Appendix. 3.2 Sea Water Quality (Sea)

1. Introduction

2. Water Quality

2.1. General Conditions in the Upper Gulf of Thailand

2.1.1. Geographical Characteristics of the Upper Gulf of Thailand

2.1.2. Existing Current Conditions

2.1.3. Water Quality

2.1.4. Existing Sediment Conditions

2.2 Pattaya Water Quality Survey

2.2.1. Current Conditions

2.2.2. Tidal Current Simulation

2.2.3. Water Quality

2.2.4. Sediment Conditions

3. Estimating Pollutants Loads in Pattaya Sea Area

3.1. Sources of Pollution

3.2. Effects of Industrial Waste Waters on the Sea

3.3. Pollutant Loads in the Study Area

4. Conclusion

4.1. Seasonal Changes in Water Quality

4.2. Cotamination of Water Quality

4.3. Suitability as the Ocean Resort

1. Introduction

Now, Pattaya has become one of the most famous international beach resorts in South East Asia although it was only a small fishing village of ten years ago. In contrast to its rapid development, the infrastructures, such as the water supply and sewage systems, are still lagging behind and then the waste waters are directly discharged into the rivers and the sea. The water quality of the swimming area, which is an important factor for a beach resort, is deteriorating progressively, and therefore the countermeasures are urgently needed. For the Tourism Development Plan, we have the opinion that a special attention shall be paid for this deterioration of the waters. Based on this judgement, we have conducted a survey on the water quality and the currents conditions in the subject waters. The basic data obtained in this survey was submitted as Appendix to the Master Plan for Pattaya Tourism Development in December, 1977.

In this Appendix, we will summarize and discuss the results of our water quality survey. It is sincerely hoped that these results would become useful in realizing the Thai Government's efforts for conserving the marine environment at Pattaya. As a matter of fact, NEB is conducting the water quality survey on a continuous basis along Pattaya Beach and conducting researches for The Environmental Guidelines for Coastal Zone Management.[1)2)3)] We hope that these results of the water quality survey will be used and follow-ups will be made.

The present water quality survey was aiming to judge the present levels of the water quality and to offer the basic data for future monitorings. We had encountered considerable difficulties in selecting the items of measurements and the station position of investigations because of the limited length of time for the survey, but we have done our best to obtain as many integrated data as possible. Considering the various development plans are being formed for the area north of Pattaya (Laem Chabung and its peripheral area), and the discharge from Na Klua River, the current and the water quality in the offshore area as well as those in front of Pattaya Beach were investigated.

Finally, we wish to express our wholehearted thanks to Thai Government for their various assistance offered to us.

2. Water Quality

2.1. General Conditions in the Upper Gulf of Thailand

2.1.1. Geographical Characteristics of the Upper Gulf of Thailand

The Upper Gulf of Thailand extends about 100 km from south to north, and about 100 km from east to west and has an area of about 10,000 km^2 with a shape similar to rectangle with an open mouth at its southern boundary. The depth is rather shallow within a range of 15 to 20 m, and it is deeper along the east coast than along the west coast. Four big rivers flow into the Gulf at the northern end, discharging water of about 4.3×10^{10} m^3/year into the Gulf[1).]

2.1.2. Existing Current Conditions

1) Circulation Pattern

There are some available records of the current observations made in the Gulf of Thailand. A number of reports made by Hydrographic Department, etc., on the circulation pattern are summarized below.

The flows in the Upper Gulf have the complex conditions of tidal currents, drift currents and density currents. Roughly speaking, there is a weak clockwise flow from May to September, while a counter clockwise flow from November to March.

The weak clockwise flow from May to September is caused mainly by the southwest monsoons, and the flow becomes stronger as the southwest monsoons become powerful in August.

The counter clockwise flow from October to March is mainly caused by the northeast monsoons. As the northeast monsoons become strong in December, this counter clockwise flow also becomes stronger.

2) Tide and Tidal Current at the Upper Gulf of Thailand

The sea level varies greatly at the Upper Gulf of Thailand due to the tide; max. of 3 m and mean value of about 2 m.[19)] The Tidal pattern is the mixed type (Figure 2.1), the flow becoming northward during the flood tide while it becomes southward during the ebb tide. The flow is unstable and rather weak. The annual mean values for the range of variation is 0.5 m/sec.-1.5 m/sec.

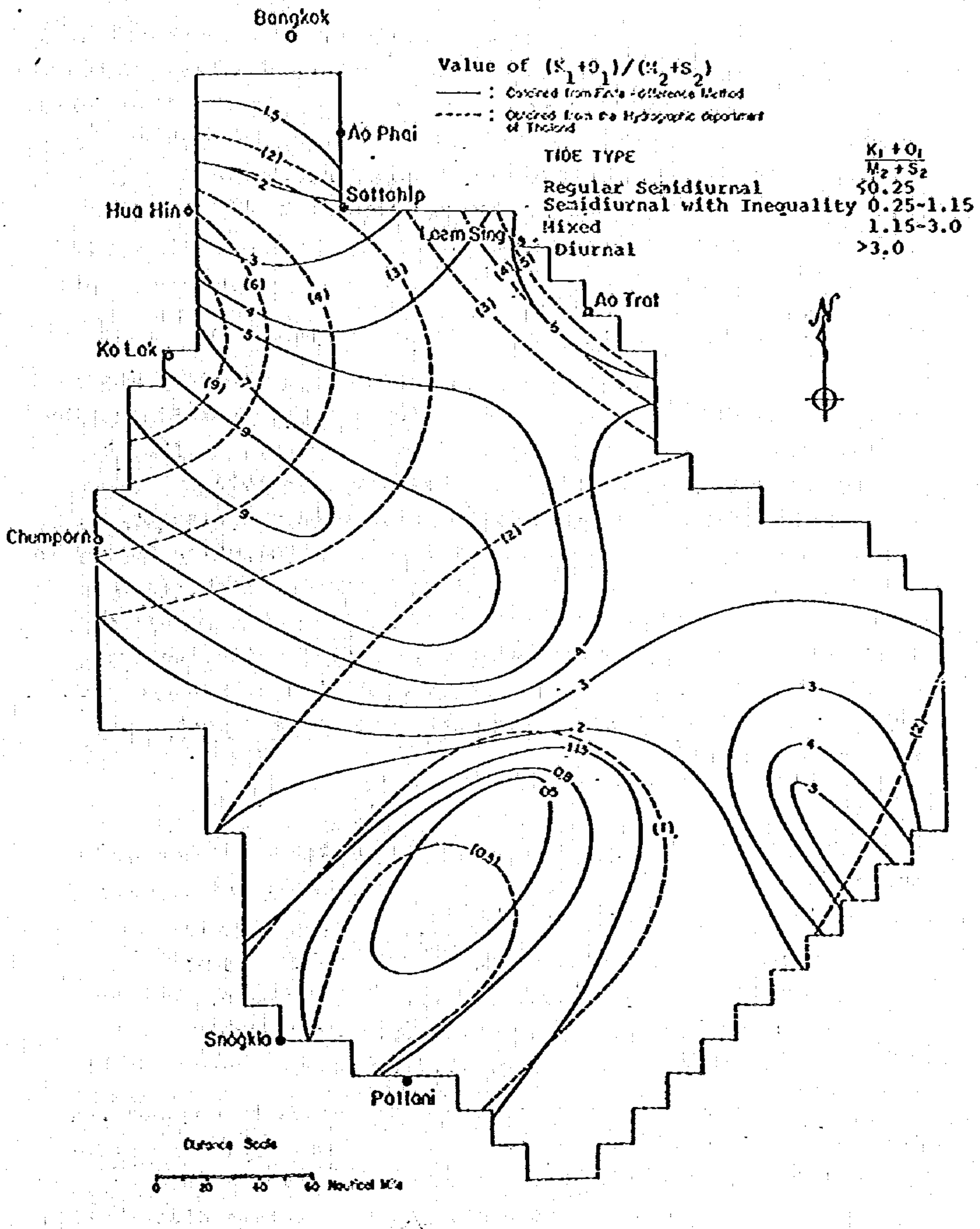


Fig. 2.1 The Tide Type in the Gulf of Thailand

3) Tide and Tidal Current at Pattaya Coast

The tide near Pattaya is semidiurnal tide represented by the high and low tides twice a day.[2) The annual mean value for the tidal level variation is about 2 m. The current flow follows a similar pattern as the general flow observed throughout the Upper Gulf of Thailand. The flow becomes northward during the flood tide and southward during the ebb tide, its velocity being about 0.80 m/sec.

2.1.3. Water Quality

1) Water Quality in the Upper Gulf of Thailand

The water quality survey in the Upper Gulf of Thailand have been conducted in several occasions; i.e., in 1963-1966 by Fishery Department during Marine Fishery Surveys, in 1967 by Hydrographic Department of Royal Thai Navy, in 1973 by Hydrographic Department in collaboration with the Fishery Department, in 1973-1975 by Subcommittee for Pollution Survey in the Gulf of Thailand (SPSGT), in 1974 by Marine Fisheries Laboratory (MFL) and Department of Fisheries. The result of these surveys are summarized in Environmental Guideline for Coastal Zone Management in Thailand,[1)2)3)] published by NEB and also reported by AIT and SPSGT.[5)4)] The outline of this report is summarized as follow.

