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Bottom sediments and benthic faunas off Tassha in Sado Island, Niigata Prefecture, central Japan

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Abstract

Bottom sediments and invertebrate benthic faunas were recovered by dredge sampling at four stations off the Tassha coast of Sado Island in the Japan Sea. Nineteen crustacean and 144 molluscan species were found in the bottom sediments. Among the decapod crustaceans, *Australeremus triserratus* (Ortmann) was identified for the first time in the Japan Sea. The following nine molluscan species were newly found around Sado Island: *Emarginula fragilis* Yokoyama, *Nodiscala matajiroi* Kuroda, *Pyreneola semipicta* (Sowerby III), *Dimiya filipina* Bartsch, *Spondylus barbatus* Reeve, *Agatha lepidula* Habe, *Cycladicama semiasperoides* (Nomura), *Abrina lunella* (Gould) and *Pitar japonicum* Kuroda and Kawamoto. The grain size analysis revealed that the bottom sediments were classified into two groups: coarse-grained sand at shallower nearshore sites and fine-grained sand at a deeper offshore site. The cluster analysis for the molluscan faunas was concordant to the grain size classification of the sediments.

Key words: benthic fauna, bottom sediments, Crustacea, grain size analysis, Japan Sea, Mollusca, Sado Island.

Introduction

Upon the introduction of a new research boat (IBIS 2000) in the Sado Marine Biological Station (SMBS), Faculty of Science, Niigata University, we launched marine environmental studies in the Japan Sea by operating plankton nets and a dredge sampler. Our first cruise was

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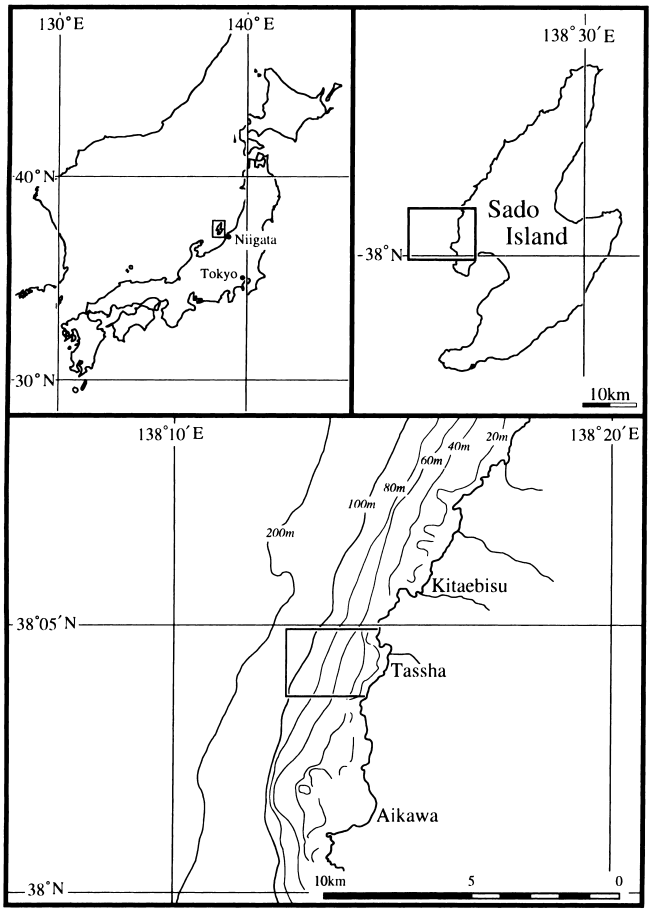

Fig. 1. Map showing the study area. The contour lines are based on the depth data in the chart of "SADO SIMA, scale 1:85,000" published by the Surveys of the Hydrographic Division, M.S.A., Japan.

carried out off Tassha in Sado Island (Fig. 1) in early September, 2000. The temperature profile and the plankton faunas from the surface waters in the study area have already been reported as our first scientific results (Matsuoka et al., 2001). This is a supplementary report dealing with the benthic faunas (crustaceans and mollusks) and the bottom sediments collected in that cruise.

