



ORGANIC MATERIAL AND SEA-LEVEL CHANGE IN MANGROVE HABITAT

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Preliminary Results from the Submarine Sediment Samplings off the Mangrove Habitats in the Khlong Thom and Satun Areas, South Thailand

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Introduction

Dense mangrove habitats are distributed in the Khlong Thom and Satun areas in the western coast of the central Malay Peninsula, South Thailand (Fig. 1). Tsukawaki and Kamiya (1998), Tsukawaki and Asano (1999) and Tsukawaki *et al.* (1999) illustrated active subaqueous sedimentary processes controlled by strong tidal-currents in and around the habitats based on spatial distributions and compositions of the subaqueous sediments obtained from both areas in 1996 and 1997. However, the problem on pursuing the origin of such biogenic sediments as calcareous benthic foraminifers and marine ostracodes still remain

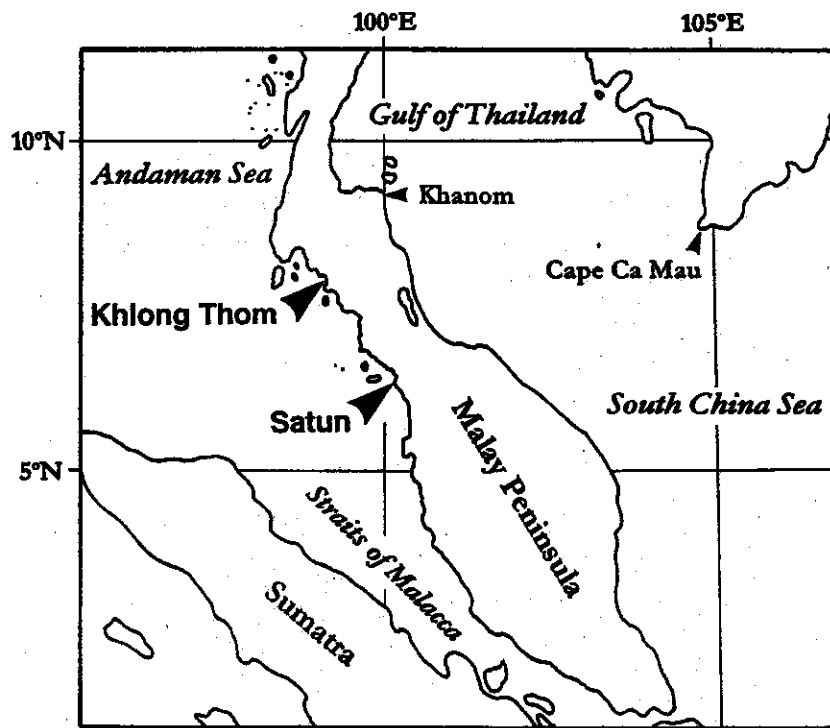


Fig. 1: Locations of the Khlong Thom and Satun areas in the western coast of the central Malay Peninsula, South Thailand.

Table 1. Results of surface sediment samplings, and measurements of water depths and chemical properties of surface waters.

