BENTHIC FAUNA IN THE NAGURA LAGOON AND VICINITY, ISHIGAKI ISLAND, OKINAWA PREFECTURE, JAPAN

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CONTENTS

ABSTRACT

Benthic fauna and their distribution in the Nagura River Estury and Vicinity were studied. One hundred and twenty five species of molluscs and thirty three species of crustacea were collected, of which several species of bivalves, *Geroina coaxans*, *Gafrarium tumida*, *Katelysia hiantina*, *Mactra maculata* and others, and two species of crustacea, *Metapenaeus monoceros* and *Scilla serrata*, were recommended as candidates of artificial breeding.

About the problem of Water-Land Interactive Systems, the influence of the Nagura River and waste water from the Sugar Factory was discussed, and concluded that red soil from the pineapple farm along the Nagura River gave destructive effect on the benthic fauna, and waste water from the Sugar Factory, Ishigaki-Seitoh, gave nutritious bases to the proliferation of benthic fauna of the lagoon and vicinity, in contrast to the starch-factory of Kagoshima Prefecture, which gives severe destructive effect to the benthic animal of the river.

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INTRODUCTION

In 1980, a comprehensive research project on the problem of Water-Land Interactive Systems was planned by the United Nations University. Professor Iwakiri's team in Kagoshima University selected the Nagura Estuary and vicinity, Ishigaki Island, Okinawa Prefecture, as its research territory (Fig. 1). The purpose of the research was the scientific analysis of the following three subjects: 1. The Natural Environment of the Coastal Zone. 2. The Bio-ecological Features of the Coastal Zone. 3. The Socio-economic Aspects of the Use of Local Resources.

The purpose of the present study is to report on the molluscan and crustacean fauna, their distribution in the area, and to offer some basic data to the use of local resources.

TOPOGRAPHY OF THE RESEARCH AREA (Fig. 2)

At the mouth of the Nagura River, there is a lagoon which is divided from the open sea by a long sand bar. The sand bar is planted with *Casuarina equisetifolia* (Mokumaoh) to prevent erosion. Along the east and south beach line of the lagoon, there is a mangrove swamp (Fig. 2). The lagoon is 1500 meters long and 500 meters wide. It is very shallow, and more than half of the lagoon floor becomes exposed at low tide. The open sea tideland is about 400 meters wide, extends about 700 meters northwest from the Nagura-Oh-hashi (Bridge), and is 55 hectares in area. Outside this tideland, there is a wide sea-grass zone of shallow water, some 250-400 meters wide. The first research area of the present study was the langoon tideland, the second, the open sea tideland, and the third, the sea-grass zone.

MATERIALS AND METHODS

Two sampling methods the quadrat and the free were applied to collect molluscs and crustaceas. The size of each quadrat was 50 cm square. Soil was dug with a common shovel to a depth less than the length of the shovel blade. A handmade sieve of 4 mm mesh was used to separate the orgamisms from sediment. In the quadrat method, only living organisms were collected, while in the free method, both living and dead were gathered, most of them being picked up while walking around each station or from station to station, except in a few cases where living bivalves were dug out.

RESULTS

The results are described according to the sampling areas, i.e. the lagoon tidelands, the open sea tideland, and the sea-grass zone. Refer to Figure 2 for sampling site locations.

The Lagoon Tidelands (Tables 1 & 2)

Station U and Transect A

i) Quadrat Sampling

St. U: At the northwestern corner of the tideland along the right bank of the Nagura River, just inside the Nagura-oh-hashi, there is a patch of grass area, where *Zoysia macrostachya* (Oni-shiba) grows. In front of this grass area, there is an *Uca lactea* zone, where a quadrat sampling was made. This *U. lactea* zone extends for 350 meters along the right bank to St. B (Fig. 2).

St. U: *Uca lactea* zone.	Pl. Fig.	Individuals
Mollusca		
Cerithidea rhizophorarum morchii	1	5
Batillaria multiformis	8	3
Crustacea		
Uca lactea lactea	23	4
Macrophthalmus convexus	26	1
Scopimera globasa	-	1
Mictyris longicarpus	-	2

1. Transect A: This was located at the most open part of the same tideland with St. U. Four stations were set along the transect (Fig. 2).

St. A-1 was located five meters from the right bank, which was covered with waterside vegetation, *Hibiscus tiliaefolium* (Oh-hamabo), *Hernandra peltata* (Hasunoha-giri), *Pongamia pinnata* (Kuroyona), *Scaevola frutescens* var. *sericea* (Kusa-tobera), *Pandanus boninensis* (Adan), and others. Near the station, small groups of young *Rhizophora mucronata* (Ohba-hirugi) were found growing, on the stem of which several *Balanus albicostatus* (Shirosuji-fujitsubo), *Cerithidea rhizophorarum morchii* (Itokake-henatari) (Pl. Fig. 1) were found attached or climbing up (Pl. Fig. 1, 2). The surface layer of the station was composed of sand and mud. However, the amount of mud was not great, the surface soil being light yellowish brown in color. A lot of coral gravel was contained in the layer deeper than 10 centimeters.

Concerning the shellfish populations at this station, *Batillaria multiformis* was dominant, being 40 in number. Of the crabs, *Mictyris longicarpus* (Minami-kometsuki-gani) was dominant in number, but *Uca lactea* (Hakusen-shiomanegi) is larger than the former, and these two species may be equivalent in biomass. This station was on the *Uca* zone extending from St. U to St. B.

St. A-1: Scientific Name	Pl. Fig.	Individuals
Mollusca		
Theliostyla squamulata	-	2
Littoraria scabra	4	1
Cerithidea rhizophorarum morchii	1	14
Batillaria multiformis	8	40
Clypeomorus sp.	7	4
Otopleura auriscati	11	1
Pillucina pisidium	12	6
Crustacea		
Uca lactea lactea	23	8
Scopimera globosa	-	2
Mictyris longicarpus	-	19

St. A-2 was located 25 meters from the right bank, in the midst of a small stream of shallow water, less than a few centimeters in depth. The surface was sandy, and many small pebbles of quartzite were scattered about. Two rocks of quartzite were standing near this station, one was 1.5 m high and the other 1 m.

Of the gastropods, *Clypeomorus* sp. (Kanimorigai sp) (Pl. Fig. 7) was dominant, *Sermyla riqueti* (Nejihida-kawanina) (Pl. Fig. 6, insert) was second in number and *Theliostyla squamulata* (Maru-amaobune) third. But, *Sermyla* were so small that, in terms of weight, the *Theliostyla* were decisively second. No crustacea was collected.

St. A-2: Scientific Name	Pl. Fig.	Individuals
Mollusca		
Lunella coronata	-	1
Theliostyla squamulata	-	15
Clithon sowerbianus	-	1
Sermyla riqueti	6	34
Batillaria multiformis	8	8
Clypeomorus sp.	7	224
Plicarcularia bellula	-	10
Psammotaea elongata	-	5
Crustacea None		

St. A-3 was located 100 meters from the right bank of the river and in the highest part of the tideland. The dominant species was *Batillaria multiformis* (pl. Fig. 8). Seven specimens of *Pillucina* (Umenohanagai) (Pl. Fig. 12) were collected. Of the crabs, one *Scopimera globosa* and one *Mictyris longicarpus* were collected.

St. A-3: Scientific Name	Pl. Fig.	Individuals
Mollusca		
Batillaria multiformis	8	96
Clypeomorus sp.	7	1
Pillucina pisidium	12	7
Crustacea		
Scopimera globosa	-	1
Mictyris longicarpus	-	1

St. A-4 was located at the tideland edge, 195 meters from the right bank, just along the main flow of the river. The tideland surface was light yellowish-brown in color. The surface layer, about 5 cm thick, was sandy and it then became muddy black. Coral gravel was scattered on the surface. Eighty percent of the surface in this quadrat was covered by the mossy red algae *Gelidium pusillum* (Hai-tengusa), and 678 bivalves *Musculista senhousia* (Hototogisugai) were found crowding amongst the fronds of the algae. This was the only station where this species of bivalve was found. *Batillaria*

multiformis was second in number and *Clypeomorus* sp., third. The crabs collected included only two specimens of *Scopimera globosa*.

St. A-4: Scientific Name	Pl. Fig.	Individuals
Mollusca		
Sermyla riqueti	6	1
Batillaria multiformis	8	61
Clypeomorus sp.	7	31
Musculista senhousia	-	678
Pillucina pisidium	12	2
Katelysia hiantina	60	1
Psammotaea elongata	-	5
Psammotaea minor	-	4
Crustacea		
Scopimera globosa	-	2

ii) Free Sampling between Station U and Transect A

The muddy area in front of St. U was a good habitat for *Laternula rostrata* (Hirokuchi-sotohorigai) (Pl. Fig. 15), which bores perpendicularly to a depth of fifteen centimeters into the soil. Six specimens of this species and one of *Katelysia hiantina* (Yaeyama-sudare) (Pl. Fig. 60) were gathered by one person shoveling for twenty minutes.

In a low wet line near St. A-2, covered with thin layer of water, *Psammotaea elongata* (Masuogai) lived in crowds. Thirty six specimens were collected by one person for twenty minutes.

Most free sampling was made by gathering from the tideland surface walking around each stations, so that all the gastropod specimens freely sampled were living, while most of the bivalve, dead, except five species which were dug out from underground. In the following list, L means living and D, dead.

Scientific Name	Pl. Fig.	Individuals
Gastropoda:		
Lunella coronata	-	L. 5
Ritena undata	3	L. 3
Theliostyla squamulata	-	L. 43
Clithon sowerbianus	-	L. 51
Batillaria multiformis	8	L. 42
Cerithidea rhizophorarum morchii	1	L. 25
Clypeomorus sp.	7	L. 17
Reishia clavigera	-	L. 4
Plicarcularia bellula	-	L. 26

Bivalvia:		
Modiolus elongatus	48	D. 2
Gafrarium tumidum	59	D. 3, L. 1
Katelysia hiantina	60	D. 5, L. 2
Coecella chinensis	-	D. 1
Psammotaea elongata	-	L. 38
Psammotaea minor	-	L. 3
Asaphis dichotoma	-	D. 1
Laternula rostrata	15	L. 6

2. Transect B

i) Quadrat Sampling along Transect B

Sts. B-1, B-2, B-3, and B-4 were located on the small sandspit at the eastern end of the right-side tideland. The sandspit is situated near the mouth of the Nagura River to the lagoon. There is a patch of grass area on the top of the sandspit, where *Zoysia macrostachya* (Oni-shiba) grows. Sts. B-1, B-2 and B-3 were located in front of this grass area, and St. B-4 was, in back of it. St. B-1 was located in the *Uca lactea* zone which occupies the higher sandy part of the sandspit, and St. B-3 in the *Uca vocans* zone which occupies the lower muddy part. Sts. B-2 and B-4 were areas where two species of *Uca* lived together.

Molluscs and crustaceas collected in these four stations were as follows:

	Pl. Fig.	Individuals
St. B-1: *Uca lactea* zone		
Mollusca None		0
Crustacea		
Uca lactea lactea	23	11
St. B-2: *Uca vocans* and *lactea* zone		
Mollusca		
Laternula rostrata	15	2
Crustacea		
Uca vocans vocans	21	7
Uca lactea lactea	23	7
St. B-3: *Uca vocans* zone		
Mollusca None		
Crustacea		
Uca vocans vocans	21	6
Macrophthalmus convexus	26	1
Laomedia astacina	-	3
St. B-4: *Uca vocans* and *lactea* zone		
Mollusca		
Clithon sowerbianus	-	1
Cerithidea rhizophorarum morchii	1	2

Psammotaea minor	-	4
Laternula rostrata	15	1
Crustacea		
Uca vocans vocans	21	2
Uca lactea lactea	23	3

ii) Free Sampling around Transect B

The narrow area lower than the *Uca vocans* zone, which was muddy and covered with a thin layer of water, was a habitat for a kind of cerith, *Clypeomorus coralium* (Koge-tsunobue) (Pl. Fig. 5), where eighty four adults were collected by free sampling by one person for five minutes.

In the main flow from the Nagura River, in front of this tideland between St. A and B, many young shrimps of *Metapenaeus monoceros* (Yoshi-ebi) * were found in groups, and thirteen individuals were collected by free sampling by one person for a few minutes.

3. River Beach Stations

Along the Nagura River proper two points were checked, Sts. R-1 and R-2.

St. R-1 was located on the first small river beach (13 m × 50 m) along the right bank, 450 meters upstream from St. B. Mud deposition was observed in a very restricted area at the downstream end of the beach. *Uca lactea* was found living in a narrow area, 1 m × 2 m, just upstream of the muddy area. The station was located in the *Uca* zone. No mud was seen to the depth of the shovel during sampling in this station. No shellfish were observed on the beach.

St. R-2 was located on the second beach (20 m × 73 m), situated along the left bank, 250 meters upstream from St. B. Half of this beach was covered with green algae, *Monostroma nitidum* (Hitoe-gusa) **, growing on the tiny gravel which was found covering the area. Fauna in the quadrat consisted of only three individuals of a tiny crab, *Ilyoplax pusillus* (Chigo-gani). No shellfish were observed on the beach.

St. R-1: *Uca lactea* zone.	Pl. Fig.	Individuals
Mollusca None		0
Crustacea		
Uca lactea lactea	23	3
Ilyoplax pusillus	-	4
St. R-2: Ilypolax pusillus zone.		
Mollusca None		0
Crustacea		
Ilyoplax pusillus	-	3

* Identification thanks to Prof. Dr. T. Saisho, Kagoshima University.
** Identification thanks to Prof. Emer. Dr. T. Tanaka, Kagoshima University.

4. Transect C

i) Quadrat Sampling along Transect C

Four stations were located along transect C on the left-side tideland of the Nagura River (Fig. 2).

St. C-1 was located just outside the mangal. The station was not very muddy.

The count of molluscan fauna was poor, only two species being collected, *Batillaria multiformis* (14 individuals) and *Pillucina pisidium* (4) (Pl. Fig. 8 & 12).

Two species of Brachyura were collected, *Scopimera globosa* (1) and *Mictyris longicarpus* (minami-kometsuki-gani) (6).

St. C-2 was located 60 meters away from St. C-1, at the highest part of the tideland. The surface layer, less than 10 cm thick, was sandy and light yellowish-brown in color. The deeper layer was black and muddy. The dominant molluscan species was *Batillaria multiformis* (31), and the dominant Crustacean, *Scopimera globosa* (7).

St. C-3 was located 100 meters away from St. C-2, along the main flow of the Nagura River. The surface layer was sandy, and attained a thickness of 10 cm, being the thickest among all the stations in the lagoon. This station was a habitat for *Psammotaea minor*, as seen in the following list.

The only Crustacea collected was *Scopimera globosa* (4).

St. C-4 was located 35 meters away from St. C-3, in the branch flow from the south, where the water was 20 cm deep, and an aquatic phanerogamous plant, *Zostera nana* (Ko-amamo), grew.

The number of molluscan fauna was the highest in this transect, eight species being collected, of which *Clypeomorus* sp. (Pl. Fig. 7) was dominant, 181 specimens being collected.

No crustacea was collected.

Fauna along transect C

St. C-1	Scientific Name	Pl. Fig.	Individuals
	Mollusca		
	Batillaria multiformis	8	14
	Pillucina pisidium	12	4
	Crustacea		
	Scopimera globosa	-	1
	Mictyris longicarpus	-	6
St. C-2			
	Mollusca		
	Batillaria multiformis	8	31
	Clypeomorus sp.	7	1
	Pillucina pisidium	12	2
	Coecella chinensis	-	6
	Psammotaea minor	-	5
	Crustacea		
	Scopimera globosa	-	7
	Mictyris longicarpus	-	4

St. C-3		
Mollusca		
Pillucina pisidium	12	3
Katelysia hiantina	60	1
Psammotaea minor	-	257
Crustacea		
Scopimera globosa	-	4
St. C-4		
Mollusca		
Sermyla riqueti	6	53
Batillaria multiformis	8	20
Clypeomorus sp.	7	181
Plicarcularia bellula	-	2
Pillucina pisidium	12	6
Gafrarium tumida	59	2
Katelysia hiantina	60	1
Psammotaea minor	-	25

Psammotaea minor in St. C-3 is a target in shellfish gathering at low tide by the inhabitants, but it has no market value.

5. Transect D

i) Quadrat Sampling along Transect D

The line was located across the southern part of the lagoon from the sand bar to the mud flat around the mangal (Fig. 2). This tideland was not as high as at A and C, most of the eastern two-thirds being underwater, crossed by two waste-water flows from the sugar factory, Ishigaki Seitoh, entering the lagoon at the eastern corner of this area (Fig. 2). At the highest part, near St. D-2, *Mictyris longicarpus* (Minami-kometsuki-gani) zone was observed in good development.

