Distribution of Shore Platforms in Southwestern Japan

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Shore platforms have not been reported enough in Japan, and even their distribution has not been clearly outlined, although they are important coastal features in Japan. The purpose of this paper is to discuss their distribution in Southwestern Japan, except the coral-reef coasts of the Ryūkyūs, by means of mapping 'reefs exposed at low tide'.

1 Some Comments on Previous Views

Few discussions have been presented about the distribution of shore platforms in Japan. Yabe and Tayama (1934) pointed out that shore platforms were remarkable on the coast of Sakhalin, Hokkaidō, Tōhoku (except ria coasts) and Kantō. Tsujimura (1948) stated that rock benches could scarcely be seen along the Pacific coast and around the Izu Islands, the Ogasawara Islands, the Satsunan Islands or the Ryūkyū Islands, but they extended fairly broadly along the Japan Sea coast and around the islands on the Korea Strait. And he estimated that they had been remarkably formed on such coasts as were washed with winter heavy waves but with calm waves in spring and summer, such as the Japan Sea coast or the Genkai coast, rather than on the coast struck with violent waves in all seasons.

From the above-mentioned views and Tokuda's view (1920, 21) about the shore platforms of Sakhalin, Yoshikawa (1950) summarized as follows: Wave-cut benches developed conspicuously on the relatively northern coast of Japan and on the Japan Sea coast, and most of them consist of Tertiary formations. Moreover, he added that such a distribution of platforms must have been regulated with lithology rather than with climate which brought frost weathering or wave action inferred by Tsujimura as before.

Since then, the discussion about the distribution of platforms has not progressed regrettably as yet.

Their common opinion is as follows: Shore platforms are distributed on the northern coast of Japan, the Japan Sea coast and the Korea Strait coast, and they are scarcely seen along the Pacific coast. And most of them consist of Tertiary formations. The writer, however, wonders whether or not their views were based on an authentic distribution map, for on the Pacific coast are seen many shore platforms in large-scale, such as on the Nichinan Coast, the southern Kii Peninsula or the Southern Shikoku Coast. Moreover, some of them consist of Mesozoic or Mesozoic-Palaeogene formations (Shimanto super group). It is doubtful that shore platforms have developed mainly on the coasts of Tertiary formations and scarcely on other coasts. In this connection, along the English Channel coast, shore platforms have developed into a variety of rock types ranging from Pre-Devonian to Pleistocene in lithology and in age (So, 1965 and Wright, 1967).

In any case, an accurate distribution map sould be presented in order to advance the discussion, and the above opinions about the role of wave action will require further attention.

2 Mapping of 'Reefs Exposed at Low Tide'

It is impossible to survey every shore platforms along the whole coasts in Southwestern Japan. Accordingly, for the discussion of their distribution we cannot but depend upon some available data. But there are very few maps, even if only partial, which represent shore platforms.

However, 'reefs exposed at low tide' which are represented on 1:25,000 topographic maps (1965 Map Representation or 1967 M.R., by Geographical Survey Institute) seem to correspond comparatively well to shore platforms at most parts,