Previous works on the benthic biota around Sado Island dealt mainly with molluscan faunas. Kuroda (1957) reported the molluscan faunas around Sado Island. Ito (1978, 1979, 1985, 1989) listed molluscan species in the Mano Bay and the surrounds of Sado Island. Honma and Kitami (1978, 1979, 1995) also reported the benthic fauna from the waters adjacent to the SMBS.

All of the authors participated in the sample collection. The first author (K.T.) and the second author (T.S.) are responsible for the analysis of molluscan and crustacean faunas, respectively. The third author (H.Y.) carried out grain size analysis of the sediments. The fourth author (A.M.) organized this project and completed the article.

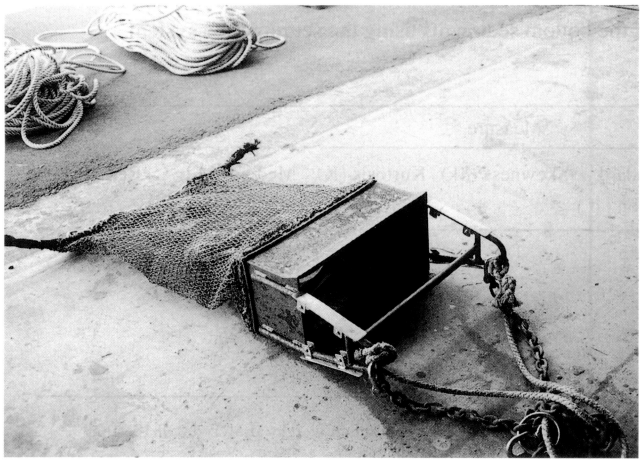

Fig. 2. Dredge (ORI type) used in this study. Size of inlet: 0.5m × 0.2 m, length of cod end: 0.8 m, mesh size: 2 mm × 2 mm.

Materials and methods

Four sediment samples were taken with a dredge (Fig. 2) from the slope perpendicular to the Tassha coast. The sampling sites were sequentially arranged from nearshore (St. 1) to offshore (St. 4). The water depths measured by sonar system were as follows: 26 m (St. 1), 34.3 m (St. 2), 64.4 m (St. 3), and 94.4 m (St. 4). Sampling was performed at St. 1, 2 and 3 on September 6 and at St. 4 on September 7 in 2000. The dredge operation at each station was for five minutes.

The grain size distribution of the bottom sediments were analyzed by using the settling tube system (Kumon and Tateishi, 1998; Kumon and Makino, 2000). Methods of Wentworth (1922), Folk and Ward (1957) and Pettijohn (1975) were applied for grain size and sorting coefficient classifications.

The samples were washed by seawater in a sieve with 1 mm × 1 mm opening on the boat except for samples for grain size analysis. In the laboratory, these samples were fixed and preserved in 70% ethanol and then the organisms were collected from the washed samples. The organisms excluding molluscan specimens, were preserved in 70% ethanol. The living molluscan individuals were preserved in 50% isopropyl alcohol, and the shells were dried.

The systematics of the Mollusca is based on Beesley et al. (1998) and Higo et al. (1999). Furthermore, we calculated the similarity of the molluscan species composition between the stations by means of the Jaccard coefficient (Jaccard, 1908) and then analyzed with the neighbor-join method (Saitou and Nei, 1987).

Table 1. Measurements of the bottom sediments using the settling tube system.

Station	Measure					Remarks
	Mean (M)	Standard deviation (σ)	Skewness (Sk)	Kurtosis (K)	Median (Md)	
St. 1	0.74	0.55	1.63	10.97	0.75	*1
St. 2	0.49	0.38	3.22	23.46	0.50	*2
St. 3	0.23	0.56	-0.71	8.45	0.25	*3
St. 4	2.35	0.80	-0.34	5.14	2.25	*4

*1: Water temperature 28℃, settling length 156cm, density 2.65, sediment weight analyzed 3.981g, time analyzed 1200.001 Sec. *2 : Water temperature 28℃, settling length 156cm, density 2.65, sediment weight analyzed 3.941g, time analyzed 1200.002 Sec. *3 : Water temperature 28℃, settling length 156cm, density 2.65, sediment weight analyzed 4.746g, time analyzed 1200.001 Sec. *4 : Water temperature 28℃, settling length 156cm, density 2.65, sediment weight analyzed 2.185g, time analyzed 1200.006 Sec.