Fauna Along Transect D

St. D-1: Scientific Name	Pl. Fig.	Individuals
Mollusca		
Clithon sowerbianus	-	9
Sermyla riqueti	6	57
Pillucina pisidium	12	12
Psammotaea minor	-	6
Crustacea		
Scopimera globosa	-	3

St. D-2:		
Mollusca		
Theliostyla squamulata	-	3
Clithon sowerbianus	-	2
Sermyla riqueti	6	5
Batillaria zonalis	-	1
Batillaria multiformis	8	51
Pillucina pisidium	12	9
Psammotaea minor	-	6
Crustacea		
Macrophthalmus convexus	26	4
St. D-3:		
Mollusca		
Clithon sowerbianus	-	1
Sermyla riqueti	6	1
Batillaria multiformis	8	6
Crustacea		
Macrophthalmus convexus	26	2
St. D-4:		
Mollusca		
Clithon sowerbianus	-	2
Sermyla riqueti	6	23
Batillaria multiformis	8	3
Psammotaea minor	-	4
Crustacea		
Uca vocans vocans	21	1
Macrophthalmus convexus	26	19
St. D-5: With 4 mm mesh net.		
Mollusca		
Sermyla riqueti	6	115
Geloina coaxans	13	1
Crustacea		
Macrophthalmus convexus	26	1
St. D-6: With 1.6 mm mesh net.		
Mollusca		
Clithon sowerbianus	-	1
Sermyla riqueti	6	1645
Geloina coaxans	13	1
Crustacea None		0

A tremendous number of snails, *Sermyla riqueti*, lived on the mud flat around D-5, and 115

specimens were collected from 50 cm square by sieving with 4 mm mesh net, which was used generally in the present surveys. But, the snail is of small size, the two largest specimens collected measuring 15 × 5.2 mm and 14 × 6.0 mm. And it was thought that many smaller specimens might have been lost through the net. So, an additional sampling was carried out at St. D-6 in the same area with St. D-5, using a 1.6 mm mesh net. The result was conspicuous as shown in the above table, fifteen times more specimens being collected.

Sermyla riqueti was found widely distributed all over the surveyed area from the lagoon to the open sea tideland and farther to the sea-grass zone; and its home habitat was ascertained to be the area around Sts. D-5 and D-6, where 1645 specimens being collected in a quadrat.

The waste water from the sugar factory, Ishigaki Seitoh, flows in front of Sts. D-5 and D-6 (Fig. 1). The flow is about 15 meters wide and 20 centimeters deep at low tide. On the bed of the flow, no *Sermyla* could be seen. But the snail lived in high population density in the zones about twenty meters wide on both sides of the flow. The density diminished towards the mangal, and no *Sermyla* could be seen in the mangal.

ii) Free Sampling in and outside the Mangal near Station D-6

In the Mangal: The soil was not so muddy as around Sts. D-5 and D-6; one's foot did not sink. There were soil mounds about 30 cm wide and about 15 cm high (Pl. Fig. 18). A kind of crab belonging to Subf. Sesarminae, *Sarmatium crassum* (Mizote-ashihara-gani) (Pl. Fig. 19), lived in the labyrinth of tunnels under the mound. Nine specimens of the crab and three of the mangal bivalve *Geloina coaxans* (Pl. Fig. 13) were gathered by one person for an hour. These two species of animals were the principal inhabitants of the Nagura mangal. The evidence of fauna was very poor.

Specimens collected by one person in an hour are as follows.

In the Mangal near St. D-6	Pl. Fig.	Individuals
Mollusca		
Cassidula nucleus	-	L. 1
Geloina coaxans	13	L. 3
Crustacea		
Sesarmops sp. (Young)	32	L. 4
Sarmatium crassum	19	L. 9

Along the Margin of the Mangal, in and outside it: A kind of mudskipper, *Periophthalmus vulgaris* (Minami-tobi-haze) was found. This fish lives in a perpendicular tubular pore, five to ten centimeters wide, with the edge projecting a few centimeters high (Pl. Fig. 22). It skips around on the mud flat very actively at low tide.

In addition, in a very wide area in and outside the mangal, a kind of blue crab, *Scylla serrata* (Nokogiri-gazami) (Pl. Fig. 24) was found. This is the largest species among Japanese blue crabs, attaining 20 cm in carapace width, and is the one most sought after at low tide by the inhabitants because of its high commercial value. But, its population density is very low, only one specimen being gathered during the present survey. Further, two additional species of large sized crabs were

collected in this area; *Baptozius vinosus* (Kumadori-ohgi-gani) (Pl. Fig. 25) and *Cardisoma carnifex* (Minami-oka-gani) * (Pl. Fig. 27). The former is not used as foodstuff, as its toxicity is suspected, belonging to the family *Xanthidae*. Of the latter species, one specimen was found by Prof. Dr. H. Tagawa and Mr. E. Suzuki, present team members, in the mangal near the land, and its photograph (Pl. Fig. 27) was available by their courtesy.

Outside the Mangal: There was a *Clypeomorus coralium* (Koge-tsunobue, Pl. Fig. 5) zone a few meters wide, just outside the mangal. This zone was also the main habitat of the mangal bivalve *Geloina*. The quantity of fauna in this zone was very high. Specimens collected by two person for thirty minutes were as follows:

Outside the Mangal near St. D-6.	Pl. Fig.	Individuals
Mollusca		
Theliostyla squamulata	-	L. 3
Clithon sowerbianus	-	L. 42
Batillaria zonalis	-	D. 1
Batillaria multiformis	8	L. 33
Clypeomorus coralium	5	L. 237
Geloina coaxans	13	L. 7
Geloina proxima	14	L. 1
Psammotaea minor	-	L. 1
Merisca diaphana	16	L. 1
Crustacea		
Macrophthalmus pacificans	31	L. 1

(L. means living and D., dead)

A deformed specimen of *Cerithidea rhizophorarum morchii*** was found near St. D-1 (Pl. Fig. 9). The reason for its deformation is not clear.

The Open Sea Tideland

The tideland outside the sand bar is 300-400 meters wide and 55 hectares in area, extending towards the northwest about 700 meters along the outflow of the Nagura River (Fig. 2). On the outer half of the tideland, there grow two species of delicate sea-grasses, *Halodule pinifolia* (Matsuba-umijigusa) and *H. uninervis* (Umijigusa). A halodule zone becomes exposed at low tide, whereas the real sea-grass zone which expands in the next outer area does not become exposed even at the spring tide. This zone develops well in the Nagura area, including six species of larger types of sea-grasses like *Cymodocea serrulata* (Ryukyu-amano), *C. rotundata* (Beni-amamo), and others. In addition, there grow many species of algae, including *Cladosiphon okamuranus* (Okinawa-mozuku), *Acetabularia ryukyuensis* (Kasa-nori) and others (T. Katsumata, 1982). Further, there live many species of benthic animals.

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* Identification thanks to Late Prof. Dr. Tune SAKAI, Tokyo University of Education.

** Identification thanks to Dr. T. HABE, President of Malacological Society of Japan

Quadrat and free samplings were made in these areas, in order to determine the fauna and the distribution of Mollusca and Crustacea.

i) Quadrat Sampling in the Open Sea Tideland

St. E-1 was located 70 meters from the Nagura-oh-hashi. This area was brackish, as was the area inside the bridge. The surface layer, a few centimeters thick, was sandy and light yellowish brown in color, with small coral gravel scattered on it. On the underside of the gravel, *Lunella coronata* (Kangiku-gai) lived. The deeper layer was black with mud. The dominant species was *Clypeomorus* sp. (Pl. Fig. 7), 127 individuals being collected in the quadrat.

St. E-1: Scientific Name	Pl. Fig.	Individuals
Mollusca		
Lunella coronata	-	4
Theliostyla squamulata	-	11
Batillaria multiformis	8	10
Clypeomorus sp.	7	127
Pillucina pisidium	12	4
Katelysia hiantina	60	2

St. E-2 was located 150 meters from St. E-1 towards the W.S.W. The sandy surface layer was a few cm thick and light yellow brown in color. Coral gravel was scattered on the surface. The deeper layer was black with mud. This is the central area for shell-fishing at low tide, the principal catch being two species of bivalves, *Katelysia hiantina* (Yaeyama-sudare) (Pl. Fig. 60), and *Gafrarium tumida* (Arasuji-kemangai) (Pl. Fig. 59). The area has been dug again and again by many inhabitants, and the sampling was poor, only three young *Katelysia* being collected in the quadrat, and no *Gafrarium*.

According to catch number, *Pillucina pisidium* was the dominant species. But this bivalve is very small, being less than 8 mm across (Pl. Fig. 12), and it would be improper to call this species dominant. However, there were no other prolific species in this quadrat.

St. E-2: Scientific Name	Pl. Fig.	Individuals
Mollusca		
Lunella coronata	-	5
Theliostyla squamulata	-	5
Plicarcularia bellula	-	2
Syrnola sp.	45	2
Anodontia edentula	50	2
Pillucina pisidium	12	8
Fragum loochooanum	-	3
Montacutona (?) sp.	80	2
Katelysia hiantina	60	3

St. E-3 was located 350 meters from St. E-2 towards the W.S.W., just outside the tideland, at the inner margin of the sea-grass zone. The surface layer was sandy, but the deeper layer, muddy.

The dominant species was *Tellinella staurella* (Hime-nikko-gai) (Pl. Fig. 65), having 21 individuals in the quadrat. The Molluscan fauna was very rich.

St. E-3: Scientific Name	Pl. Fig.	Individuals
Mollusca		
Liotinaria peroni	-	1
Euplica versicolor	-	10
Pinna muricata	49	1
Anodontia edentula	50	3
Pitar pellucidum	57	1
Semele carnicolor	-	7
Tellinella staurella	65	21

St. F-1 was located 300 meters from St. E-1 towards the N.W., along the river outflow. The station was situated in the delicate sea-grass *Halodule pinifolia* (Matsuba-umijigusa) zone, which was about 100 meters wide. The surface layer a few centimeters thick was compact sand, but the deeper part was black with mud. Molluscan fauna was scarce, only two species being collected. One of these two, *Anodontia edendula*, consisted only of juvenile forms.

St. F-1: Scientific Name	Pl. Fig.	Individuals
Mollusca		
Anodontia edentula	50	12
Tellinella staurella	65	3

St. F-2 was located 150 meters from St. F-1 towards the W.S.W., in the *Halodule pinifolia* zone. The surface layer was compact, but the deeper layer was black with mud. In this zone, there were some massive eroded coral stumps (Pl. Fig. 66), which were crowded with *Chama iostoma* (Kanetsuke-zaru) (Pl. Fig. 67), *Clypeomorus bifasciatus* (Kasuri-kanimori) (Pl. Fig. 68), and others (Pl. Fig. 69-79) about which details will be mentioned later. Nine species were collected in the quadrat, but only in small quantities, and the quadrat had no dominant species.

St. F-2: Scientific Name	Pl. Fig.	Individuals
Mollusca		
Lunella coronata	-	1
Clypeomorus bifasciatus ?	68	1
Clypeomorus trailli kikaiensis	-	1
Clypeomorus sp.	-	2
Euplica versicolor	-	2
Milda ventricosa	10	1

Semele carnicolor	-	2
Loxoglypta transcalpta	-	2
Tellinella staurella	65	2

St. F-3 was located 150 meters from St. F-2, towards the W.S.W., at the inner part of the sea-grass *Cymodocea* zone. The station was under water. The bivalve *Tellinella staurella* (Pl. Fig. 65) was dominant, seven specimens being retrieved.

St. F-3: Scientific Name	Pl. Fig.	Individuals
Mollusca		
Chama iostoma	67	1
Bonartemis histrio	52	1
Semele carnicolor	-	1
Quadrans garadia	63	1
Tellinella staurella	65	7

St. G was located 350 meters from St. F-1 towards the N.W., just outside the tip of the tideland, at the inner margin of the sea-grass zone. the surface layer, a few centimeters thick, was sandy, but the deeper layer was muddy. *Quadrans garadia* was dominant.

St. G: Scientific Name	Pl. Fig.	Individuals
Mollusca		
Canarium urceum	35	1
Euplica versicolor	-	4
Niotha albescens	-	4
Quadrans garadia	63	7

St. H-1 was located 400 meters from St. E-3 towards the south, just outside the tideland, at the inner margin of the sea-grass zone. The station was under water. The surface layer, a few centimeters thick, was sandy, but the deeper layer, muddy. In number, *Euplica versicolor* was dominant, 9 specimens having been collected, but this species is so small that it would be improper to call it dominant. The dominant species, therfore, may be said to be either *Modiolus plumescens* (Ryukyu-hibarigai) (Pl. Fig. 47) or *Anodontia edentula* (Pl. Fig. 50). Specimens of the latter species were all young.

St. H-1: Scientific Name	Pl. Fig.	Individuals
Mollusca		
Clypeomorus trailli kikaiensis	-	1
Euplica versicolor	-	9
Modiolus plumescens	47	3
Andontia edentula	50	7

Pillucina striata	-	2
Fragum loochooanum	-	1
Tellinella staurella	65	1

St. H-2 was located 500 meters from St. H-1 towards the S.E., in the delicate sea-grass *Halodule pinifolia* zone, just in front of the outflow from Nagura-Ko-Bashi. The bed included a lot of coral gravel and its deeper layer was not as black as in the other stations, however it had a strong mud smell. *Pillucina pisidium* (Pl. Fig. 12) was dominant. Though this bivalve is very small, smaller than 8 mm, 69 specimens were collected in the quadrat.

St. H-2: Scientific Name	Pl. Fig.	Individuals
Mollusca		
Canarium urceum	35	1
Plicarcularia bellula	-	1
Pillucina pisidium	12	69
Fragum loochooanum	-	10
Quadrans garadia	63	1

ii) Free Sampling in the Open Sea Tideland

Collected specimens comprise 50 species of gastropods and 39 species of bivalves, which are listed in Table 4.

Near St. E-1, *Theliostyla squamulata*, *Batillaria multiformis*, and *Clypeomorus* sp. were collected in large numbers, just as in the quadrat sampling at St. E-1. These species like brackish circumstances. Ninety three specimens of *Batillaria multiformis* were collected at the tideline near St. E-1.

Six species of moon shells were collected, of which two species, *Cryptonatica lurida* and *Polinices mellosus*, were numerous (Table 4). These two species were found in two different habitats, the former near the beach and the latter away from it, but both in the low and wet areas.

The abraded coral masses which are left in the outer part of the tideland were covered with the adhesive bivalve, *Chama iostoma*, among which *Clypeomorus bifasciatus* and others were found in large numbers. Seventeen species were collected here, all typical to rocky shores, as shown in the following list (Pl. Fig. 66).

Scientific Name	Pl. Fig.	Individuals
Trochus maculatus	70	3
Lunella coronata	-	5
Clypeomorus bifasciatus ?	68	83
Monetaria moneta rhomboides	74	3
Erronea errones	73	2
Ponda vitellus	71	2

Cymatriton nicobaricus	72	1
Chicoreus brunneus	75	2
Cronia margariticola	-	1
Muricodrupa fiscellum	78	4
Peristernia sulcata ustulata	-	2
Strigatella zebra	-	2
Strigatella retusa	77	2
Milda ventricosa	10	1
Barbatia cruciata	79	4
Malleus daemoniacus	69	38
Chama iostoma	67	34

Sea-Grass Zone

The sea-grass zone outside the open sea tideland is 250-400 meters in width and 75 hectares in area, of which the northern two-thirds was the research area. Seven species of sea-grasses and 98 species of algae were recorded in this zone by T. Katsumata (1981), of which two species of the sea-grasses, *Cymodocea serrulata* (Ryukyu-amamo) and *C. rotundata* (Beni-amamo) and two species of the algae, *Acetabularia ryukyuensis* (Kasanori) and *Cladosiphon okamuranus* (Okinawa-mozuku) were conspicuous. This zone is always under water, even in the spring tide.

Six stations were checked in this zone, two each in three transects, the northern, the middle, and the southern (Fig. 2). The sampling was made by sieving ten shovelfuls of soil dug up in place of making a quadrat sampling at each station.

i) Station Sampling in the Sea-Grass Zone

St. SG-1, in the northern transect, was located 100 meters south of St. G and 50 meters from the inner margin of the sea-grass zone. It was 20 centimeters deep. Sixteen species and forty-nine individual molluscs and one species and one individual crustacea were collected. *Tellinella staurella* was dominant. The species collected are shown in the following list.

St. SG-1 Scientific Name	Pl. Fig.	Individuals
Gastropoda		
Iwakawatrochus urbanus	-	3
Ethminolia stearnsii	-	D. 2
Smaragdia rangiana puella	-	D. 1
Sermyla riqueti	6	5
Batillaria multiformis	8	3
Naticarius onca	-	1
Euplica versicolor	-	9
Niotha albescens	-	1
Conus marmoratus bandanus	-	1

Bivalvia		
Modiolus plumescens	47	1
Modiolus elongatus	48	1
Anodontia edentula	50	3
Tapes phenax	-	1
Semele carnicolor	-	1
Quadrans garadia	63	3
Tellinella staurella	65	13
Brachyura		
Etisus electra	87	1

St. SG-2 was located 250 meters from St. SG-1 to the N.W. and 150 meters from the outer margin of the sea-grass zone. It was 45 centimeters deep. Seven species and nine individual molluscs, and four species and four individual crustacea were collected. *Quadrans garadia* and *Tellinella staurella* were dominant, though only two of each were gathered. The species collected are shown in the following list.

St. SG-2 Scientific Name	Pl. Fig.	Individuals
Gastropoda		
Ischnocerithium rostratum	-	D. 1
Naticarius onca	-	1
Euplica versicolor	-	1
Daucicomus vitulinus	36	1
Bivalvia		
Glycymeris reevei	-	1
Quadrans garadia	63	2
Tellinella staurella	65	2
Macrura		
Pseudosquilla ciliata	-	1
Brachyura		
Menaethius monoceros	-	1
Thalamita admete	-	1
Etisus electra	87	1

St. SG-3 was located 50 meters from St. E-3 to the south and 50 meters from the inner margin of the sea-grass zone. It was 20 centimeters deep. Fifteen species and thirty individual molluscs, and three species and three individual crustacea were collected. *Anodontia edentula* was dominant, and *Quadrans garadia*, subdominant. The species collected are shown in the following list.