Temperature

Monthly mean values of the water temperature on the surface are:

January - February	26°C - 27°C
March	28°C - 29°C
April - June	29°C - 30.5°C
July - October	29°C - 30°C
November - December	28°C - 30°C

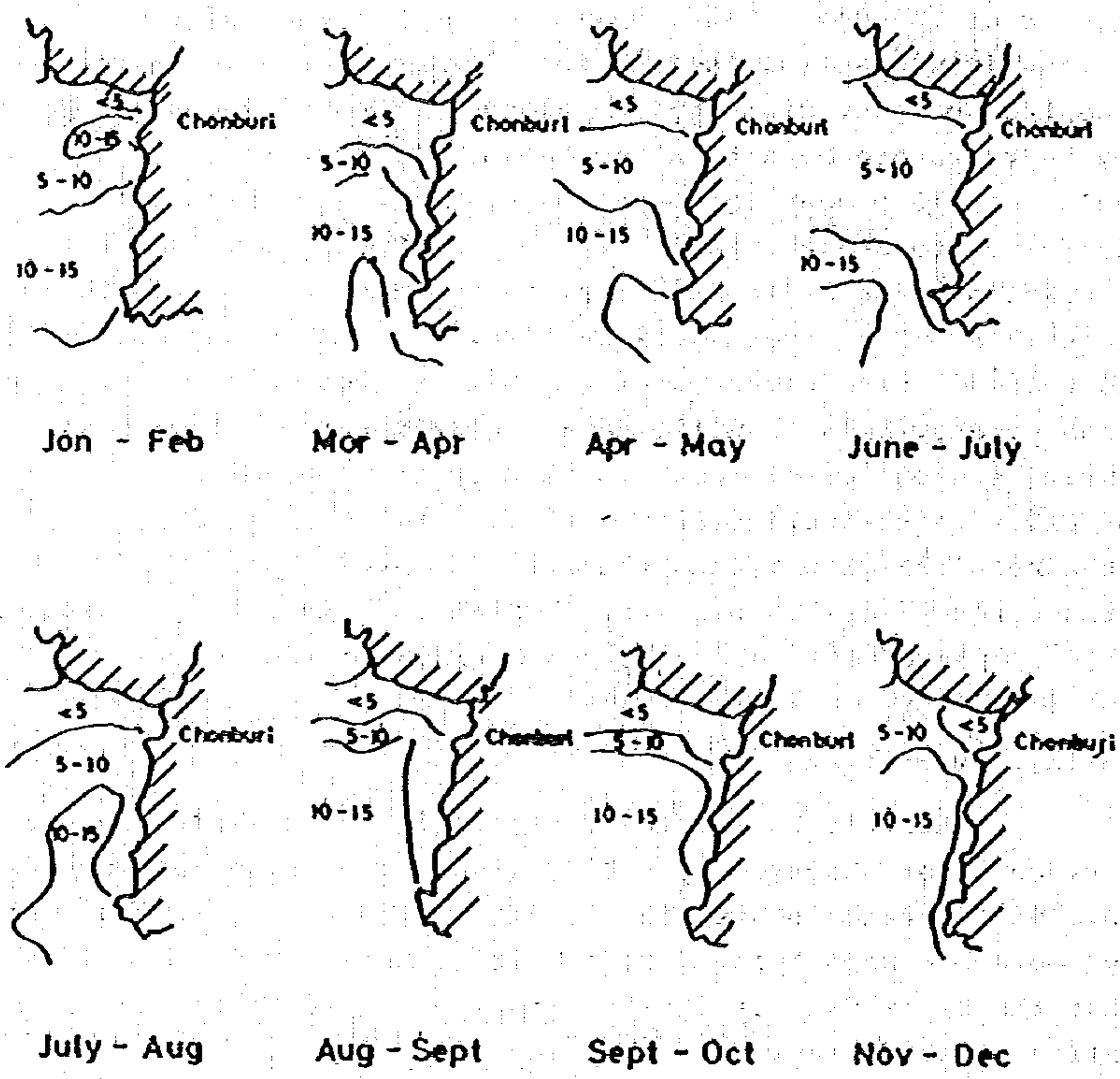
A rather high temperature distributes throughout the year, and the temperature increases at the inner part from the mouth of the Upper Gulf. Because of the southwest monsoons during the period of April to June, the temperature distribution along the eastern coast is somewhat higher than that along the western coast. Hardly any changes are seen throughout the year along the vertical direction, the maximum range being less than 1.0°C. This is due to the shallow depth of the Upper Gulf.

Transparency

According to the 17 surveys made by SPSGT, the transparency of sea water was within the range of 10-18 m in average at the center of the Upper Gulf, while at the vicinity of the river mouths it was as low as less than 5 m in average. In Figure 2.2, the transparency distribution along the Chonburi coast observed by Hydrographic Department is shown. It shows almost same value of 10 m near the open mouth, but the transparency decreases toward the inner part of the Upper Gulf. Near the estuaries it is as low as 5 m, indicating a similar pattern as that in SPSGT's investigations. This is due to suspended solids contained in the river water. MFL investigations observed the transparency less than 1 m near the estuaries on the coast. During the period of April to October when the discharge volume of river water increases, the area of low saline water becomes wide (the next paragraph), and the area of turbid water, having the transparency less than 5 m, widens. Along the Pattaya coast, higher transparency are observed during the winter than in the summer.

Salinity Variations

Monthly horizontal distribution of salinity in the surface layer observed by NEDECO (1965) are shown in Figure 2.3. This distribution showed the similar pattern as that observed by Hydrographic Department (1967). It is known from the figure that the Upper Gulf of Thailand is subject to the effect of highly saline waters entering through the mouth during the period of January to April, and the salinity becomes considerably higher except at the area near the estuaries. From May to July, the effects of the land water gradually increases, and from August to October, the salinity in the Upper Gulf becomes approximately 30‰ or less. A remarkable increase of salinities extending from the estuary is observed. From November to December, oceanic water is observed to enter the Upper Gulf along the Sattahip side, and the salinity in the inner part of the Gulf increases gradually.



Source : HYDROGRAPHIC DEPARTMENT (1967)

Fig. 2.2 Seawater Transparency(m) along the Chonburi Coast

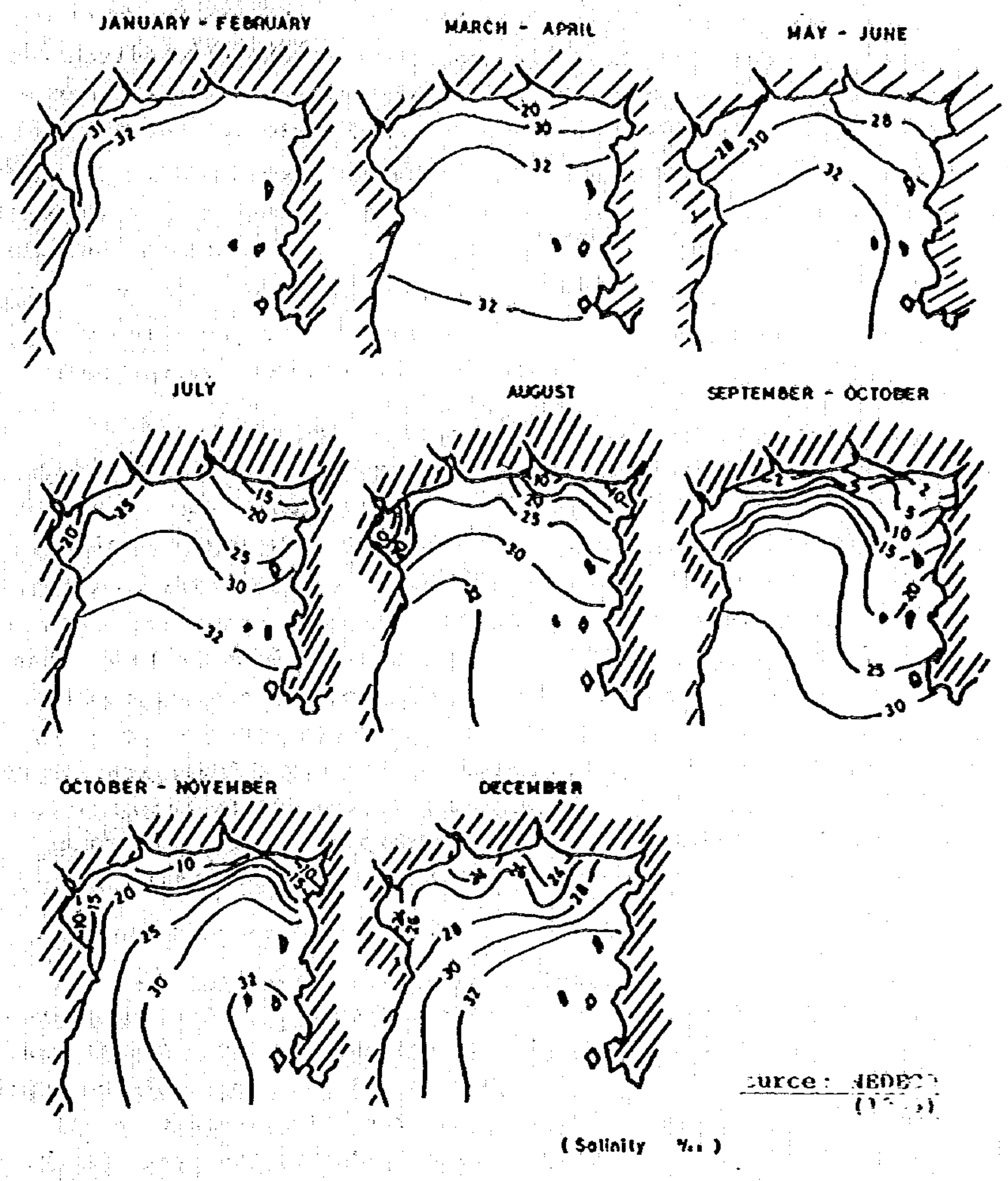


Fig. 2.3 Salinity Distribution in the Inner Gulf

Salinity distribution in the coastal area near Pattaya shows strong effects of oceanic water from January to April, and lower salinity from May to July because of the clockwise flow within the Gulf and the increased volume of the river discharges. From August to October, the effect of the land water further increases and salinity decreases to 25‰ or less. Between October and November, due to the counter clockwise flow in the Gulf and also the oceanic water entering through the mouth of the Gulf, the salinity increases gradually, and reaches to the value of 32‰ or more in December.