Grain size analysis

The results of grain size analysis are shown in Fig. 3 and Table 1. The mean grain size of the bottom sediments at St. 1, St. 2 and St. 3 ranges from 0.23 to 0.74 phi, assignable to coarse-grained sand. On the other hand, the mean grain size at St. 4 is 2.35 phi, indicating fine-grained sand. The standard deviation of the bottom sediment is 0.38 at St. 2, which is indicative of well-sorted sand. The standard deviations of the bottom sediments at St. 1, St. 3 and St. 4 range from 0.55 to 0.80, which are regarded to be of moderately well-sorted sand.

Crustacean fauna

The crustacean species identified in this study are shown in Table 2 and Plate 1. The number of crustacean species from St. 1 and St. 2 are very scanty, but crustacean species from St. 3 and St. 4 are relatively abundant.

Among the Crustacea, 15 decapodian species (14 genera of 10 families) and four species of Euphausiacea, Amphipoda and Cumacea occurred from St. 2, 3 and 4. The species composition of the fauna from St. 3 is characterized by species of the infraorder of Anomura, whereas that from St. 4 is characterized by species of the orders of Euphausiacea, Amphipoda and Cumacea.

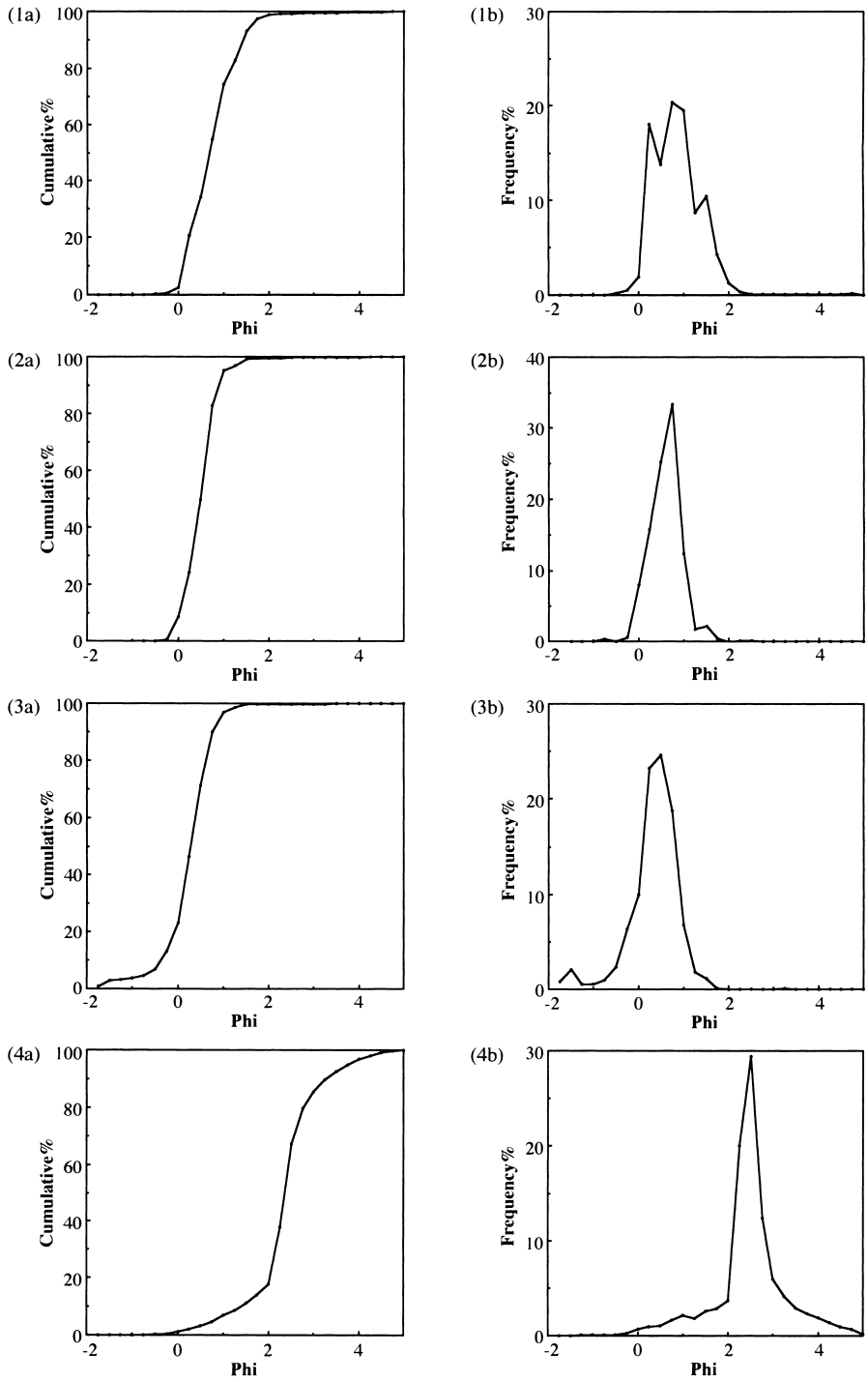

