

Plate 5, Fig. 12

Occurrences: Osaka Bay (Locs. 1-13)

Synonym: *Arcopsis symmetrica* Reeve in Okutani, 2000; *S. Oyami* Reeve,

Japanese name: Mimi-egai

Description: Shell small, antero-posteriorly elongated quadrate, well inflated. Posterior margin obliquely truncated. Posterior ventral corner pointed. Ligamental area very small.

Shell length: 12 mm

Shell height: 7 mm

Habitat: intertidal to 10 m., attached by byssus to rocks and stones.

Distribution: northeastern Honshu (Iwate Prefecture) and southwards, Japan Sea (Sado island), East China Sea; Yellow Sea, Bo-hai Sea, South China Sea, Hongkong, Philippines, Tropical Indo-Pacific.

Subfamily Noetiinae Stewart

Genus *Didimacar* Iredale

Didimacar tenebrica Reeve, 1844

Plate 5, Fig. 8

Occurrences: Osaka Bay (Locs. 1-10)

Synonym: *Arca nigra* Lamy; *A. decussate* Yokohama; *Barbatia koshibensis* Hatai and Nishiyama.

Japanese name: Maru-mimi-egai

Description: Shell small, elongated, trapezoidal, well inflated. Outer surface ornamented by fine riblets. Posterior dorsal margin gently arched.

Shell length: 14 mm

Shell height: 8 mm

Habitat: intertidal to 20 m. , coarse sand and stones.

Distribution: Boso Peninsula and southwards, Japan Sea (northern Yamaguchi Prefecture) East China Sea; Philippines, South China Sea, Yellow Sea.

Family Mytilidae Rafinesque

Subfamily Mytilinae Rafinesque

Genus *Mytilus* Linnaeus

Mytilus trossulus Gould, 1850

Plate 3 and 5, Figs. 6 and 47

Occurrences: Ise Bay (Locs. 1-13), Osaka Bay (Locs. 1-10)

Japanese name: Kita-no-murasaki-igai

Description: shell elongate and equivalve with beak anteriorly situated and not strongly scultured. Periostracum is black and glossy.

Shell length: 4 cm.

Shell height: 2.5 cm

Habitat: hard bottom in intertidal zone to 20 m. deep.

Distribution: northeastern Honshu and northwards, Hokkaido to Okhotsk Sea (Okutani, 2000), northwestern USA.

Genus *Perna* Retzius

Perna viridis Linnaeus, 1758

Plate 3, Fig. 5

Occurrences: Ise Bay (Loc. 4)

Synonym: *Mytilus smaragdimus* Gmelin; *M. opalus* Lamarck

Japanese name: Midori-igai

Description: Shell thin and green in color. Anterior abductor scar lacking but posterior abductor scras separated into two.

Shell length: 4 cm.

Shell height: 2.5 cm

Habitat: intertidal to 20 m., attached by byssus to rocks and stones

Distribution: Tokyo Bay (introduced) East China Sea; Taiwan; Hainan; Hongkong; South China Sea; Philippines; Indonesia.

Note: Settled in Japan in 1980 from southeast Asia. Tokyo Bay to southwestern Japan (Okutani, 2000).

Genus *Xenostrobus*

Xenostrobus securis (Lamarck, 1819)

Plate 3, Fig. 3

Occurrences: Ise Bay (Loc. 11); Osaka Bay (Loc. 3 and 4).

Synonym: *Limnoperna fortunei* Habe

Japanese name: Kouroesokawahibarigai

Description: Shell elongated and weakly inflated. Ventral margin weakly concave and periostracum is dark purple and smooth.

Shell length: 30 mm

Shell height: 9 mm

Habitat: hard and soft bottoms in intertidal zone to 10 m.

Distribution: Tokyo Bay to southwestern Japan.

Note: Settled in Japan in 1970's from Australia or New Zealand. It was confirmed in Tokyo Bay to Kochi Prefecture and Japan Sea side of Yamaguchi Prefecture in 1980's. After year 2000 distribution has expanded in various parts of Kyushu, Kanto region except Niigata Prefecture and north of Ibaraki Prefecture. (MOE Japan)

Subfamily Musculinae Iredale

Genus *Musculista* Yamamoto and Habe

Musculista senhausia Benson, 1842

Plates 3 and 5, Figs. 2 and 22

Occurrences: Ise Bay (Locs. 2, 3, 5, 8-10, 13); Osaka Bay (Locs. 8-5)

Synonym: *Modiola bellardiana* Tapparone-Canefri; *Brachidontes aquarius* Grabau et King.

Japanese name: Hototogisu

Description: Shell thin compressed, periostracum greenish brown, weak ribs in anterior end and smooth. Radial stripes in posterior part.

Shell length: 20 mm

Shell height: 6 mm

Habitat: intertidal to 20 m., in eelgrass.

Distribution: all areas from Primorye region (Japan Sea coast of Russia) to south China Sea.

Superfamily Ostreoidea Wilkes

Family Osteridae Wilkes

Subfamily Crassostreinae Torigoe

Genus *Crassostrea* Sacco

Crassostrea gigas (Thunberg, 1793)

Plates 3 and 5, Figs. 22 and 48

Occurrences: Ise Bay (Locs. 1-4, 6, 8, 10-13); Osaka Bay (Locs. 1-8, 10)

Synonym: *Ostrea laperousi* Schrenck, *O. talienwhanensis* Crosse, *O. plicata* Chemnitz, *O. shikame* Amemiya, *O. elongate* Amemiya.

Japanese name: Magaki

Description: shell is white to purplish brown and irregulary folded.

Shell length: 13 cm.

Shell height: 6 cm.

Habitat: intertidal to 5 m., in bays, left valve cemented to rocks and stones.

Distribution: Kuril islands, Japan Sea, Russia, Sakhalin, Korea, Yellow Sea, Bo-hai, China, southeast Asia.

Superfamily Carditoidea Fleming

Family Carditidae Fleming

Subfamily Carditinae Fleming

Genus *Cardita* Bruguière

Cardita leana Dunker, 1860

Plate 5, Fig. 29

Occurrences: Osaka Bay (Locs. 1-5, 7-10)

Synonym: *C. cumingiana* Dunker.

Japanese name: Tomayagai

Description: Shell is small and thick, outer surface is ornamented with 18 ribs with nodules.

Shell length: 3 cm.

Shell height: 1.5 cm.

Habitat: intertidal to 20 m., attached by byssus to stones and gravel.

Distribution: Mutsu Bay (Aomori prefecture and southwards, Tsugaru peninsula, Japan Sea, East China Sea, Korea, Taiwan, south China Sea.

Superfamily Mactroidea Lamarck

Family Mactridae Lamarck

Subfamily Mactrinae Lamarck

Genus *Mactra* Linnaeus

Subgenus *Mactra s. str.*

Mactra (*Mactra*) *chinensis* Philippi, 1846

Plates 3 and 5, Figs. 9 and 35

Occurrences: Ise Bay (Loc. 2-13), Osaka Bay (Locs. 1-4, 6-8)

Synonym: *M. sulcataria* Deshayes, *M. carneopicta* Pilsbry.

Japanese name: Bakagai

Description: shell is subtrigonal, thin, glossy and commarginal ribs with brown radial streaks.

Shell length: 8 cm.

Shell height: 6 cm.

Habitat: intertidal to 20 m., sand and mud

Distribution: Otsuchi Bay, Hokkaido, Okhotsk Sea, Kuril islands, Japan Sea, East China Sea, Russia, Sakhalin, Korea, China, Bo-hai, Yellow Sea, Taiwan.

Mactra (*Mactra*) *veneriformis* Reeve, 1854

Plate 2 and 5, Figs. 19-20

Occurrences: Ise Bay (Loc. 1-13), Osaka Bay (Locs. 1-3)

Synonym: *M. sulcataria* Deshayes, *M. carneopicta* Pilsbry.

Japanese name: Shio-fuki

Description: shell is subtrigonal, thin and ornamented with low commarginal ribs.

Shell length: 4.5 cm

Shell height: 4 cm.

Habitat: intertidal to 20 m., sand and mud

Distribution: northeastern Honshu (Miyagi Prefecture) and southwards, Seto Inland Sea, Japan Sea, East China Sea, southern Primoriye region (Japan Sea coast of Russia), Korea, Yellow Sea, China, south China Sea, Hainan.

Family Donacidae Fleming

Genus *Donax* Linnaeus

Subgenus *Chion* Scopoli

Donax (*Chion*) *semigranosus* Dunker, 1877

Plate 2, Fig. 7

Occurrences: Ise Bay (Loc. 9-10).

Synonym: *D. proximus* Bertin, *D. introradiatus* Yokoyama

Japanese name: Fuji-no-hana-gai

Description: shell is small, subtrigonal and thick. Outer surface is ornamented with radial riblets.

Shell length: 1.5 cm.

Shell height: 1 cm.

Habitat: sand bottom of upper intertidal zone.

Distribution: Boso Peninsula and southwards, japan Sea (Oga Peninsula), Taiwan, Hainan, Hongkong, southern China, Indian Ocean, western Pacific.

Family Psammobiidae Fleming

Subfamily Psammobiinae Fleming

Genus *Nuttallia* Dall

Nuttallia japonica (Reeve, 1857)

Plate 2, Fig. 16

Occurrences: Ise Bay (Locs. 5-13).

Synonym: *Soletellina olivacea* Jay, *Psammobia olivacea* Jay.

Japanese name: Iso-shijimi

Description: shell is compressed smooth and covered with thick periostracum.

Shell length: 4 cm.

Shell height: 3 cm.

Habitat: intertidal to 10 m., sandy mud

Distribution: southern Hokkaido and southwards, Tsugaru Peninsula, southern Kuril islands, Sakhalin, Korea, China, Yellow Sea, Bo-hai.

Family Solenidae lamarck

Genus *Solen* Linnaeus

Solen grandis Dunker, 1861

Plate 3, Fig. 23

Occurrences: Ise Bay (Locs. 3, 5-10, 12, 13)

Synonym: *S. beckii* Grabau and King, *Psammobia olivacea* Jay.

Japanese name: O-mate

Description: shell large and cylindrically straight, outer sutface is covered with thick periostracum.

Shell length: 15 cm.

Shell height: 3.3 cm

Habitat: intertidal to 75 m., sand.