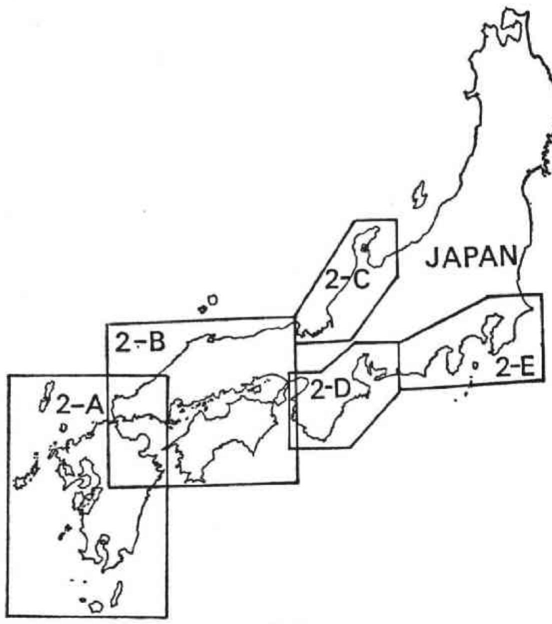

Fig. 1 Index map

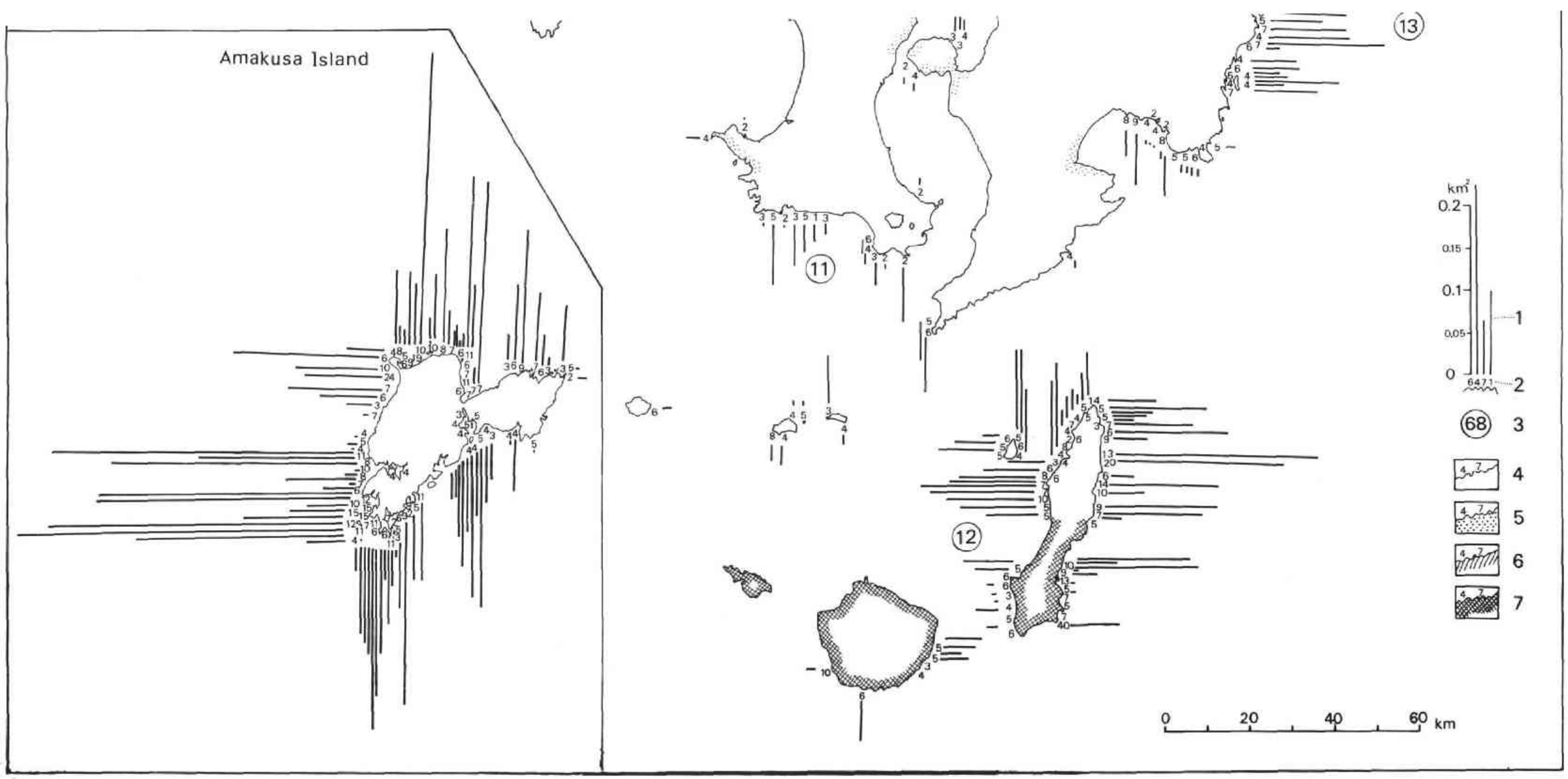

Fig. 2 — (1) Distribution map of 'reefs exposed at low tide' (2–A)

1: area of 'reefs exposed at low tide' in each mesh

2: width of 'reefs exposed at low tide' in each mesh (in decameter)

3: coast number for reference to Table 1

4: coast on which reefs are measured on 1:25,000 topographic maps with representation regulated in 1965 and revised in 1967

5: coast on which reefs are measured on 1:50,000 topographic maps with representation regulated in 1965 and revised in 1967

6: coast on which reefs are measured on 1:25,000 topographic maps with other representation

7: coast on which reefs are measured on 1:50,000 topographic maps with other representation