Fig. 3. Cumulative (a) and frequency (b) curves of the bottom sediments.
1a, 1b: Station 1; 2a, 2b: Station 2; 3a, 3b: Station 3; 4a, 4b: Station 4.

Table 2. List of crustacean species.

Species	Number of individuals St.2	St.3	St.4
DECAPODA			
PENAEIDEA			
PENAEIDAE			
Metapenaeopsis delei (Rathbun)	1♀		
CARIDEA			
PASHIPHIPHAEIDAE			
Leptochela gracilis Stimpson			1♂, 1 ovig.♀, 1♀
CRANGONIDAE			
Paracrangon sp.			1♀
HIPPOLYTIDAE			
Heptacarpus rectirostris (Stimpson)	1♀	5♀♀	
PANDALIDAE			
Pandalus sp.		2	
ANOMURA			
DIOGENIDAE			
Paguristes digitalis Stimpson		1♂	
PAGURIDAE			
Pagurus brachiomastus (Thallwitz)		3♂♂	
Pagurus sp.		1♀	
Australeremus triserratus (Ortmann)		1♂, 1 ovig.♀, 1♀	
Anapagurus japonicus Ortmann		1♂	
Catapaguroides japonicus de Saint Laurent		2♂♂	
GALATHEIDAE			
Galathea orientalis (Stimpson)		2♂♂, 1 ovig.♀	
Munida japonica Stimpson			1♂
BRACHYURA			
RANINIDAE			
Cosmonotus grayii Adams and White			2♂♂
PALICIDAE			
Palicus hatsusimaensis Sakai			1♀
EUPHAUSIACEA			3
AMPHIPODA			
CAPRELLIDEA			1
GAMMARIDEA	2		25
CUMACEA			6♂♂, 5♀♀

Table 3. List of molluscan species. L: living individual, y: young individual, n*1/2: indicate the number of individuals of the Bivalvia.