Distribution: Boso Peninsula and southwards, Japan Sea (Oga Peninsula), east China Sea, Korea, China, Yellow Sea, Bo-hai, Hainan, south China Sea.

Family Corbiculidae Lamarck

Subfamily Corbulinae Lamarck

Genus *Corbicula* Megerle von Mühlfeld

Corbicula fluminea (Müller, 1774)

Plate 2, Fig. 18a-b

Occurrences: Ise Bay (Locs. 2, 5, 6, 7, 8 and10).

Synonym: *Corbicula leana* (Prime), *Corbicula fluminalis* (Muller), *Corbicula manilensis* (Philippi)

Japanese name: Taiwan-shijimi

Description: Shell is yellowish brown with concentric evenly space ridges on the surface.

Shell length: 4 cm.

Shell height: 3.5 cm.

Habitat: lakes and streams with silt, mud, sand and gravel substrate

Distribution: native to southeastern China, Korea, southeastern Russia and the Ussuri Basin (Lachner *et al.* 1970).

Note: Collected in Japan in 1985 and confirmed in the waterway of Okayama prefecture in 1987 and established in various parts of Kanto, Kyushu and Shikoku Prefecture (MOE Japan).

Superfamily Veneroidea Rafinesque

Family Veneridae Rafinesque

Genus *Meretrix* Lamarck

Meretrix petechialis (Lamarck, 1818)

Plate 3, Fig. 12

Occurrences: Ise Bay (Locs. 11-13)

Japanese name: Shina-hamaguri

Description: shell is triangular with very shallow pallial sinus. Postero-dorsal margin is more convex than *M. lusoria*.

Shell length: 7.5 cm.

Shell height: 6.2 cm.

Habitat: sandy mud bottom in lower intertidal to 20 m.

Distribution: central Honshu (Mie Prefecture), western Kyushu (Ariake inland sea); western Korea to coastal China.

Note: seedlings were introduced into Mie Prefecture in 1969 and Kagawa Prefecture in 1975 and spread into Tokyo Bay from 1997 to 2001 (MOE, Japan).

Genus *Ruditapes* Chiamenti

Ruditapes philippinarum (Adams and Reeve, 1850)

Plate 2, Figs. 26a-c

Occurrences: Ise Bay (Locs. 1-13), Osaka Bay (Locs. 1-10)

Synonym: *Tapes japonica* Deshayes, *T. semidecussata* Reeve, *T. Ducalis* Römer, *T. Defurcata* Quayle.

Japanese name: Asari

Description: shell is oval thin and inflated, outer surface is ornamented with radial riblets and growth lines.

Shell length: 4 cm.

Shell height: 2.5 cm.

Habitat: intertidal to 10 m., coarse sand and stones, mud.

Distribution: Hokkaido and southwards, Japan Sea, east China Sea, Russia, Sakhalin, Korea, south China Sea, Yellow Sea, Bo-hai, Hongkong, coastal China.

Ruditapes bruguiere Hanley, 1845

Plate 2, Figs. 23a-b

Occurrences: Ise Bay (Locs. 1-8, 10-13), Osaka Bay (Locs. 1-10)

Synonym: *Tapes variegata* Hanley, *T. tessellate* Adams and Reeve, *T. punicea* Deshayes, *T. violascens* Deshayes, *T. cinerea* Deshayes.

Japanese name: Hime-asari

Description: shell is small, oval and inflated, outer surface is ornamented with radial riblets and fine growth lines.

Shell length: 3.5 cm.

Shell height: 2.5 cm.

Habitat: intertidal, coarse sand and stones, mud.

Distribution: northeastern Honshu and southwards, Japan Sea, east China Sea, Korea, south China Sea, China, southeastern Asia, Australia, Indo Pacific.

Genus *Paphia* Röding

Subgenus Neotapes Kuroda and Habe

Paphia (*Neotapes*) *undulata* Born, 1778

Plate 2, Figs. 22

Occurrences: Ise Bay (Locs. 1, 2, 4-6, 11-13), Osaka Bay (Locs. 4-7, 9-10)

Synonym: *Venus rimosa* Philippi, *Tapes vernicosa* Reeve, *Paratapes scordalus* Iredale.

Japanese name: Iyo-sudare

Description: shell is thin, shinning and brownish with dark network pattern arranged radially.

Shell length: 4.5 cm.

Shell height: 2.3 cm

Habitat: subtidal to 20 m. , mud in bays.

Distribution: northeastern Honshu (Iwate Prefecture) and southwards, Seto Inland Sea, Japan Sea (Oga Peninsula), east China Sea, Korea, Taiwan, south China Sea, Beibu gulf, Philippines, Australia, Indo Pacific.

Genus *Phacosoma* Jukes-Brown

Phacosoma japonicus (Reeve, 1850)

Plate 2, Fig. 22

Occurrences: Ise Bay (Locs. 2, 3, 5, 6, 8-13), Osaka Bay (Locs. 1, 2, 4-6, 9)

Synonym: *Cytherea tumida* Gray, *Artemis duplicata* Reeve, *A. tenuilamellata* Sowerby, *Dosinia specularis* Römer.

Japanese name: Kagami-gai

Description: shell is circular with regularly spaced commarginal ribs and with deep pallial sinus.

Shell length: 7.5 cm

Shell height: 7.5 cm

Habitat: subtidal to 60 m. , fine sand.

Distribution: southern Hokkaido and southwards, Japan Sea (Tsugaru Peninsula), east China Sea, Korea, Yellow Sea, China (Bo-hai, Hong Kong, Hainan, southern coast).

Genus *Globivenus* Coen

Globivenus toreuma Gould, 1850

Plate 5, Fig. 34

Occurrences: Osaka Bay (Locs. 1, 2)

Synonym: *Venus jukesii* Deshayes, *V. crebrisulca* Sowerby, *V. sculpta* Deshayes, *V. hawaiensis* Dall, Bartsch and Rehder, *V.* (*Ventricolaria*) *toreuma* Gould in Okutani, 2000).

Japanese name: Maru-sudare-gai

Description: shell is subcircular and thick. Outer surface is ornamented with regular spaced nodulous commarginal lamellae with growth lines.

Shell length: 2.5 cm.

Shell height: 2.5 cm

Habitat: subtidal to 200 m. , sand and gravel.

Distribution: Boso Peninsula ans southwards, Japan Sea (southern Niigata Prefecture, east China Sea, south China Sea, Philippines, China (Beibu gilf, Hainan), tropical Pacific.

Genus *Saxidomus* Conrad

Saxidomus purpurata (Sowerby, 1852)

Plate 2, Figs. 22

Occurrences: Ise Bay (Locs. 2, 3, 5, 6, 8-13), Osaka Bay (Locs. 1, 2, 4-6, 9)

Japanese name: Uchi-murasaki

Description: shell is large oval, thick and white to yellowish. Outer surface is ornamented with irregularly spaced growth lines. Inner surface is smooth and purplish.

Shell length: 8 cm

Shell height: 6.5 cm.

Habitat: subtidal to 40 m. , sandy mud and gravel.

Distribution: southern Hokkaido and southwards, Japan Sea, Korea, Yellow Sea, China Bo-hai, coastal China, Indian Ocean.

Genus *Dosinella* Dall

Dosinella corrugata (Reeve, 1850)

Plate 3, Fig. 15

Occurrences: Ise Bay (Loc. 1)

Synonym: *Artemis penicillata* Reeve, *Dosinia trailli* A. Adams, *D, angulosa* Philippi.

Japanese name: Ura-kagami

Description: shell is angulated and truncated posterior margin. Outer surface is plae brown and shiny with concentric riblets.

Shell length: 5 cm.

Shell height: 4.3 cm

Habitat: subtidal to 10 m. , sandy mud.

Distribution: Mutsu Bay, (Aomori Prefecture) and southwards, Seto Inland Sea, Japan Sea (Oga Peninsula), east China Sea, Korea, south China Sea, China.