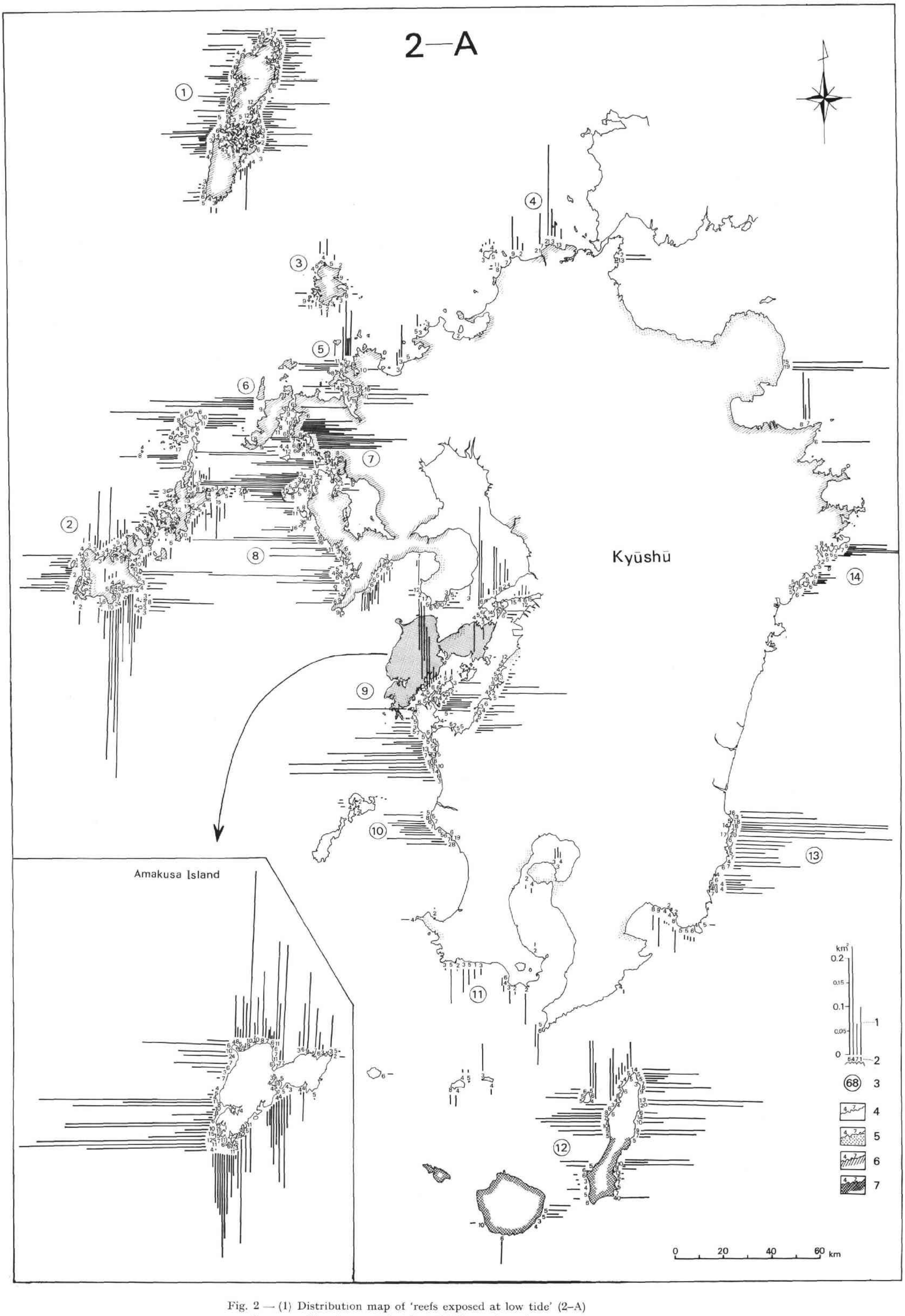

Fig. 2 — (1) Distribution map of 'reefs exposed at low tide' (2–A)

1: area of 'reefs exposed at low tide' in each mesh
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7: coast on which reefs are measured on 1:50,000 topographic maps with other representation

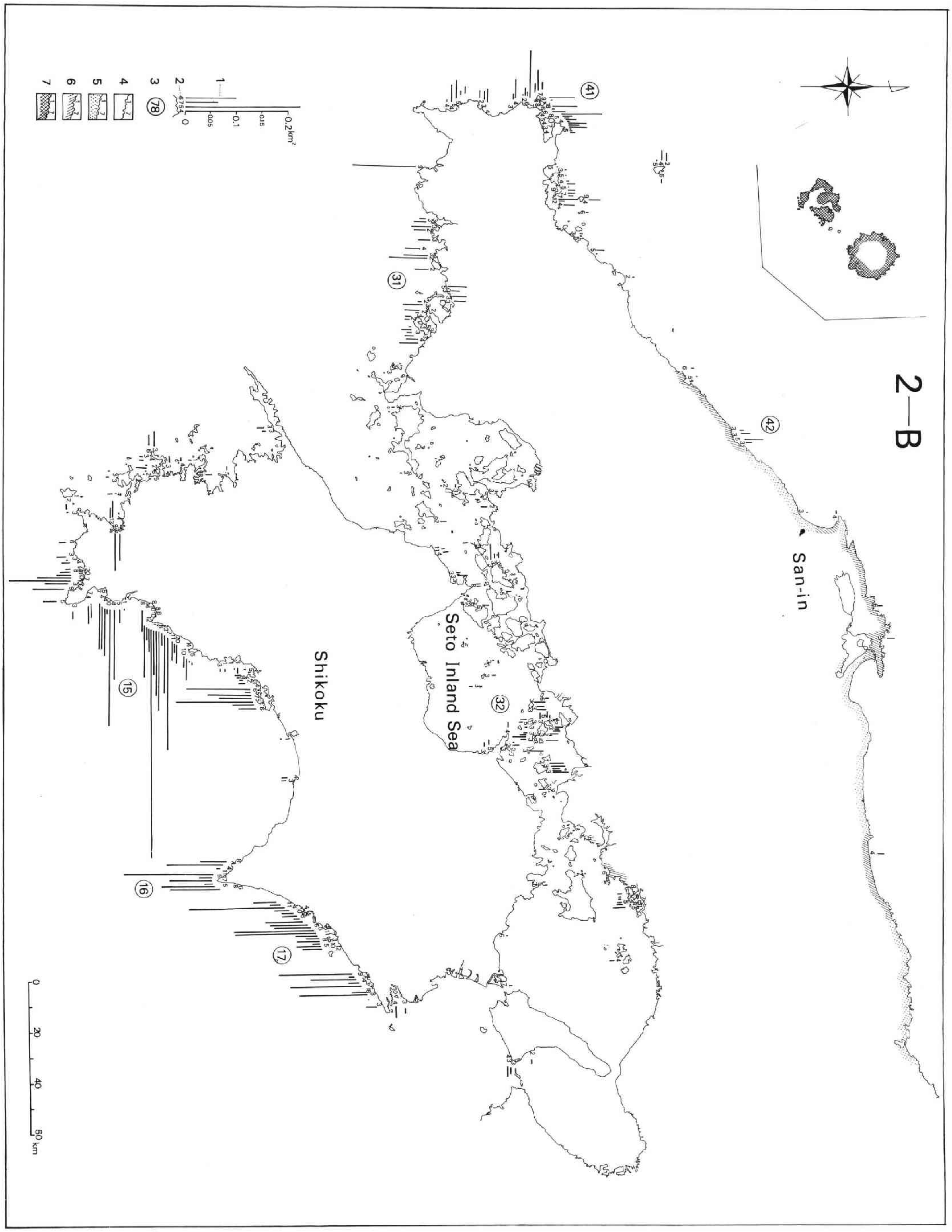

Fig. 2 — (2) Distribution map of 'reefs exposed at low tide' (2-B)

1: area of 'reefs exposed at low tide' in each mesh
2: width of 'reefs exposed at low tide' in each mesh (in decameter)
3: coast number for reference to Table 1
4: coast on which reefs are measured on 1:25,000 topographic maps with representation regulated in 1965 and revised in 1967
5: coast on which reefs are measured on 1:50,000 topographic maps with representation regulated in 1965 and revised in 1967
6: coast on which reefs are measured on 1:25,000 topographic maps with other representation
7: coast on which reefs are measured on 1:50,000 topographic maps with other representation