Species	Number of individuals St.1	St.2	St.3	St.4
GASTROPODA				
EOGASTROPODA				
PATTELLOGASTROPODA				
NCELLIDAE				
Cellna toreuma (Reeve)	y2	y3		
LOTTIIDAE				
Patelloida pygmaea pygmaea (Dunker)	y1			
Lottia kogamogai Sasaki and Okutani	y4	y1	1	
Lottidae sp.1	y7	y8	y4	y1
ACMAEIDAE				
Acmaea pallidae (Gould)	y4	y4	y3	
ORTHOGASTROPODA				
VETIGASTROPODA				
FISSURELIDAE				
Emarginula fragilis Yokoyama				2(y1)
Puncturella nobilis (A.Adams)				2
Cranopsis pelex A,Adamds				4(y1)
Macroshisma sinensis (A.Adams)			1	
Macroshisma dilatata (A.Adams)	y1			
TURBINIDAE				
Liotina semiclathratula (Schrenck)				y1
Homalopoma granuliferum Nomura and Hatai				y1
Neocollonia pilula (Dunker)	2	y1	3	
TROCHIDAE				
Granata lyrata (Pilsbry)	y1			
Enida japonica A.Adams				y1
Cantharidus callichroa (Philippi)	y10	y6		
Calliostoma aculeatum Sowerby Ⅲ				y4
Minolia punctata A.Adams				L4(y2), 10(y7)
Minolia subangulata Kuroda and Habe			L10 , 5(y3)	y1
Umbonium costatum (Valenciennes)		y2		
Ethminolia stearnsii (Pilsbry)	L2, y2			
Conotalopia ornata (Sowerby Ⅲ)	4	4	1	
CAENOGASTROPODA				
SONBEOCHONCA				
CERITHIDAE				
Rhinoclava kochi (Philippi)	y1	y2		
Bittium glareosum Gould	1			
Bittium variegatum Kuroda and Habe	2	1		
BATILLARIIDAE				
Haustator cingulifera (Sowerby Ⅰ)			y2	
RISSOIDAE				
Rissoina costulata (Dunker)	16	38	21	
Rissoina pura (Gould)	1			2
CAECIDAE				
Pseudoliotina pulchella (Dunker)	y1			
STROMBIDAE				
Doxander japonicus (Reeve)	y3			
HIPPONICIDAE				
Hipponix conica (Suhumacher)	y8	8	15	
CALYPTRAEIDAE				
Crepidula gravispinosus Kuroda and Habe		y1		
NATICIDAE				
Cryptonatica janthostomoides (Kuroda andHabe)				y1
FICIDAE				
Tonna luteostoma (Kuster)			y1	
TRIPHORIDAE				
Viriola tricincta (Dunker)	1	y2		
Inella japonica Kuroda and Kosuge	1	y1		
Triphora conspera (E.A.Smith)	1	1		
Triphora otsuensis (Yokoyama)	1			
EPITONIIDAE				
Nodiscala matajiroi Kuroda		1		
Spiniscala japonica (Dunker)	1			
Cinctiscala sagamiensis (Pilsbry)				y1
Depressiscala aurita (Sowerby Ⅱ)				Ly1
EULIMIDAE				
Eulimidae sp.1				1
BUCCINIDAE				

Table 3. (continued)

Species	Number of individuals St.1	St.2	St.3	St.4
Microfusus agutispiratus (Sowerby III)				1
Siphonofusus fusoides (Reeve)			y3	y3
COLUMBELLIDAE				
Mitrella bicincta (Gould 1860)	3	3(y1)	y1	
Sundamittrea impollta (Sowerby II)		2		
Pyreneola semipicta (Sowerby III)	1			
Zafra mitriformis A.Adams	1			
Zeuxis castus (Gould)				1
Nassa japonica A.Adams	4(y3)	3(y2)		
CYSTISCIDAE				
Crithe nipponica (Habe)				1
COSTELLARIIDAE				
Volutomitra inerme (Reeve)	1	5		
CANCELLARIIDAE				
Tylotiella humilis (F.A.Smith)				2
CONIDAE				
Microdrillia sagamiensis Kuroda and Oyama				y1
Citharella sp.	3	1		
Taranis sp.				y1
Clathrella sp.			1	
Conidae sp.1	2	1		
Conidae sp.2	1			
Conidae sp.3			1	
Conidae sp.4				1
HETEROBRANCHIA				
ARCHIRECHTONIDAE				
Heliacus enoshimensis (Melvill)				1
PYRAMIDELLIDAE				
Marginodostomia subangulata (A. Aadms)				1
Agatha lepidula Habe				1
Chemnitzia multigyra (Dunker)	y2			2
Paracingulina triarata (Pilsbry)			1	
Leucotina dianae (A.Adams)			1	
CEPHALASPIDEA				
RINGICULIDAE				
Ringicula niinoi Nomura				1
RETUSIDAE				
Retusa insignis (Pilsbry)	7	L1, 1	2	
Pyrunculus phialus (A.Adams)				6
Sulcoretusa minima (Yamakawa)	1			
Volvwlella eburnea (A.Adams)				7
Retusidae sp.	1	1		
CYLICHNIDAE				
Adamnestia japonica (A.Adams)	2			
HAMINOEIDAE				
Liola porcellana (Gould)	L1			10
THECHOSOMATA				
CAVOLINIIDAE				
Cavolinia uncinata (Rang)				9
Gastropoda sp. 1	1			
Gastropoda sp. 2		1		
Gastropoda sp. 3			1	
BIVALVIA				
PROTOBRANCHIA				
NUCULOIDA				
NUCLIDAE				
Nucula paulula A.Adams				L1
Ennucula niponica (E.A.Smith)				Ly8, 14(y11)*
SAREPTIDAE				
Sarepta japonica A.Adams				y1*
Yoldiella philippiana (NYST)				9*
NUCULANIDAE				
Nuculana yokoyamai Kuroda				L2(y1), 39(y5)*
Saccella sematensis (Suzuki and Ishizuka)			y2*	5(y2)*
PTERIOMORPHIA				
MYTILOIDEA				
MYTILIDAE				
Mytilus coruscus Gould			1*	
Septifer keeni Nomura	y11*	3(y2)*		