St. SG-3 Scientific Name	Pl. Fig.	Individuals
Gastropoda		
Iwakawatrochus urbanus	-	D. 4
Smaragdia rangiana puella	-	D. 1
Indomitrella hirundo	-	D. 1
Euplica versicolor	-	2
Arenimitra exasperata	88	1
Otopleura auriscati	11	1, D. 2
Bivalvia		
Modiolus elongatus	48	1
Pinna muricata	49	1
Anodontia edentula	50	5
Codakia paytenorum	55	2
Glycydonta marica	-	1
Mactra maculata	61	1
Meropesta nicobarica	-	1
Quadrans garadia	63	4
Tellinella staurella	65	2
Macrura		
Upogebia sp.		1
Brachyura		
Gomeza bicornis	86	1
Etisus electra	87	1

St. SG-4 was located more than 100 meters from St. SG-3 to the west and less than 100 meters from the outer margin of the sea-grass zone. It was 45 centimeters deep. Six species and 36 individuals of molluscs, and one species and one individual of crustacea were collected. The fauna was simple, but individual numbers were high. *Tellinella staurella* was dominant, and *Anodontia edentula*, subdominant. *Euplica versicolor* is of small size and quite inconspicuous. The species collected are shown in the following list.

St. SG-4 Scientific Name	Pl. Fig.	Individuals
Gastropoda		
Canarium urceum	35	1
Euplica versicolor	-	9
Aliculastrum cylindricum	-	1
Bivalvia		
Anodontia edentula	50	9
Pillucina striata	-	1
Tellinella staurella	65	15
Brachyura		
Etisus electra	87	1

St. SG-5 was located 400 meters from Nagura-ko-hashi to the west and 50 meters from the inner margin of the sea-grass zone. It was 20 centimeters deep. Fifteen species and 121 individual molluscs and two species and two individual crustaceas were collected. *Tellinella staurella* was dominant, and *Anodontia edentula*, subdominant. *Sermyla riqueti* and *Euplica versicolor* were of small size and inconspicuous, though their individual numbers were high. The species collected are shown in the following list.

St. SG-5 Scientific Name	Pl. Fig.	Individuals
Gastropoda		
Iwakawatrochus urbanus	-	2
Sermyla riqueti	6	59
Clypeomorus trailli kikaiensis	-	D. 4
Natica solida	46	1
Naticarius onca	-	1
Muricodrupa fiscellum	78	2
Euplica versicolor	-	15
Nassarius costatus	43	1
Cylindrobulla sp.	-	1
Bivalvia		
Barbatia cruciata	79	1
Anodontia edentula	50	13
Pitar pellucidum	57	1
Semele carnicolor	-	2
Tellinella staurella	65	17
Macoma incongrua	16	D. 1
Brachyura		
Menaethius monoceros	-	1
Typhlocarcinops canaliculata	83	1

St. SG-6 was located 220 meters from St. SG-5 to the west and 100 meters from the outer margin of the sea-grass zone. It was 45 centimeters deep. Ten species and 47 individual molluscs and one species and one individual crustancea were collected. *Tellinella staurella* was dominant, and no subdominant species was found. The species collected are shown in the following list.

St. SG-6 Scientific Name	Pl. Fig.	Individuals
Gastropoda		
Iwakawatrochus urbanus	-	8
Euplica versicolor	-	1
Cylindrobulla sp.	-	1
Acteocina coarctata	-	D. 1

Bivalvia		
Modiolus plumescens	47	1
Modiolus elongatus	48	1
Anodontia edentula	50	3
Pillucina striata	-	3
Semele carnicolor	-	1
Tellinella staurella	65	28
Brachyura		
Etisus electra	87	3

ii) Free Sampling in the Sea-Grass Zone

Near St. SG-1, the following species of molluscs and crustaceas were collected by free sampling.

Scientific Name	Pl. Fig.	Individuals
Gastropoda		
Naticarius onca	-	1
Arenimitra exasperata	88	1
Milda ventricosa	10	1
Bivalvia		
Anodontia edentula	50	1
Vasticardium nigropunctatum	-	1
Quadrans garadia	63	3
Tellinella staurella	65	10
Brachyura		
Matuta lunaris	-	1
Thalamita stimpsoni	81	1
Portunus pelagicus	-	1
Portunus cf. *argentatus*	82	1

DISCUSSION AND CONCLUSION

1. Mollusca: Out of one hundred and twenty five species, only six were principal targets of the inhabitants in shellfish gathering at low tide; in the lagoon four species, *Geloina coaxans*, *Geloina proxima*, *Psammotaea elongata*, and *Psammotaea minor*; and on the open sea tideland two species, *Gafrarium tumida* and *Katelysia hiantina*.

Geloins live in and around the mangal. They were most frequently collected just outside the forest near Sts. D-5 and D-6 (Fig. 2), together with a kind of cerith *Clypeomorus coralium* (Pl. fig. 5).

Psammotaea elongata was found in abundance in a low wet line near St. A-2, and Psammotaea minor in St. C-3, a sandy part. These two species may be said to belong to the secondline targets for gatherers.

Gafrarium (Pl. Fig. 59) and *Katelysia* (Pl. Fig. 60) are the most valued species in the Nagura tidelands and most of them live in the open sea tideland, where many inhabitants dig again and again to collect them, so that their population density is not great.

If molluscan culture is planned in this area, three likely candidates are *Geloina coaxans*, *Gafrarium tumida*, and *Katelysia hiantina*. In addition, there are other bivalves which might have value as candidates: *Anadara maculosa*, *Pinna muricata*, *Vasticardium nigropunctatum*, *Regozara flavum*, *Pitar striatum*, *Tapes phenax*, *Mactra maculata*, *Mactra mera*, *Meropesta nicobarica*, *Asaphis dichotoma*, and *Tellinella staurella*. Which of these should be selected must be decided by considering their taste and the degree of difficulty in culturing them.

Tellinella staurella (Pl. Fig. 65) is the dominant species in the sea-grass zone outside the open sea tideland. It lives in a very high population density. It may have some relation with its taste that this bivalve is left in such a high population density.

2. Other molluscs which have no value as human foodstuffs are, nevertheless, important as members of the natural food chain in this area, espescially the brackish water mud snail *Sermyla riqueti* (Nejihida-kawanina) (Pl. Fig. 6). This small snail lives most abundantly on the mud flat around the mangal near St. D-6, where 1645 snails were collected in a 50 cm square by sieving with a 1.6 mm mesh net. This small snail seems to be a kind of mud feeder. It lives all over the area surveyed, as far as the sea-grass zone which seems to be covered with pure sea water at high tide.

3. In front of Sts. D-5 and D-6, there flows the waste water from the sugar factory Ishigaki Seitoh Co., Ltd. Sermyls live on both sides of the flow most abundantly. Their population density diminishes towards the mangal, and they do not live in the mangal itself. Sermyls are not always connected with the mangal, but with the mud.

4. Among the molluscs, the large sized clam *Geloina* (Pl. Fig. 13, 14) lives in the mud flat in and around the mangal, and is a valued target of the shell gatherers at low tide. In the Nagura mangal, no such large sized mud-whelks as *Telescopium* and *Terebralia* were found, though these are common in tropical mangals, but *Clypeomorus coralium* (Pl. Fig. 5) was thought to be what corresponds to these large sized tropical species. An abraded shell of *Telescopium telescopium* was collected in the open sea tideland, but no living individual was seen.

5. In the tideland situated near the mouth of the lagoon, along the right side of the main flow of the Nagura River, an area which is rather sandy and harder than the *Sermyla* area, the following molluscs were common: *Clypeomorus* sp. (Pl. Fig. 7), *Batillaria multiformis* (Pl. Fig. 8), *Clithon sowerbianus*, *Theliostyla squamulata*, *Musculista senhousia*, *Psammotaea elongata*, *Psammotaea minor*, and *Laternula rostrata* (Pl. Fig. 15).

6. Mud was distributed all over the studied area, except in the Nagura River proper. It was abundantly deposited even in the sea-grass zone outside the open sea tideland. Mud was most deeply deposited in the D-5 and D-6 areas of the lagoon (Fig. 2), at the eastern corner of which waste water from the sugar factory, Ishigaki Seitoh, flows in.

The waste drain from Ishigaki Seitoh (Fig. 2) is about 70 centimeters wide. The waste water was about 25 centimeters deep, flowing with fairly good speed. It was translucent, slightly turbid, with yellow tints, and sometimes had a sweet odor. After reaching the lagoon, the flow expands its width and reduces its speed.

The present writer (1975) reported an example of severe pollution by organic waste from starch factories on the rivers around Shibushi Bay, Kagoshima Prefecture, which destroyed the river snail *Semisalcospira libertina* and other benthic animals[5].

The waste water from Ishigaki Seitoh was not so heavily polluted as that from the starch factories. Organic pollution is not always harmful. The existence of a proper amount of organic substances, represented by mud accumulation in this case, is rather necessary to the life of various benthic organisms, helping to account for the fact that there 125 species of shell bearing molluscs and 32 species of crustaceas were collected during the present surveys. The good development of the sea-grass zone outside the open sea tideland seems also to have been due to a proper accumulation of mud. Thus pollution due to the waste water from Ishigaki Seitoh was seen to be mild, and was thought to have had rather positive effects on the flora and fauna of the Nagura Estuary and vicinity. But, it is always necessary to try to avoid heavy pollution.

7. Concerning the River Nagura-gawa, there were two kinds of contamination in the past, the first by the waste matter casted from a pineapple canning factory and the second by the red soil transported from the pineapple farms along the river.

The pineapple canning factory was established in 1955 and was in operation till 1972, when the financial support which had been given to the pineapple cultivation by government was stopped. According to the present study, no trace of this kind of contamination was observed, both at Sts. R-1 and R-2 no mud deposition being seen to the depth of shovel blade.

It is necessary for the pineapple farms to scrape off the surface soil every three years in order to keep their productivity, and then considerable amount of soil is transported by rain and this causes terrible damage to the benthic fauna downstream. About this kind of damage due to soil deposition, there are some other reports: Okinawa Prefecture (1978) reported on the destructive effect of red soil outflow on the coastal fishing ground[2], K. Yamazato (1978) made an experimental observation on the effect of red soil on the life of scleractinian corals[13], K. Hirata (1980) reported on two cases where severe damage was given to the coral reefs in Amami-Oshima by red soil deposition[6], and A. Shinagawa et al. (1981) referred to this problem from the pedological standpoint[11].

No mollusca was found living in two river beaches examined in the Nagura river. And this added one more case where destructive effect of the red soil may suspected against the life of benthic organisms downstream.

8. Crustacea: There is a well developed *Uca lactea* zone along the right bank of the Nagura Estuary, at the high level of the tideland for about 350 meters, at the eastern end of which, where the Nagura River flows into the lagoon, there is a very restricted area of *Uca vocans* (Fig. 1, B). *U. vocans* lives in a lower and more deeply muddy zone than *U. lactea*. The former has red chelates in contrast to the white of the latter (Pl. Figs. 21 & 23). In general, this tideland was diagnosed to be healthy.

Eight species of Macrurs and twenty five species of Brachyurs were recorded during the present surveys, of which only two species, *Metapenaeus monoceros* and *Scylla serrata* (Pl. Fig. 24), may be thought of as candidates for culture. The blue crab *Scylla serrata* is the most valued take in the gathering at low tide in the area. It burrows in the mud flat in and around the mangal and grows to the size of twenty centimeters in carapace width. This is the largest species of the Japanese *Portunidae*.

Sarmatium crassum (Pl. Fig. 19) is a mangal crab smaller than 2.5 centimeters in carapace width, dark violet in color. It has a thick body and is nearly cubic. It is said to be a rare species in Japan and was reported by Tune Sakai in 1973 for the first time as having been found in the Fukido-gawa, Ishigaki Island and Shirahama, Iriomote Island[10], but it is not rare in the Nagura mangal, where it burrows labyrinths underground in the mangrove forest and makes mounds, very large in comparison with its body size. The mound is usually about thirty centimeters across and sometimes attains sixty centimeters (Pl. Fig. 18). Nine specimens were collected by one person for an hour in the mangal near St. D-6.

9. Dominant species of Mollusca and Crustacea in all quadrats are shown in Tables 5 & 6.

SUMMARY

1. Molluscan and Crustacean fauna and their distribution in the Nagura River Estuary and vicinity were described. The sampling area was divided into three sub-areas: the lagoon tidelands, the open sea tideland, and the sea-grass zone.

2. Collection of specimens was made by two methods, quadrat sampling and the free; the size of each quadrat was 50 cm square, and the sieve mesh was 4 mm in general, but 1.6 mm in a single quadrat in a *Sermyla* area.

3. One hundred and twenty five species of molluscs were recorded, of which only six were target species in shell-fish gathering at low tide by the inhabitants: *Geloina coaxans*, *Geloina proxima*, *Psammotaea elongata*, *Psammotaea minor*, *Gafrarium tumida*, and *Katelysia hiantina*. Three out of six species were recommended as candidates for artificial culture: *Geloina coaxans*, *Gafrarium tumida*, and *Katelysia hiantina*.

4. Out of 125 species of molluscs, eleven additional species were picked up as candidates. Which of these should be selected must be decided by comparison of their taste and by the degree of difficulty they present in culture.

5. Thirty three species of crustacea were recorded, of which two were recommended as candidates for artificial culture, *Metapenaeus monoceros* and *Scylla serrata*.

6. The blue crab *Scylla serrata* lives in holes in and around the mangal and is the take with the highest price in this area. But, its population density was not so high, only one small specimen of 62 mm in carapace width being found during the present survey.

7. The dark violet crab *Sarmatium crassum* was added to *Scylla serrata* as a species of mangal crab. It lives in labyrinth tunnels under the mound in the mangal. The fauna of benthic animals as a whole was very poor in the mangal.

8. An *Uca* zone has developed well along the north bank of the lagoon for about 350 meters from the prefectural road to the mouth of the Nagura River. From this fact and also from the rich molluscan fauna observed, this tideland was diagnosed to be very healthy.

9. Outside the open sea tideland, there is a wide sea-grass zone. In the present study, ten stations were checked in this zone, and *Tellinella staurella* was found to be dominant in eight stations, while *Quadrans garadia* and *Anodotia edentula* were each dominant in a single station.

10. About the Nagura River proper, two kinds of pollution were discussed, and it was concluded that no trace of pollution due to a pineapple canning factory, which was under operation

from 1955 to 1972, was discovered by the present study, no mud deposition having been seen in the Nagura River proper except in a very restricted area, but proof of destructive effect of red soil against benthic organisms was discussed to be certain, no living shellfish having been found in two river beaches studied.

11. Mud was distributed all over the studied area, from the lagoon to the seagrass zone, except in the Nagura River proper. Most of it seemed to be derived from the waste water discharged from the sugar factory Ishigaki Seitoh. The pollution due to this waste water was mild and was inferred to have been rather useful in making the fauna rich in this area. But it is always necessary to try to avoid heavy pollution.

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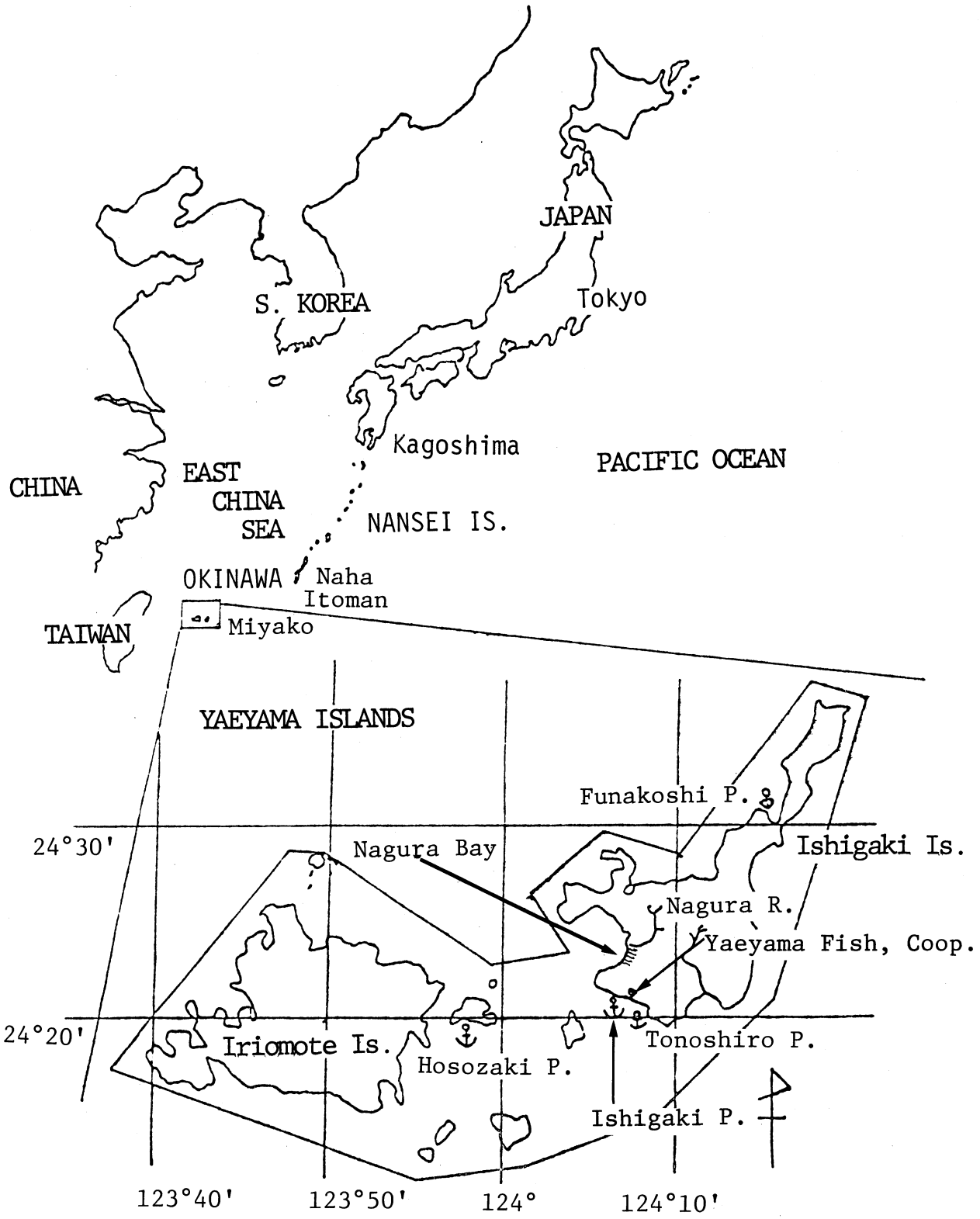


Fig. 1. A Location Map of the Study Area (Shaded) (Modified from Yaeyama Fisheries Cooperative 1982). The Water area inside the line surrounding Yaeyama Islands is the specified fishing area with the Common Fishery Right grated to the Yaeyama Fisheries Cooperative.