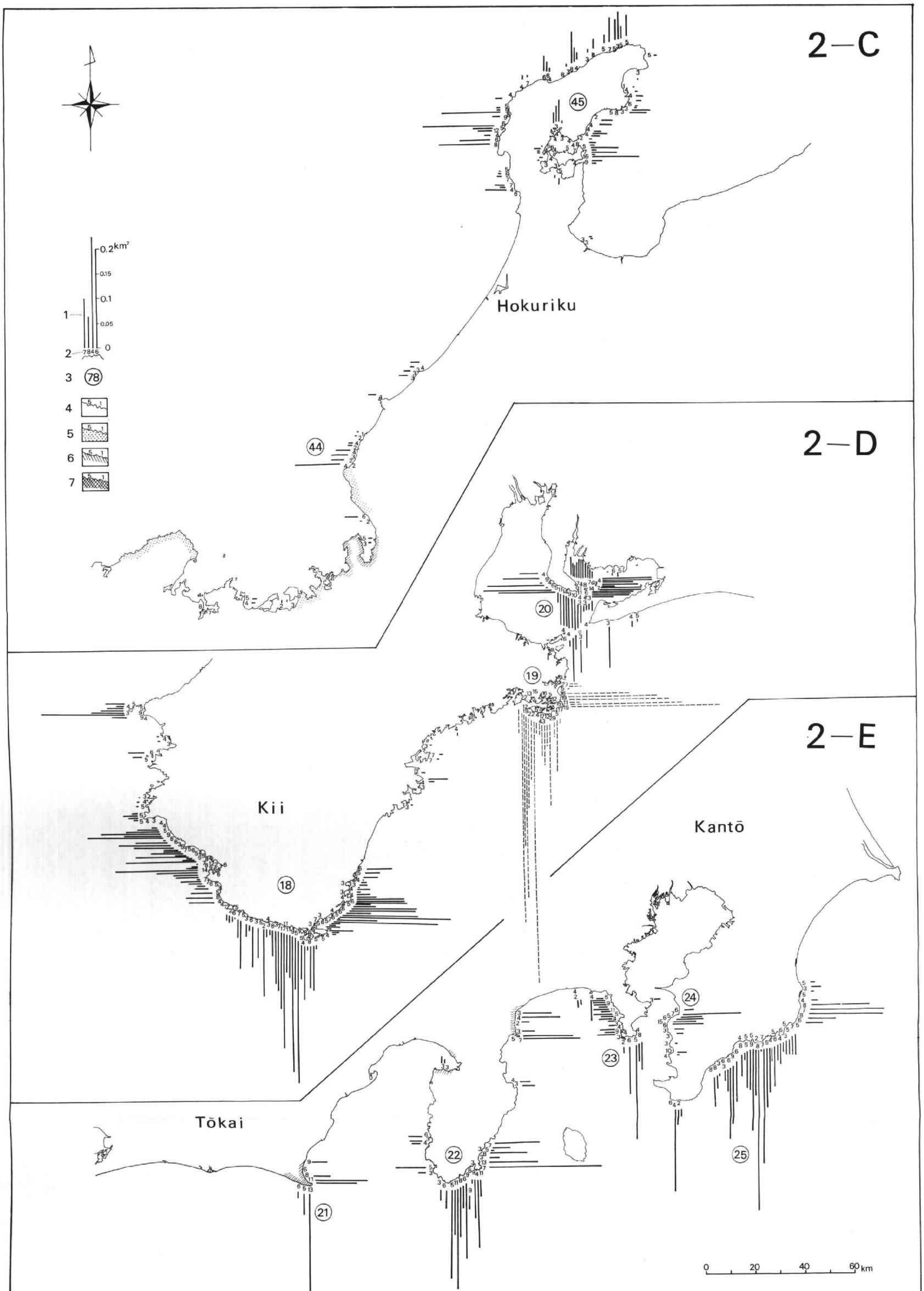

Fig. 2 — (3) Distribution map of 'reefs exposed at low tide' (2-C, D and E)

1: area of 'reefs exposed at low tide' in each mesh
2: width of 'reefs exposed at low tide' in each mesh (in decameter)
3: coast number for reference to Table 1
4: coast on which reefs are measured on 1:25,000 topographic maps with representation regulated in 1965 and revised in 1967
5: coast on which reefs are measured on 1:50,000 topographic maps with representation regulated in 1965 and revised in 1967
6: coast on which reefs are measured on 1:25,000 topographic maps with other representation
7: coast on which reefs are measured on 1:50,000 topographic maps with other representation

and these reefs are able to be available data. They are defined as reefs submerged at high tide and exposed at low tide. On some spots the writer has often assured that they accord fairly with inter-tidal platforms and high tide platforms (Takahashi, 1973a, b).

The writer made a distribution map of reefs in Southwestern Japan, westward of Cape Inubōzaki on the Pacific coast and westward of Toyama Bay on the Japan Sea coast, with the following method: Measuring the area of reefs in each mesh of 1'N-S and 1.5'E-W on 1:25,000 topographic maps (bar graph in Fig. 2), and calculating the width, which is defined as the ratio of their area to the length of the shoreline bordered with them in each mesh (number in decameter in Fig. 2), then measuring the broadest width, which is the width of the broadest reef in each mesh. Concerning some coasts, mostly among the Japan Sea coasts not covered as yet by 1:25,000 topographic maps (in the same Map Representation), maps of other representation or other scale, as are shown in Fig. 2, had to be used unavoidably. In this case, the representation of 'reefs exposed at low tide' is not always the same. For the reason, the distribution of reefs on the Japan Sea coasts seems to be expressed slightly less.

'Reefs exposed at low tide' are not always accordant with shore platforms, such as on the southern Kii Peninsula (Takahashi, 1973a). Shore platforms slightly over high tide level and coastal platforms fairly above high tide level are not frequently represented as such reefs. On the other hand, at the shore zone without platforms but with scattered reefs in and slightly above inter-tidal zone, such reefs are occasionally represented. Consequently, it is necessary to survey the spot or to compare with other data, in order to confirm these reefs as shore platforms.