Plate 1

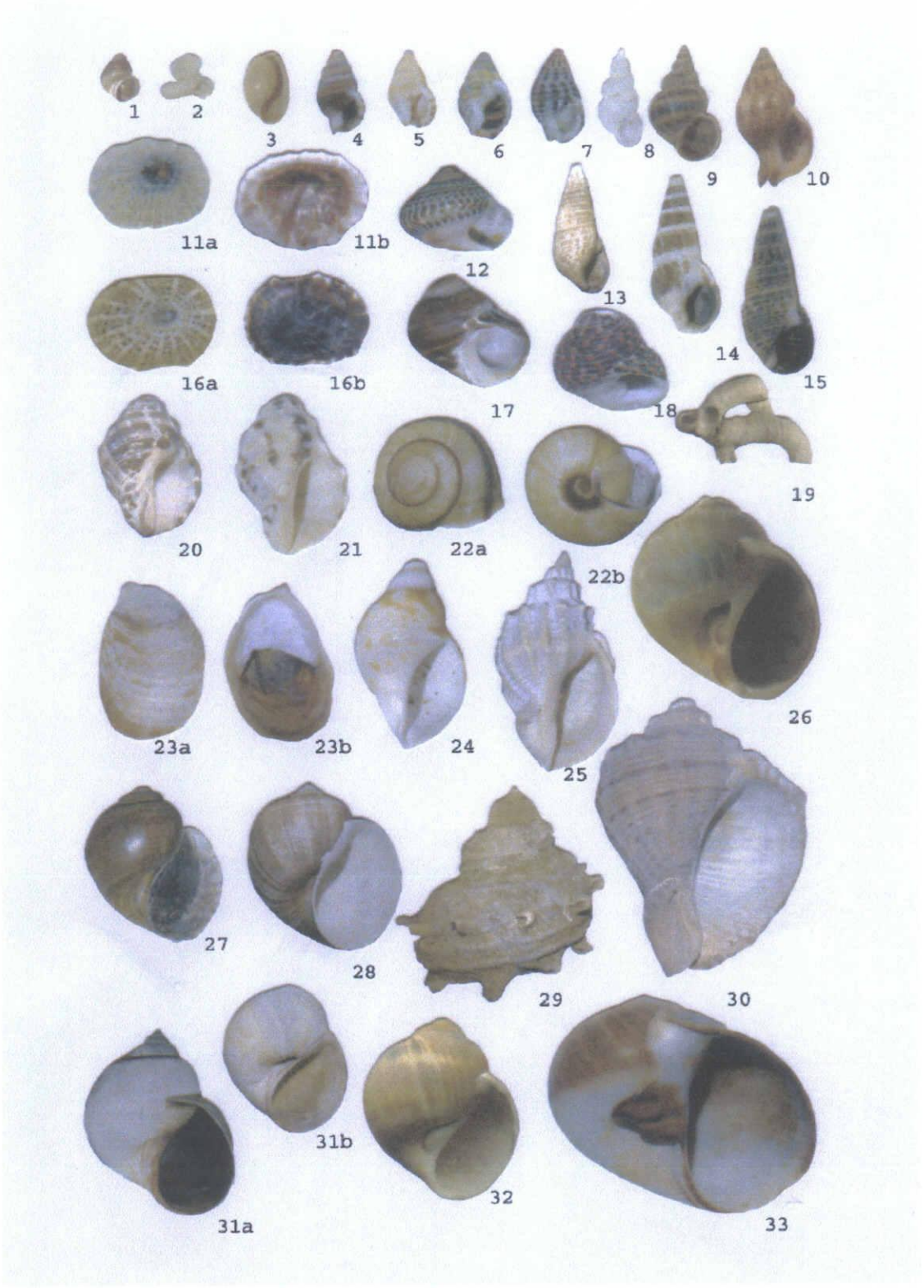

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Plate 2

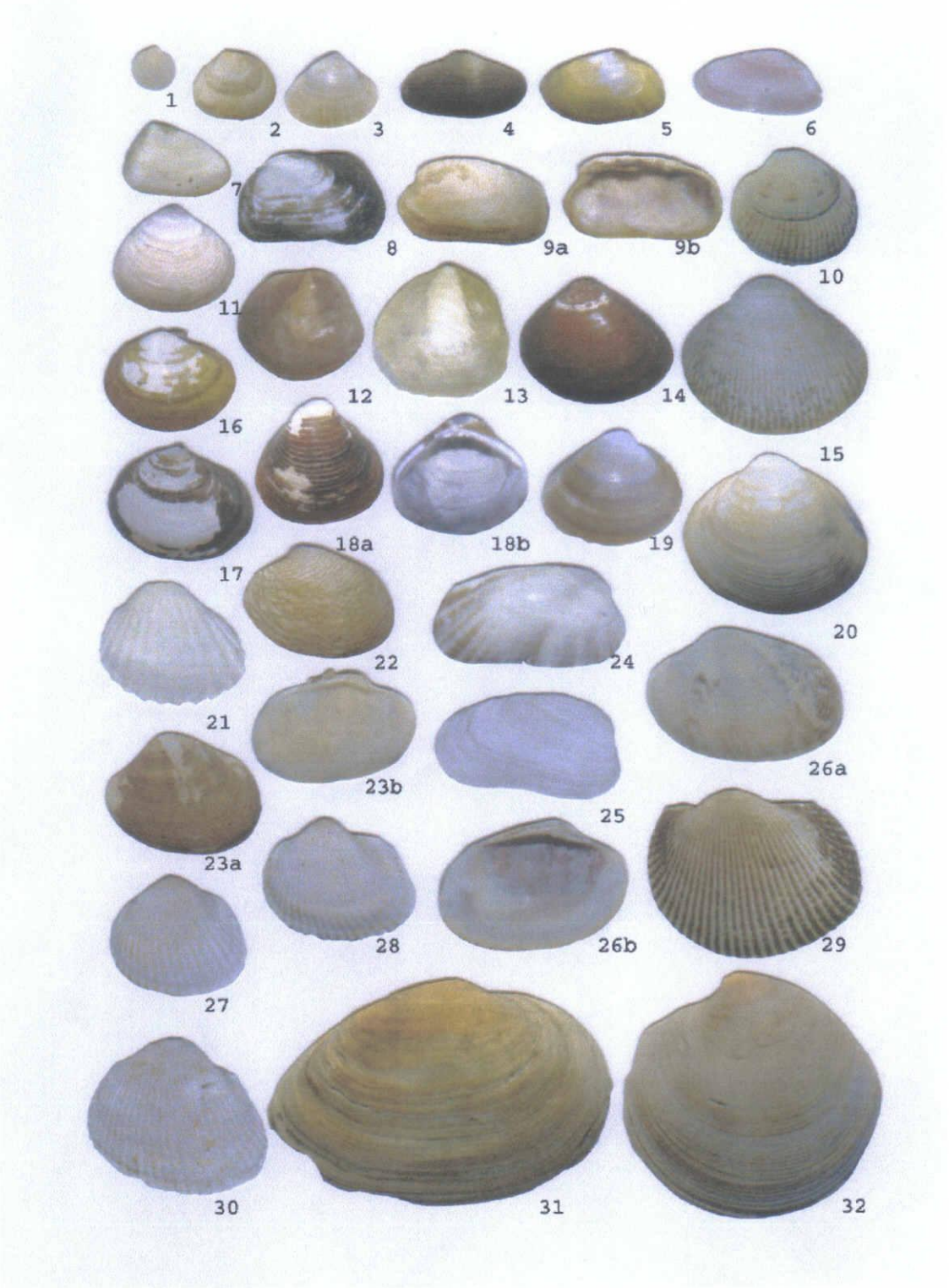
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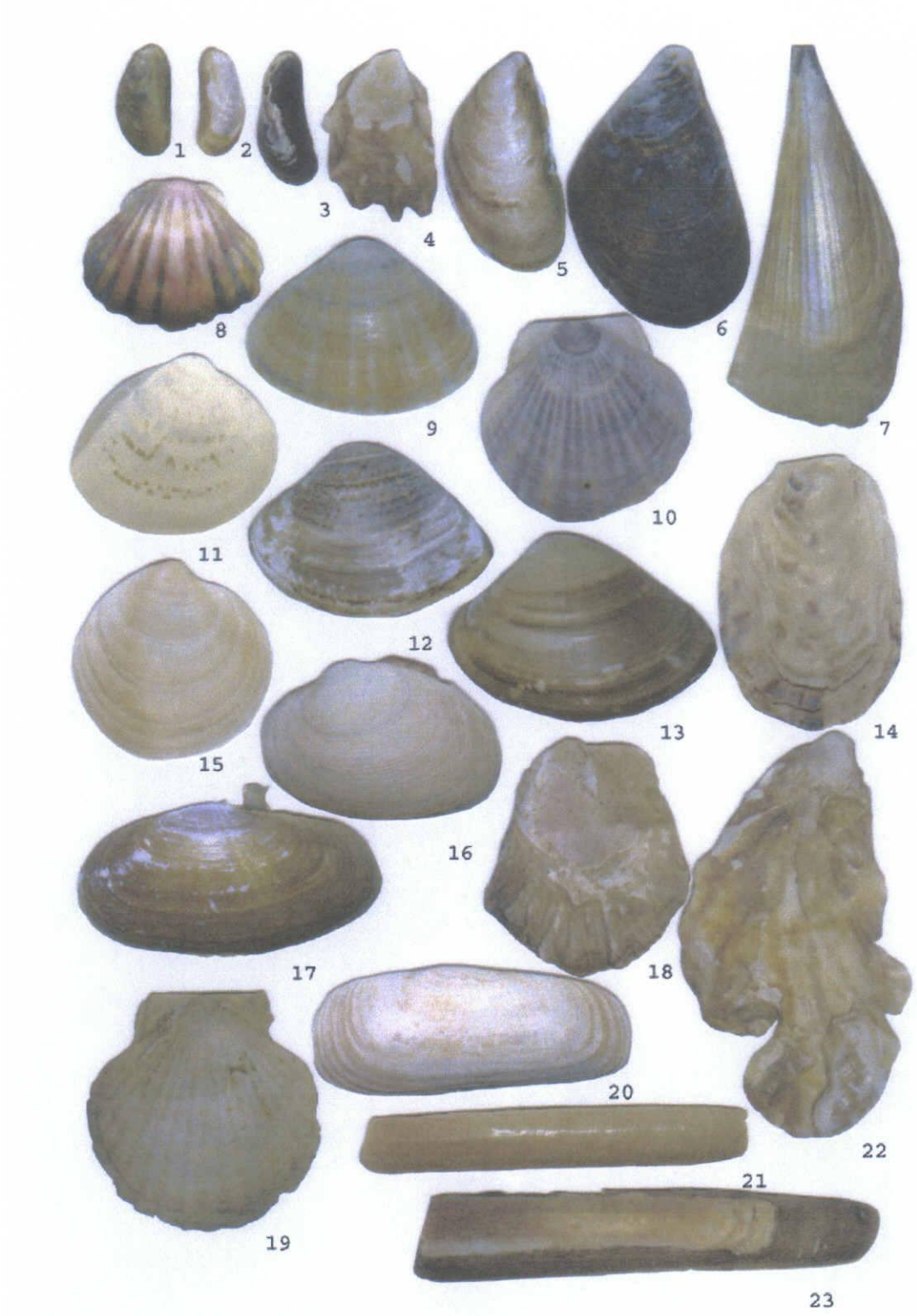
Plate 3