Hardly any changes are observed throughout the year as far as the vertical distribution is concerned except near the estuary. This is because of a shallow depth.

DO (Dissolved Oxygen)

DO surveys in the Upper Gulf of Thailand were conducted by MFL in October, 1974 and SPSGT from 1973 to 1975. According to these surveys, the DO content in the seawater in the Upper Gulf was 3.5-4.5 ml/l in average, which is lower than the saturation. Comparing to the value of the eastern coast to that of the western coast, the latter was somewhat lower by the SPSGT's report. At the estuary, the DO was lower than those in the offshore waters. This is considered due to the organic matters flowing into the Upper Gulf through rivers. In some part, it was less than 1.0 ml/l, critical to biological activity.

pH

According to the surveys made by SPSGT, the mean range of pH values in the Upper Gulf of Thailand was 7.9-8.3. It was very low in the estuary and higher toward the center of the Upper Gulf. Except near the estuaries, the variation is quite small. The low value at the estuary is clearly due to the fresh water. No remarkable variation was seen in pH values in the mid-layer and the values in the bottom-layer was slightly higher than those in the surface-layer. In the first survey made by SPSGT, they were rather high in generally, and a particularly high value of 8.6 was observed at the center of the Gulf.

Nutrient Salts

Analyses of NO_2-N, NO_3-N, PO_4-P, SiO_2-Si were conducted SPSGT surveys. The results are shown in the following table.

	NO_3-N (µg at/l)	NO_2-N (µg at/l)	PO_4-P (µg at/l)	SiO_2-Si (µg at/l)
Surface layer	0.38-9.85	0.62-2.32	0.98-10.60	mean 48
Middle Layer	1.70-2.49	0.53-3.99	0.53-3.65	
Bottom layer	-	0.16-5.93	-	

All the nutrient salts near the estuaries showed considerably high values. The overall distribution pattern observed in the Gulf was that the contents of nutrient salts were low in the center of the Gulf than in the estuaries. Along the coast of Sattahip, however, all the nutrient salts values were very low.

While the present survey was being carried out, there was a report that red tide occurred by the multiplication of Ceratium.[4] Another report[1] showed that the waters near the east coast was eutrophic and therefore the phytoplanktons were abundant. This suggests that, although the concentration of phytoplanktons may vary seasonally, a part of the waters in the Upper Gulf is now under the step of progressive eutrophication.

Coliform Bacteria

Coliform bacteria investigations were carried out during the surveys conducted by 1st- 7th SPSGT. According to the 1st-3rd SPSGT survey,[1] somewhat high values within the range of 80 to 350 MPN/100 ml were observed throughout the Upper Gulf, and the high values were observed in the central part of the Upper Gulf. In the 4th- 7th survey,[4] the values were within 20-40 cell/100 ml, but similar high value of 150 cell/100 ml was observed in the center of the Upper Gulf of Thailand.

Heavy Metals

Heavy metal analyses in the sea waters were conducted during the surveys by SPSGT. These surveys revealed that all the heavy metals values showed the values similar to the world average values except for Pb.

2) Water Quality Along Pattaya Coast

Surveys along the shoreline of Pattaya Coast were conducted monthly by NEB from December, 1976 to March, 1977. The survey stations are shown in Figure 2.4 and Table 2.1(a)-(d) shows the results of the surveys. They are summarized below.

Temperature

The water temperature ranged from 26°C to 29°C and the temperature remained unchanged during a season.

pH

pH considerably fluctuated in space and time but its values lie generally within the range of 7.8-8.3. This is considered due to the effect of the fresh water running from the inland area. The abnormally low value of 6.6 at high tide at Station 3,000 in January, 1977 (the estuary of Na Klua River) may be due to the effect of domestic sewage, etc.

DO

Mean DO content of 4.5-7.5 ml/l is close to the saturation point or above. However, near the estuary of Na Klua River, it was considerably low. In particular at the Station 3,000, it was often 0 ml/l, showing the area was not suitable for any biological activities. This was created by the discharge of domestic sewage in the neighboring areas and of the waste water from the tapioca plants into the Gulf of Thailand via Na Klua River. The organic matters contained in these waste water were decomposed and had consumed the dissolved oxygen in the water.

SS

SS has a remarkably variation ranging from 5 ppm to 200 ppm, with one extraordinary value of more than 1,500 ppm.

Fig. 2.4 Location map of the Sampling Station

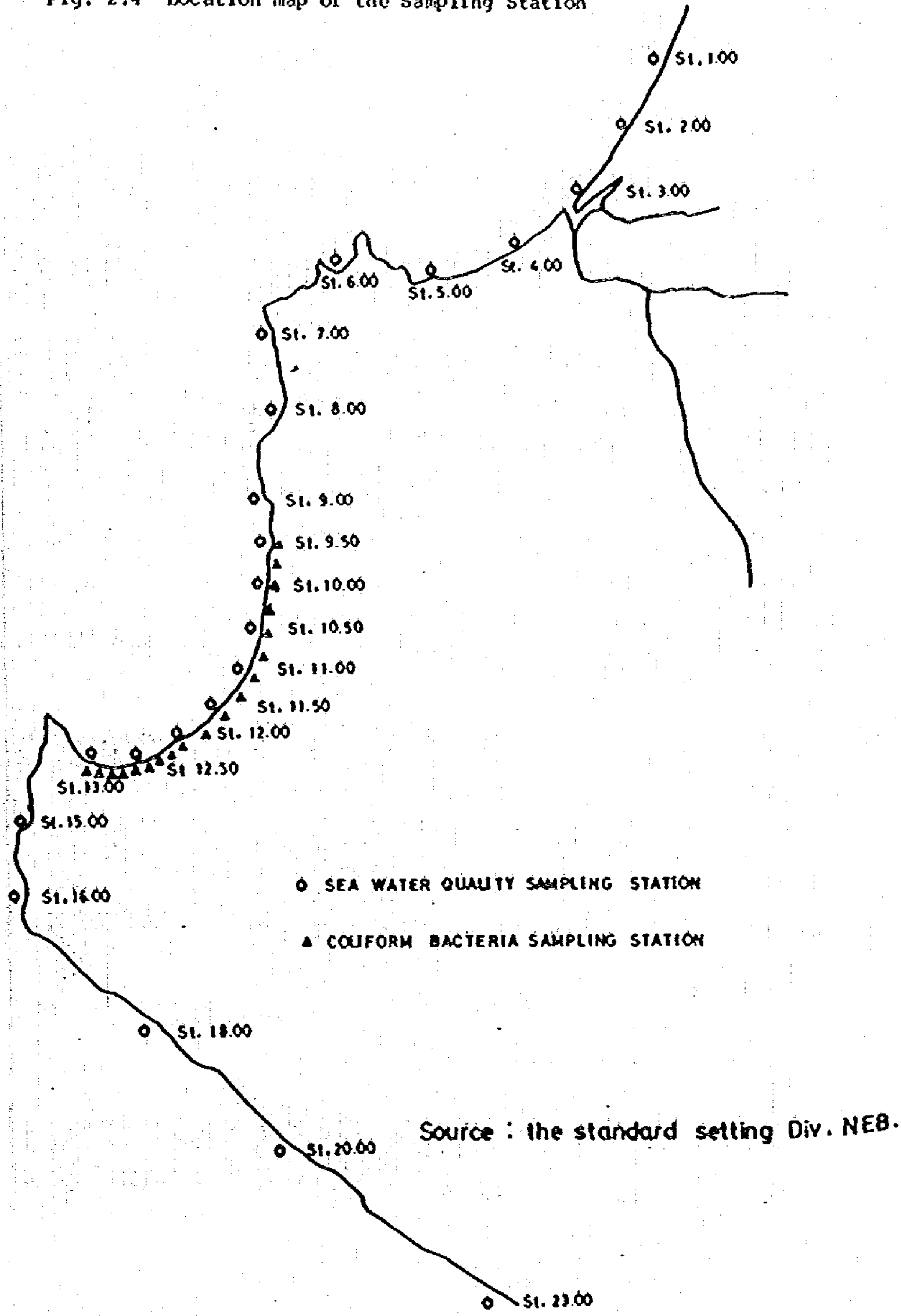


Table 2.1(a) The Observation Results of Pattaya Coast

	17 Dec. 1976		14:00		Low Tide	18 Dec. 1976		9:00		High Tide
Station	TEMP °C Air	TEMP °C Water	PH	DO mg/	SS mg/	TEMP °C Air	TEMP °C Water	PH	DO mg/	SS mg/
1.000	34	28	7.75	3.0	1,596		28	7.9	3.7	150
2.000	30.5	28.5	7.6	4.6	430		28	8.1	5.7	276
3.000	31	29	7.1		226		28	8.0	5.4	192
4.000	30.5	28.5	8.0	5.2	380		27.5	8.1	5.5	266
5.000		27	8.05	5.0	298		27	8.1	5.25	56
6.000			8.1	6.1	90		28	8.3	6.15	54
7.000		27.0	8.35	6.1	96		28	8.4	6.75	106
8.000		27.0	8.25	6.5	94		28	8.2	6.70	100
9.000		28.0	8.35	6.6	68			8.3	6.45	64
9.500										
10.000		28.0	8.30	6.4	66		26.5	8.35	5.5	56
10.500										
11.000	31	27.0	8.30	6.5	78		28.5	8.0	5.1	106
11.500										
12.000	31	27.5	8.40	6.3	19		27	8.0	5.85	156
12.500										
13.000		28	8.20	6.3	39		26.5	8.0	5.65	138
15.000		27	8.30	6.5	28		27	8.15	6.55	106
16.000		27	8.00	6.5	42		27.5		6.5	
18.000		27.5	8.30	6.9	68		28	8.15	6.9	72
20.000		26.5	8.40	6.9	30		26	8.0	7.55	38
23.000		26	8.30	5.7	70		28	8.15	7.20	124