On chart there are represented 'rock ledges and rocks' on coastline, which are useful to confirm shore platforms, although they are not always in accord with shore platforms. It is desirable that the distribution map of 'reefs exposed at low tide' has to be checked with 'rock ledges and rocks' on charts. Correspondence between both reefs and rock ledges in the study area is roughly shown in Table 1.

Nichinan Coast with the broadest shore platforms in the inter-tidal zone is a fine example of well-correspondence between 'reefs exposed at low tide' on topographic map and 'rock ledges and rocks' on chart. And it was ascertained there that the shore platforms agree well with both (Takahashi, 1973b). Contrary to this, very broad reefs on the topographic maps are not almost represented on chart along the coast of the Shima Peninsula, where Nakano (1967) did not recognize broad shore platforms, and the writer also observed in the same way. Hereafter the measurements on the reefs along this coast was omitted from the total.

Table 1 Coasts on which shore

Coast			lithology	reefs exposed at		
				mesh (number)	area (km²)	area/ mesh
East China Sea Coast	1	Tsushima Island	M (m, s)	108	3.4	0.03
	2	Gotō Islands	M (m, s), N (m, b), I (v)	121	5.1	0.04
	3	Iki Island	N (b), I(v)	15	0.2	0.01
	4	Wakamatsu Peninsula	M (t, b), N (a, c)	15	0.5	0.03
	5	Imari Bay	N (m, s)	17	1.0	0.06
	6	Hirado Island	N (m, s, b)	8	0.9	0.11
	7	Kitamatsuura Peninsula	N (m, s)	28	2.3	0.08
	8	Nishisonogi Peninsula and Nagasaki Peninsula	M (m, s), N (b), P	70	3.9	0.06
	9	Amakusa Isls. and Yatsushiro Sea	M (m, s, a, c), P, N (m, s, a, b), I (v), D (w)	182	12.8	0.07
	10	near Kushikino	N (b), I (v)	13	0.8	0.06
Pacific Coast	11	Southern Satsuma Peninsula	D (w)	7	0.2	0.03
	12	Tanegashima Isl., Yakushima Isl.,	M (m, s, a), N (m, s, a)	61	3.8	0.06
	13	Nichinan Coast	N (a)	24	2.8	0.12
	14	Kitahyūga Coast	M (m, a)	23	0.7	0.03
	15	Western Tosa Bay	M (m, s, a)	57	3.4	0.06
	16	Muroto Cape Peninsula	M (m, a)	9	0.7	0.07
	17	Anan Coast	M (m, a)	28	1.7	0.06
	18	Kii Peninsula	M (m, s, a), N (a, c), I (p)	101	6.0	0.06
	19	Shima Peninsula	M (m, s, c)	26	3.5	0.14
	20	Chita Peninsula	N (m)	23	2.1	0.09
	21	Omaezaki Cape	N (a)	7	0.5	0.07
	22	Izu Peninsula	N (b)	25	1.8	0.07
	23	Miura Peninsula	N (m, a)	18	0.8	0.04
	24	Uraga Channel	N (m, a)	11	0.4	0.04
	25	Bōsō Peninsula	N (m, a)	40	2.8	0.07
Seto Inland Sea Coast	31	Western Seto Inland Sea	P	37	1.6	0.04
	32	Middle Seto Inland Sea	P, I (p, v)	63	0.8	0.01
Japan Sea Coast	41	Kitanagato Coast	M, I (p, v)	46	0.9	0.02
	42	near Hamada	M, N (b, c)	7	0.1	0.01
	44	Echizenzaki	N (b)	9	0.2	0.02
	45	Noto Peninsula	N (m, a, c, b, t)	71	1.7	0.02

(lithology) P: Palaeozoic M: Mesozoic-Palaeogene N: Neogene D: Diluvium I: Igneous c: conglomerate t: tuff b: tuff breccia w: welded tuff p: plutonic rock v: volcanic rock
(mean wave height) after Aramaki (1971) *after Ishima (1960)

platforms have developed

low tide				tidal range (m) (spring tide)	mean wave height (m)		
width (×10m)		maximum width (×10m)	correspondence with chart		swell	wind wave	
range	mean						
12-1	4.6	25		1.6 (Izuhara)	0.40	0.26	(Izuhara)
24-1	5.3	40			1.40	0.95	(Tomie)
11-2	5.8	18	○				
21-2	8.1	48	△	1.6 (Fukuoka)			
16-5	9.8	25	△				
11-7	8.9	28	△				
15-3	7.3	20	△	2.5 (Sasebo)			
36-2	6.5	45	×	2.2 (Nagasaki)			
24-2	6.6	48	△	2.3 (Akune)			
					1.05	1.03	(Ushibuka)
28-5	8.8	28	○				
5-1	3.1	26	△			0.78*	(Makurazaki)
40-2	7.0	45	△				
20-4	9.3	53	○	1.5 (Uchiumi)			
7-2	5.4	24	△	1.4 (Hososhima)			
20-1	6.8	25	△		1.64	1.25	(Ashizuri)
17-5	7.9	23	×		1.19	1.09	(Muroto-misaki)
14-3	7.0	35	△				
17-2	5.6	33	△	1.3 (Kushimoto)	1.70	1.11	(Shiono-misaki)
43-2	14.1	53	×	1.5 (Toba)			
14-3	7.2	30	○				
13-5	8.3	23	△	1.2 (Shimizu)	0.57	0.86	
11-3	6.2	40	△	1.2 (Shimoda)			(Omaezaki)
11-2	5.1	30	×	1.1 (Uraga)			
15-3	6.2	20		1.1 (Uraga)		0.56	(Tomisaki)
9-2	5.3	33		1.0 (Katsuura)	0.61	0.99*	(Chōshi)
19-2	4.4	30	×	2.6 (Tokuyama)			
11-2	3.9	18	△	1.6 (Takamatsu)	0.22	0.44	(Tadotsu)
18-2	5.6	20	△				
9-3	4.6	23	×	0.2 (Hamada)	0.83	0.71	(Hamada)
4-1	2.7	8		0.2 (Tsuruga)		1.08	
16-1	5.3	40	△	0.2 (Fushigi)	0.25	0.55*	(Wajima)

rock s: sandstone m: mudstone, siltstone a: alternation of sandstone and mudstone
(correspondence with chart) ○: good △: good in some degree ×: bad