Station	Area	Locality	Sampler	Date (DAY/M)	Time	Latitude (N)	Longitude (E)	Water Depth (m)	Water Temp (°C)	Water Salinity (‰)	Water pH	Water DO (ppm)	Sediment
KT98-1	Khlong Thom	Straits of Malacca	Tamura Grab	25/02/99	08:20	7° 58'37.8"	98° 55'00.0"	5.2	27.8	32.0	8.0	6.02	moluscan shell fragment rich bluish grey fine-grained sand
KT98-2	"	"	"	"	08:26	7° 57'29.6"	98° 54'43.8"	6.2	28.1	32.0	8.0	6.26	moluscan shell fragment rich bluish grey fine- to medium-grained sand
KT98-3	"	"	"	"	08:25	7° 58'14.4"	98° 54'36.0"	6.0	28.6	32.0	8.0	6.24	moluscan shell fragment bearing bluish grey fine- to medium-grained sand
KT98-4	"	"	"	"	10:23	7° 53'44.4"	98° 54'14.3"	8.4	28.1	31.0	8.1	6.01	moluscan shell fragment bearing bluish grey fine- to medium-grained sand
KT98-5	"	"	"	"	10:23	7° 53'44.4"	98° 54'14.3"	8.4	28.1	31.0	8.1	6.01	moluscan shell fragment bearing bluish grey fine- to medium-grained sand
KT98-6	"	"	"	"	10:47	7° 52'51.7"	98° 53'18.9"	14.8	30.4	31.0	8.1	6.24	greyish brown muddy sand
KT98-7	"	"	"	"	11:10	7° 52'12.3"	98° 53'01.1"	7.2	30.2	31.0	8.1	6.11	moluscan shell fragment rich bluish grey fine- to medium-grained sand
KT98-8	"	"	"	"	11:25	7° 51'14.3"	98° 53'07.0"	7.4	29.7	31.0	8.1	6.27	moluscan shell and shell fragment rich bluish grey fine-grained sand
KT98-9	"	"	"	"	11:47	7° 50'00.3"	98° 54'52.2"	9.5	30.0	31.0	8.2	6.27	moluscan shell fragment bearing brownish grey fine-grained sand covered by brownish yellow mud
KT98-10	"	"	"	"	12:04	7° 49'45.3"	98° 53'12.8"	10.3	29.6	31.0	8.2	6.04	moluscan shell fragment rich bluish grey fine- to medium-grained sand covered by brown mud
KT98-11	"	"	"	"	12:22	7° 48'45.1"	98° 53'17.7"	8.4	30.1	31.0	8.2	6.33	moluscan shell fragment rich bluish grey fine- to medium-grained sand covered by brown mud
KT98-12	"	"	"	"	12:42	7° 48'50.9"	98° 57'30.4"	6.7	28.5	31.0	8.2	6.48	moluscan shell fragment rich moderate grey fine- to medium-grained sand
KT98-13	"	"	"	"	13:31	7° 48'05.2"	98° 57'47.3"	4.2	30.1	31.0	8.1	6.09	moderate grey fine-grained sand covered by brown mud
KT98-14	"	"	"	"	13:51	7° 47'29.9"	98° 57'30.0"	7.9	30.2	31.0	8.2	6.22	moluscan shell fragment rich bluish grey fine- to medium-grained sand covered by brown mud
KT98-15	"	"	"	"	14:13	7° 46'10.9"	98° 48'50.1"	7.2	30.1	33.0	8.2	6.49	moluscan shell fragment bearing bluish grey fine-grained sand covered by brown mud
KT98-17	"	"	"	"	14:34	7° 45'58.2"	98° 50'05.7"	8.2	29.3	33.0	8.2	6.08	yellowish brown medium-grained sand with bluish grey mud balls
KT98-18	"	"	"	"	14:32	7° 47'00.3"	98° 03'31.2"	8.4	29.3	32.0	8.1	6.71	moluscan shell fragment rich yellowish brown medium- to coarse-grained sand
KT98-19	"	"	"	"	18:15	7° 48'25.4"	98° 01'19.3"	6.0	29.8	32.0	8.2	5.71	moluscan shell fragment rich dark grey fine-grained sand
KT98-20	"	"	"	"	18:32	7° 48'34.2"	98° 00'46.8"	15.0	29.4	32.0	8.2	5.78	granule- to pebble-gravel and moluscan shell fragment bearing brown mud
KT98-15	"	"	"	25/02/99	08:38	7° 54'48.0"	98° 59'16.5"	4.5	29.5	33.0	8.0	5.89	moluscan shell fragment rich moderate grey medium-grained sand with sea weeds
KT98-21	"	"	"	"	10:30	7° 53'53.7"	98° 52'00.1"	17.0	29.8	31.0	8.2	6.26	moluscan shell fragment bearing bluish grey muddy fine-grained sand
KT98-22	"	"	"	"	10:49	7° 53'25.2"	98° 52'55.8"	16.0	31.8	31.0	8.1	6.30	moluscan shell fragment bearing bluish grey muddy sand covered by brown mud