Source: National Environmental Board

Table 2.1(b) The Observation Results of Pattaya Coast

	8 Jan. 1977	10:00	High Tide			8 Jan. 1977	15:00	Low Tide		
Station	TEMP °C Air	TEMP °C Water	PH	DO mg/	SS mg/	TEMP °C Air	TEMP °C Water	PH	DO mg/ℓ	SS mg/ℓ
1.000		27	8.35	3.1	37		29	7.45	1.1	235
2.000		27	7.7	3.95	7		28.5	7.1	0	271
3.000		26.5	6.6	2.05	27		29	7.7	2.65	208
4.000		27	7.7	5.10	10		28.5	7.85	6.90	203
5.000		27.5	7.75	5.0	217		29.0	7.95	6.80	214
6.000		27.5	7.8	5.35	48		28.0	7.9	6.55	130
7.000		28	7.8	6.0	72		29.0	8.0	7.0	202
8.000		28	7.75	6.4	40		29.0	8.0	7.3	154
9.000		27	7.65	5.5	36		29.0	7.95	6.9	29
9.500										
10.000		27.5	7.65	5.9	33		29.0	8.0	7.05	31
10.500										
11.000		27.5	7.8	6.2	19		29.0	8.0	6.95	203
11.500										
12.000		26.5	8.2	4.75	43		29.0	7.9	6.8	203
12.500										
13.000		27.5	8.1	6.1	32		27.0	8.0	7.65	203
15.000		28	8.2	6.1	39		29.0	8.05	6.90	217
16.000		28	7.6	6.3	37		29.0	8.0	7.05	220
18.000			7.6	6.2	29		29.0	8.05	6.40	22
20.000		28	7.7	6.6	40		29.0	8.0	6.35	202
23.000		28	7.7	6.25	59		29.0	8.0	6.45	203

Source: National Environmental Board

Table 2.1(c) The Observation Results of Pattaya Coast

Station	6 Feb. 1977 9:30 Low Tide						6 Feb. 1977 16:10 High Tide					
	TEMP °C Air	Water	PH	DO mg/l	SS mg/l	BOD_5 mg/l	TEMP °C Air	Water	PH	DO mg/ℓ	SS mg/ℓ	BOD_5 mg/l
1.000	27	26	7.65	4.5	36	26	28	27	7.6	6.45	78	12
2.000	"	"	7.4	1.7	3	20	"	"	7.5	4.70	59	10
3.000	"	"	7.3	0	6	21	"	"	7.6	3.70	54	12.5
4.000	"	"	7.6	1.2	10	16	"	"	7.9	0	124	12
5.000	"	"	8.0	2.9	2	3.5	"	"	7.7	4.80	66	7.5
6.000	"	"	7.7	4.0	13	4.0	"	"	8.0	4.55	116	4.5
7.000	"	"	7.75	6.15	20	2.5	"	"	8.1	7.20	130	1.0
8.000	"	"	8.05	6.6	8	3.2	"	"	8.1	7.20	119	5.0
9.000	"	"	8.25	5.8	29	2.2	"	"	8.3	6.90	89	<1
9.500	"	"	8.3	6.3	17	3.2	"	"	8.1	7.30	49	1.0
10.000	"	"	8.4	6.55	35	3.0	"	"	8.2	7.40	156	<1
10.500	"	"	8.1	6.5	35	2.4	"	"	8.1	7.50	169	9.5
11.000	"	"	8.35	6.45	22	7.2	"	"	8.0	7.20	72	7.0
11.500	"	"	8.25	6.60	24	3.6	"	"	8.1	7.05	55	5.8
12.000	"	"	8.30	6.30	8	28	"	"	7.9	7.00	86	4.0
12.500	"	"	8.1	5.50	66	6.0	"	"	8.2	7.30	115	5.0
13.000	"	"	8.4	6.0	39	1.6	"	"	8.3	7.30	106	4.0
15.000	"	"	8.3	6.7	40	1.6	"	"	8.4	7.10	90	3.2
16.000	"	"	8.4	6.65	99	1.6	"	"	8.4	7.20	176	1.0
18.000	"	"	8.4	6.90	95	<1	"	"	8.2	7.60	84	1.0
20.000	"	"	8.2	7.05	53		"	"	8.0	7.70	20	1.0
23.000	"	"	8.3	6.80	232	<1	"	"	8.2	7.90	273	1.5

Source: National Environmental Board

Table 2.1(d) The Observation Results of Pattaya Coast

Station	March 1977		High Tide				March 1977		Low Tide			
	TEMP °C		PH	DO	SS	BOD	TEMP °C		PH	DO	SS	BOD
	Air	Water		mg/ℓ	mg/ℓ	mg/ℓ	Air	Water		mg/ℓ	mg/ℓ	mg/ℓ
1.000	30.5		8.55	7.9	6	1.5			8.6	5.2	157	3.2
2.000	30.5		8.4	4.9	56	2.4			8.6	4.9	57	2.0
3.000	29.5		8.5	7.6	140	1.0			7.9	0	89	6.8
4.000	30.5		8.5	7.1	124	0.9			8.2	5.3	4	1.6
5.000			8.4	6.8	152	0.9			8.2	6.1	42	1.6
6.000			8.5	6.9	95	0.4			8.2	6.3	5	0.5
7.000			8.4	7.0	75	0.9			8.2	6.7	34	0.9
8.000			8.4	7.0	160	1.0		29	8.2	6.9	31	0.4
9.000			8.5	6.5	184	0.9		29	8.2	6.3	8	-
9.500			8.5	6.8	112	1.1		29	8.2	6.7	8	0.2
10.000			8.5	7.0	40	0.8		29	8.2	6.5	34	0.1
10.500			8.75	7.1	12	1.1		29	8.2	6.4	23	0.5
11.000			8.45	7.3	5	0.7		29	8.2	7.1	50	0.4
11.500			8.4	7.3	15	0.9		29	8.25	6.5	86	0.6
12.000			8.45	7.4	19	1.0		29	8.2	6.6	76	0.6
12.500			8.5	7.6	73	0.8		29	8.2	6.4	83	0.4
13.000			8.45	7.7	6	0.6		29	8.2	6.5	40	0.6
15.000			8.6	6.6	34	1.0		29	8.3	6.8	53	1.0
16.000			8.6	6.3	95	0.6		29	8.3	7.1	7	0.8
18.000			8.5	7.6	29	1.6		29	8.3	6.8	136	0.8
20.000			8.5	6.5	139	1.5		29	8.2	6.7	59	0.9
23.000			8.5	6.3	68	2.0		29	8.3	6.6	82	0.6

Source: National Environmental Board

BOD

According to the surveys of BOD in February and March of 1977, the most part of the coastal area showed the low values of below 3 ppm, except at some stations in February, i.e., the water near the estuary of Na Klua River was polluted in February and the BOD was as much as above 10 ppm, and also at Pattaya Beach BOD exceeding 5 ppm where observed at Stations 10-12.5. This must be due to the temporary effects of the waste water discharged from restaurants, etc., in downtown of Pattaya.

Coliform Bacteria

Coliform Bacteria in the human excreta are a good indicator for the contamination originated from the domestic sewage. Since the human excreta contain, in some cases other harmful enterobacterceacae, they are used as a standard for showing the contamination of bathing beaches, in the United States and Japan.

In Chonburi Coastal areas and Pattaya Beach, coliform bacteria surveys were conducted in 1970 and 1971 by Chulalongkorn University jointly with Department of Marine Science, in 1972 and 1973 by AIT, and in March, 1973 and January and February, 1977 by the National Environmental Board.

Tables 2.2 and 2.3 show the results of the survey conducted by AIT and National Environmental Board respectively. According to the former, 29% of the samples investigated in July, 1972 at Pattaya Beach exceeded the U.S. Standard of 1,000 MPN/100 ml, indicating that the water was not suitable for swimming/bathing. However, the samples investigated in January, 1973 were all below U.S. Standards.

NEB's surveys in March, 1976 and January-February, 1977, also detected the values exceeding 100 MPN/100 ml in same points. This high value varied according to the days of the week and the time of the day at the same station, it is considered that the contamination occurs locally and periodically by the domestic sewage and the waste water discharged from the restaurants, etc., through recreational activities.