3 Distribution of Shore Platforms in Southwestern Japan

Based on the map of 'reefs exposed at low tide,' the coasts with conspicuous shore platforms in Southwestern Japan are arranged (Table 1). And the total area of reefs in each region is collected (Table 2).

Generally speaking, on the Pacific coast and the East China Sea coast in Southwestern Japan the shore platforms are so remarkable and dense in distribution as they occupy about 90 percent of total area, and on the contrary they are scarce and sporadical on the Japan Sea coast and the Seto Inland Sea coast. This is different in part from the above-mentioned previous views.

On the Pacific coast where large peninsulas and bays alternate, large-scale shore platforms develop fairly concentratively on peninsulas or arched prominent rock coast, such as the Bōsō Peninsula, the Miura Peninsula, the Izu Peninsula, the southern Kii Peninsula, the Muroto Cape Peninsula, the southwestern Shikoku coast, the Nichinan Coast or the Tanegashima Island. On the East China Sea side where coastline indented delicately, they are distributed much densely, especially on the Tsushima Islands, the Gotō Islands and west Kyūsyū from the North Matsuura Peninsula to Akune. On the other hand, on the Japan Sea coast, they are limited only on Noto Peninsula and the northwestern Nagato Coast and sporadically on other parts. On the Seto Inland Sea coast they are very sporadical and small-scale, except on the Suō Coast.

Such regional differences in development of shore platforms are not only shown in the total area of reefs, but also in each size of reefs. The width and the broadest width of reefs were collected in each region (Table 3 and Fig. 3).

The mean width is about 60 m on the Pacific coast and the East China Sea coast, about 50 m on the Japan Sea coast and about 40 m on the Seto Inland Sea coast. Also the most frequent grade in histogram is higher on the Pacific coast and the East China Sea coast than on the Japan Sea coast, and lowest on the Seto Inland Sea coast. Moreover, frequency distribution in respect of the broadest width has a similar tendency.

As factors for such regional differences in development, it is adequate to consider lithology, geomorphological environment or wave condition, but it has not been clarified enough which is the most dominant one. Nevertheless, it is probable that wave condition regulates the development of shore platforms as wave agency retreats sea cliff and removes debris. The above-mentioned distribution of shore platforms seems to correspond roughly with wave condition: the violent wind wave and the high swell by typhoon on the Pacific and the East China Sea, the winter heavy wave by whirl wind and prevailing wind and the relative gentleness in other seasons on the Japan Sea, and the calm wave on the Seto Inland Sea.

Table 2 Area of 'reefs exposed at low tide' in each region

		East China Sea coast	Pacific coast					Seto Inland Sea coast	Japan Sea coast			total
			South-eastern Kyūshū	Southern Shikoku	Kii*	Tōkai and Southern Kantō	total		San-in	Hokuriku	total	
mesh (number)		604	148	119	123	142	532	110	67	98	165	1411
area	(km^2)	31.5	8.1	6.3	6.7	9.2	30.2	2.5	1.1	2.1	3.2	67.4
	(%)	46.8	12.0	9.3	9.9	13.6	44.8	3.7	1.6	3.1	4.7	100
area (km^2)/mesh		0.05	0.06	0.05	0.05	0.06	0.06	0.02	0.02	0.02	0.02	0.05

* exclusive of Shima Peninsula

Table 3 Width and the broadest width of 'reefs exposed at low tide'

(in 10 meters)

		East China Sea coast	Pacific coast					Seto Inland Sea coast	Japan Sea coast			total
			South-eastern Kyūshū	Southern Shikoku	Kii*	Tōkai and Southern Kantō	total		San-in	Hoku-riku	total	
width	mean	6.0	6.4	6.5	5.5	5.9	6.1	4.3	5.3	4.8	5.0	5.8
	range	1-36	1-40	1-20	1-18	1-16	1-40	1-20	1-18	1-16	1-18	1-40
	standard deviation	3.8	4.6	3.9	2.5	2.9	3.6	2.7	2.6	2.3	2.5	3.6
the broadest width	mean	10.5	11.3	9.8	11.8	12.9	11.5	5.1	7.8	7.1	7.4	10.0
	range	1-50	1-55	1-35	1-35	1-40	1-55	1-30	1-25	1-40	1-40	1-55
	standard deviation	8.8	8.9	6.5	6.6	7.4	7.6	4.5	4.7	5.5	5.2	7.6