KT98-23	"	"	"	"	11:16	7° 53'08.8"	98° 54'24.3"	8.0	29.6	32.0	8.1	6.34	moluscan shell fragment rich moderate grey fine-grained sand
KT98-24	"	"	"	"	11:28	7° 53'30.1"	98° 55'59.4"	4.8	29.4	32.0	8.1	6.08	moluscan shell fragment rich bluish grey fine-grained sand
KT98-25	"	"	"	"	12:01	7° 53'37.7"	98° 57'09.8"	4.5	29.6	32.0	8.1	7.11	moluscan shell fragment rich bluish grey fine- to medium-grained sand covered by brown mud
KT98-26	"	"	"	"	12:18	7° 53'48.9"	98° 58'15.7"	2.0	30.1	32.0	8.1	6.00	moluscan shell fragment rich bluish grey fine- to medium-grained sand covered by brown mud
KT98-27	"	"	"	"	12:48	7° 52'28.6"	98° 59'28.9"	4.8	30.6	32.0	8.1	6.15	moluscan shell fragment rich bluish grey fine- to medium-grained sand covered by brown mud
ST98-1	Satun	Straits of Malacca	"	26/02/99	08:04	6° 31'04.1"	100° 02'00.3"	1.8	37.4	32.0	8.1	4.23	moluscan shell fragment rich bluish grey muddy sand covered by brownish yellow mud
ST98-2	"	"	"	"	08:18	6° 30'01.0"	100° 02'03.0"	2.4	38.1	32.0	8.2	3.88	oyster shells and shell fragments with a small amount of bluish grey sandy mud
ST98-3	"	"	"	"	08:25	6° 30'00.9"	100° 01'01.0"	5.1	37.9	32.0	8.3	4.80	moluscan shell fragment bearing olive grey mud covered by brownish grey mud
ST98-4	"	"	"	"	08:48	6° 29'00.8"	100° 00'56.0"	6.0	40.0	32.0	8.3	3.99	moluscan shell fragment bearing olive grey mud covered by plant debris bearing brownish grey mud
ST98-5	"	"	"	"	10:01	6° 28'00.8"	100° 00'56.0"	4.8	38.8	33.0	8.3	4.04	moluscan shell fragment and plant debris bearing olive grey mud
ST98-6	"	"	"	"	10:15	6° 27'00.3"	100° 01'03.0"	8.3	38.5	32.0	8.2	3.78	moluscan shell fragment bearing olive grey mud covered by plant debris rich brown mud
ST98-7	"	"	"	"	10:29	6° 26'55.4"	100° 01'39.0"	4.8	37.5	32.0	8.2	3.77	moluscan shell fragment bearing olive grey mud covered by plant debris bearing brown mud
ST98-8	"	"	"	"	10:48	6° 27'38.0"	100° 02'02.3"	5.0	37.7	32.0	8.2	4.34	moluscan shell fragment bearing bluish grey mud covered by plant debris bearing brown mud
ST98-9	"	"	"	"	11:03	6° 28'36.6"	100° 03'30.2"	3.1	35.1	32.0	8.1	5.01	moluscan shell fragment bearing olive - bluish grey mud covered by plant debris bearing brown mud
ST98-10	"	"	"	"	11:31	6° 29'03.8"	100° 03'48.2"	2.8	31.8	32.0	8.1	5.78	plant debris bearing bluish grey mud covered by yellowish grey mud
ST98-11	"	"	"	"	11:48	6° 28'04.1"	100° 05'36.9"	1.8	28.3	31.0	8.2	6.58	moluscan shell fragment and plant debris bearing bluish grey mud covered by reddish brown mud
ST98-12	"	"	"	"	12:02	6° 28'58.8"	100° 06'00.0"	1.4	28.6	31.0	8.1	6.28	moluscan shell fragment and plant debris bearing bluish grey mud covered by yellowish brown mud
ST98-13	"	"	"	"	13:29	6° 29'39.3"	100° 04'37.3"	2.4	30.7	32.0	8.2	6.80	moluscan shell fragment and plant debris bearing moderate grey sandy mud covered by brown mud
ST98-14	"	Tam Ma Lang Bay	"	"	14:00	6° 30'52.8"	100° 05'52.1"	1.0	30.3	32.0	8.2	5.98	plant debris rich bluish grey mud covered by yellowish brown mud
ST98-15	"	"	"	"	14:12	6° 31'58.9"	100° 06'56.4"	6.8	29.9	31.0	8.2	4.69	plant debris rich bluish grey mud covered by reddish brown mud
ST98-16	"	Phrao Estuary	"	"	14:42	6° 33'53.4"	100° 09'55.7"	2.4	29.7	31.0	8.0	3.89	plant debris rich yellowish brown muddy sand covered by brownish grey mud