Explanation of Plate 1

1. *Lacuna* (*Haloconcha*) *reflexa* (Pilsbry), Loc.13, x 4
2. *Tenagodus* (*Agathirses*) *cumingii* (Mörch), Loc. 2, x 1
3. *Haloa nigropunctata* (Pease), Loc. 13, x 1
4. *Hima fuscolineata* (E.A Smith), Loc. 2, x 1.2
5-7. *H. festiva* (Sowerby and Powys), Loc. 2, x 1
8. *Epitonium* (*Hirtoscala*) *castum* (A. Adams), Loc. 9, x 1.5
9. *E.* (*Papyriscala*) *clementium* Grateloup, Loc. 9, x 1.5
10. *Siphonalia modificata* (Reeve), Loc. 5, x 1.4
11a-b. *Siphonaria* (*Sacculosiphonaria*) *japonica* (Donovan), Loc. 1, x 1.2
12. *Umbonium* (*Succhium*) *moniliferum* (Lamarck), Loc. 1, x 1
13-14. *Batillaria cumingii* (Crosse), Loc. 2, x 1.3
15. *B. multiformis* (Lischke), Loc. 2, x 1
16a-b. *Siphonalia laciniosa* (Linnaeus), Loc. 1, x 1.4
17. *Littorina* (*Littorina*) *brevicula* (Philippi), Loc. 4, x 1.4
18. *Monodonta labio* form *confusa* Tapparone-Canefri, Loc. 13, x 1
19. *Serpolurbis xenophorus* Habe, Loc. 13, x 1.4
20. *Thais* (*Reishia*) *clavigera* (Küster), Loc. 4, x 1
21. *T.* (*Reishia*) *bronni* (Dunker), Loc. 4, x 1.3
22a-b. *Euhadra senckenbergiana* (Kobelt), Loc. 7, x .75
23a-c. *Crepidula onyx* Sowerby, Loc. 1, x 1
24. *Babylonia japonica* (Reeve), Loc. 10, x 1.6
25. *Cancellaria* (*Sydaphera*) *spengleria* Deshayes, Loc. 8, x .75
26. *Natica spadicea* (Gmelin), Loc. 8, x 1.3
27-28. *Pomacea canaliculata* (Lamarck), Loc. 5, x 1.3
29. *Turbo* (*Batillus*) *cornutus* Lightfoot, Loc. 2, x .8
30. *Rapana venosa* (Valenciennes), Loc. 1, x .4
31a-b. *Euspira fortunei* (Reeve), Loc. 2, x 1
32. *Cryptonatica hirasei* (Pilsbry), Loc. 4, x 1.4
33. *Glossaulax didyma* (Röding), Loc. 1, x 1

Explanation of Plate 2

1. *Pillucina* (*Pillucina*) *pisidium* (Dunker), Loc. 7, x 1
2. *Macoma tokyoensis* Makiyama, Loc. 3, x 1.4
3. *Mactra* (*Mactra*) *nipponica* Kuroda and Habe, Loc. 7, x 1
4. *Psammotaea minor* (Deshayes), Loc. 1, x 1
5. *P. virescens* (Deshayes), Loc. 2, x 1.2
6. *Nitidotellina hokkaidoensis* (Dunker), Loc. 7, x 1
7. *Donax* (*Chion*) *semigranosus* (Dunker), Loc. 7, x 1
8. *Barbatia* (*Savignyarca*) *virescens* (Reeve), Loc. 4, x .75

9a-c. *Trapezium* (*Neotrapezium*) *liratum* (Reeve), Loc. 3, x 1

10. *Protothaca euglypta* (Sowerby), Loc. 4, x 1
11. *Corbicula japonica* Prime, Loc. 2, x 1

12-13. *Anomia cheniensis* Philippi, Loc. 3, x 1

14. *Gomphina* (*Macridiscus*) *veneriformis* (Lamarck), Loc. 8, x .75
15. *Fulvia mutica* (Reeve), Loc. 1, x .50
16. *Nutallia japonica* (Jay), Loc. 2, x .5
17. *N. ezonis* (Kuroda and Habe), Loc. 1, x .5

18a-b. *Corbicula fluminea* (Müller), Loc. 3, x 1

19-20. *Mactra* (*Mactra*) *veniformis* Reeve, Loc. 1, x 1

21. *Tegillarca granosa* (Linnaeus), Loc. 1, x 1
22. *Paphia* (*Neotapes*) *undulata* (Born), Loc. 2, x 1

23a-b. *Ruditapes bruguieri* (Hanley), Loc. 2, x 1

24-25. *Trapezium sublaenvigatum* (Lamarck), Loc. 4, x 1

26a-c. *Ruditapes philippinarum* (Adams and Reeve), Loc. 2, x 1

27. *Scapharca sativa* (Bernard), Loc.1, x .75
28. *S. inaequivalvis* (Bruguière), Loc. 1, x 1
29. *S.broughtonii* (Schrenck), Loc. 1, x 1
30. *S. satowi* (Dunker), Loc. 1, x .5
31. *Mya* (*Arenomya*) *arenaria oonogai* Makiyama, Loc. 1, x .5
32. *Phacosoma japonicus* (Reeve), Loc. 1, x .75

Explanation of Plate 3

1. *Muscullista. japonicus* (Dunker), Loc. 4, x 1
2. *M. senhausia* (Benson), Loc. 2, x 1
3. *Xenostrobus securis* (Lamarck), Loc. 2, x 1
4. *Hyotissa hyotis* (Linnaeus), Loc. 4, x .75
5. *Perna viridis* (Linnaeus), Loc. 13, x 1
6. *Mytilus trossulus* Gould, Loc. 3, x 1
7. *Atrina* (*Servatrina*) *pectinata* (Linnaeus), Loc. 1, x .5
8. *Pecten* (*Notovola*) *excavatus* (Anton), Loc. 4, x 1
9. *Mactra* (*Mactra*) *chinensis* Philippi, Loc. 1, x 1
10. *Mizuhopecten yessoensis* (Jay), Loc. 4, x .3
11. *Meretrix lamarckii* Deshayes, Loc. 2, x .5
12. *M. pectechialis* (Lamarck), Loc. 2, x .5
13. *M. lusoria* (Röding), Loc. 2, x .5
14. *Crassostrea nippona* (Seki), Loc. 13, x .25
15. *Dosinella corrugata* (Reeve), Loc. 4, x .5
16. *Saxidomus purpurata* (Sowerby), Loc. 1, x .75
17. *Soletellina diphos* (Linnaeus), Loc. 1, x .3
18. *Ostrea denselamellosa* Lischke, Loc. 3, x .4
19. *Chlamys* (*Mimachlamys*) *nobilis* (Reeve), Loc. 2, x .4
20. *Solecurtus divaricatus* (Lischke), Loc. 1, x .4
21. *Solen strictus* Gould, Loc. 1, x 1
22. *Crassostrea gigas* (Thunberg), Loc. 4, x .25
23. *Solen grandis* Dunker, Loc. 1, x 1

Plate 4


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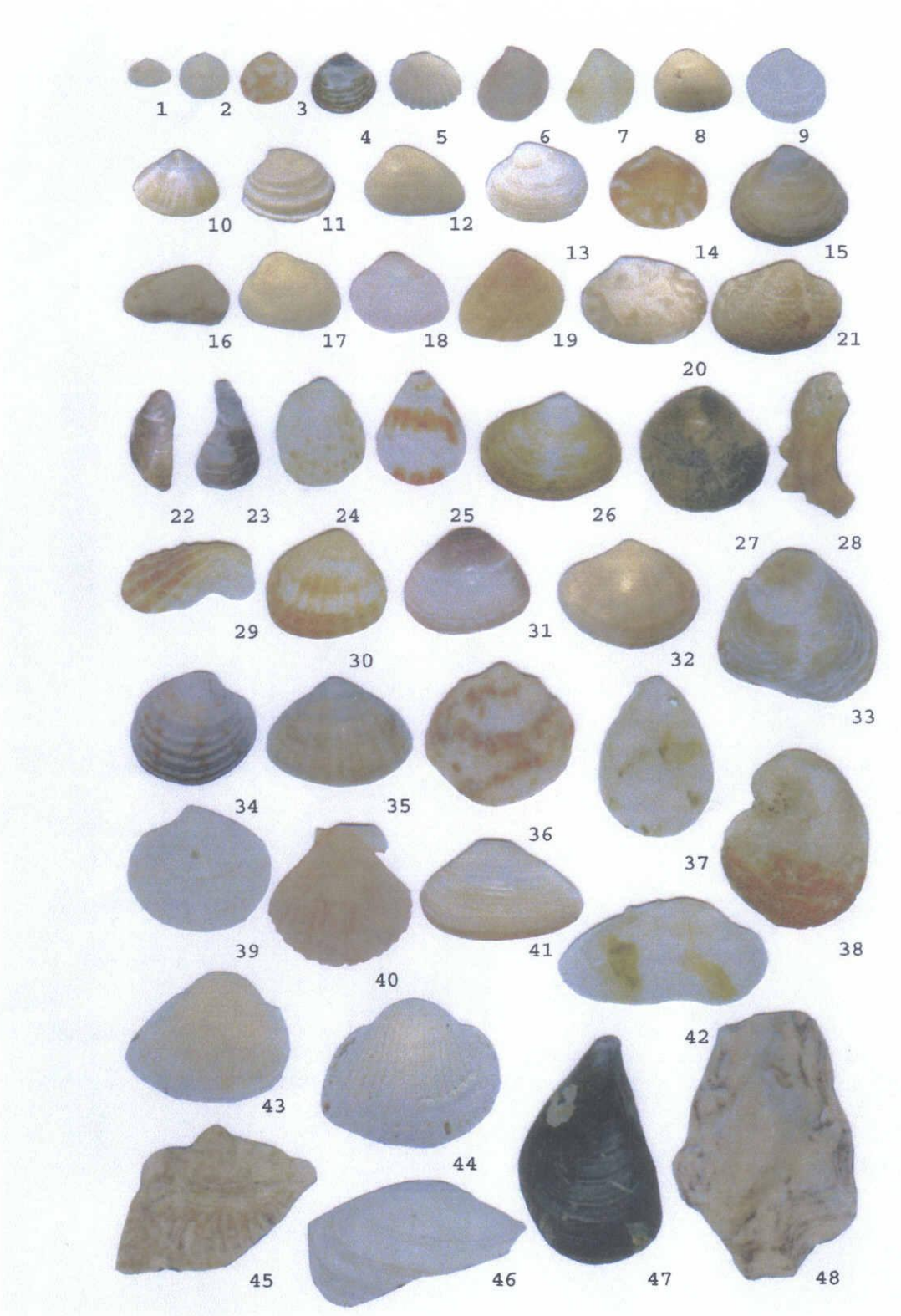
Plate 5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Explanation of Plate 4