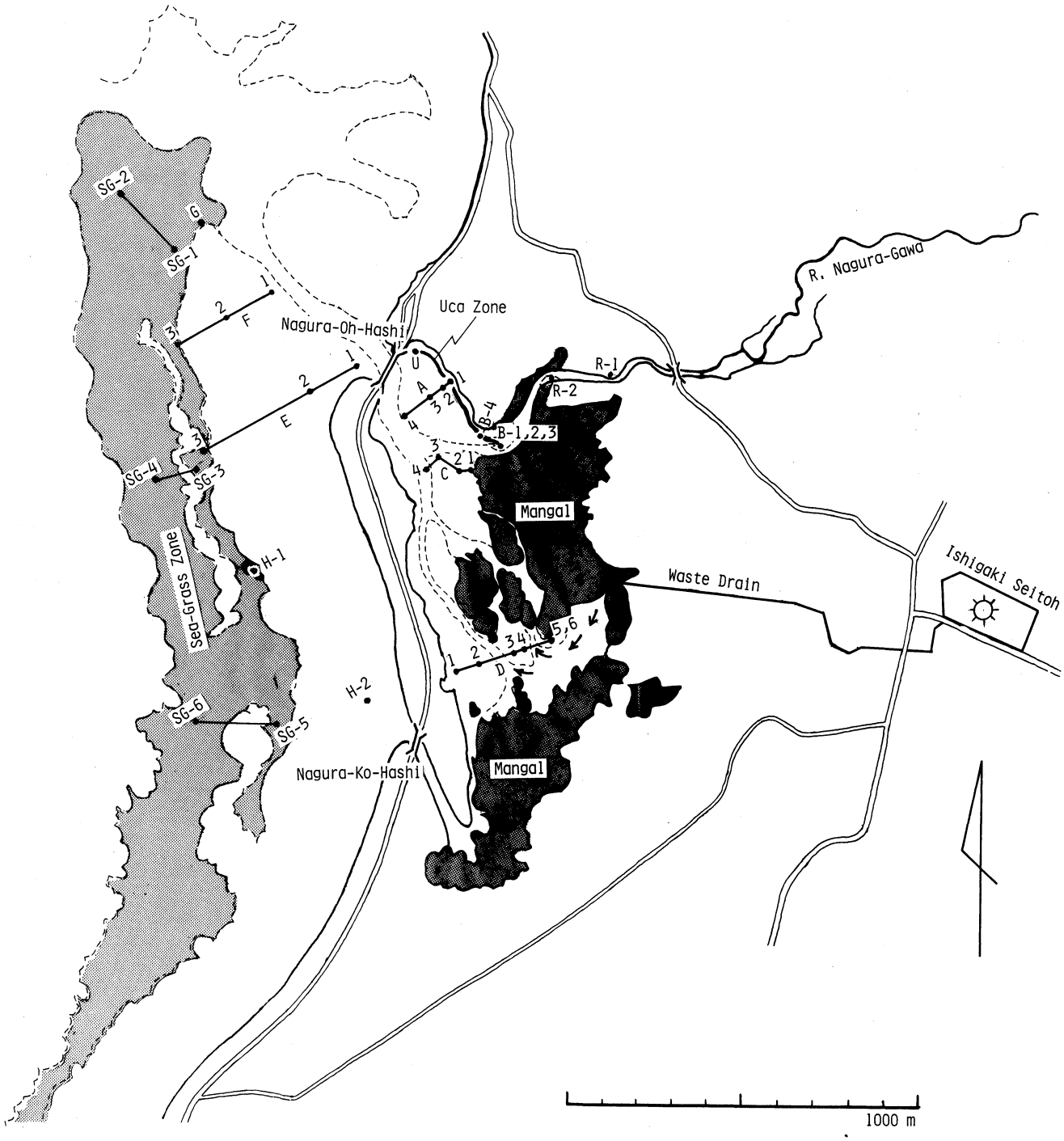


Fig. 2. Sampling Stations in the Nagura Estuary and Vicinity

Table 1. Quadrat* Sampling at Twenty One Stations in the Nagura Lagoon Tideland.

SCIENTIFIC NAME	PL.FIG.	U	A-1	A-2	A-3	A-4	B-1	B-2	B-3	B-4	R-1	R-2	C-1	C-2	C-3	C-4	D-1	D-2	D-3	D-4	D-5	D-6	TOTAL
GASTROPODA																							
1. *Lunella coronata*	—			1																			1
2. *Theliostyla squamulata*	—		2	15														3					20
3. *Clithon sowerbianus*	—			1						1							9	2	1	2		1	17
4. *Littoraria scabra*	4		1																				1
5. *Sermyla riqueti*	6			34		1										53	57	5	1	23	115	1645	1934
6. *Cerithidea rhizophorarum morchii*	1	5	14							2													21
7. *Batillaria zonalis*	—																	1					1
8. *Batillaria multiformis*	8	3	40	8	96	61							14	31		20		51	6	3			333
9. *Clypeomorus sp.*	7		4	224	1	31								1		181							442
10. *Plicarcularia bellula*	—			10												2							12
11. *Otopleura auriscati*	11		1																				1
BIVALVIA																							
12. *Musculista senhousia*	—					678																	678
13. *Geloina coaxans*	13																				1	1	2
14. *Pillucina pisidium*	12		6		7	2							4	2	3	6	12	9					51
15. *Gafrarium tumidum*	59															2							2
16. *Katelysia hiantina*	60					1									1	1							3
17. *Coecella chinensis*	—													6									6
18. *Psammotaea elongata*	—			5		5																	10
19. *Psammotaea minor*	—					4				4				5	257	25	6	6		4			311
20. *Laternula rostrata*	15							2		1													3
MACRURA																							
21. *Laomedia astacina*									3														3
BRACHYURA																							
22. *Uca vocans vocans*	21							7	6														13
23. *Uca lactea lactea*	23	4	8				11	7			3												33
24. *Macrophthalmus convexus*	26	1							1									4	2	19	1		28
25. *Scopimera globosa*	—	1	2		1	2							1	7	4		3						21
26. *Ilyoplax pusillus*	—										4	3											7
27. *Mictyris longicarpus*	—	2	19		1								6	4									32
	TOTAL	16	97	298	106	785	11	16	10	8	7	3	25	56	265	290	87	81	10	51	117	1647	3986

*50cm square

Table 2. Free Sampling in the Nagura Lagoon Tidelands.

SCIENTIFIC NAME	PL. FIG.	TRANSECTS				
GASTROPODA		A	B	D	MANGAL	TOTAL
1. *Ritena undata*	3	3		4		7
2. *Theliostyla squamulata*	—	9		18		27
3. *Clithon sowerbianus*	—	46		56		102
4. *Dostia violacea*	—			1		1
5. *Sermyla riqueti*	6	1				1
6. *Cerithidea rhizophorarum morchii*	1	17		1		18
7. *Batillaria zonalis*	—			D.2		2
8. *Batillaria multiformis*	8			3		3
9. *Clypeomorus coralium*	5		84	237		321
10. *Clypeomorus sp.*	7	1				1
11. *Plicarcularia bellula*	—	3		4		7
12. *Cassidula nucleus*	—				1	1
BIVALVIA						
13. *Regozara flavum*	53	D.1				1
14. *Geloina coaxans*	13			14	3	17
15. *Geloina proxima*	14			2		2
16. *Gafrarium tumidum*	59	D.4				4
17. *Katelysia hiantina*	60	D.5L.2				7
18. *Coecella chinensis*	—	D.1				1
19. *Psammotaea elongata*	—	38				38
20. *Psammotaea minor*	—	D.3		1		4
21. *Asaphis dichotoma*	—	D.1				1
22. *Merisca diaphana*	16			1		1
23. *Laternula rostrata*	15	6				6
MACRURA						
24. *Metapenaeus monoceros*	—		13			13
BRACHYURA						
25. *Scylla serrata*	24			1		1
26. *Baptozius vinosus*	25	1				1
27. *Macrophthalmus pacificans*	31			1		1
28. *Sesarmops sp.*	32				4	4
29. *Cardisoma carnifex*	27				1	1
30. *Sarmatium crassum*	19				9	9
	TOTAL	142	97	346	18	603

Table 3. Quadrat* Sampling at Fifteen Stations in the Nagura Open Sea Tideland and the Sea-Grass Zone.

SCIENTIFIC NAME	PL. FIG.	E-1	E-2	E-3	F-1	F-2	F-3	G	H-1	H-2	SG-1	SG-2	SG-3	SG-4	SG-5	SG-6	TOTAL
GASTROPODA																	
1. *Iwakawatrochus urbanus*	—										3		D.4		2	8	17
2. *Ethminolia stearnsii*	—										D.2						2
3. *Liotinaria peroni*	—			1													1
4. *Lunella coronata*	—	4	5			1											10
5. *Theliostyla squamulata*	—	11	5														16
6. *Smaragdia rangiana puella*	—										D.1		D.1				2
7. *Sermyla riqueti*	6										5				59		64
8. *Batillaria multiformis*	8	10									3						13
9. *Ischnocerithium rostratum*	—											D.1					1
10. *Clypeomorus bifasciatus*	68					1											1
11. *Clypeomorus trailli kikaiensis*	—					1			1						D.4		6
12. *Clypeomorus sp.*	7	127				2											129
13. *Canarium urceum*	35							1		1				1			3
14. *Natica solida*	46														1		1
15. *Naticarius onca*	—										1	1			1		3
16. *Muricodrupa fiscellum*	78														2		2
17. *Indomitrella hirundo*	—												D.1				1
18. *Euplica versicolor*	—			10		2		4	9		9	1	2	9	15	1	62
19. *Plicarcularia bellula*	—		2							1							3
20. *Nassarius costatus*	43														1		1
21. *Niotha albescens*	—							4			1						5
22. *Arenimitra exasperata*	88												1				1
23. *Dauciconus vitulinus*	36											1					1
24. *Conus marmoratus bandanus*	—										1						1
25. *Milda ventricosa*	10					1											1
26. *Otopleura auriscati*	11												1,D.2				3
27. *Syrnola (?) sp.*	45		2														2
28. *Aliculastrum cylindricum*	—													1			1
29. *Cylindrobulla sp.*	—														1	1	2
30. *Acteocina coarctata*	—															D.1	1
BIVALVIA																	
31. *Barbatia cruciata*	79														1		1
32. *Glycymeris reevei*	—											1					1
33. *Modiolus plumescens*	47								3		1					1	5
34. *Modiolus elongatus*	48										1		1			1	3
35. *Pinna muricata*	49			1									1				2
36. *Anodontia edentula*	50		1	3	12				7		3		5	9	13	2	55
37. *Codakia paytenorum*	55												2				2
38. *Pillucina striata*	—								2					1		3	6
39. *Pillucina pisidium*	12	4	8							69							81
40. *Chama iostoma*	67						1										1
41. *Fragum loochooanum*	—		3						1	10							14
42. *Montacutona(?) sp.*	80		2														2
43. *Pitar pellucidum*	57			1											1		2
44. *Bonartemis histrio*	52						1										1
45. *Katelysia hiantina*	60	2	3														5
46. *Tapes phenax*	—										1						1
47. *Glycydonta marica*	—												1				1
48. *Mactra maculata*	61												1				1
49. *Meropesta nicobarica*	—												1				1
50. *Semele carnicolor*	—			7		2	1				1				2	1	14
51. *Quadrans garadia*	63						1	7		1	3	2	4				18
52. *Quidnipagus palatam*	—									1							1
53. *Loxoglypta transcalpta*	—					2											2
54. *Tellinella staurella*	65			21	3	2	7		1		13	2	2	15	17	28	111
55. *Macoma incongrua*	16														D.1		1
MACRURA																	
56. *Upogebia sp.*	—												1				1
57. *Pseudosquilla ciliata*	—											1					1
BRACHYURA																	
58. *Menaethius monoceros*	—											1					1
59. *Gomeza bicornis*	86												1				1
60. *Thalamita admete*	—											1					1
61. *Etisus electra*	87											1	1	1		3	7
62. *Typhlocarcinops canaliculata*	83														1		1
	TOTAL	158	31	44	15	14	11	16	24	83	50	13	33	37	122	50	701

* 50cmsquare

Table 4. Free Sampling in the Nagura Open Sea Tideland.

SCIENTIFIC NAME	PL. FIG.	NUMBER OF SPECIMENS COLLECTED AROUND EACH STATION											TOTAL
		E-1	E-2	E-3	T.L.-F1	F1-G	G-H1	H1-H2	H.T.L.	N.	M.	S.	
GASTROPODA													
1. *Chrysostoma paradoxum*	—								D.1				1
2. *Trochus maculatus*	70						3						3
3. *Lunella coronata*	—	2	4		4				D.65	5			80
4. *Theliostyla squamulata*	—	10	4						D.53		1	1	69
5. *Clithon sowerbianus*	—		1				1				1		3
6. *Vittina turrita*	—					D.1							1
7. *Sermyla riqueti*	6		2										2
8. *Telescopium telescopium*	—											D. 1	1
9. *Batillaria multiformis*	8	20			93								113
10. *Clypeomorus bifasciatus*	68					13	11		D.1	83			108
11. *Clypeomorus coralium*	5	D.1											1
12. *Clypeomorus trailli kikaiensis*	—							D.2					2
13. *Clypeomorus sp.*	7	17			4								21
14. *Rhinoclavis vertagus*	33					D.3	2					2	7
15. *Ochetoclava sinensis cedonulli*	—				1		D.1						2
16. *Canarium urceum*	35			1		1	14			3	6		25
17. *Cheilea equestris*	—						D.4		D.2	D.5			11
18. *Monetaria moneta rhomboides*	74					2					1		3
19. *Erronea errones*	73					1		1					2
20. *Ponda vitellus*	71						2						2
21. *Cryptonatica lurida*	39					D.2			D.2		15	2	21
22. *Natica solida*	46									D.1	1		2
23. *Naticarius onca*	—									D.3		D.1	4
24. *Polinices flemingianus*	42										1		1
25. *Polinices pyryformis*	41									D.1	1		2
26. *Polinices mellosus*	40	D.1				D.3	1			D.1	22		28
27. *Septa munda*	76										D.1		1
28. *Cymatriton nicobaricus*	72						1						1
29. *Gutturnium muricinum*	—				D.1								1
30. *Chicoreus brunneus*	75									4			4
31. *Cronia margariticola*	—						1						1
32. *Muricodrupa fiscellum*	78					1				1		2	4
33. *Morulina concatenata*	—										D.1		1
34. *Euplica versicolor*	—							D.3					3
35. *Pollia proteus*	—									D.1			1
36. *Plicarcularia bellula*	—		1										1
37. *Nassarius coronatus*	37			1						4			5
38. *Nassarius costatus*	43		D.1								D.1		2
39. *Peristernia sulcata ustulata*	—									2			2
40. *Strigatella zebra*	—						1						2
41. *Strigatella retusa*	77									2			2
42. *Vexillum gruneri*	44										1		1
43. *Vexillum plicarium*	38					D.1							1
44. *Vexillum rugosum*	34			1		2	2						5
45. *Arenimitra exasperata*	88									D.1	1		2
46. *Conus marmoratus bandanus*	—								D.2		D.1		3
47. *Milda ventricosa*	10							D.1		1			2
48. *Solidula sulcata*	—									1			1
49. *Bulla cruentata vernicosa*	—						D.1						1
50. *Aliculastrum cylindricum*	—								D.1	D.1			2
BIVALVIA													
51. *Barbatia cruciata*	79						4						4
52. *Anadara maculosa*	—											D.1	1
53. *Modiolus plumescens*	47								D.1				1
54. *Pinna muricata*	49				1								1
55. *Malleus daemoniacus*	69						5			33			38
56. *Anodontia edentula*	50		D.4				D.1	D.2	D.36				43
57. *Codakia tigerina*	54			D.1									1
58. *Codakia paytenorum*	55		D.2	D.8			D.1		D.1				12
59. *Epicodakia divergens*	51									D.1			1
60. *Epicodakia delicatula*	—							D.2					2
61. *Pillucina pisidium*	12											12	12
62. *Chama iostoma*	67			D.15	D.1				D.8	10			34
63. *Vasticardium nigropunctatum*	—									D.6	D.2	2	10
64. *Regozara flavum*	—			1			D.2		D.2	D.1	D.2		8
65. *Fragum unedo*	53		1	D.1					D.2		D.1	D.1	6
66. *Fragum loochooanus*	—								D.1				1
67. *Gafrarium tumidum*	59	D.1	D.2		D.4			D.1	D.7		5		20
68. *Pitar striatum*	56			D.2			D.1		D.6	D.1		D.1	11
69. *Pitar pellucidum*	57		D.1				D.1		D.3				5
70. *Pitar subpellucidum*	58						D.2		D.1				3
71. *Bonartemis histrio*	52						D.1				D.1		2
72. *Katelysia hiantina*	60	D.1	D.2				D.1	D.1	D.9	2	3,D.4		23
73. *Tapes phenax*	—				1		D.1		D.2	D.1			5
74. *Ruditapes variegata*	—		D.1						D.1				2
75. *Periglypta clathrata*	—									D.1			1
76. *Mactra cuneata*	—				1	D.3	1		D.11			2	18
77. *Mactra maculata*	61			D.1			D.1		D.1				3
78. *Mactra mera*	62							D.1					1
79. *Meropesta nicobarica*	—					D.3			D.2				5
80. *Psammotaea elongata*	—	D.3	D.2					D.1	D.6				12
81. *Asaphis dichotoma*	—								D.1				1
82. *Semele carnicolor*	—				D.1	D.2			D.2				5
83. *Quadrans garadia*	63					D.5							5
84. *Merisca margaritina*	—						2						2
85. *Quidnipagus palatum*	—							D.1	D.1				2
86. *Loxoglypta transcalpta*	—					D.7							7
87. *Tellinella virgata*	64				D.1				D.1				2
88. *Tellinella staurella*	65					D.3	D.6		D.5	D.6		1	21
89. *Pharaonella perna*	—								D.1				1
TOTAL		56	28	32	113	53	75	16	238	182	73	29	895

Table 5. Dominant Species of Mollusca and Crustacea in All Quadrats in The Lagoon Tidelands.