* exculusive of Shima Peninsula

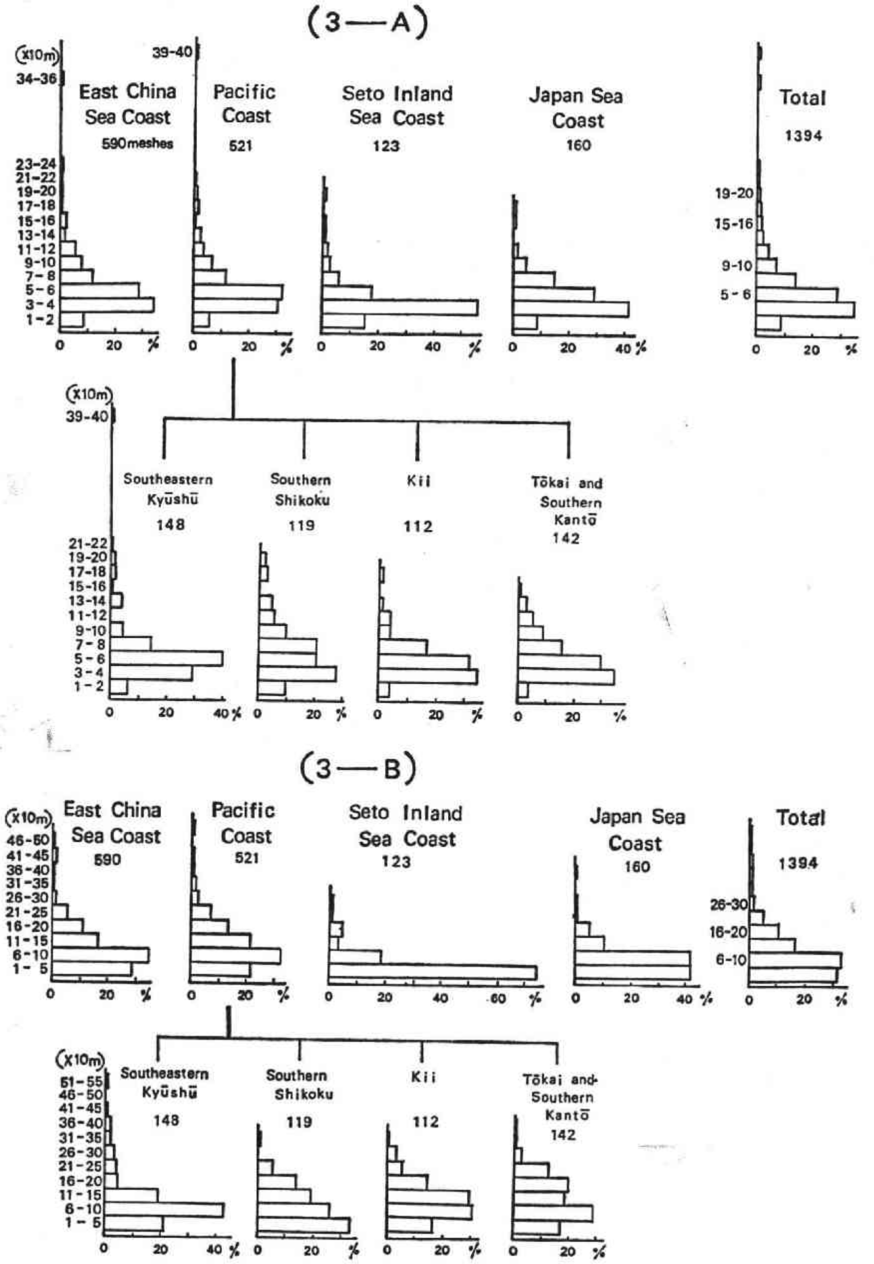

Fig. 3 Histograms of width (3-A) and the broadest width (3-B) of 'reefs exposed at low tide'

This is endorsed also by a few data on wave condition in Table 1, but more detailed discussion on the causation between the distribution of shore platforms and the wave condition is the subject for future study.

It is more difficult to recognize the correspondence between the distribution of shore platforms and tidal range (Table 1) and it is appropriate to presume that the tidal range has no direct causation with the development of shore platforms.

Lithologic condition must regulate the development of shore platforms. The area and the width of 'reefs exposed at low tide' are listed in each lithology (Table 4 and Fig. 4).

Shore platforms developed conspicuously on the coasts of Neogene (N) and the coasts of Mesozoic and Palaeogene (M), but scarcely on the coasts of Palaeozoic (P) and the coasts of igneous rock (I). Reefs of Neogene (N) and of Mesozoic and Palaeogene (M) occupies 44% and 47% in area respectively. Though the area of reefs of both Mesozoic and Palaeogene are summed up together because it is not always easy to distinguish between Mesozoic and Palaeogene on some geological maps, not a little reefs of Mesozoic are seen among them. Accordingly, it is not necessarily right to presume that shore platforms have developed mainly on the coasts of Tertiary formation. On such dominant distribution of shore platforms at the Tertiary formations, it is rather better interpretation that it is not because of easy formation but because of dominance of Tertiary coasts. Few shore platforms are at the Palaeozoic formation, except along the Saganoseki Peninsula, the Nishisonogi Peninsula or the Nagasaki Peninsula which consist of Palaeozoic shist (Takahashi, 1963b). Rather, the very coasts of Palaeozoic are few. Accordingly, it is better judgement that it is not because of difficult formation but because of scarcity of Palaeozoic coasts. Contrary to this, the coasts of igneous rock, in spite of their relatively numerous existence, have not conspicuous shore platforms. The coasts of granite have not remarkable shore platforms not only on the Seto Inland Sea with calm environment but also on open coast, such as around the Ōsumi Peninsula.