1. *Angiola zonata* (Gould), Loc. 7, x 1.4

2. *Odetta tenpei* (Nomura), Loc. 8, x 2.5

3. *Phos laeve* Kuroda and Habe, Loc. 5, x 1.3

4a-b. *Proterato* (*Sulcerato*) *callosa* (Adams and Reeve), Loc. 5, x 1.2

5. *Phos naucrators* Watson, Loc. 5, x 1.3

6. *Gyroscala* (*Pomiscala*) *perplexa* (Pease), Loc. 5, x 1.3

7. *Clathromangelia coffea* (Kuroda), Loc. 5, x 1.5

8. *Triphora tristoma* (Blainville), Loc. 7, x 1.5

9. *Notoseila morishimai* Habe, Loc. 7, x 1.5

10. *Furukawaia fukuiensis* Kuroda & Habe, Loc. 1, x 1.2

11a-b. *Mitrella bicinta* Gould, Loc. 5, x 1.3

12. *Komaitrochus pulcher* Kuroda and Taki

13a-b. *Liotina semiclathratula* (Shrenck), Loc. 6, x 1.8

14 & 16. *Cantharidus japonicus* (A. Adams), Loc. 3, x 1.2

15. *Limneria bulla* (Habe), Loc. 3, x 2.5

17. *Patelloida pygmaea pygmaea* (Dunker) Loc.1, x 1.3

18. *Lottia kogamogai* Sasaki and Okutani, Loc. 3, x 1.4

19a-b. *Amathina tricarinata* (Linnaeus), Loc. 5, x 1.4

20. *Cerithiopsis spongicola* Habe, Loc. 5, x 1.3

21a-b. *Thais* (*Reishia*) *bronni* (Dunker), Loc. 2, x 1

22. *Bittium* (*Stylidium*) *batillarium* (Kuroda and Habe)

23. *Hima fuscolineata* (E.A. Smith), Loc. 2, x 1

24. *Tenagodus* (*Tenagodus*) *cumingii* (Mörch), Loc. 9, x 1

25. *Monotygma eximia* (Lischke), Loc. 5, x 1.3

26. *Orinella puchella* (A. Adams), Loc. 5, x 2.5

27. *Ptycheulimella misella* (Yokoyama), Loc. 5, x 2.5

28. *Vexillum* sp. Loc. 1 x 1.3

29. *Batillaria zonalis* (Bruguière), Loc. 7, x 1.2

30a-b. *Monodonta labio forma confusa* Tapparone-Canefri, Loc. 1, x 1

31a-b. *Tanea pavimentum* (Sowerby), Loc. 6, x 1

32. *Umbonium* (*Succhium*) *moniliferum* (Lamarck), Loc. 9, x 1

33. *Akoya akoya* (Kuroda), Loc. 1 x .8

34. *Diodora mus* (Reeve), Loc. 5, x 1.2

35. *Serpolurbis xenophorus* (Habe), Loc. 5, x 1

36. *Pomacea canaliculata* (Lamarck), Loc. 9, x 1

37a-b. *Nerita* (*Heminerita*) *japonica* (Dunker), Loc. 5, x 1.5

38a-b. *Eurytrochus affinis cognatus* (Pilsbry), Loc. 3, x 1

39. *Ceratostoma inornatum* (Récluz), Loc. 1, x 1

40. *Thais* (*Reishia*) *clavigera* (Küster)

41. *Sigatica bathyraphe* (Pilsbry), Loc. 1, x 1.3

42a-b. *Purpuradusta* (*Purpuradusta*) *gracilis* Gaskoin, Loc. 1, x 1.2

43. *Glossaulax didyma didyma* (Röding), Loc. 4, x 1

44. *Littorina* (*Littorina*) *brevicula* (Philippi), Loc. 4, x 1.3

45. *Trochus stellatus* (Gmelin) Loc. 1, x 1.2

46a-b. *Latirus kandai* (Kuroda), Loc. 6, x 1.2

47. *Horaiclavus* (*Cytharoclavus*) *stenocyma* (Kuroda and Oyama), Loc. 7, x 2.5