Station		Scientific Name	Pl. Fig.	Individuals
A −1	Mollusca	*Batillaria multiformis*	8	40
	Crustacea	*Uca lactea lactea*	23	8
A −2	Mollusca	*Clypeomorus* sp.	7	224
	Crustacea	*Metapenaeus monoceros*	—	1
A −3	Mollusca	*Batillaria multiformis*	8	96
	Crustacea	*Mictyris longicarpus*	—	1
A −4	Mollusca	*Musculista senhousia*	—	678
	Crustacea	*Scopimera globosa*	—	2
B −1	Mollusca	None		0
	Crustacea	*Uca lactea lactea*	23	11
B −2	Mollusca	*Laternula rostrata*	15	2
	Crustacea	*Uca lactea lactea*	23	7
		Uca vocans vocans	21	7
B −3	Mollusca	None		0
	Crustacea	*Uca vocans vocans*	21	6
B −4	Mollusca	*Psammotaea minor*	—	4
	Crustacea	*Uca lactea lactea*	23	3
		Uca vocans vocans	21	2
C −1	Mollusca	*Batillaria multiformis*	8	14
	Crustacea	*Mictyris longicarpus*	—	6
C −2	Mollusca	*Batillaria multiformis*	8	31
	Crustacea	*Scopimera globosa*	—	7
C −3	Mollusca	*Psammotaea minor*	—	257
	Crustacea	*Scopimera globosa*	—	4
C −4	Mollusca	*Clypeomorus* sp.	7	181
	Crustacea	*Pagurus dubius*	—	7
R −1	Mollusca	None		0
	Crustacea	*Uca lactea lactea*	23	3
R −2	Mollusca	None		0
	Crustacea	*Ilyoplax pusillus*	—	3
D −1	Mollusca	*Clithon sowerbianus*	—	9
	Crustacea	*Macrophthalmus convexus*	26	4
D −2	Mollusca	*Batillaria multiformis*	8	51
	Crustacea	*Macrophthalmus convexus*	26	2
D −3	Mollusca	*Batillaria multiformis*	8	6
	Crustacea	*Macrophthalmus convexus*	26	19
D −4	Mollusca	*Sermyla riqueti*	6	23
	Crustacea	*Macrophthalmus convexus*	26	1
D −5	Mollusca	*Sermyla riqueti*	6	115
	Crustacea	*Macrophthalmus convexus*	26	1
D −6	Mollusca	*Sermyla riqueti*	6	1645
	Crustacea	None		0

Table 6. Dominant Species of Mollusca and Crustacea in All Quadrats in The Open Sea Tideland.

Station		Scientific Name	Pl. Fig.	Individuals
E −1	Mollusca	*Clypeomorus* sp.	7	127
	Crustacea	None		0
E −2	Mollusca	*Pillucina pisidium*	12	8
	Crustacea	None		0
E −3	Mollusca	*Tellinella staurella*	65	21
	Crustacea	None		0
F −1	Mollusca	*Anodondia edentula*	50	12
	Crustacea	None		0
F −2	Mollusca	*Tellinella staurella*	65	2
	Crustacea	*Daldorfia* (?) sp.	—	1
F −3	Mollusca	*Tellinella staurella*	65	7
	Crustacea	None		0
G	Mollusca	*Quadrans garadia*	63	7
	Crustacea	*Leucosia* sp.	85	1
H −1	Mollusca	*Anodontia edentula*	50	7
	Crustacea	*Typhlocarcinodes hirsutus*	84	1
H −2	Mollusca	*Pillucina pisidium*	12	69
	Crustacea	*Callianassa japonica*	—	1
SG−1	Mollusca	*Tellinella staurella*	65	11
	Crustacea	*Portunus* cf. *argentatus*	82	1
SG−2	Mollusca	*Tellinella staurella*	65	3
	Crustacea	None		0
SG−3	Mollusca	*Tellinella staurella*	65	5
	Crustacea	None		0
SG−4	Mollusca	*Tellinella staurella*	65	15
	Crustacea	*Daldorfia* (?) sp.	—	1
SG−5	Mollusca	*Tellinella staurella*	65	17
	Crustacea	*Etisus electra*	87	1
SG−6	Mollusca	*Tellinella staurella*	65	28
	Crustacea	None		0

Table 7. General List of All Species of Gastropods, Bivalves, Macrurs, and Brachyurs Collected in Nagura Bay during 1981 and 1982. List Includes the Scientific Name and the Japanese Name.

	SCIENTIFIC NAME	JAPANESE NAME
	GASTROPODA	**FUKUSOKU-RUI**
1.	*Chrysostoma paradoxum*	Sarasadama
2.	*Iwakawatrochus urbanus*	Iwakawa-chigusa
3.	*Trochus maculatus*	Nishiki-uzu
4.	*Ethminolia stearnsii*	Kinu-shitadami
5.	*Liotinaria peroni*	Ryukyu-himekatabe
6.	*Lunella coronata*	Kangikugai
7.	*Ritena undata*	Arasuji-amagai
8.	*Theliostyla squamulata*	Maru-amaobune
9.	*Clithon sowerbianus*	Kanokogai

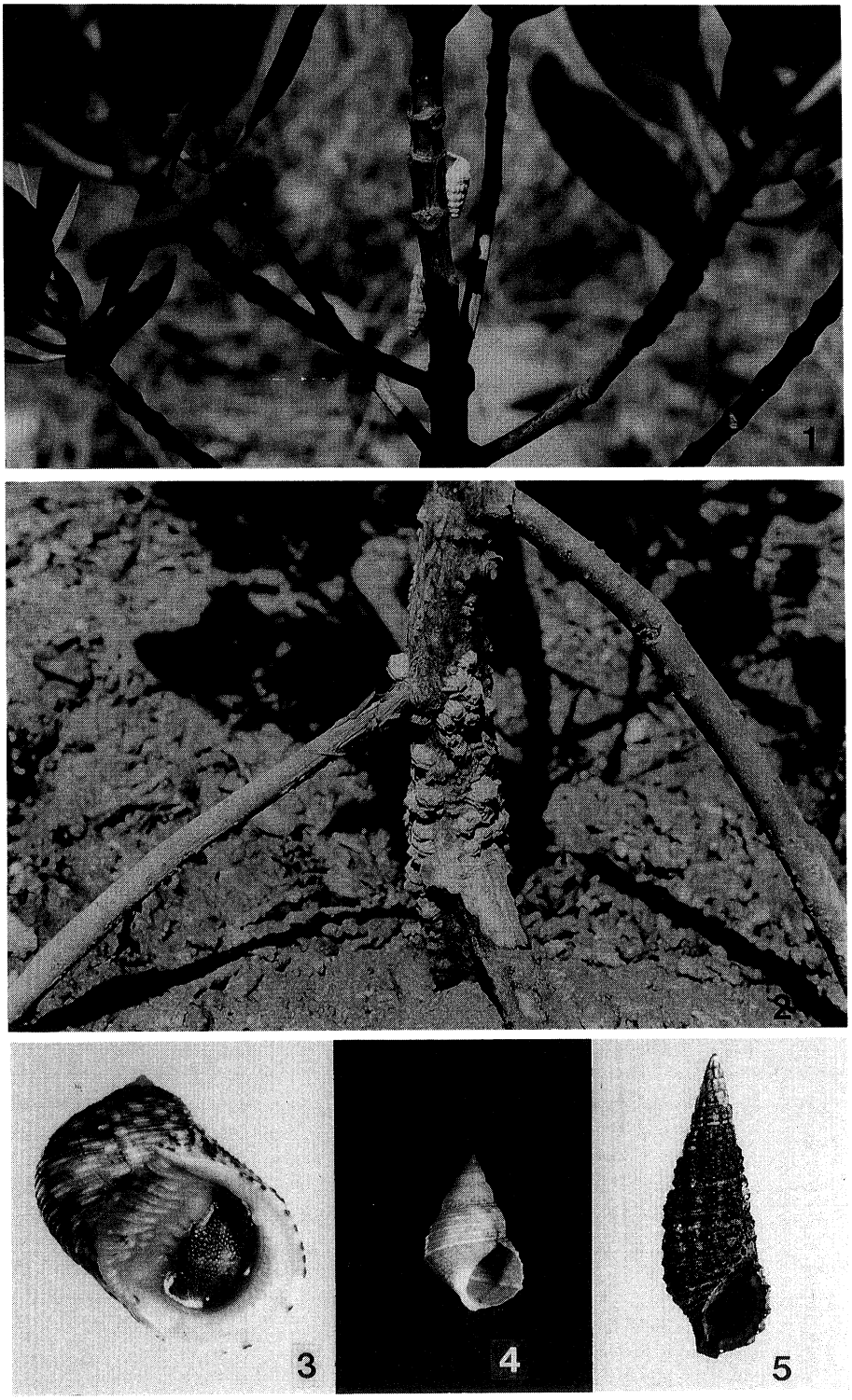
	GASTROPODA	FUKUSOKU-RUI
10.	*Dostia violacea*	Hirokuchi-kanoko
11.	*Vittina turrita*	Shima-kanoko
12.	*Smaragdia rangiana puella*	Kusairo-Kanoko
13.	*Littoraria scabra*	Uzura-tamakibi
14.	*Sermyla riqueti*	Nejihida-Kawanina
15.	*Cerithidea rhizophorarum morchii*	Itokake-henatari
16.	*Telescopium telescopium*	Senningai
17.	*Batillaria zonalis*	Ibo-uminina
18.	*Batillaria multiformis*	Uminina
19.	*Ischnocerithium rostratum*	Hashinaga-tsunobue
20.	*Clypeomorus bifasciatus* ?	Kasuri-kanimori ?
21.	*Clypeomorus coralium*	Koge-tsunobue
22.	*Clypeomorus trailli kikaiensis*	Hime-kuwanomi-kanimori
23.	*Clypeomorus* sp.	Kanimorigai sp.
24.	*Rhinoclavis vertagus*	Takenoko-kanimori
25.	*Ochetoclava sinensis cedonulli*	Hime-tohgata-kanimori
26.	*Canarium urceum*	Ohagurogai
27.	*Cheilea equestris*	Fuhrinchidori
28.	*Monetaria moneta rhomboides*	Kiiro-dakara
29.	*Erronea errones*	Natsume-modoki
30.	*Ponda vitellus*	Hoshi-kinuta
31.	*Cryptonatica lurida*	Hohshuno-tama
32.	*Natica solida*	Kuchiguro-tamagai
33.	*Naticarius onca*	Aragomafu-dama
34.	*Polinices flemingianus*	Heso-aki-tomigai
35.	*Polinices pyryformis*	Tomigai
36.	*Polinices mellosus*	Roh-iro-tomigai
37.	*Septa munda*	Shiro-shinomaki
38.	*Cymatriton nicobaricus*	Mitsukado-bora
39.	*Gutturnium muricinum*	Shio-bora
40.	*Chicoreus brunneus*	Ganzeki-bora
41.	*Cronia margariticola*	Une-reishi-damashi
42.	*Muricodrupa fiscellum*	Yohraku-reishi-damashi
43.	*Morulina concatenata*	Kuchibeni-reishi-damashi
44.	*Reishia clavigera*	Ibo-nishi
45.	*Indomitrella hirundo*	Shajiku-matsumushi
46.	*Euplica versicolor*	Futokorogai
47.	*Pollia proteus*	Hora-damashi
48.	*Plicarcularia bellula*	Kaninote-mushiro
49.	*Nassarius coronatus*	Ibo-yofubai
50.	*Nassarius costatus*	Hime-oriire-mushiro
51.	*Niotha albescens*	Awa-mushiro
52.	*Peristernia sulcata ustulata*	Hashiguro-tsunomata-modoki
53.	*Strigatella zebra*	Ko-shimayatate
54.	*Strigatella retusa*	Oh-shimayatate
55.	*Vexillum gruneri*	Haiiro-minomushi
56.	*Vexillum plicarium*	Oh-minomushi

	GASTROPODA	FUKUSOKU-RUI
57.	*Vexillum rugosum*	Shiwa-minomushi
58.	*Arenimitra exasperata*	Hamazutogai
59.	*Dauciconus vitulinus*	Sarasaminashi-modoki
60.	*Conus marmoratus bandanus*	Kuro-minashi
61.	*Milda ventricosa*	Oh-shiinomi-kuchikire
62.	*Otopleura auriscati*	Nekonomimi-kuchikire
63.	*Syrnola* sp.	Hosokuchikire sp.
64.	*Solidula sulcata*	Kayanomigai
65.	*Bulla cruentata vernicosa*	Natsumegai
66.	*Aliculastrum cylindricum*	Kaikogai
67.	*Cylindrobulla* sp.	Iwazuta-budohgai sp.
68.	*Acteocina coarctata*	Oh-kometsubugai
69.	*Cassidula nucleus*	Kata-shiinomi-mimigai
	BIVALVIA	**NIMAIGAI-RUI**
70.	*Barbatia cruciata*	Kuromino-egai
71.	*Anadara maculosa*	Ryukyu-saruboh
72.	*Glycymeris reevei*	Somewakeguri
73.	*Modiolus plumescens*	Ryukyu-hibarigai
74.	*Modiolus elongatus*	Karasunomakura
75.	*Musculista senhousia*	Hototogisugai
76.	*Pinna muricata*	Iwakawa-hagoromo
77.	*Malleus daemoniacus*	Niwatori-gaki
78.	*Anodontia edentula*	Kabura-tsukigai
79.	*Codakia tigerina*	Tsukigai
80.	*Codakia paytenorum*	Uraki-tsukigai
81.	*Epicodakia divergens*	Hime-tsukigai
82.	*Epicodakia delicatula*	Umiasagai
83.	*Pillucina pisidium*	Umenohanagai
84.	*Pillucina striata*	Chijimiume
85.	*Chama iostoma*	Kanetsuke-zaru
86.	*Vasticardium nigropunctatum*	Gomafu-zaru
87.	*Regozara flavum*	Ryukyu-zaru
88.	*Fragum unedo*	Kawaragai
89.	*Fragum loochooanum*	Ryukyu-hishigai
90.	*Geloina coaxans*	Mangurohbu-shijimi
91.	*Geloina proxima*	Hirugi-shijimi
92.	*Montacutona* (?) sp.	Maru-yadorigai sp.
93.	*Gafrarium tumidum*	Arasuji-kemangai
94.	*Pitar striatum*	Yuhkage-hamaguri
95.	*Pitar pellucidum*	Omina-eshi
96.	*Pitar subpellucidum*	Otoko-eshi
97.	*Bonartemis histrio*	Oino-kagami
98.	*Katelysia hiantina*	Yaeyama-sudare
99.	*Coecella chinensis*	Kuchibagai
100.	*Tapes phenax*	Hime-ryukyu-asari
101.	*Ruditapes variegata*	Hime-asari
102.	*Periglypta clathrata*	Oh-nunomegai