Table 3. (continued)

Species	Number of individuals St.1	St.2	St.3	St.4
Modiolus margaritaceus (Nomura and Hatai)	3*	2*		abundant
ARCOIDA				
ARCIDAE				
Arca avellana Lamarck	7*		4*	
Arca boucardi Jousseaume		y5*		y 3*
Barbatia stearnsii (Pilsbry)	10*	6*	6*	
NOETIIDAE				
Striarca symmetrica (Reeve)	3(y1)*	y5*	2*	
PARALLELODONTIDAE				
Porterius dalli (E.A.Smith)	y1*	y1*		
LIMOPSIDAE				
Crenulilimopsis crenata (A.Adams)			y21*	Ly3, abundant
GLYCYMERIDIDAE				
Glycymeris imperialis Kuroda		y6*	abundant	L6, 132(y125)*
Tucetilla pilsbryi (Yokyama)			4(y3)*	
LIMOIDEA				
LIMIDAE				
Limaria hirasei (Pilsbry1)				1*
Limatula vladivostokcnsis (Scarlato)	4*	3*	3*	14*
Limatula japonica A.Adams				1*
OSTREOIDA				
GRYPHAEIDAE				
Neopycnodonte cochlear (Poli)			Ly7,11*	1*
DIMIDAE				
Dimiya filipina Bartsch				1*
PECTINIDAE				
Chlamys irregularis (Sowerby Ⅱ)	y1*	y1*	y1*	
Cryptopecten vesiculosus (Dunker)				y2*
Delectopecten macrocheilicola (Habe)				3*
PROPEAMUSSIIDAE				
Parvamussim intuscostatus (Yokoyama)				4*
SPONDYLIDAE				
Spondylus barbatus Reeve	y1*			
HETERODONTA				
VENEROIDA				
CHAMIDAE				
Chama japonica Lamarck	y7*	1*	6*	
LUCINIDAE				
Epikodakia bella (Conrad)		3*	2*	
Wallucina striata (Tokunaga)			2*	
THYASIRIDAE				
Thyasira tokunagai Kuroda and Habe				20*
UNGULINIDAE				
Cycladicama semiasperoides (Nomura)		1*	1*	
Cycladicama lunaris (Yokoyama)	y 2*			2*
GALEOMMATIDAE				
Pseudogaleomma japonica (A.Adams)				1*
CARDITIDAE				
Cardita leana (Dunker)	13*	y2*	8*	y4*
CRASSATELLIDAE				
Eucrassatella japonica (Dunker)		y2*	7(y6)*	
ASTARTIDAE				
Tridonta benetti (Dall)			8*	
CARDIIDAE				
Keenaea samarangae (Makiyama)			y1*	y6*
Fuscocardium undatopicta (Pilsbry)	L2, 12*	L1	1*	1*
TELLINIDAE				
Cadella lubrica (Gould)			1*	
Moerella iridescens (Benson)	y1*			
SEMELIDAE				
Leptomya cuspidariaeformis Habe				3*
Abrina lunella (Gould)				17(y10)*
SOLECURTIDAE				
Solecurtus sagamiensis Kuroda and Habe				1*
KELLIELLIDAE				
Alveinus ojianus (Yokoyama)			L1	
VENERIDAE				
Timoclea micra (Pilsbry)			14(y2)*	Ly2, 18(y16)*
Timoclea mindanensis (E.A.Smith)	5(y2)*	2*	y1*	