48. *Siphonalia modificata* (Reeve), Loc. 1, x 2.5

49. *Thais* (*Reishia*) *clavigera* (Küster), Loc. 2, x 1

50. *Eunaticina papilla* (Gmelin), Loc. 4, x 1.4

51. *Pollia subrubiginosus* (Smith), Loc. 5, x 1. 3

52. *Bedeva brileffi* (Lischke), Loc. 1, x 1.3

53. *Capulus badius* (Dunker), Loc. 5, x 1.3

54a-b. *Rapana venosa* (Valenciennes), Loc. 7, x .4

55. *Fissidentalium* (*Fissidentalium*) *lima* (Kuroda and Habe), Loc. 5, x 1.5

56a-b. *Crepidula onyx Sowerby*, Loc. 9, x 1

57. *Chlorostoma turbinatum* A. Adams, Loc. 1, x 1

58. *Catharus cecillei* (Philippi), Loc. 7, x 1.2

Explanation of Plate 5

1. *Anisocorbula venusta* (Gould), Loc. 2, x 1.3

2. *Glycemeris* (*Glycemeris*) *aspersa* (Adams and Reeve), Loc. 5, x 1.3

3. *Pleuromeris pygmaea* (Kuroda and Habe), Loc. 5, x 1

4. *Felaniella sowerbyi* (Kuroda and Habe), Loc. 1, x 1.2

5. *Tegillarca granosa* (Linnaeus), Loc. 6, x 1

6. *Wallucina striata* (Tokunaga), Loc. 5, x 1.5

7. *Lima vulgatula* Yokoyama, Loc. x 1.2

8. *Didimacar tenebrica* (Reeve), loc. 5, x 1. 5

9. *Pillucina* (*Sydlorina*) *yamakawai* (Yokoyama), loc. 7, x 1. 5

10. *Mactra* (*Mactra*) *nipponica* (Kuroda and Habe), Loc. 1, x 1.3

11. *Bellucina civica* (Yokoyama), Loc. 7, x 1.3

12. *Striarca symmetrica* (Reeve), Loc. 6, x 2

13. *Ruditapes bruguieri* (Hanley), Loc. 2, x 1

14. *Epikodakia delicatula* (Pilsbry), Loc. 1, x 1

15. *Mactra* (*Mactra*) *veniformis* Reeve, Loc. 1, x 1

16. *Arca bourcardi (Jousseaume)*, Loc. 7, x 1

17. *Barbatia* (*Savignyarca*) *virescens* (Reeve), Loc. 7, x 1

18. *Indocrasatella oblongata* (Yokohama), Loc. 4, x 1.3

19. *Nipponocrassatella adamsi* (Kobelt), Loc. 1, x 1.9

20. *Ruditapes philippinarum* (Adams and Reeve), Loc. 1, x 1

21. *Paphia* (*Neotapes*) *undulata* (Born), Loc. 4, x 1

22. *Musculista senhausia* (Benson), Loc. 3, x 1

23. *Xenostrobus securis* (Lamarck), Loc. 3, x 1

24. *Lima vulgaris* Link, Loc. 1, x 1.3

25. *Plicatula simplex* Gould, loc. 1, x 1.5

26. *Nutallia olivacea* (Jay), Loc. 6, x 1.2

27. *Anomia cheniensis* (Philippi), loc. 5, x 1.2

28. *Parahyotissa inermis* (Sowerby), Loc. 7, x 1.5

29. *Cardita leana Dunker*, Loc. 5, x 1.4

30. *Megacardita ferruginosa* (Adams and Reeve), Loc. 1, x 1.5

31. *Corbicula japonica* (Prime), Loc. 1, x 1

32. *Cyclosunetta concinna* (Dunker), loc. 2, x 1

33. *Dimya filipina* Bartsch, Loc. 5, x 1.4

34. *Globivenus toreuma* (Gould), Loc. 1, x 1.4

35. *Mactra* (*Mactra*) *chinensis* Philippi, Loc. 2, x 1

36. *Spondylus* (*Spondylus*) *longitudinalis* (Lamarck), Loc. 1, x 1.5

37. *Ctenoides ales* (Finley), Loc. 1, x 1.6

38. *Chama japonica* (Lamarck), loc. 14, x 1.4

39. *Phacosoma japonicus* (Reeve), Loc. 1, x 1

40. *Chlamys* (*Veprichlamys*) *empressae* Kuroda and Habe, Loc. 5, x 2.5

41. *Solidicorbula erythroden* (Lamarck), Loc. 1, x 1

42. *Nipponarca bistrigata* (Dunker), Loc. 5, x 1.4

43. *Scapharca sativa* (Lischke), Loc. 2, x 1

44. *Scapharca inaequivalves* (Bruguière), Loc. 3, x 1.2

45. *Ostrea denselamellosa* Lischke, Loc. 1, x 1.3

46. *Saxidomus purpurata* (Sowerby), Loc. 3, x 1

47. *Mytilus trossulus* Gould, Loc. 1, x 1.3

48. *Crassostrea gigas* (Thunberg), Loc. 3, x 1.5

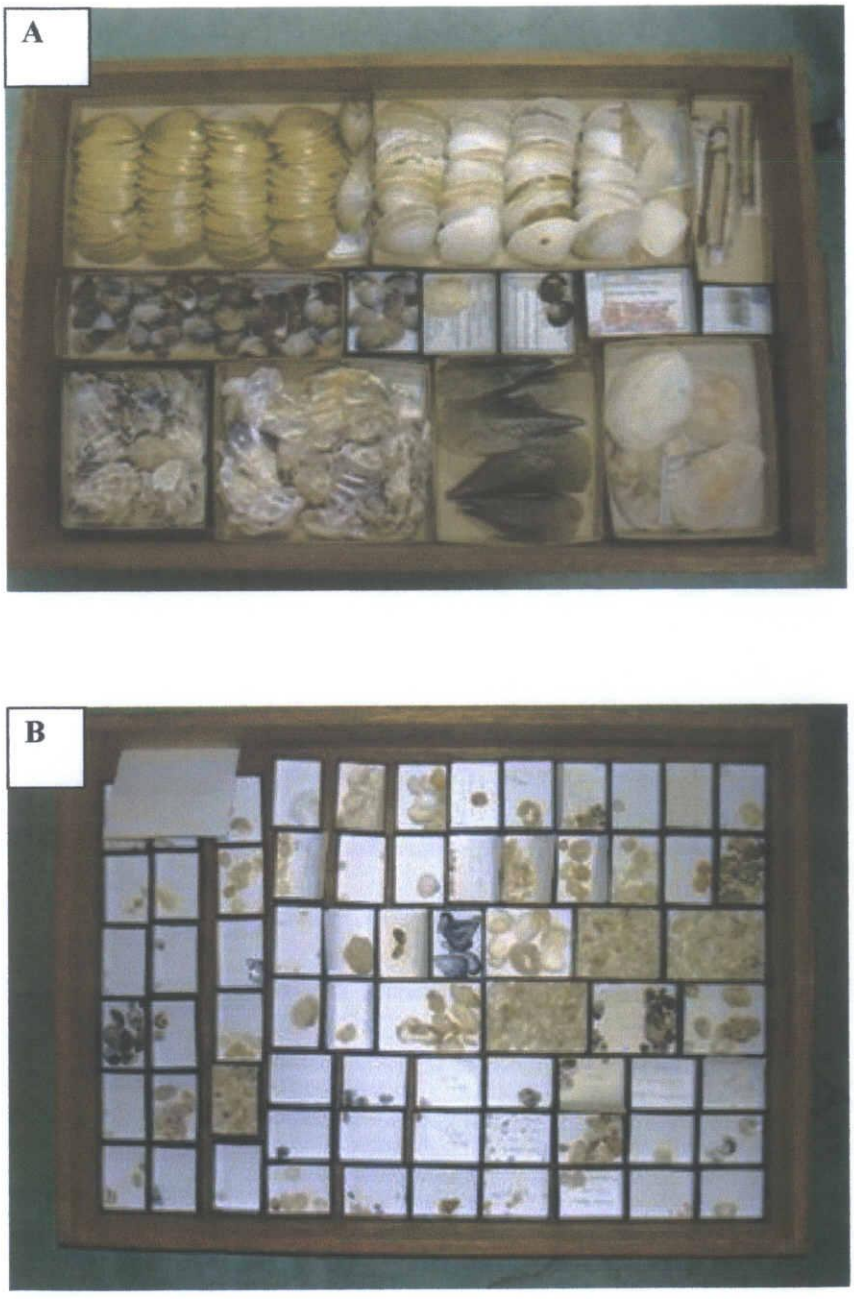


Fig. 13A-B. Collection of beach shells of Ise and Osaka Bays.

Table 3. Comparison of taxonomic composition of beach shell mollusks between Ise and Osaka Bays.

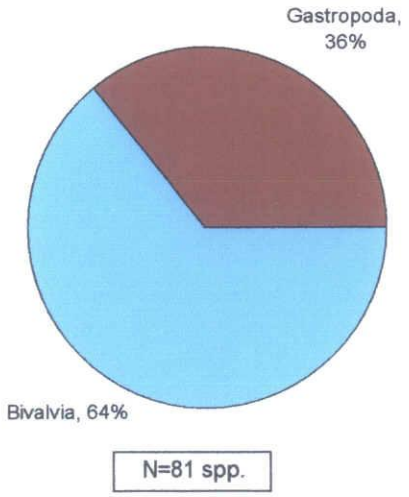
	Ise Bay	Osaka Bay
Species diversity	81	105
Gastropods		
No. of genera	24	53
No. of species	29	56
Bivalves		
No. of genera	37	43
No. of species	52	48
Scaphopod	0	1
Total number of individuals	13,620	6,657

Table 4a. Relatively dominant species in Ise Bay

	Species	No. of individuals (%)
1	*Mactra (Mactra) veneriformis*	2, 286 (19)
2	*Scapharca inaequivalvis*	2, 121 (17)
3	*Ruditapes philippinarum*	2, 042 (17)
4	*Crassostrea gigas*	1, 350 (11)
5	*Ruditapes bruguieri*	751 (6)
6	*M. (Mactra) chinensis*	719 (6)
7	*S. sativa*	638 (5)
8	*Crepidula onyx*	491 (4)
9	*Mytilus trossulus*	353 (3)
10	*Donax (Chion) semigranosus*	297 (2)
11	*Batillaria cumingii*	262 (2)
12	*Hima festiva*	242 (2)
13	*Nutallia japonica*	238 (2)
14	*Solen grandis*	234 (2)
15	*Musculista senhausia*	217 (2)
	Total	12, 241 (100)

Table 4b. Relatively dominant species in Osaka Bay

	Species	No. of individuals (%)
1	*Ruditapes bruguieri*	1, 685 (27)
2	*R. philippinarum*	1, 430 (17)
3	*Striarca symmetrica*	519 (8)
4	*Didimacar tenebrica*	461 (8)
5	*Scapharca sativa*	402 (8)
6	*Nipponarca bistrigata*	250 (7)
7	*Crepidula onyx*	183 (4)
8	*Cardita leana*	164 (3)
9	*S. inaequivalves*	159 (3)
10	*Mytilus trossulus*	96 (3)
11	*Mactra (Mactra) chinensis*	85 (2)
12	*Crassostrea gigas*	72 (1)
13	*Arca bourcardi*	67 (1)
14	*Musculista senhausia*	66 (1)
15	*Hima festiva*	51 (1)
	Total	5, 690(100)



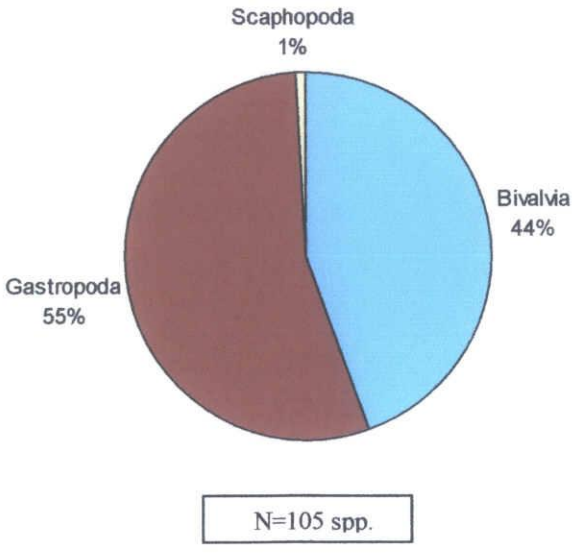


Fig. 14. Composition at class level in Ise and Osaka bays.

Table 5a. Simpson's Index (n=the total number of individuals of a particular species; N=total number of individuals of all species in Ise Bay).

Species	No. of individuals	n(n-1)
Mactra (Mactra) veniformis	2286	5223510
Scapharca inaequivalvis	2121	4496520
Ruditapes philippinarum	2042	4167722
Crassostrea gigas	1350	1821150
R. bruguieri	751	563250
M. (Mactra) chinensis	719	516242
S. sativa	638	406406
Crepidula onyx	491	240590
Mytilus trossulus	353	124256
Donax (Chion) semigranosus	297	87912
Batillaria cumingii	262	68382
Hima festiva	242	58322
Nutallia japonica	238	56406
Solen grandis	234	54522
Musculista senhausia	217	46872
Phacosoma japonicus	177	31152
Thais (Reishia) clavigera	124	15252
S. strictus Gould	123	15006
Musculista japonicus	100	9900
Anomia cheniensis	72	5112
Corbicula fluminea	60	3540
Paphia (Neotapes) undulata	58	3306
M. (Mactra) nipponica	53	2756
Nitidotellina hokkaidoensis	47	2162
Rapana venosa venosa	46	2070
Psammotaea minor	46	2070
Glossaulax didyma didyma	45	1980
B. multiformis	41	1640
Mya (Arenomya) arenaria oonogai	39	1482
Euspira fortunei	38	1406
Fulvia mutica	36	1260
N. ezonis	28	756
Littorina (Littorina) brevicula	25	600
S. satowi	25	600
P. virescens	22	462
Umbonium (Succhium) moniliferum	20	380
T. (Reishia) bronni	19	342
Macoma tokyoensis	19	342
Meretrix lusoria	11	110
C. japonica	10	90
Saxidomus purpurata	9	72
H. fuscolineata	6	30
Hyotissa hyotis	5	20
Cryptonatica hirasei	4	12
Cancellaria (Sydaphera) spengleria	4	12
Atrina (Servatrina) pectinata	4	12
Ostrea denselamellosa	4	12
Gomphina (Macridiscus) veneformis	4	12
Tenagodus (Agathirses) cumingii	3	6
Pecten (Notovola) excavatus	3	6
Soletellina diphos	3	6
Solecurtus divaricatus	3	6
Trapezium (Neotrapezium) liratum	3	6
Pomacea canaliculata	2	2
Natica spadicea	2	2
Siphonaria (Sacculosiphonaria) japonica	2	2
Haloa nigropunctata	2	2
Epitonium (Papyriscala) clementium	2	2
Perna viridis	2	2
Mizuhopecten yessoensis	2	2
C. nippona	2	2
M. petechialis	2	2
M. lamarckii	2	2
T. sublaenvigatum	2	2
Protothaca euglypta	2	2
Turbo (Batillus) comutus	1	0
Serpolurbis xenophorus	1	0
Babylonia japonica	1	0
S. laciniosa	1	0
Siphonalia modificata	1	0
Smeatonia eddystonensis	1	0
Lacuna (Haloconcha) reflexa	1	0
E. (Hirtoscala) castum	1	0
Monodonta labio form *confusa*	1	0
Barbatia (Savignyarca) virescens	1	0
Tegillarca granosa	1	0
S. broughtonii	1	0
Xenostrobus securis	1	0
Chlamys (Mimachlamys) nobilis	1	0
Pillucina (Pillucina) pisidium	1	0
Dosinella corrugata	1	0
Total Number of Individuals	13599	
Species Richness	81	
N(N-1)	184919202	
SUMn(n-1)	18036074	
Diversity index	10.25	

Table 5b. Simpson's Index (n=the total number of individuals of a particular species; N=the total number of individulas of all organisms in Osaka Bay).