unsolved. Further, the subaqueous surface sediments of the southernmost and largest strait in the Khlong Thom area that seems to be the main water course in the area had been known. As a part of the field research project "Organic Material and Sea-level Change in Mangrove Habitat", submarine sediments off the mangrove habitats in the Khlong Thom and Satun areas were collected and investigated to comprehend present distribution and composition of them. Further, measurements of water depth and chemical properties of surface water were carried out in the area. Taking the results of the previous searchings into account, this article describes mainly the spatial distribution and composition of the submarine sediments from the studied areas on the basis of the results of both onboard observations and sedimentological analyses in the laboratory of the sediments. Topographical and geological backgrounds of the studied areas are referable in above-mentioned articles.

Sampling Methods and Analytical Procedures

Submarine sediment samples used for the present study were collected in February 1999 in the Khlong Thom and Satun areas. The samplings were carried out mainly in the offshore areas, the area of the Straits of Malacca in both (Figs. 2 and 3). Four sampling sites were located in the estuarine mouth area in the Khlong Thom area, and two and one sites were selected in a subaqueous channel in the eastern marginal part of the Tam Ma Lang Bay (Tsukawaki *et al.*, 1999) and the Phrao Estuary on the north of the bay in the Satun area, respectively. Sampling devices were a Tamura-type grab surface sampler, about 2,000 ml in volume. Salinity, hydrogen ion exponent value (pH), and temperature and dissolved oxygen amount (DO)

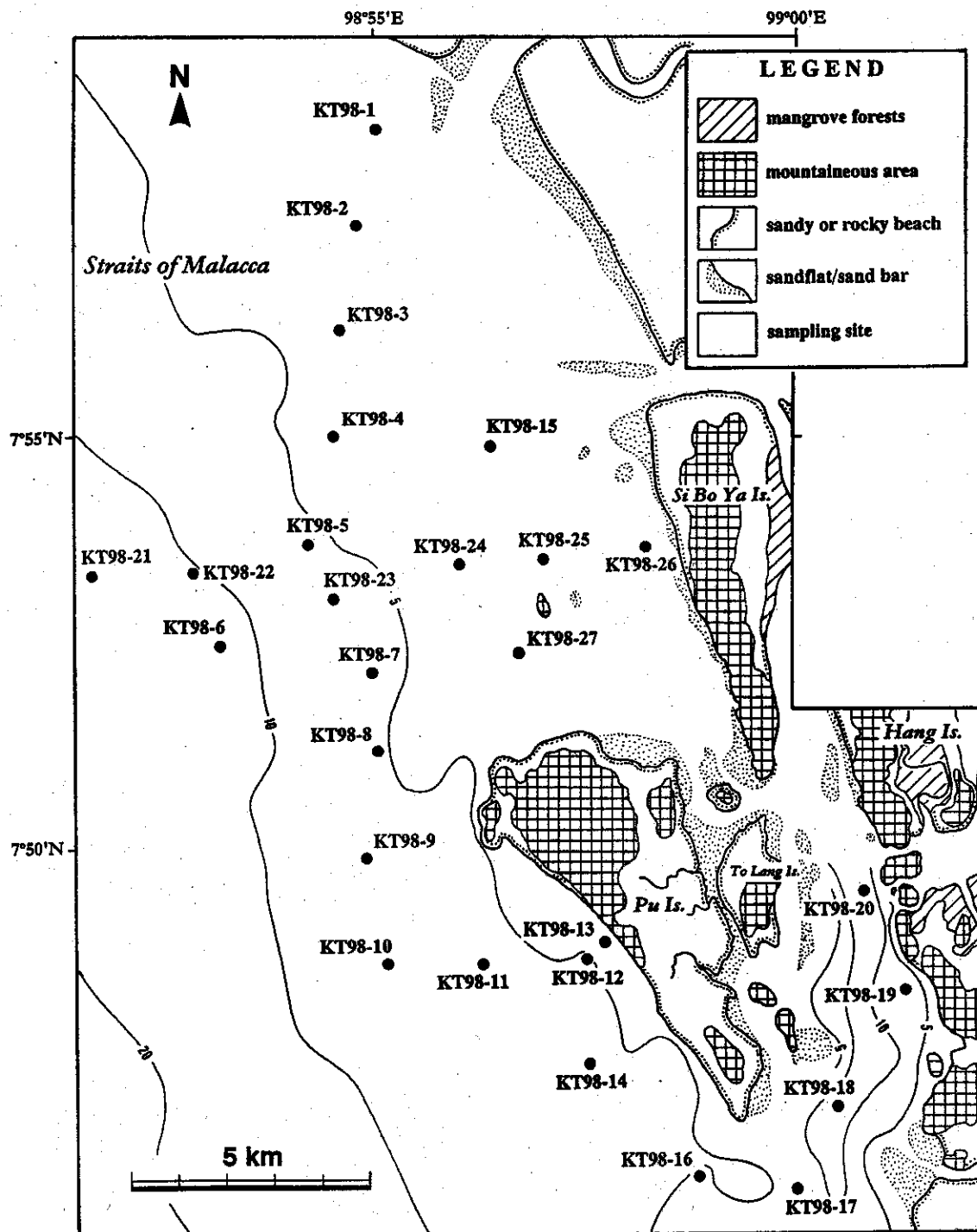


Fig. 2. Sites of subaqueous sediment samplings and measurements of chemical properties of surface waters in the Khlong Thom area in February 1999.