Table 3. (continued)

Species	Number of individuals St.1	St.2	St.3	St.4
Protothaca jedoensis (Lischke)			1*	
Microcirce dilecta (Gould)	5*			L2, abundant
Pitar japonicum Kuroda and Kawamoto				Ly1, y7*
Callista politissima Kuroda	y2*			
Callista pilsbryi Habe	y1*			
Phacosoma japonica (Reeve)	Ly2, y2*	y2*		Ly1, y10*
Bonatemis histrio iwakawai (Oyama and Habe)				3(y2)*
Irus mitis (Deshayes)	L1			
Irus ishibashianus Kira	y2*			
Cyclosanetta truncata (Deshayes)			2*	
Sunettina solanderii (Gray)			4(y2)*	
Veneridae sp.1	10*			
Veneridae sp.2	2*	2*	2*	
MYOIDEA				
MYIDAE				
Sphenia coreanica Habe	2*			
Paramya recluzi (A.Adams)	Ly1, 12(y8)*			
CORBULIDAE				
Anisocorbula venusta (Gould)			3*	
HIATELLIDAE				
Hiatella orientalis (Yokoyama)				2*
LYONSIIDAE				
Lyonsia ventricosa Gould	y1*			
ANOMALODESMATA				
PHOLADOMYOIDA				
PANDORIDAE				
Pandora wardiata A.Adams				5*
Pandorella pseudobilirata (Nomura and Hatai)				L1
MYOCHAMIDAE				
Myadora fluctuosa Gould				L3(y1), 59(y53)*
POROMYIDAE				
Poromya flexuosa Yokoyama				y4*
CUSFIDARIIDAE				
Cardiomya gouldiana (Hinds)				11(9 y)*
Rengea cadula (E.A.Smith)				L1
Plectodon ligulis (Yokoyama)	L2 , 10*	L5, 4*	L1 , 2*	17*
SCAPHOPODA				
DENTALIIDA				
DENTALIIDAE				
Dentalium octangulatum Donovan				Ly13, y14
Antalis tibanum Nomura				y3
Antalis weinkanffi (Dunker)	y2	Ly1, y9	31(y30)	L13(y5) , 12(y7)
Striodentalium rhabdotum (Pilsbry)				3(y1)
GADILINIDAE				
Episiphon yamakawai (Yokoyama)				L26, 14(y4)
GADILIDA				
ENTALINIDAE				
Entalinopsis intercostata (Boissevain)				37(y32)
PULSELLIDAE				
Pulsellum hige Habe			1	

In this study, we collected three specimens of decapod crustacea *Australeremus triserratus* (Ortmann) (Pl. 1, figs. 3a, b) inhabiting the shells of Scaphopoda (Mollusca). The species is recorded here for the first time from the Japan Sea judging from the previous reports (Takeda and Miyake, 1970; Sakai, 1976; Miyake, 1978; Komai, 1999).