Species	No. of individuals	n(n-1)
Ruditapes bruguieri	1685	2837540
R. philippinarum	1430	2043470
Striarca symmetrica	519	268842
Didimacar tenebrica	461	212060
Scapharca satiya	402	161202
Nipponarca bistrigata	250	62250
Crepidula onyx	193	37056
Cardita leana	164	26732
S. inaequivalves	159	25122
Mytilus trossulus	96	9120
Mactra (Mactra) chinensis	85	7140
Crassostrea gigas	72	5112
Arca boucardi	67	4422
Musculista senhausia	66	4290
Hima festiva	51	2550
Chlorostoma turbinatum	49	2352
Perahyotissa inermis	48	2256
Mitrella bicinta	47	2162
Capulus badius	47	2162
Anomia chenlensis	46	2070
Indocrassatella oblongata	44	1892
Proterato (Sulcerato) callosa	43	1806
Nipponocrassatella adamsi	36	1260
Anisocorbula venusta	36	1260
Angiola zonata	33	1155
Cherne japonica	31	1260
Chlamys (Veprichlamys) empressae	30	870
Dimya filipina Bartsch	26	650
Megacardita ferruginosa	26	650
Paphia (Neotapes) undulata	23	650
Tenagodus (Tenagodus) cumingii	21	420
Glossaulax didyma didyma	20	380
Tanea toseensis	20	380
Liotina semiclathratula	19	342
Pleuromeris pygmaea	18	306
Catharus cecilei	17	272
M. (Mactra) venentiformis	18	272
Thais (Reishia) clavigera	15	272
Plicatula simplex	12	132
Cyclosunetta concinna	12	210
Odetta tenpei	12	210
Limneria bulla	11	210
Phacosoma japonicus	11	110
H. fuscolineata	10	90
Wallucina striata	10	90
Siphonalia modificata	8	90
Corbicula japonica	8	56
Latirus kandai	7	56
Cerithiopsis spongicola	7	42
Tegillarca granosa	7	42
Umbonium (Suchium) moniliferum	6	30
Littorina (Littorina) brevicula	6	30
Spondylus (Spondylus) longitudinalis	6	30
Rapana venosa venosa	5	30
Batillaria zonalis	4	12
T. (Reishia) bronni	4	12
Barbatia (Savignyarca) virescens	4	12
Glycymeris (Glycymeris) aspersa	4	12
Eplicodakia delicatula	4	12
M. (Mactra) nipponica	4	12
Cantharidus japonicus	3	6
Akoya akoya	3	6
Bittium (Stylidium) batillarium	3	6
Notoseila morishimai	3	6
Ceratostoma inornatum	3	6
Phos (Phos) naucrators	3	6
Clathromangelia coffea	3	6
Horaiclevus (Cytheroclavus) stenocyrta	3	6
Ptycheulimella miselle	3	6
Ctenoides ales	3	6
Ostrea denselamellosa	3	6
Solidicorbula erythrodon	3	6
Pillucina (Sydlorina) yamakawai	3	6
Bedeva briefi	3	6
Patelloida pygmaea pygmaea	2	2
Diodora mus	2	2
Eurytrochus affinis cognatus	2	2
Komaltrochus pulcher	2	2
Triphora tristoma	2	2
Sigatica bathyraphe	2	2
Orinella puchella	2	2
Eunaticina papilla	2	2
Pomacea coneliculata	2	2
Xenostrobus securis	2	2
Bellucina civica	2	2
Globivenus toreuma	2	2
Saxidomus purpurata	2	2
Nutallia olivacea	2	2
Fissidentalium (Fissidentalium) lima	2	2
Lottia kogamogai	1	0
Trochus stellatus	1	0
Monodonta labio confusa	1	0
Serpolurbis xenorphorus	1	0
Furukewela fukuiensis	1	0
Gyroscala (Pomiscala) perplexa	1	0
Amathina tricarinata	1	0
Purpuraduste (Purpuraduste) gracilis	1	0
Pollia subrubiginosus	1	0
P. (Phos) laeve	1	0
Vexillum sp.	1	0
Monotygma eximia	1	0
Nerita (Heminerita) japonica	1	0
Lima vulgatula	1	0
L. vulgaris	1	0
Felaniella sowerbyi	1	0
Total Number of Individuals	6, 657	
Species Richness	105	
N(N-1)	44308992	
SUMn(n-1)	5729286	
Diversity Index	7.73	

Table 6. Number of individuals (per 10 sq.m) of Ise and Osaka Bays.

	No. of Individuals		
Locality No.	Ise Bay	Locality No.	Osaka Bay
1	867	1	890
2	851	2	1269
3	316	3	537
4	1613	4	274
5	857	5	825
6	572	6	696
7	698	7	527
8	1944	8	250
9	431	9	789
10	574	10	602
11	1660		
12	2094		
13	1122		
Total	13599.0		6659.0
Mean	1046.1		665.9
SD	591.2		302.2

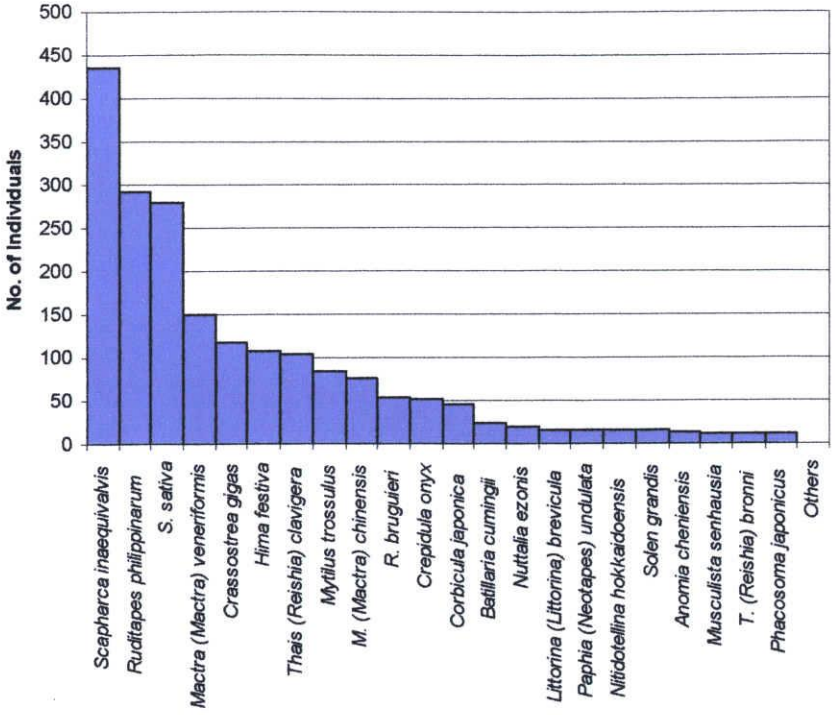


Fig. 15a. Specific composition in Sambashi beach (Locs 1, 2, 3).

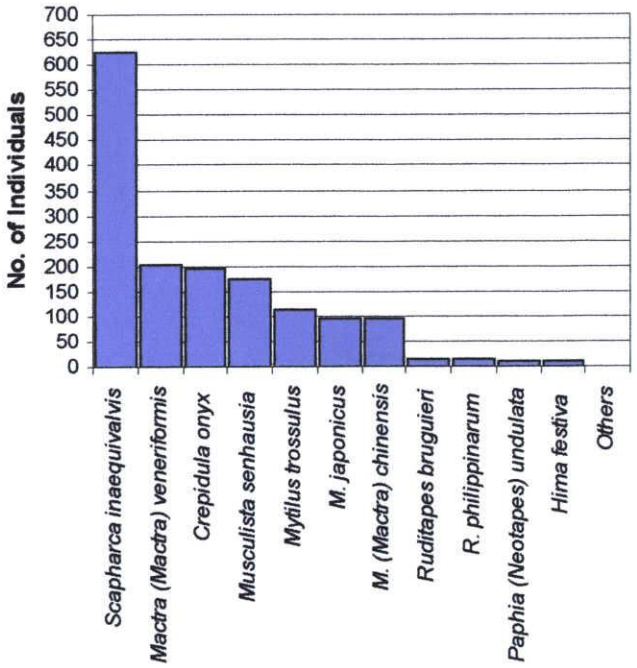


Fig. 15b. Specific composition in Chiyozaki beach (Loc. 4)

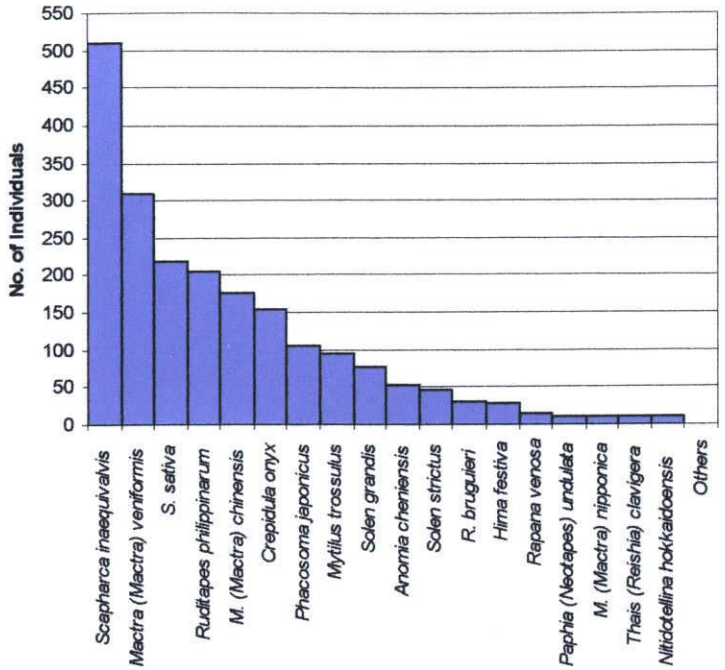


Fig. 15c. Specific composition in Tsuzumigaura beach (Locs. 5, 6, 7)

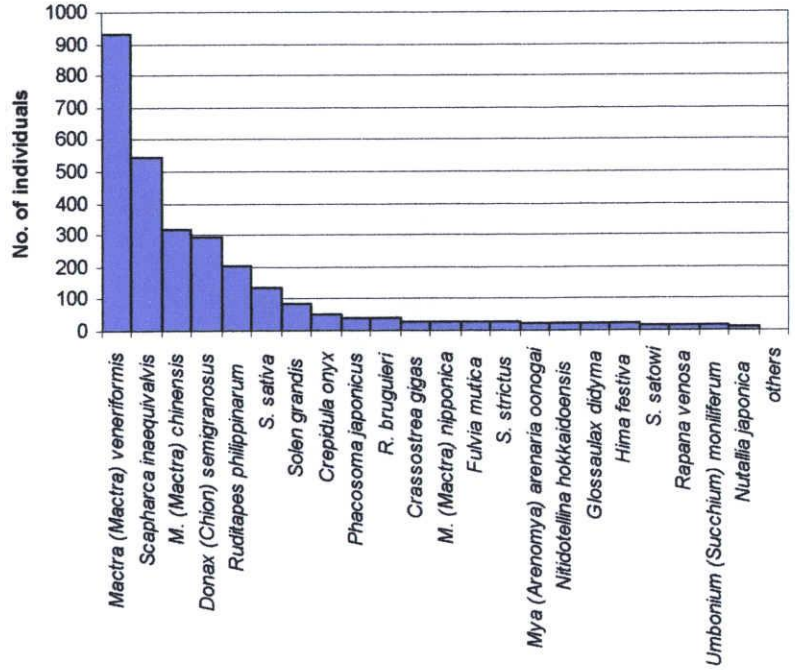


Fig. 15d. Specific composition in Gotemba beach (Locs. 8, 9, 10)