Table 2.2 Coliform Analysis of Bang Saen and Pattaya Beach Waters

Samples	Bang Saen	Pattaya
<u>15/7/72</u>	%	%
greater than 1,000/100 ml	59	29
less than 1,000/100 ml	29	36
spoiled samples	12	35
<u>14/1/73</u>		
greater than 1,000/100 ml	66	0
less than 1,000/100 ml	33	100
spoiled samples	0	0

Table 2.3 Coliform Bacteria Sampling (unit: MPN/100 ml)

Station	Location	8 Jan. 1977				22 Jan. 1977		**6 Feb.1977		**21 Feb. 1977		
		9:00	12:00	15:00	18:00	9:30	15:00	9:30 (L)	16:30 (H)	10:00 (L)	15:00 (H)	
9.250	Orchid Lodge Hotel					20	20	140	0	490	110	
9.500	Weekender Hotel	300	110	40	50	50	110	170	20	330	1,100	
9.750	Pattaya Soi 7					20	330	330	120	20	50	
10.000	Hyatt Pattaya Hotel	1,100	70	130	790	90	80	110	330	80	50	
10.250	Tropicana Hotel					130	50	170	80	490	130	US standard
10.500	Holiday Inn Hotel	330	130	230	80	220	50	-	330	130	490	for caliform
10.750	Sai-Thong Bungalow					80	130	220	270	490	330	bacteria
11.000	Ocean View Hotel	210	80	80	50	20	230	50	110	170	270	less than
11.250	Yatch Club					490	170	330	140	130	1,300	1000 MPN/100 ml
11.500	Sea Side Hotel	700	170	110	330	490	460	340	1,300	110	1,100	for Swimmer
11.750	Boat House Restaurant					230	3,480	1,700	1,300	1,300	3,500	
12.000	Thai Phanich Bank	≥9,200	16,000	1,700	2,800	490	2,780	2,400	3,500	≥24,000	5,400	
12.125	Habour Market					1,300	≥24,000	16,000	2,800	2,200	2,400	
12.250	Fantasy Club					790	1,720	9,200	5,400	5,400	5,400	
12.375	Marine Restaurant					1,410	16,090	≥24,000	5,400	≥24,000	330	
12.500	Barbos Restaurant*	≥24,000	≥24,000	≥24,000	≥24,000	1,720	2,400	16,000	1,700	1,300	≥24,000	
12.625	Sang Kaew Bungalow					1,300	330	9,200	3,500	5,400	3,500	
12.750	Siam Bayshore Hotel					1,300	110	9,200	16,000	460	330	
12.875	South Pattaya Canal					1,720	20	16,000	1,300	80	230	
13.000	South End of Pattaya Beach	1,700	5,400	490	330	490	20	≥24,000	5,400	50	0	

(H): High Tide (L): Low Tide

* Resulted by discharge from mouth of Pattaya canal (MPN in canal ≥24,000).
** CHINESE NEW YEAR on 18-19 Feb. 1977, Maximum number of local tourists during a year.

Source: National Environmental Board, Standard Setting Division.

2.1.4. Existing Sediment Conditions

Sediments can be used as an effective indicator of the contamination of the marine environment since sediments are subject to the influence of contamination of the water lying above them, and change much more gradually than the water quality, and also the pollutants accumulate on the sediments. It is also an excellent element for learning the ecology of the marine lives represented by benthos through food chains. No survey of a considerable scale on the sediments in the Upper Gulf of Thailand has been conducted in the past. However, SPSGT (Subcommittee for Pollution Survey in the Gulf of Thailand), and MFL (The Marine Fisheries Laboratory) had conducted researches on heavy metals and benthos in a limited area.[1)4)]

Sediment Distribution

Figure 2.5 shows the sediment distribution in the Upper Gulf of Thailand. Most of the bottom of the Upper Gulf is covered with mud and sand and the major part on the northern side with mud alone. This is probably caused by the suspended soils discharged from the rivers, which flows toward the western coast rather than toward the eastern coast reflecting the current patterns within the Gulf. Sediments found along the Pattaya coast are mixture of mud, sand, gravel and rock.

Heavy Metals

According to the first investigation conducted by SPSGT,[1)] rather high concentration of heavy metals were detected in the vicinity near the estuaries of major rivers. In the second investigation, concentration of silver, cadmium and mercury were found to be somewhat higher than the general average of oceanic sediments. However, those and zinc and chromium were not considered significantly high. According to the investigations carried out by SPSGT, the earlier investigations discovered considerably higher values of Hg and Cd compared to the world average. They gradually declined and became approximately the same or lower than the world average in their 5th and 6th investigations.

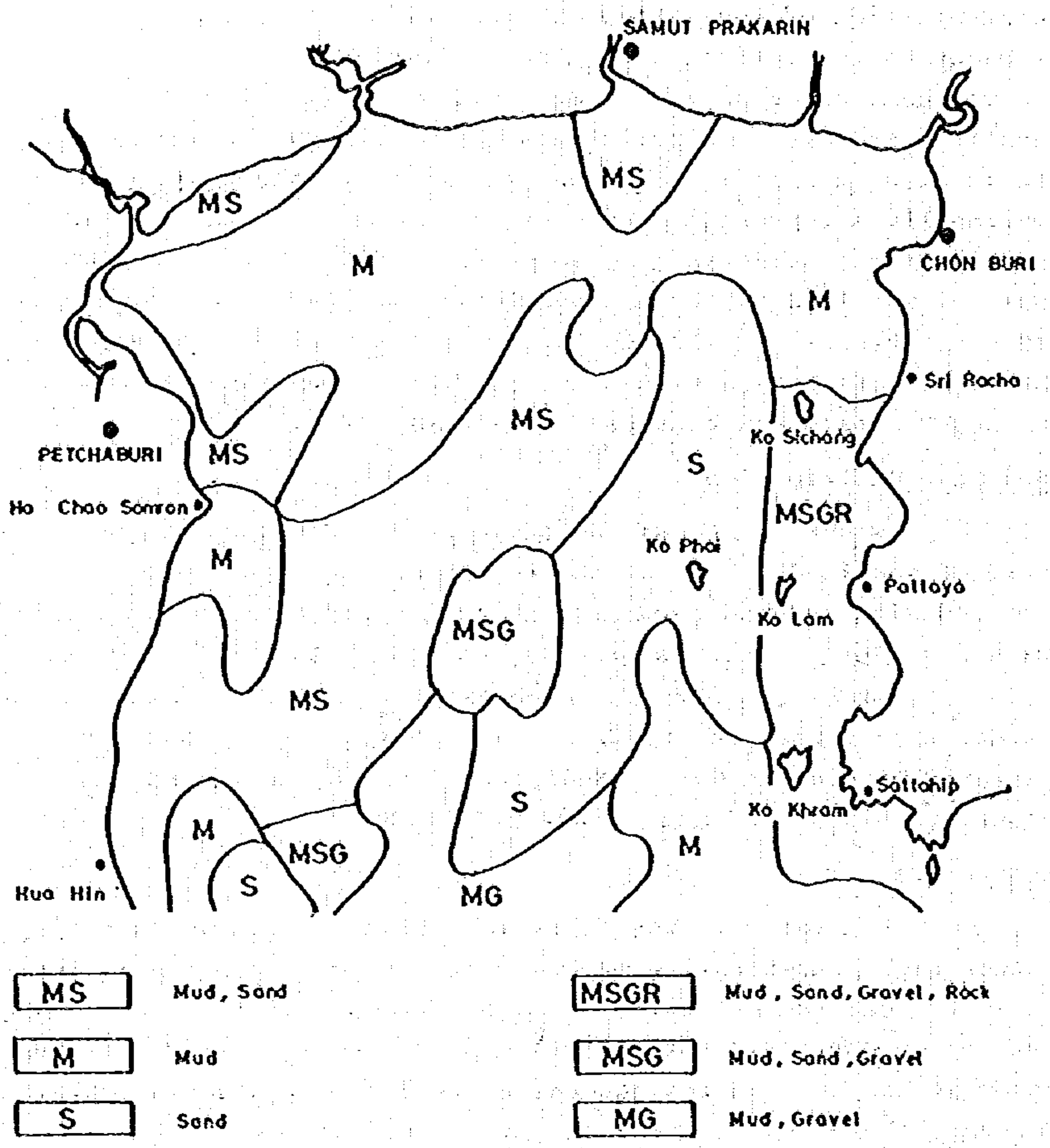


Fig. 2.5 Sediment Distribution in the inner Gulf of Thailand

(Ref:)

Grease and Oils

Concentration of Grease and oils detected at the estuaries of the major rivers were somewhat high, but those in the Upper Gulf, as a whole, were not significant.

2.2 Pattaya Water Quality Survey

Data given above serve its purpose as the basic material for understanding the marine environment in the Upper Gulf of Thailand and the area around Pattaya Beach. Japanese Team had conducted surveys on the water quality, sediments and currents in the Pattaya area (Figure 2.6) from August 10, 1977 to September 8, 1977 so as to supplement the above data and also to prepare the fundamental materials for reviewing the marine environment of the study area for the Pattaya Tourism Development Plan.

2.2.1. Current Conditions

The current survey in Pattaya area was conducted during the period of August 14 to 31, 1977 at Station B for continuous 15 days and at Stations A, C, D and F for continuous 25-hours measurements as shown in Figure 2.7. Based on the result obtained from observations at these stations and the tide observation at Ko Sichang, the stationary and tidal currents at the spring tide and the tropical tide based on the high tide at Ko Si Chang were calculated. The results are shown in Figure 2.8 - 2.12.

The predominating tidal current in the waters in front of Pattaya Beach is semidiurnal, while the current in the offing is the mixed type as it received the effect of the current from the Gulf of Thailand. The current flows toward the north during the flood tide and to the south during the ebb tide. The maximum current velocity at the spring tide is 0.4 m/sec. and no significant variations were observed at each station.

During the survey period, the direction of stationary current was southward, and the velocity was as slow as 0.03 - 0.04 m/sec. at Station B. This results agree well with the past reports made on the current conditions in the Upper Gulf of Thailand, and at the time of the investigation (August), a weak clockwise current exists in the Upper Gulf.