The width of reefs of Neogene is the largest (mean=64 m). Among them the reefs of mudstone, sandstone and the alternation of mudstone and sandstone are especially broad (mean=73 m). The reefs of Mesozoic and Palaeogene are relatively broad (mean=56 m). The width of reefs of the Palaeozoic coasts are slightly less (mean=49 m). In this case it is necessary to note that the mean value seems to be represented less because several reefs are located on inland sea. On the open coasts of Palaeozoic, such as the Nishisonogi Peninsula and Nagasaki Peninsula, reefs are relatively broad. The width of the reefs of igneous rock is the least not only on sheltered coasts but also on open coasts. The shore platforms of granite or andesite, which were studied on Sanriku Coast (Kosugi, 1958), San-in Coast

Table 4 Area and width of 'reefs exposed

		Palaeozoic (P)	Mesozoic and Palaeogene (M)	Neogene (N)	
				a, s, m	c
mesh (number)		67	642	244	28
area	(km²)	2.7	31.9	16.2	1.2
	(%)	3.9	47.4	24.1	1.8
width	mean (10m)	4.9	5.6	7.3	6.4
	range (10m)	1-16	1-36	1-40	1-14
	standard deviation	3.1	3.4	4.4	2.6
the broadest width	mean (10m)	8.6	11.0	13.6	12.4
	maximum (10m)	40	48	53	40

a: alternation of sandstone and mudstone s: sandstone m: mudstone and siltstone

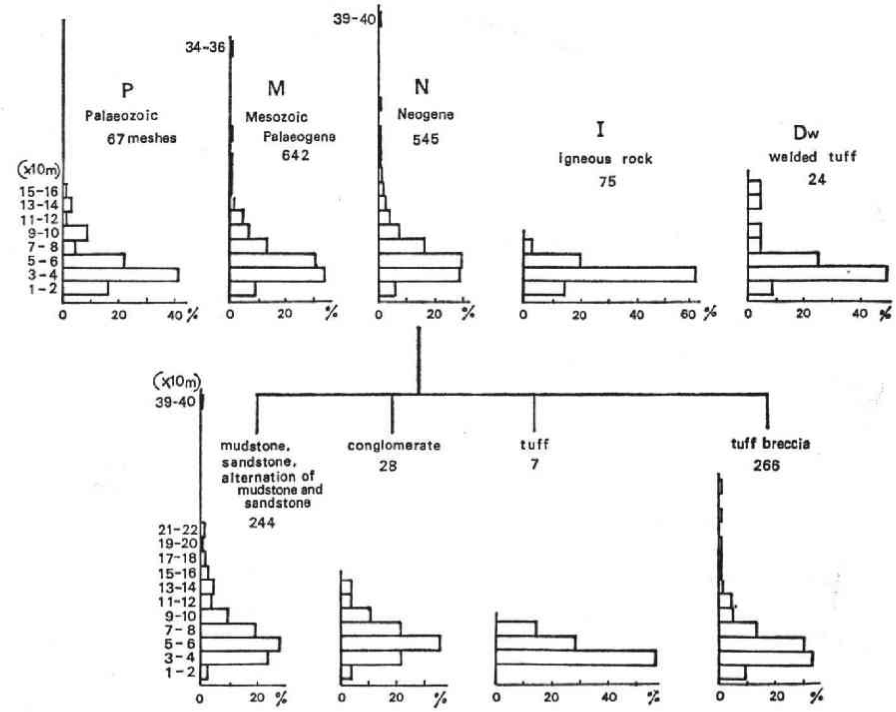

Fig. 4 Histograms of width of 'reefs exposed at low tide' in each lithology

at low tide' in each lithology

Neogene (N)			Igneous rock (I)	Welded tuff (Dw)	others	total
t	b	total				
7	266	545	75	24	58	1411
0.1 0.2	11.7 17.3	29.3 43.5	1.2 1.7	1.4 1.1	1.0 1.5	67.4 100
4.7 1-8 1.7	5.6 1-28 3.4	6.4 1-40 4.0	3.5 1-8 1.3	5.1 1-16 3.5	— — —	5.8 1-40 3.6
6.3 13	10.3 40	11.8 53	5.8 19	10.8 28	— —	10.0 53

c: conglomerate t: tuff b: tuff breccia (exclusive of Shima Peninsula)

(Toyoshima, 1965, 67) or Hirado Island (Takahashi, 1972), are small in scale. Shore platforms of igneous rock seem to have hardly developed on a large-scale.

According to the analysis of 400 platform profiles on several coasts of Japan (though the detailed discussions of which are left for another opportunity), the average length of those profiles is 65 m on Neogene, 68 m Mesozoic and Palaeogene and 30 m on igneous rock. It has little difference from the width of 'reefs exposed at low tide'.

It may well be considered from the results described above that the width of shore platforms in Southwestern Japan is approximately 30–80 m in average and about 500 m in maximum, with some differences according to lithology.

A continuous shore platform without breaks along a coastline is not too long. The longest one is a shore platform which extends 4 km in distance and 100 m or more in width along nearly straight coastline from Tozakibana to Uchiumi, Nichinan Coast (Takahashi, 1973b). However, ordinary platforms are almost less than several hundred meters in distance, as they are cut in pieces with small inlets.

4 Summary

The outline of the distribution of shore platforms on Southwestern Japan coast is arranged as follows by mapping of 'reefs exposed at low tide' from 1:25,000 topographic maps and by map measuring.

(1) The shore platforms in Southwestern Japan have developed conspicuously on the Pacific coast and the East China Sea coast, less on the Japan Sea coast and least on the Seto Inland Sea coast. Accordingly, previous views about the distribution will have to be corrected in part. Corresponding to the distribution, the width

of 'reefs exposed at low tide' is larger on the Pacific coast and the East China Sea coast (mean=60 m), and less on the Japan Sea coast (mean=50 m) and on the Seto Inland Sea coast (mean=40 m). The regionality in their development seems to correspond roughly to the wave condition on each coast. But the detailed discussion about the causation between the development and the wave condition is left for future study.

(2) In the previous views shore platforms had been considered to be almost on the coast of Tertiary formation. However, they are distributed remarkably not only on the coasts of Neogene but also on the coasts of Mesozoic and Palaeogene. Moreover, broad shore platforms seem to be distributed on the coasts of Palaeozoic, but the platforms are hard to be broad at the igneous rock.

(3) The shore platforms on Southwestern Japan are 30–80 m in the average width, about 0.5 km in the maximum width and nearly 4 km in the maximum distance continuing along a coastline.

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