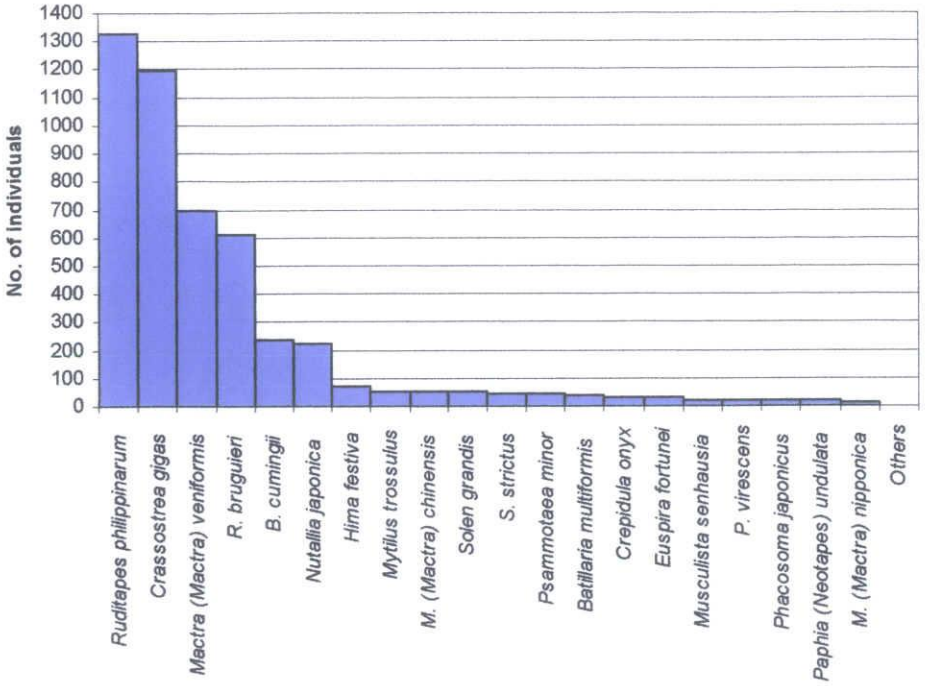


Fig. 15e. Specific composition in Gonushi beach (Locs. 11, 12, 13)

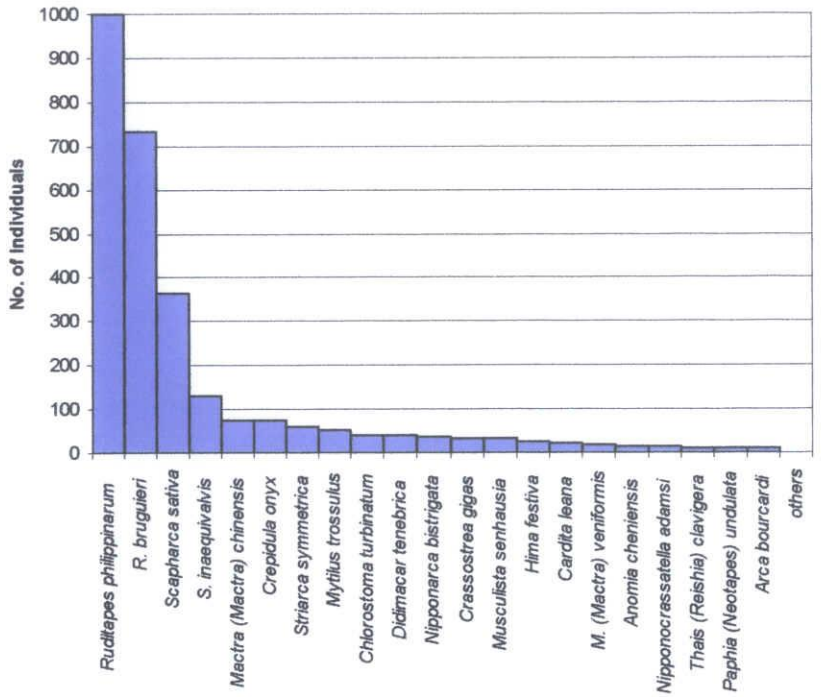


Fig. 16a. Specific composition in Nishikinohama beach (Locs. 1, 2, 3, 4)

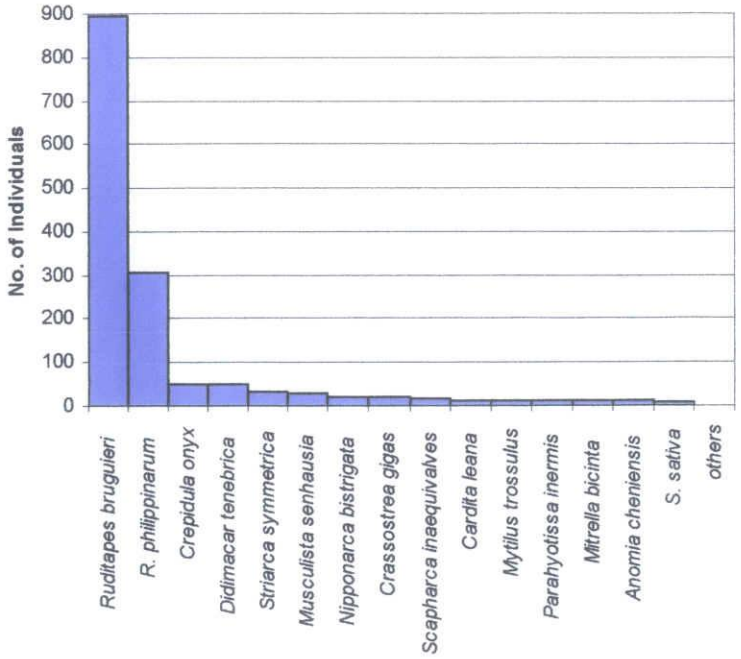


Fig. 16b. Specific composition in Tarui-minami (Locs. 5, 6, 7)

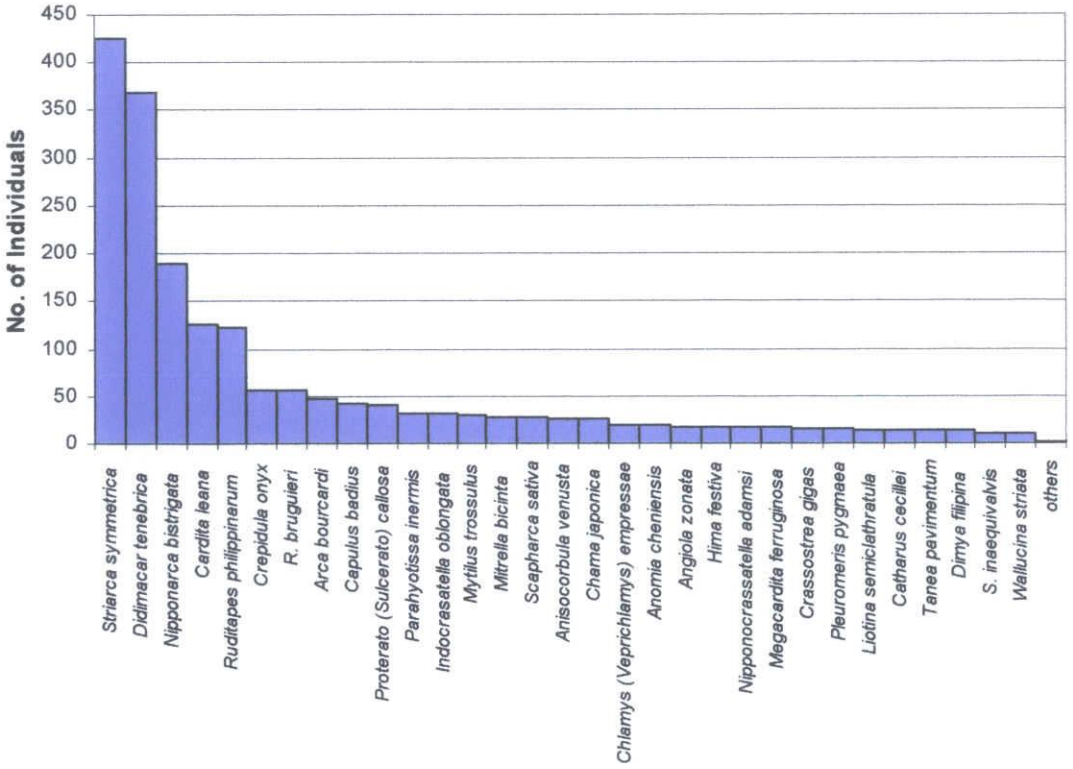


Fig. 16c. Specific composition in Hakotsukuri beach (Locs. 8, 9, 10)

4. Summary

1. Ise and Osaka Bays show unique taxonomical composition. Osaka Bay has the highest species diversity (105) but lower Simpson's Index (8.6) which is a reflective of a lower frequency of beach shell mollusks. Ise Bay has species diversity of 81 with higher Simpson's Index (10.9) which indicates higher frequency of beach shell mollusks, thus benthic production is high.

2. Ise Bay contains 36 % gastropod species and 64 percent bivalve species. On the other hand, Osaka Bay has 55 % gastropods and 44 % bivalves.

3. Each locality in Ise Bay contained 1,046 individuals on average (SD=590) and that in Osaka Bay has 666 individuals on average (SD=302).

4. Presence of alien species was recognized in both bays. Fresh dead specimens are mostly collected at the sand beaches of Ise Bay however, old dead ones are collected in Osaka sand beaches.

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