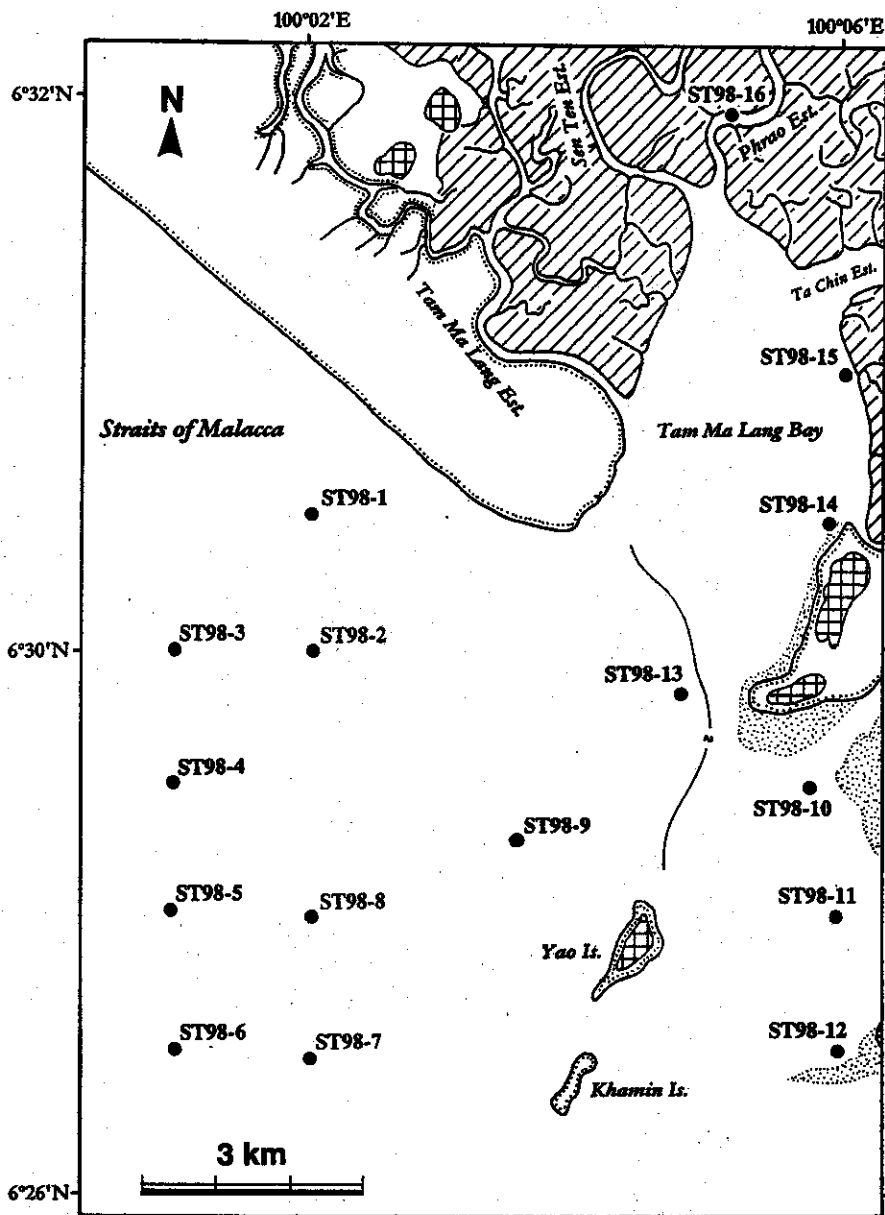


Fig. 3. Sites of subaqueous sediment samplings and measurements of chemical properties of surface waters in the Satun area in February 1999.

measurements for surface waters were conducted using by an Atago digital salt-meter type ES-421, a Horiba compact pH meter type B-212 and a Horiba handy DO meter type OM-12, respectively. The site survey was always carried out with a water depth measurement by using an about 20-metres-long nylon rope with an about two kilogrammes weight. Latitude and longitude of each sampling site were confirmed by using a Sony type IPS-360 GPS receiver. Twenty-seven and 16 subaqueous surface sediments were successfully obtained from the Khlong Thom and Satun areas, respectively (Table 1).