	BIVALVIA	NIMAIGAI-RUI
103.	*Glycydonta marica*	Kanoko-asari
104.	*Atactodea striata*	Iso-hamaguri
105.	*Davila planum*	Naminoko-masuo
106.	*Mactra cuneata*	Tamamakigai
107.	*Mactra maculata*	Ryukyu-bakagai
108.	*Mactra mera*	Ryukyu-arisogai
109.	*Meropesta nicobarica*	Yukigai
110.	*Latona faba*	Ryukyu-naminoko
111.	*Psammotaea elongata*	Masuogai
112.	*Psammotaea minor*	Hazakuragai
113.	*Asaphis dichotoma*	Ryukyu-masuo
114.	*Semele carnicolor*	Samezara-modoki
115.	*Quadrans garadia*	Oh-togeunegai
116.	*Merisca diaphana*	Ichoh-shiratori
117.	*Merisca margaritina*	Akoya-zakura
118.	*Quidnipagus palatam*	Ryukyu-shiratori
119.	*Moerella rutila*	Yuhshiogai
120.	*Loxoglypta transcalpta*	Hasume-zakura
121.	*Tellinella virgata*	Nikkohgai
122.	*Tellinella staurella*	Hime-nikkoh
123.	*Pharaonella perna*	Daimyohgai
124.	*Macoma incongrua*	Hime-shiratori
125.	*Laternula rostrata*	Hirokuchi-sotohrigai
	MACRURA	**CHOBI-RUI**
1.	*Metapenaeus monoceros*	Yoshi-ebi
2.	*Alpheus brevicristatus*	Teppoh-ebi
3.	*Alpheus lobidens lobidens*	Iso-teppoh-ebi
4.	*Axius euryrhynchus*	Beni-ana-ebi
5.	*Laomedia astacina*	Hasami-shako-ebi
6.	*Upogebia* sp.	Ana-jako sp.
7.	*Callianassa japonica*	Nihon-sunamoguri
8.	*Pseudosquilla ciliata*	Hosoyubi-jako
	BRACHYURA	**TANBI-RUI**
1.	*Leucosia* sp.	Kobushi-gani sp.
2.	*Matuta lunaris*	Kinsen-gani
3.	*Elamena* sp.	Hime-sobagara-gani sp.
4.	*Menaethius monoceros*	Ikkaku-gani
5.	*Daldorfia* (?) sp.	Karuishi-gani sp.
6.	*Gomeza bicornis*	Tama-hige-gani
7.	*Scylla serrata*	Nokogiri-gazami
8.	*Portunus pelagicus*	Taiwan-gazami
9.	*Portunus cf. argentatus*	cf. Hime-ibo-gazami
10.	*Thalamita stimpsoni*	Amami-benitsuke-gani
11.	*Thalamita admete*	Futaha-benitsuke-modoki
12.	*Etisus electra*	Hime-hizume-gani
13.	*Baptozius vinosus*	Kumadori-ohgi-gani
14.	*Typhlocarcinops canaliculata*	Mekura-gani-modoki

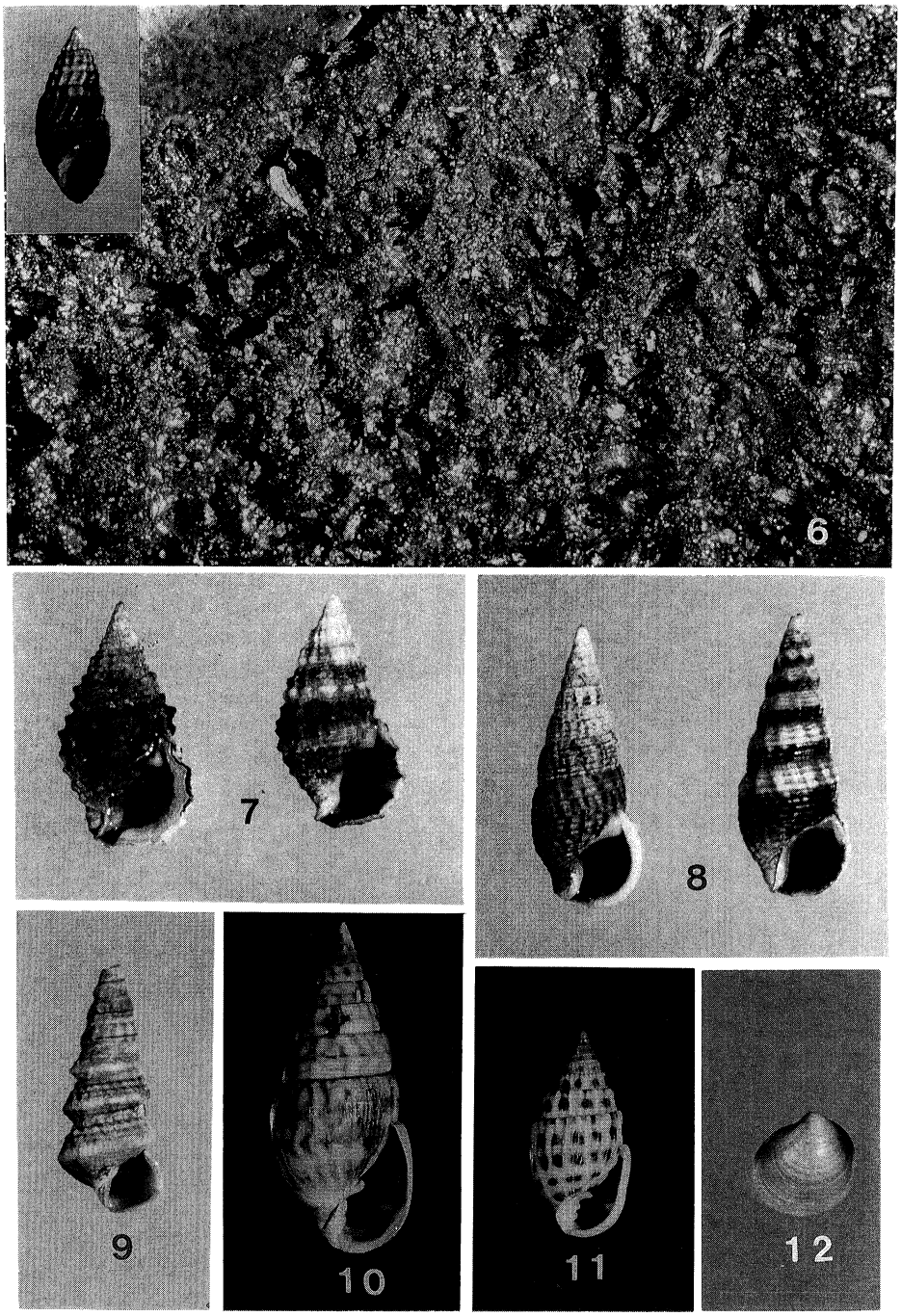
	BRACHYURA	TANBI-RUI
15.	*Typhlocarcinodes hirsutus*	Tsubu-mekura-gani
16.	*Uca vocans vocans*	Hime-shiomanegi
17.	*Uca lactea lactea*	Hakusen-shiomanegi
18.	*Macrophthalmus convexus*	Futaha-osa-gani
19.	*Macrophthalmus pacificans*	Taiyo-osa-gani
20.	*Scopimera globosa*	Kometsuki-gani
21.	*Ilyoplax pusillus*	Chigo-gani
22.	*Mictyris longicarpus*	Minami-kometsuki-gani
23.	*Sesarmops* sp. (Young)	Kuro-benkei-gani sp.
24.	*Cardisoma carnifex*	Minami-oka-gani
25.	*Sarmatium crassum*	Mizote-ashihara-gani

Plate I



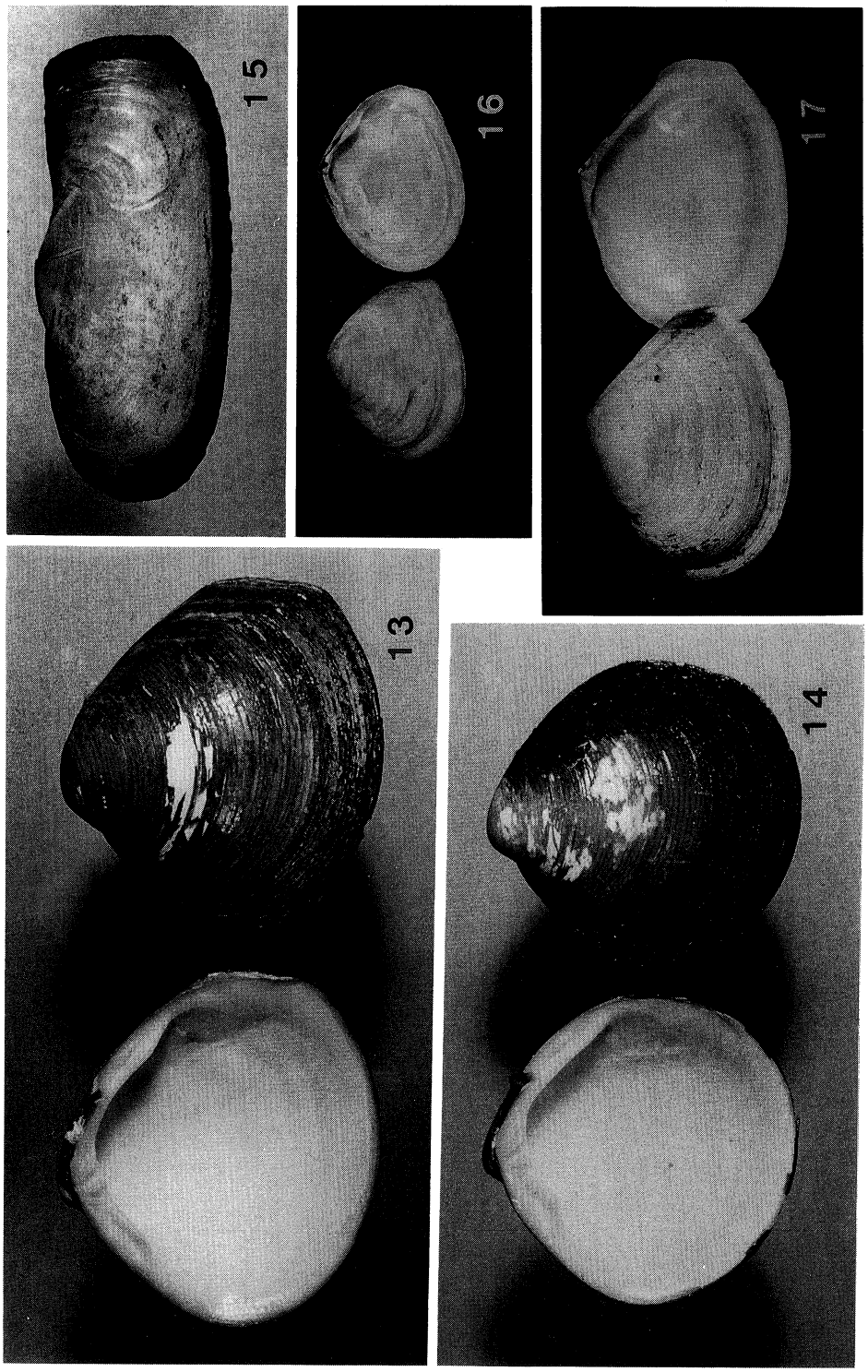
1. *Cerithidea rhizophorarum morchii* climbing up the stem of *Rhizophora mucronata*.
2. A group of *Balanus albicostatus* on the stem of *Rhizophora mucronata*.
3. *Ritena undata*.
4. *Littoraria scabra*.
5. *Clypeomorus coralium*.

Plate II



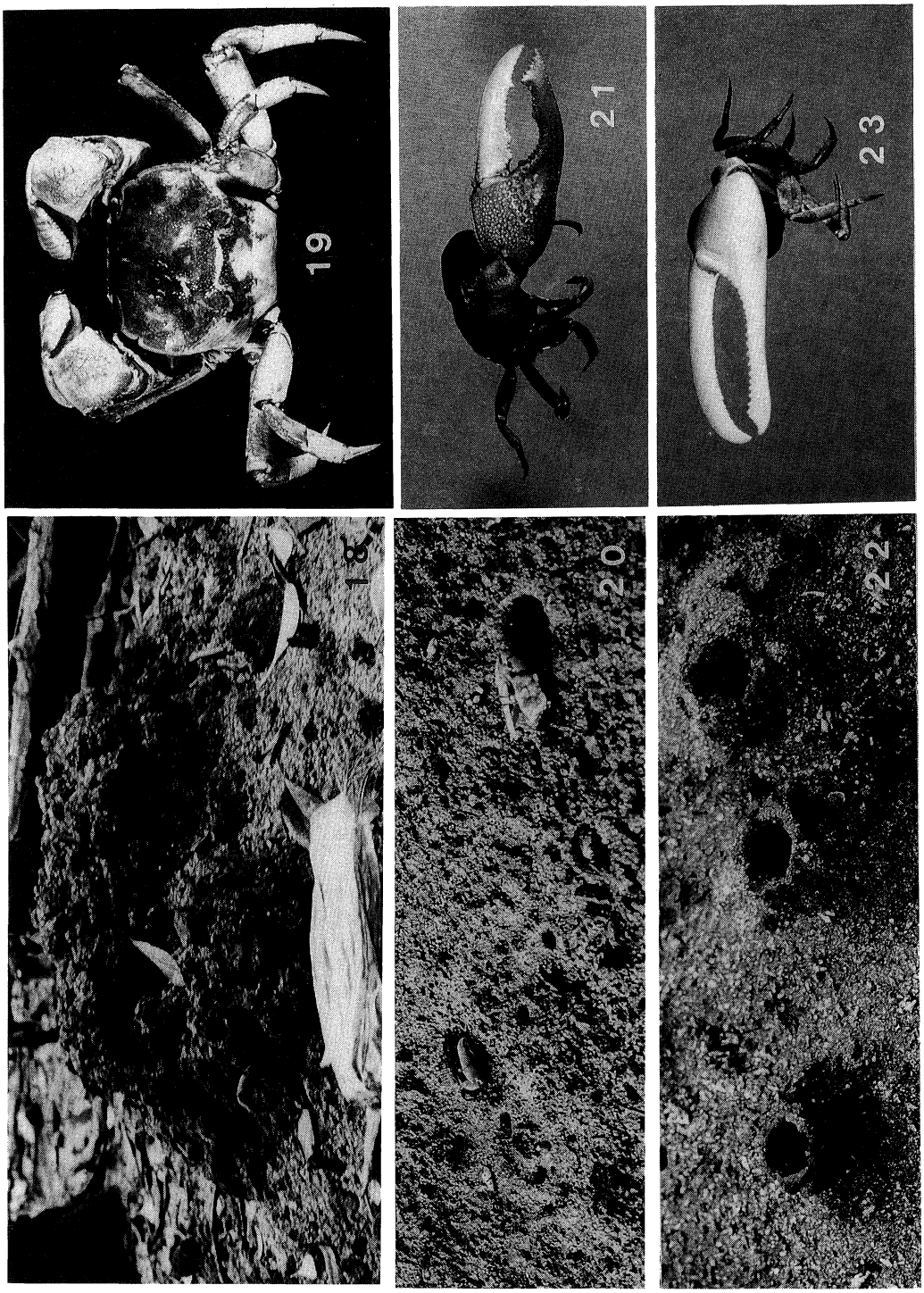
6. High population density of *Sermyla riqueti* on the mud flat around St. D-5.
7. *Clypeomorus* sp.
8. *Batillaria multiformis*.
9. Abnormal type of *Cerithidea rhizophorarum morchii*.
10. *Milda ventricosa*.
11. *Otopleura auriscati*.
12. *Pillucina pisidium*.