Fig. 2.6 Location Map

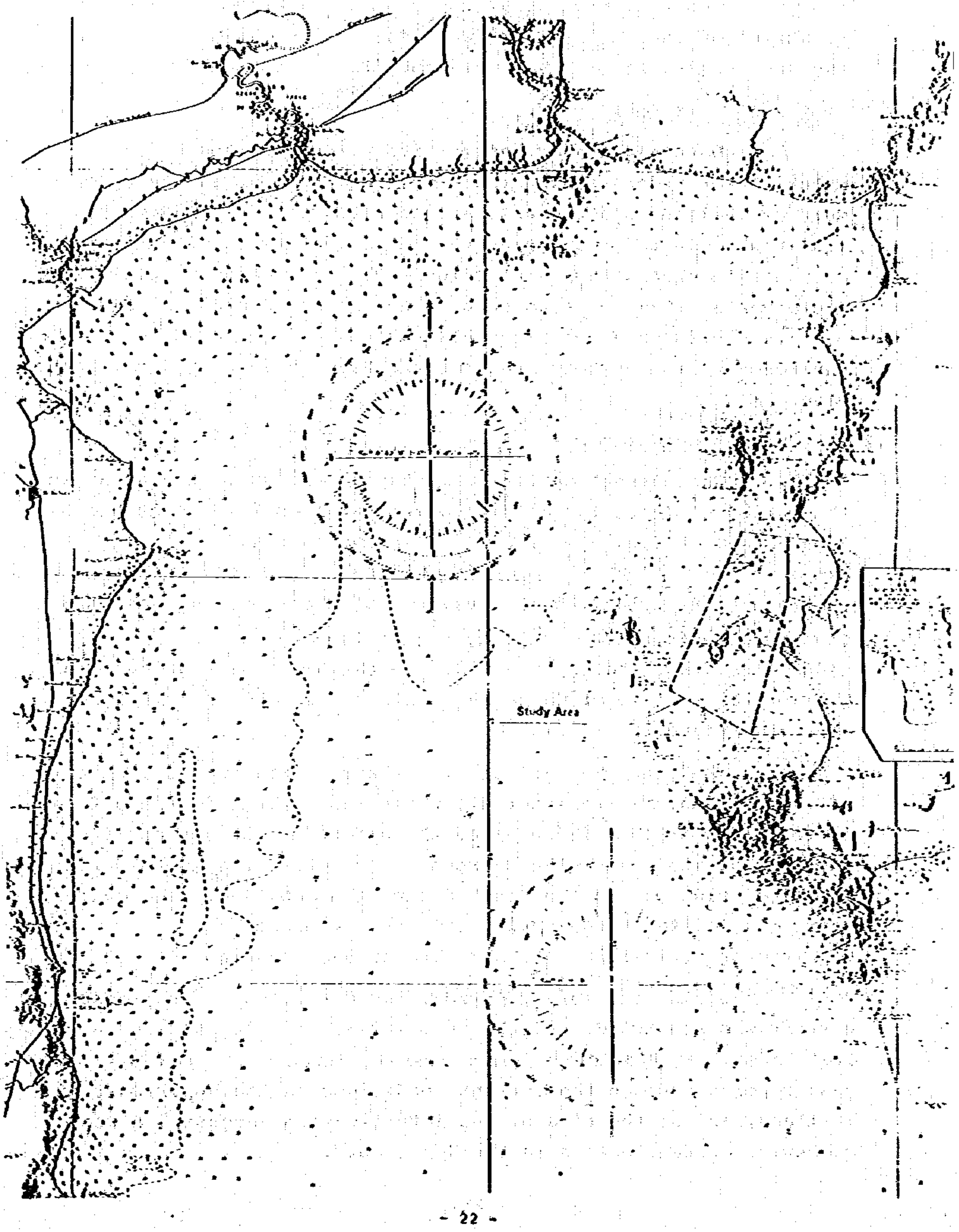
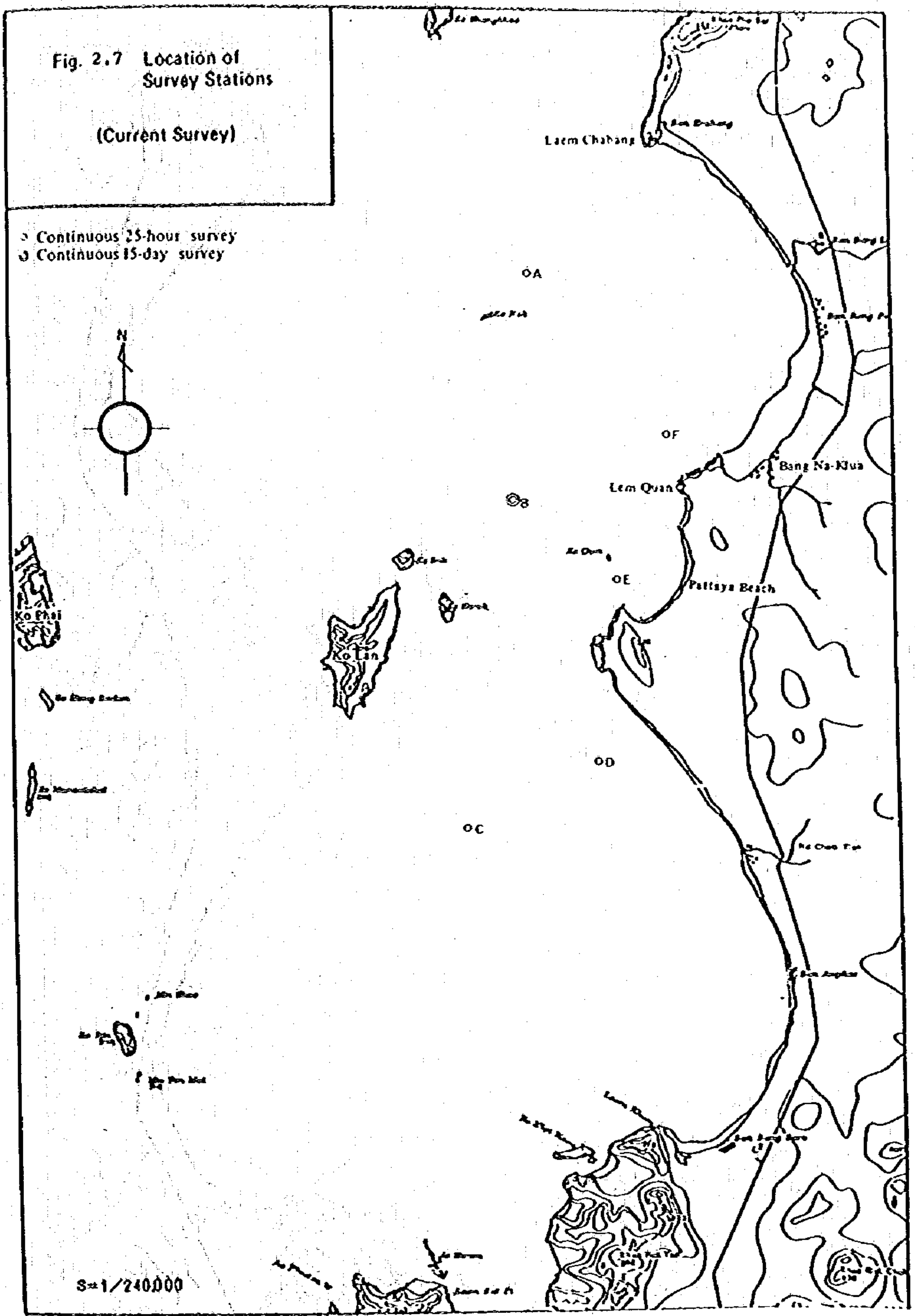


Fig. 2.7 Location of Survey Stations

(Current Survey)