In the laboratory, smear slides were prepared first and examined under a microscope for compositional description of muddy sediments. For sandy sediments, the entire sample was heated over 24 hours at about 50 °C, and its dry weight was measured. Then, it was washed over a screen with an opening of 63 μ m to remove muddy sediments, and dried and weigh again to obtain proportional mud contents. The remained sandy sediments were sieved over screens with openings of 90, 125, 180, 250, 355, 500, 710, 1,000, 1,400, 2,000, 2,800 and 4,000 μ m. Then, dry weights of remains on each screen were measured to obtain proportional grain-size distribution in weight for sandy sediments. Further, microscopic observations for each remain were conducted to the textural and compositional description for sandy sediments.

Results

Water Depths and Chemical Properties of Surface Waters

Table 1 shows the results of measurements of water depths and chemical properties of surface waters in both Khlong Thom and Satun areas.

Khlong Thom Area: An offshoreward gradual deepening from a few metres near the coast to 17 m at the offshoremost site is recognizable in the Khlong Thom area. Water depths in the strait situated between the Pu Island and the mainland are generally 6 - 10 metres, but deeper part is located near the straits between the Hang Island and the mainland. The results from the measurements of chemical properties of the surface waters in the studied area are mostly concordant with them of Tsukawaki *et al.* (1999). It has no tendency in the spatial distribution of salinity and temperature of the surface waters which are almost high round 32 ‰ and 30 °C, respectively. No tendency is also recognizable in the distribution of hydrogen ion exponent value (pH) which are 8.0 - 8.2 in whole area. However, a certain gradient is distinguished in the spatial distribution of dissolved oxygen amount (DO). The highest DO, 7.11 ppm, is distinguished at the site KT99-25 about 2 km west off the Si Bo Ya Island, and high DO area is traceable southwards to off the Pu Island. In contrast to this, the lowest DO is recognized at the site KT99-6 about 10 km west off the Si Bo Ya Island, and the sites KT99-12 and 13 on the western coast of the Pu Island. The DO in the strait between the Pu Island and the mainland is relatively low round 5.7 ppm.

Satun Area: Offshore water depths in the Satun area are shallow 3 - 6 m deep in general. The deepest part is recognized in the subaqueous channel situated near the eastern coast of the Tam Ma Lang Bay (Tsukawaki *et al.*, 1999) where the water depth is 6.8 metres. The results from the measurements of chemical properties of the surface waters in the studied area are roughly concordant with them of Tsukawaki *et al.* (1999). It has no marked tendency in the spatial distribution of hydrogen ion exponent

Table 2. Proportional mud contents and compositions of sandy sediments of the selected submarine sediments from the Khlong Thom and Satun areas (+++: dominant, ++: common, +: present, *: pyroxenes and zircon, **: limestones and laterites).

Station	Locality	Mud Content (%)	Terrigenous Sediments					Biogenic Sediments										Artificial Sediments	
			l. quartz	m. c. quartz	biocite	heavy min. *	pyrite	silic. frag. **	benth. foram.	plank. foram.	ostracode	radiolarian	diatom	sponge spicule	sponge microc.	echinoid	plant debris	mollus. shell	charcoal grain
KT98-1	Straits of Malacca	36	+++					+	++							+	+	+++	+
KT98-3	"	20	+++						++							++	++	+++	+
KT98-4	"	10	+++						++							++	++	+++	+
KT98-5	"	23	+++						++							++	+	+++	+
KT98-6	"	81	+++						++							+	++	+++	
KT98-7	"	22	+++					+	++							++	+	+++	
KT98-8	"	16	+++						++							++	+	+++	
KT98-10	"	18	+++					+	++							+	+	+++	
KT98-11	"	32	+++						+	+						+	+	+++	+
KT98-12	"	5	+++						++							+	+	+++	
KT98-13	"	18	+++						++							++	+	+++	
KT98-14	"	14	+++						++							+	+	+++	
KT98-15	"	3	+++						++							+	+	+++	+
KT98-16	"	14	+++						++							+	+	+++	
KT98-17	Southern Strait	1	+++					+	++							+	+	+++	
KT98-18	"	3	+++	+					++							+	+	+++	
KT98-19	"	12	+++	+					++							+	+	+++	+
KT98-20	"	24	+++	++					+							+	++	+++	
KT98-21	Straits of Malacca	59	+++						++							+	++	+++	+
KT98-22	"	37	+++		+				++	+	++					++	+++	+++	
KT98-24	"	12	+++						+		++					++	+	+++	
KT98-25	"	14	+++						++		++					+	+	+++	
KT98-26	"	13	+++						++		++					++	+	+++	+
KT98-27	"	11	+++						+		++					++	+	+++	+
ST98-2	Straits of Malacca	23	+++	+					+							+	+	+++	+++
ST98-13	"	33	+++	+	+				++	+++						+	+++	+++	+
ST98-15	Tam Ma Lang Bay	98	+++	++					+	++						+	+++	+++	+
ST98-18	Phrao Estuary	45	+++		+			+	++							+	+++	+++	++