Plate Ⅲ



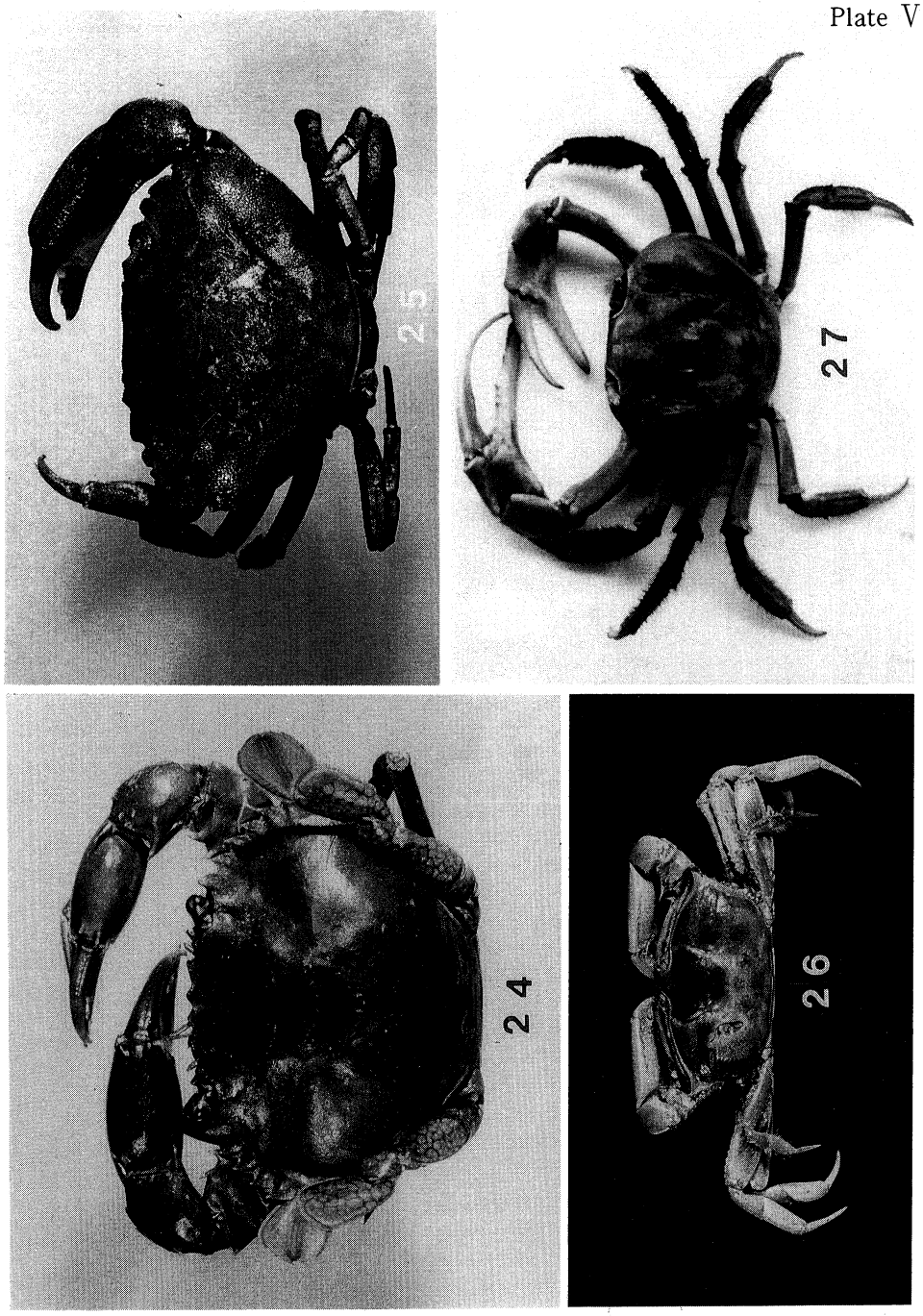
13. *Geloina coaxans*
14. *Geloina proxima*
15. *Laternula rostrata*
16. *Macoma incongrua*
17. *Merisca diaphana*

Plate IV



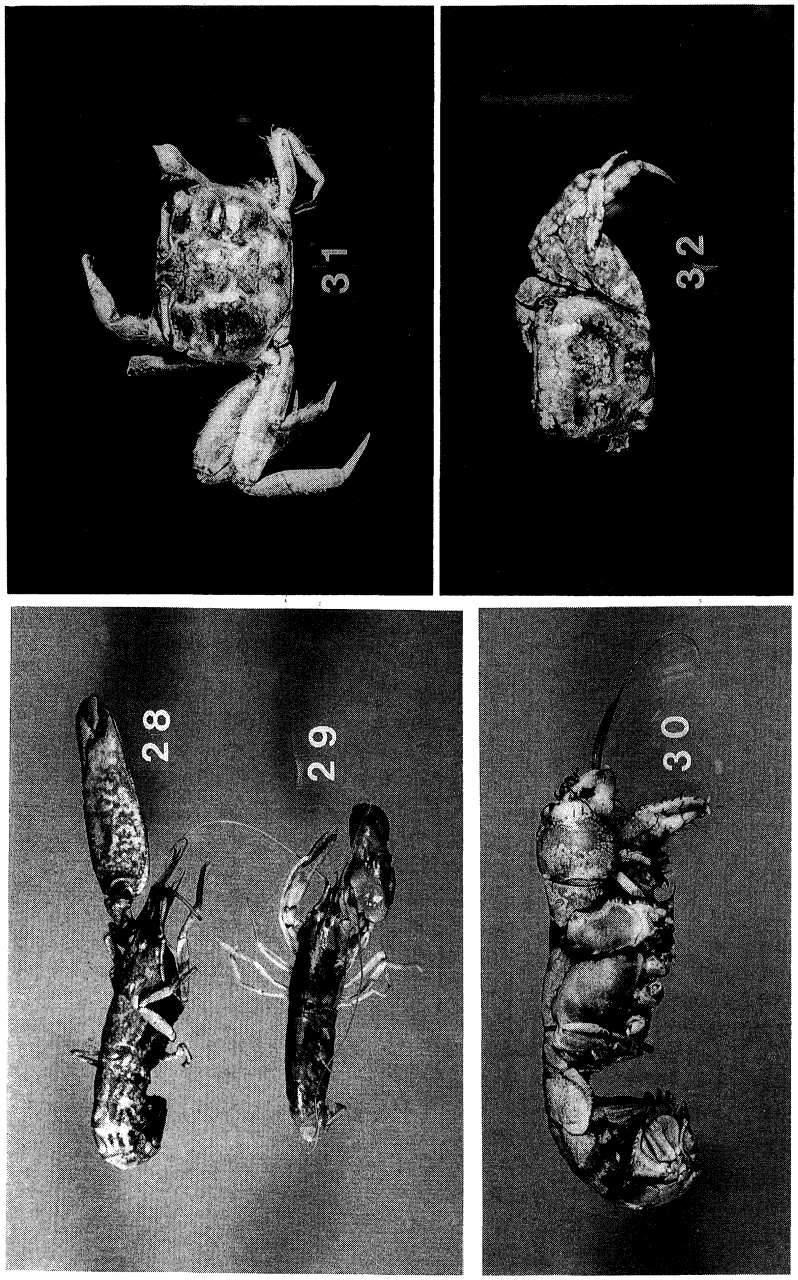
18. The largest mound in the mangal. Vinyl sac in front is 35 cm long.
19. *Sarmatium crassum*.
20. Habitat of *Uca vocans vocans*.
21. *Uca vocans vocans*.
22. Living pores of the mudskipper *Periophthalmus vulgaris*.
23. *Uca lactea lactea*.

Plate V



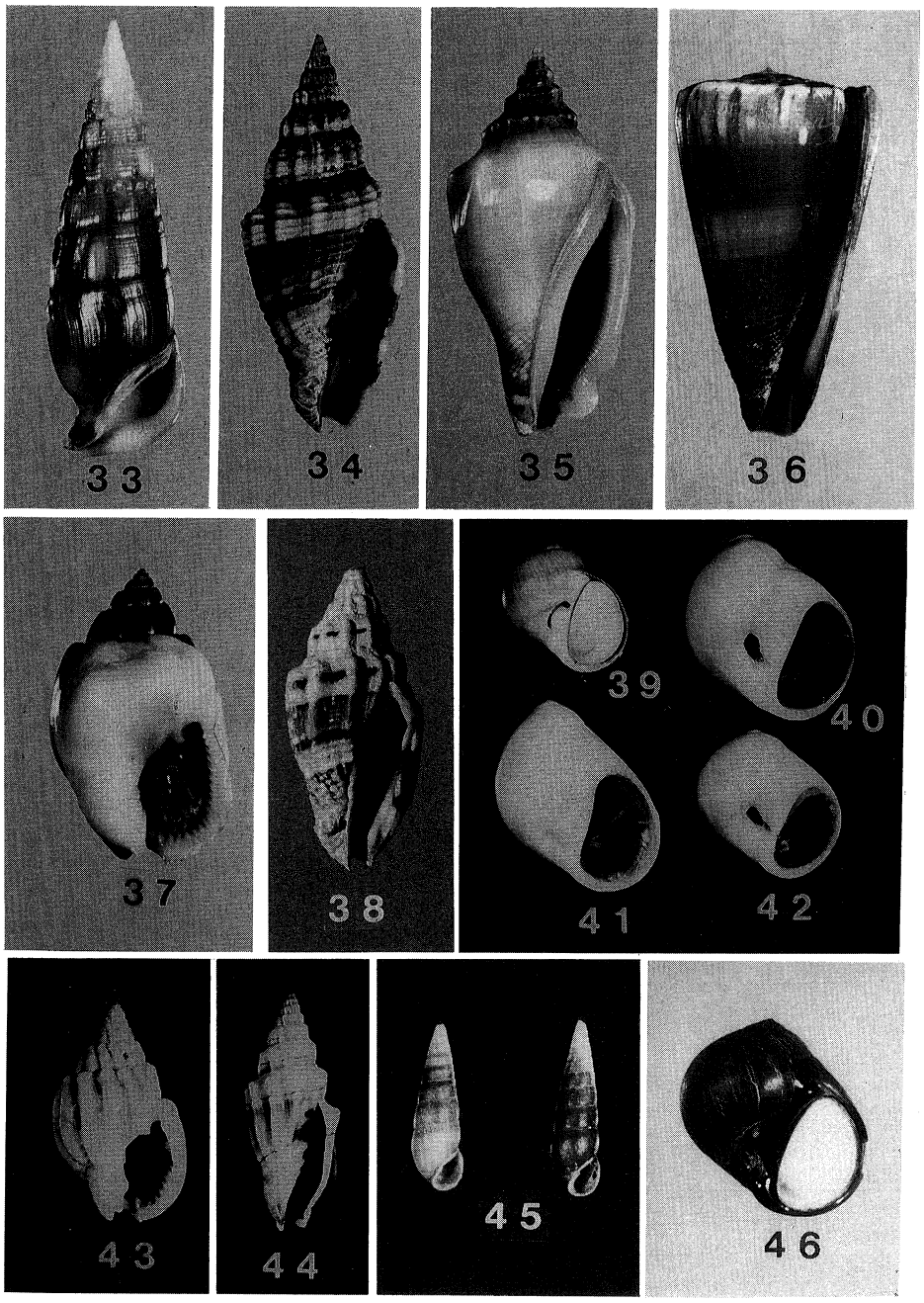
24. *Scylla serrata*.
25. *Baptozius vinosus*.
26. *Macrophthalmus convexus*.
27. *Cardisoma carnifex*, collected and photographed by Prof. H. Tagawa and Mr. E. Suzuki.

Plate VI



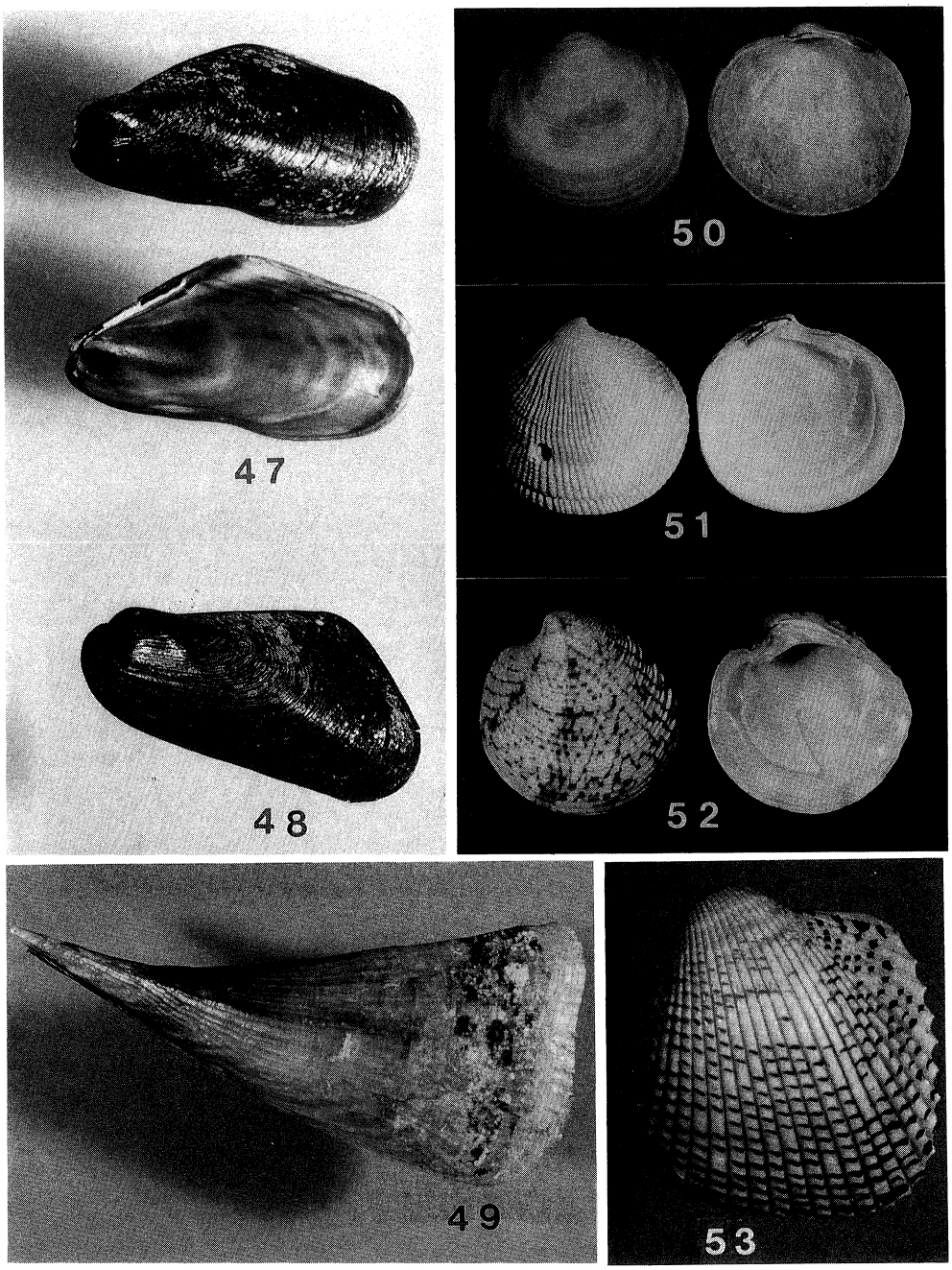
28. *Alpheus brevicristatus*
29. *Alpheus lobidens lobidens*
30. *Axius euryrhynchus*
31. *Macrophthalmus pacificans*
32. *Sesarmops* sp.

Plate Ⅶ



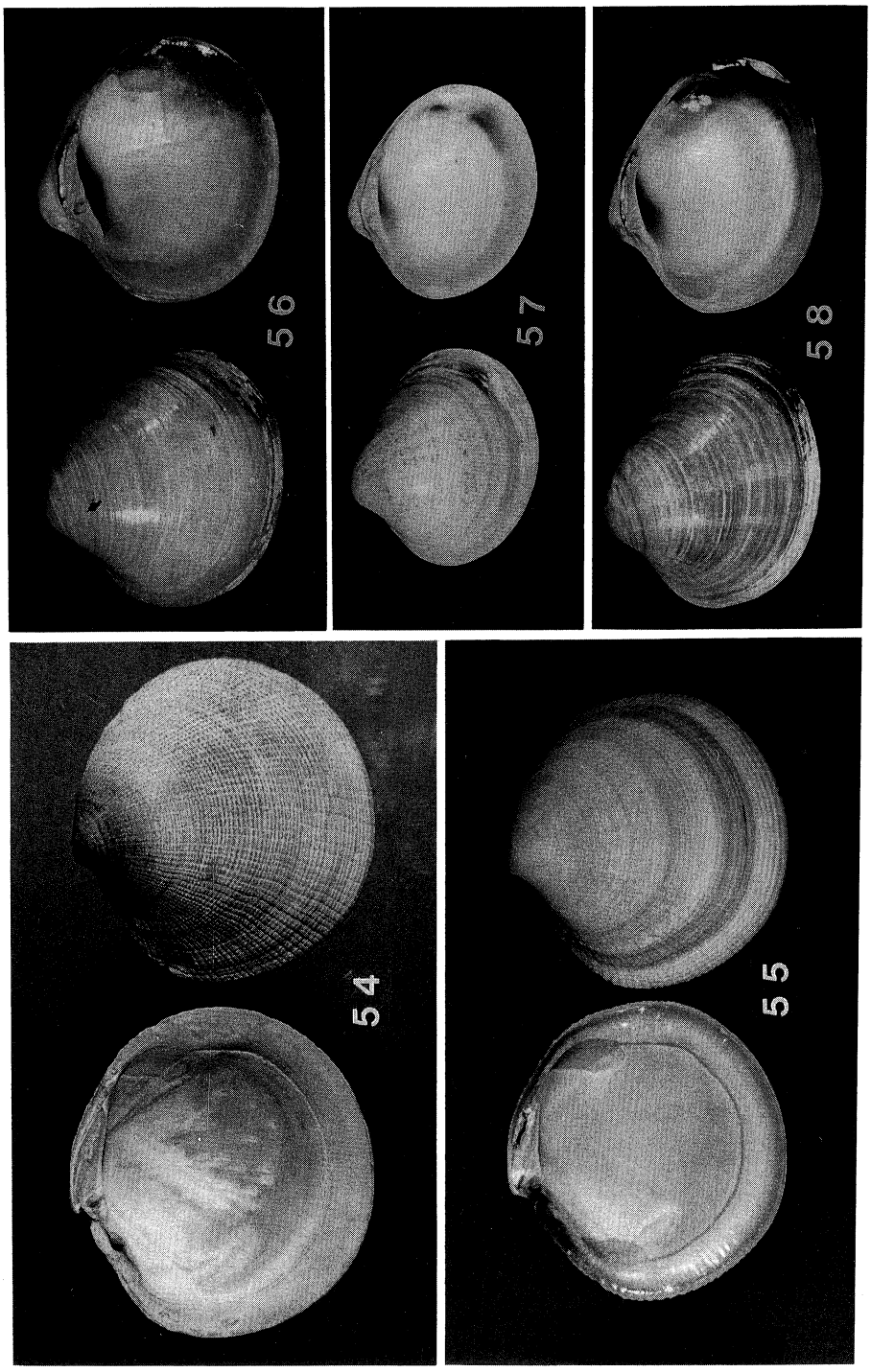
33. *Rhinoclavis vertagus*
34. *Vexillum rugosum*
35. *Canarium urceum*
36. *Dauciconus vitulinus*
37. *Nassarius coronatus*
38. *Vexillum plicarium*
39. *Cryptonatica lurida*
40. *Polinices mellosus*
41. *Polinices pyryformis*
42. *Polinices flemingianus*
43. *Nassarius costatus*
44. *Vexillum gruneri*
45. *Syrnola* sp.
46. *Natica solida*