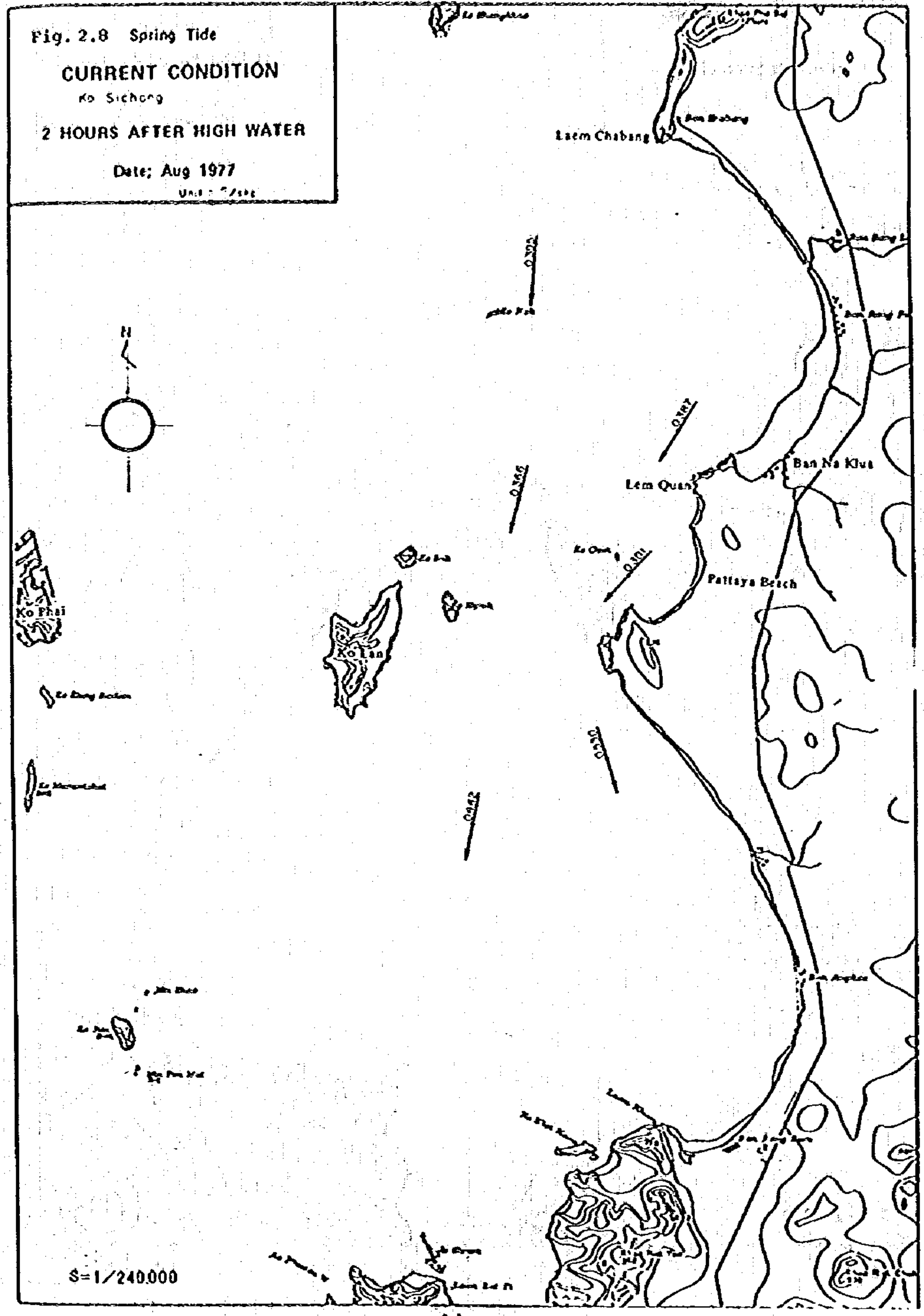


Fig. 2.8 Spring Tide
CURRENT CONDITION
Ko Sichang
2 HOURS AFTER HIGH WATER
Date; Aug 1977
N
Laem Chabang
Ban Na Klua
Lem Quan
Pattaya Beach
Ko Lan
Ko Phai
S=1/240,000

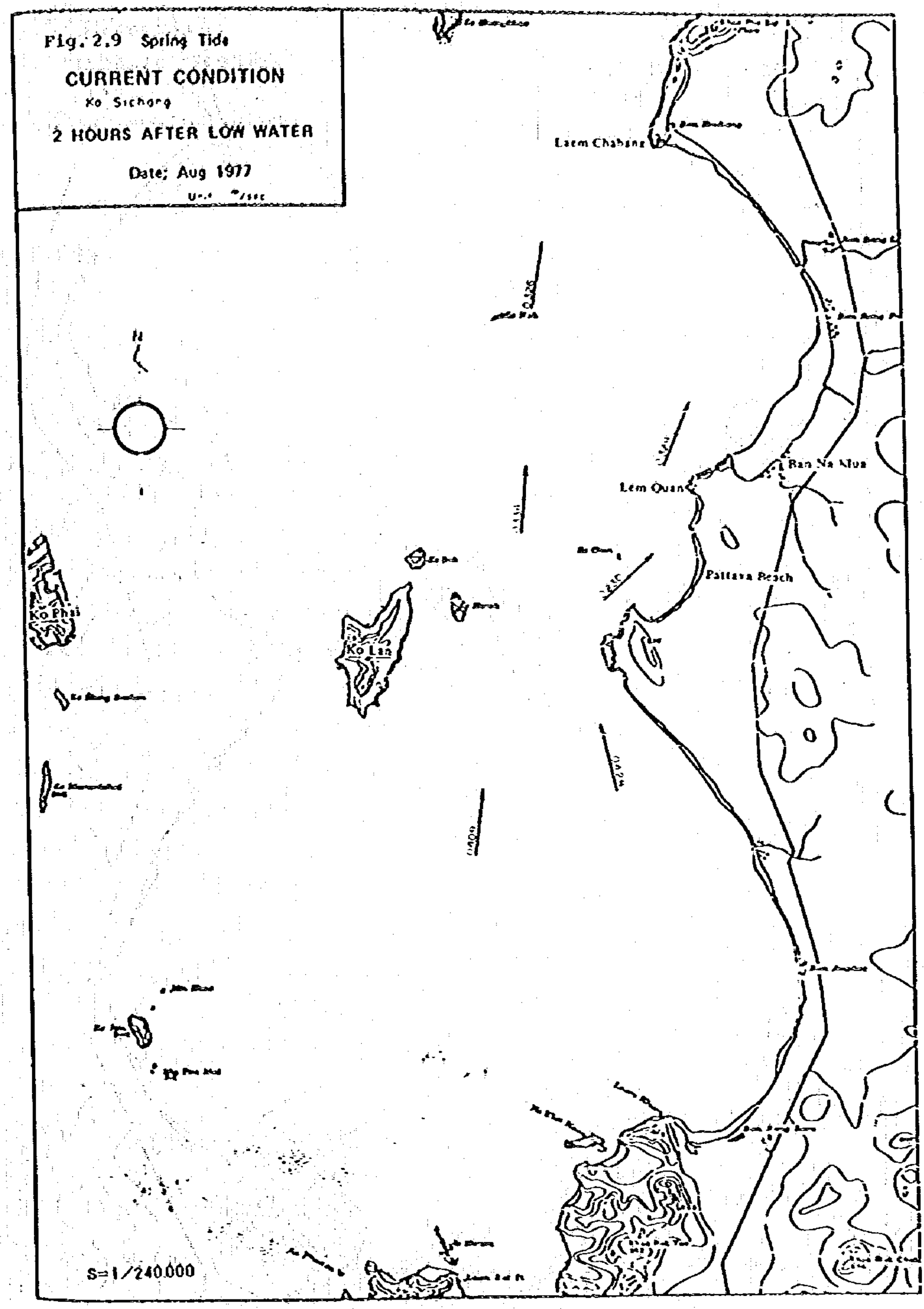


Fig. 2.9 Spring Tide

CURRENT CONDITION

Ko Sichang

2 HOURS AFTER LOW WATER

Date; Aug 1977

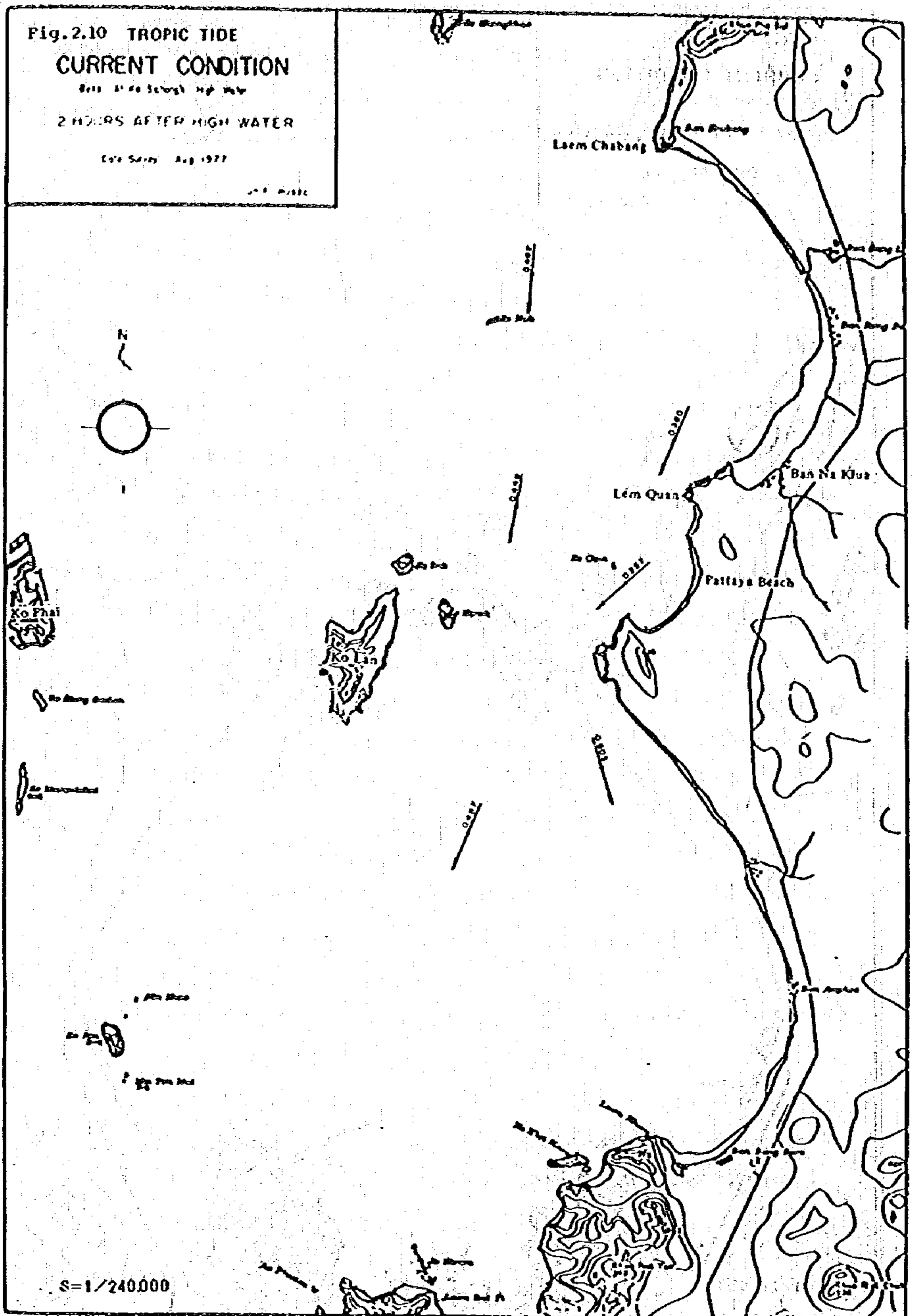


Fig.2.10 TROPIC TIDE
CURRENT CONDITION
AFTER HIGH WATER
N
Laem Chabang
Lem Quan
Ban Na Klua
Pattaya Beach
Ko Lan
Ko Phai
S=1/240000