value which are 8.0 - 8.3 and salinity about 32 ‰ in whole area. In contrast to these, clear differences are recognized on the distribution of water temperature and dissolved oxygen amount (DO) in the surface waters distributed between in the western and eastern halves of the studied area. The former and latter are characterized by high water temperature 35 - 40 °C and low DO less than 4.5 ppm, and comparatively low water temperature round 30 °C and high DO over 5.0 ppm, respectively.

Subaqueous Sediments

Table 1 shows the results of onboard observations of the submarine sediments obtained from the Khlong Thom and Satun areas. Compositions and microscopic photographs for sandy sediments from the selected samples are shown in the Table 2 and the Plate figures, respectively.

Khlong Thom Area: Molluscan shells and shell fragments rich or bearing bluish grey very fine-grained sand or muddy sand mostly covers the sea-floor in the area of the Straits of Malacca. Proportional mud contents of these sediments are generally low less than 30%, but it increases offshorewards clearly from 13 % to 59 % at the sites 2 km and 13 km west of the Pu Island, respectively. Calcareous benthic foraminifers and marine ostracodes are frequently contained in these sediments (Plate, figs. 1 and 2). Planktonic foraminifers and radiolarians are occasionally detected. Sandy terrigenous sediments are composed chiefly of very fine- to fine-grained quartz with a very little amount of heavy minerals such as zircon (Plate, figs. 5 and 6). Muddy sediments consist mainly of clay minerals. Coccolith is frequently recognized in the muddy sediments. In contrast to this, yellowish brown medium- to coarse-grained sands composed mainly of quartz and lateritic rock fragments are distributed in the sea-floor of the strait between the Pu Island and the mainland (Plate, figs. 3 and 4). Molluscan shells and shell fragments are the dominant biogenic sediments in these samples. Plant debris, both calcareous and agglutinated benthic foraminifers

and marine ostracodes are rare. The sample obtained at the innermost site, KT99-20, of the studied area consists of granule- to pebble-gravels and molluscan shell fragment bearing brown mud.

Satun Area: Molluscan shells and shell fragments rich or bearing olive grey or bluish grey homogeneous muds are distributed in the sea-floor of the area of the Straits of Malacca and the Tam Ma Lang Bay area. Reddish brown mud, less than one centimetre thick, covers the surface in part. Proportional mud contents of these samples are varied from 12 to 98 %, but they excluding the molluscan shells and shell fragments are inferred to be more than 90 %. Plant debris, calcareous benthic foraminifers and marine ostracodes are commonly recognized in these sediments. Sandy terrigenous sediments consist mainly of very fine- to fine-grained quartz (Plate, fig. 7). Muddy sediments consist mainly of clay minerals. Coccolith is frequently recognized in the muddy sediments. On the other hand, plant debris rich yellowish brown muddy sand is obtained from the bottom of the Phrao Estuary. Sandy sediments are composed mainly of medium- to very coarse-grained quartz with a small amount of lithic fragments consisting mainly of limestones. Charcoal grains and very fine-grained zircon are frequently recognized in the sediments. Both calcareous and agglutinated foraminiferal tests, and molluscan shell fragments are rarely distinguished.

Discussion: Spatial Distributions and Compositions of Offshore Sediments

As already mentioned, Tsukawaki and Kamiya (1998) and Tsukawaki *et al.* (1999) demonstrated the active subaqueous sediment exchanging processes in and around the mangrove habitats in the Khlong Thom and Satun areas due to the strong tidal currents. Within the water areas of both, such marine biogenic sediments as calcareous benthic foraminifers and marine ostracodes are detected in most of sediments from the middle to innermost parts of the areas. In contrast to this, plant debris and charcoal grains derived from the mangrove habitats and local villages or kilns located in the habitats in the inner parts of the areas are traceable into almost all sediments from the offshore areas. On the basis of the spatial distribution and composition of these traceable biogenic and artificial sediments stated above in the subaqueous sediments, and taking subaqueous topographical transitions in compliance with the tidal-level into account, Tsukawaki *et al.* (1999), and Tsukawaki and Asano (1999) illustrated main course ways of sediment transportation in both Khlong Thom and Satun areas by the strong tidal currents at various stages during both flooding and ebbing periods.