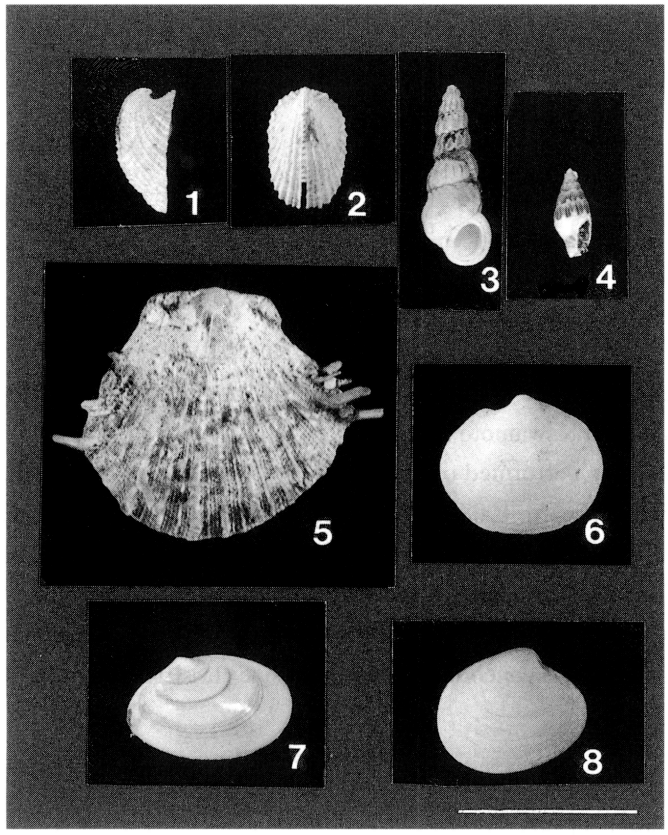

Fig. 4. Mollusks obtained for the first time around Sado Island. Scale bar: 10 mm. 1: *Emarginula fragilis* Yokoyama, dead shell, left side view, 2: *Emarginula fragilis* Yokoyama, dead shell, dorsal view, 3: *Nodiscala matajiroi* Kuroda, dead shell, 4: *Pyreneola semipicta* (Sowerby III), dead shell, 5: *Spondylus barbatus* Reeve, dead shell, 6: *Cycladicama semiasperoides* (Nomura), dead shell, 7: *Abrina lunella* (Gould), dead shell, 8: *Pitar japonicum* Kuroda and Kawamoto, living shell.

Molluscan fauna

A total of 144 molluscan species were identified in the dredge samples (Table 3). Among them, 67 species belong to Gastropoda, 70 to Bivalvia and 7 to Scaphopoda. Living individuals of 25 species were recovered: 6 Gastropoda, 16 Bivalvia and 3 Scaphopoda. Nine species were identified for the first time around Sado Island: *Emarginula fragilis* Yokoyama (Figs. 4.1, 4.2), *Nodiscala matajiroi* Kuroda (Fig. 4.3), *Pyreneola semipicta* (Sowerby III) (Fig. 4.4), *Dimiya filipina* Bartsch, *Spondylus barbatus* Reeve (Fig. 4.5), *Agatha lepidula* Habe,

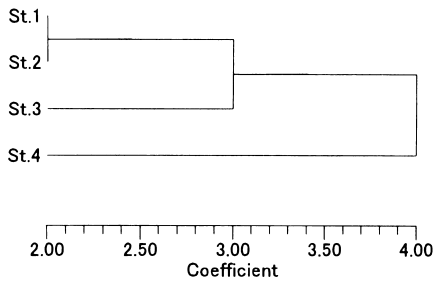

Fig. 5. Dendorgram showing the similarity in molluscan faunas of both living and dead shells from the dredge sites (Station 1 - Station 4).

Cycladicama semiasperoides (Nomura) (Fig. 4.6), *Abrina lunella* (Gould) (Fig. 4.7) and *Pitar japonicum* Kuroda and Kawamoto (Fig. 4.8).

Cluster analysis is performed on the data sets of both living and dead shells using the Jaccard coefficient (Jaccard, 1908) and the neighbor-join method of Saitou and Nei (1987). The highest similarity in species composition of living shells is recognized between St. 1 and St. 2 (Fig. 5). The lowest similarity is recorded between St. 4 and the other stations. A result similar to this was obtained from the cluster analysis for the dead shells. The cluster analysis for the molluscan faunas is concordant to the grain size classification of the sediments.

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Explanation of Plate 1

Decapod crustaceans obtained in this study. Scale bars: Figs. 1-3a, 4-6: 5 mm, Fig. 3b: 2 mm.

Fig. 1. *Anapagurus japonicus* Ortmann, male, dorsal view.
Fig. 2. *Catapaguroides japonicus* de Saint Laurent, male, dorsal view.
Fig. 3. *Australeremus triserratus* (Ortmann), male, 3a, dorsal view, 3b, dorsal view of shield and cephalic appendages.
Fig. 4. *Galathea orientalis* (Stimpson), male, dorsal view.
Fig. 5. *Cosmonotus grayii* Adams and White, male, dorsal view.
Fig. 6. *Palicus hatsusimaensis* Sakai, female, dorsal view.

Plate 1