Plate VIII



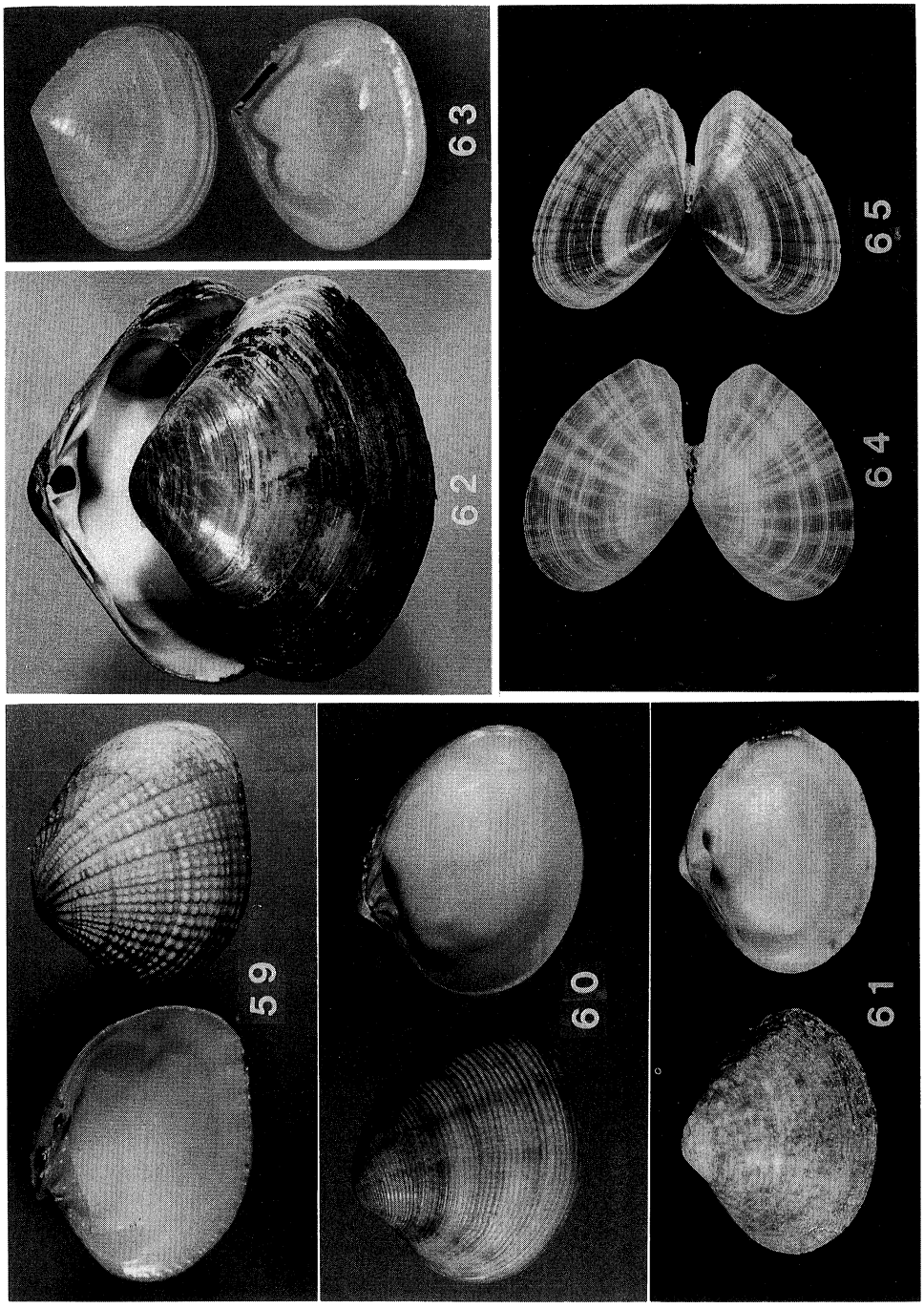
47. *Modiolus plumescens*
48. *Modiolus elongatus*
49. *Pinna muricata*
50. *Anodontia edentula*
51. *Epicodakia divergens*
52. *Bonartemis histrio*
53. *Fragum unedo*

Plate IX



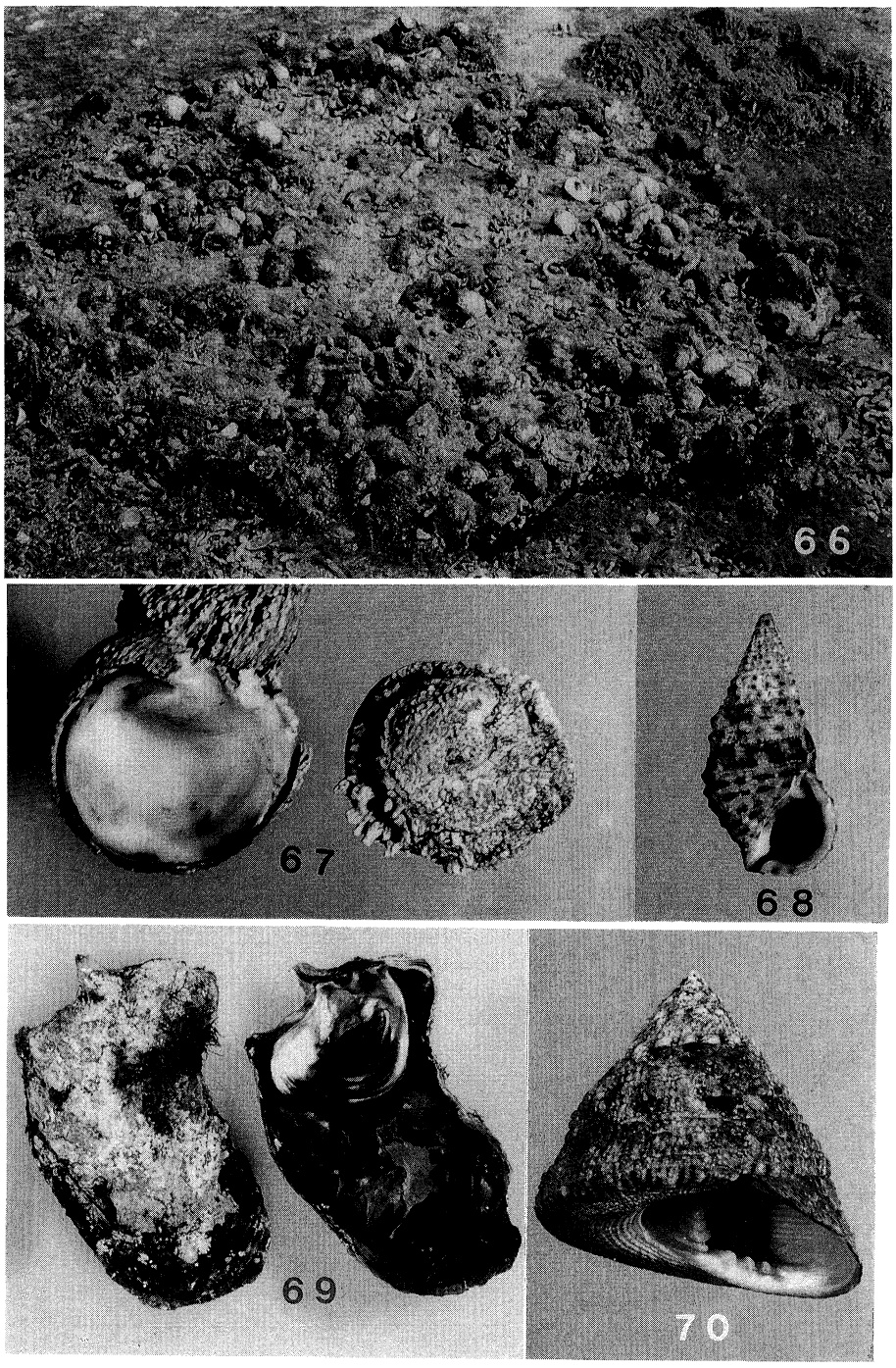
54. *Codakia tigerina*
55. *Codakia paytenorum*
56. *Pitar striatum*
57. *Pitar pellucidum*
58. *Pitar subpellucidum*

Plate X



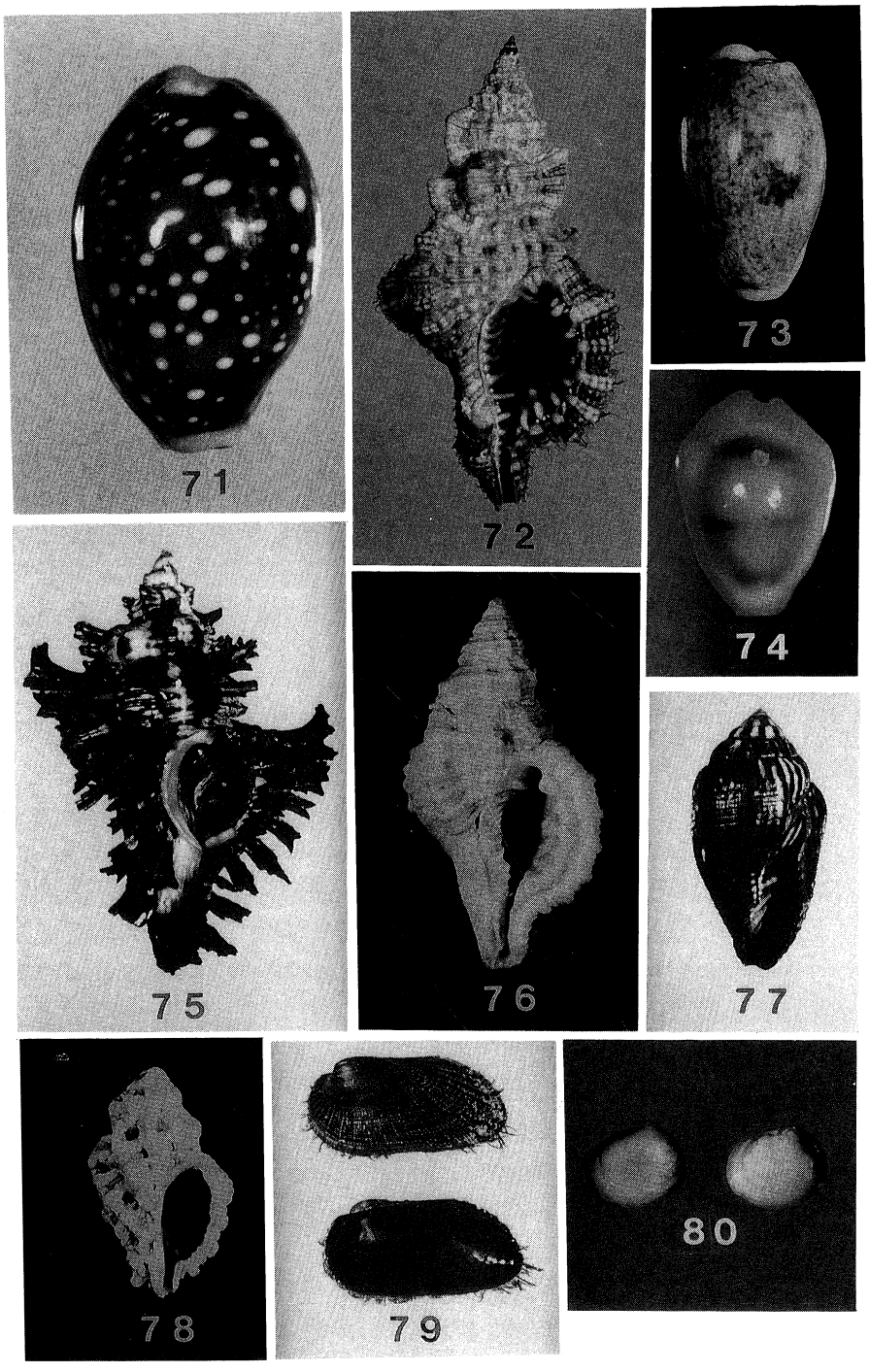
59. *Gafrarium tumidum*
60. *Katelysia hiantina*
61. *Mactra maculata*
62. *Mactra mera*
63. *Quadrans garadia*
64. *Tellinella virgata*
65. *Tellinella staurella*

Plate XI



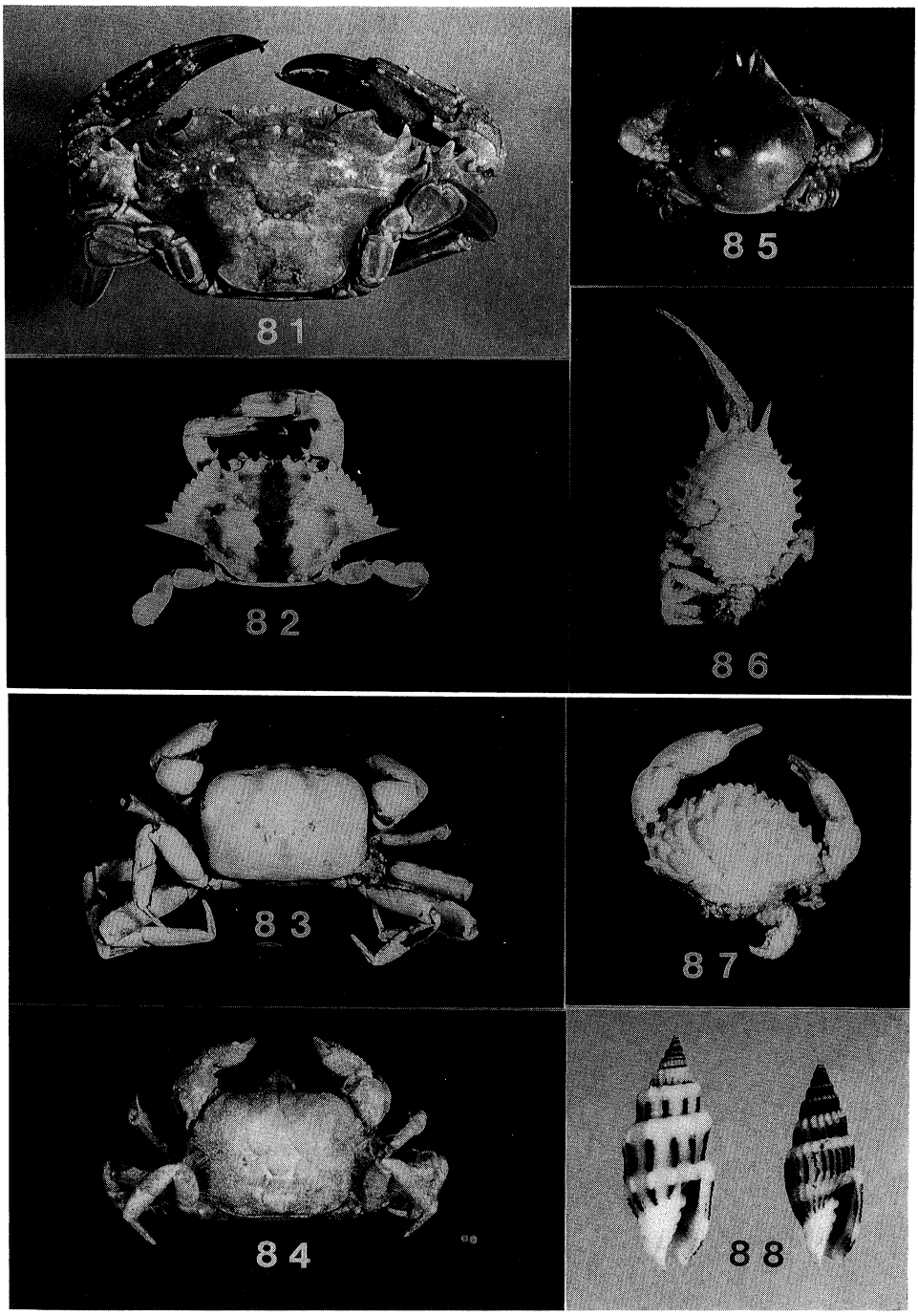
66. One of the coral stumps left on the outer zone of the open sea tideland.
67. *Chama iostoma*
68. *Clypeomorus bifasciatus* ?
69. *Malleus daemoniacus*
70. *Trochus maculatus*

Plate XII



71. *Ponda vitellus*
72. *Cymatriton nicobaricus*
73. *Erronea errones*
74. *Monetaria moneta rhomboides*
75. *Chicoreus brunneus*
76. *Septa munda*
77. *Strigatella retusa*
78. *Muricodrupa fiscellum*
79. *Barbatia cruciata*
80. *Montacutona* (?) sp.

Plate XIII



81. *Thalamita stimpsoni*
82. *Portunus* cf. *argentatus*
83. *Typhlocarcinops canaliculata*
84. *Typhlocarcinodes hirsutus*
85. *Leucosia* sp.
86. *Gomeza bicornis*
87. *Etisus electra*
88. Two types of *Arenimitra exasperata*