Tsukawaki *et al.* (1999) inferred that the main sediment transportation in the Khlong Thom area during both flooding and ebbing periods takes place through both northern and southern straits between the Si Bo Ya Island and the mainland, and between the Pu Island and the mainland, respectively. The submarine sediments obtained from the southern strait in the present study are characterized by dominance of coarse- to very coarse-grained quartz that is the dominant sediments in the inner part of the area. Further, they contain comparatively large amounts of plant debris and charcoal grains originated in the inner parts. The relative quantity of the coarse-grained quartz and above-stated biogenic sediments is much greater than that in the northern strait (Tsukawaki and Kamiya, 1998). These facts support the idea that the main sediment transportation during the ebbing tide is taking place through the southern strait in the Khlong Thom area.

On the other hand, Tsukawaki *et al.* (1999) recognized a subaqueous channel that starts from the northeastern marginal part of the Tam Ma Lang Bay near the entrance of the Ta Chin Estuary and reaches west off the Yao Island through the central bay mouth area. They and Tsukawaki and Asano (1999) judged that the subaqueous sediments are transported mainly through the channel during both flooding and ebbing periods in the Satun area. The results of their bathymetrical survey and sedimentological analysis for the subaqueous sediments support the existence of the channel, but details of its southwestern extension have been left pending. In spite of offshore sediments from presumable southwestern extension of the channel and around the channel were collected and investigated in the present study, no evidence for the existence of the southwestern extension of the channel has been obtained in the studied area. Owing to a lack of field evidence, a definite conclusion for existence of the southwestern extension of the channel in the studied area must be reserved.

Conclusion

The principal findings of this study can be summarized as follows.

1. Water depths and chemical properties of surface waters.

A. Khlong Thom area

- a. An offshoreward gradual deepening is recognized west off the Si Bo Ya Island, and water depths in the southern strait are 6 - 10 m
- b. A certain gradient is distinguished in the spatial distribution of DO in the area of the Strait of Malacca.

B. Satun area

- a. Water depths in offshore area are generally 3 - 6 m.
- b. Clear differences are recognized on the distribution of temperature and DO in the surface waters between in the west and east of the studied area.

2. Subaqueous sediments around the mangrove habitats

A. Khlong Thom area

- a. Molluscan shells and shell fragments rich or bearing bluish grey very fine-grained sand or muddy sand mostly covers the sea-floor in the area of the Straits of Malacca.
- b. Yellowish brown medium- to coarse-grained sands composed mainly of quartz and lateritic rock fragments are distributed in the southern strait.

B. Satun area

- a. Molluscan shells and shell fragments rich or bearing olive grey or bluish grey homogeneous muds are distributed in the sea-floor of the areas of the Straits of Malacca and the Tam Ma Lang Bay.
- b. Plant debris rich yellowish brown muddy sand covers the bottom surface of the Phrao Estuary.

3. The main sediment transportation during the ebbing tide is taking place through the southern strait in the Khlong Thom area.

4. A definite conclusion for existence of the southwestern extension of the subaqueous channel that is the

main sediment transportational route in the Satun area must be reserved.

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Explanation of Plate

Microscopic photographs of sandy sediments of the subaqueous off the Khlong Thom and Satun mangrove habitats, South Thailand

Figs. 1 and 2: Very fine to fine-grained quartz with calcareous benthic foraminifers and marine ostracodes from the site KT98-1 in the northern part of the Khlong Thom area.

Figs. 3 and 4: Poorly sorted but well rounded medium- to coarse-grained quartz with a small amount of lithic fragments and calcareous materials from the site KT98-17 in the southern strait of the Khlong Thom area.

Figs. 5 and 6: Very fine-grained quartz with calcareous benthic foraminifers and marine ostracodes from the site KT98-21 in the westernmost offshore of the Khlong Thom area.

Fig. 7: Fine-grained quartz with calcareous materials from the site ST98-6 in the offshoremost part of the Satun area.

Fig. 8: Plant debris bearing medium- to coarse-grained quartz from the site ST98-16 in the Phrao Estuary in the northernmost part of the Satun area.