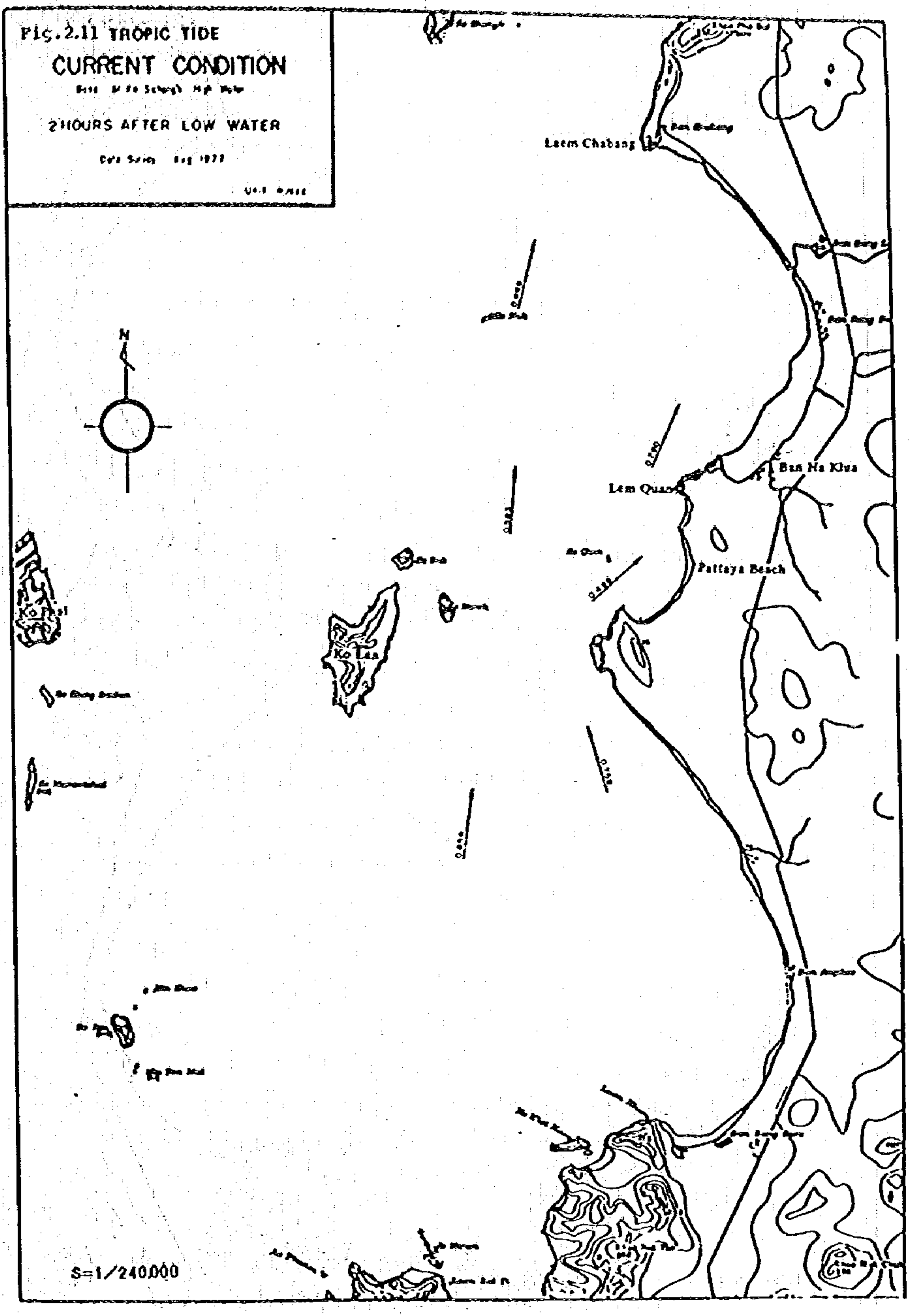
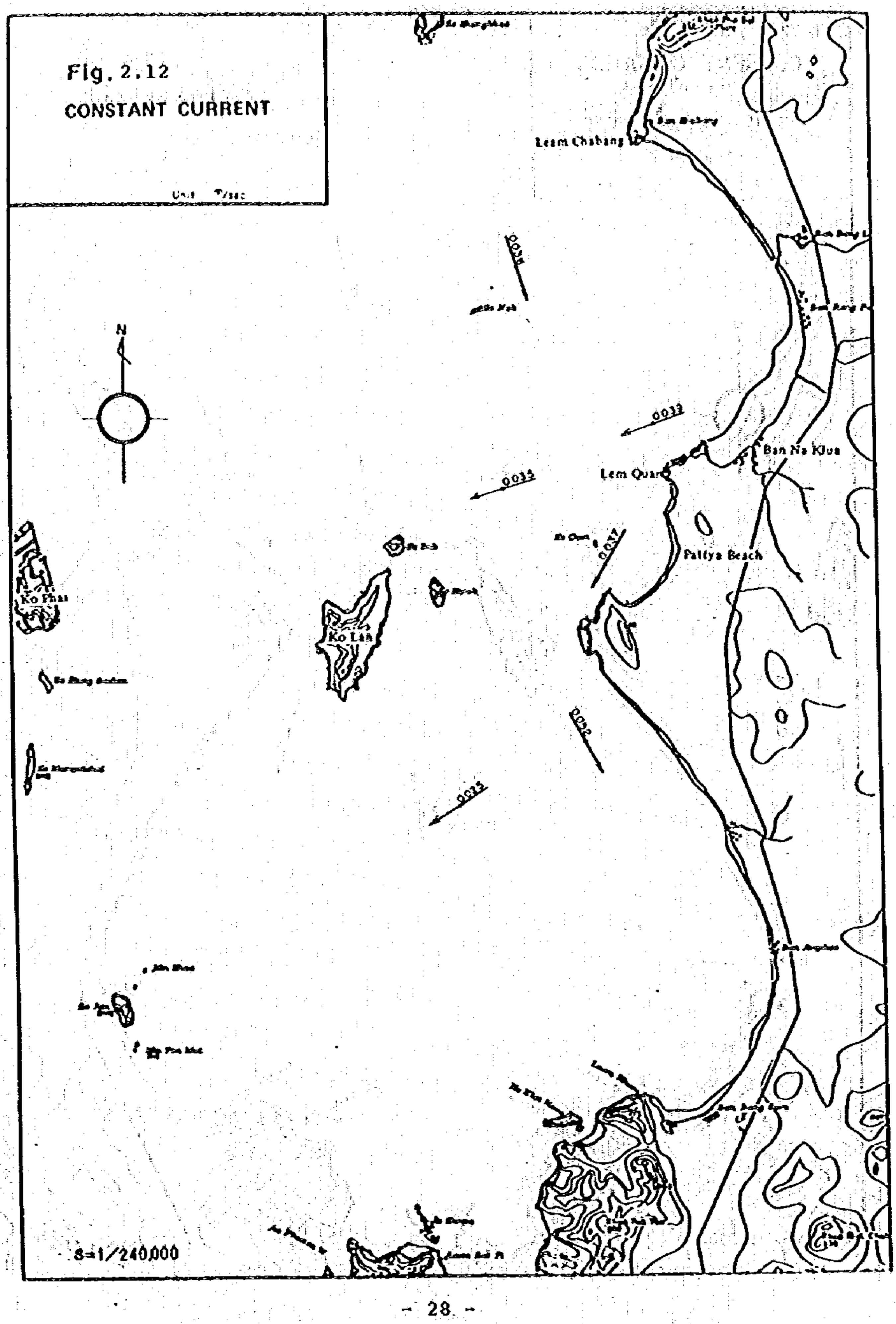


Fig.2.11 TROPIC TIDE
CURRENT CONDITION
2HOURS AFTER LOW WATER
Laem Chabang
Ban Na Klua
Lem Quan
Pattaya Beach
Ko Pai
Ko Lan
S=1/240000

Fig. 2.12
CONSTANT CURRENT



The diffusion coefficients obtained through the current measurements had relatively large orders for a coastal area (Table 2.4) suggesting a considerable diffusion of pollutants in the study area.

Table 2.4 Diffusion coefficient

St.	Layer	Data number	Main-Comp		X-Comp	
			Variance cm^2/sec^2	K $cm^2/sec.$	Variance cm^2/sec^2	K $cm^2/sec.$
B	10m	2286	29.9	1.188×10^5	20.1	3.150×10^4

2.2.2. Tidal Current Simulation

Through the results of the current measurement, we can get a rough picture of the current in the Pattaya sea area, but they are not sufficient to understand the coastal currents in detail which are strongly influenced by the topography. Based on the results of the current measurement and the submarine topography, the study area was covered by grid points of 1,000 m mesh and the mathematical simulation of tidal current was carried out. The outline is discussed below.

Basic Equation

The equation of momentum for the unit mass of the seawater is represented in the following manner assuming the incompressibility of the seawater.

$$\frac{\partial V}{\partial t} + V_{grad}V + 2\omega x\ V = K - \frac{1}{\rho_\omega} \text{grad}\ P^* + \nu^* \Delta V$$

Wherein,

- V : velocity vector of the seawater (u, v, w)
- ω : rotational vector of coordinates $(\omega_x, \omega_y, \omega_z)$
- K : external force per unit mass working on the substantial portion of the seawater (o, o, g)
  g; acceleration of gravity

P^* : total pressure at points (x, y, z)

P_w : density of seawater

ν^* : kinematic viscosity coefficient of the seawater $(\nu^*_H, \nu^*_H, \nu^*_V)$

t : time

The equation of continuity to represent the continuity of the fluid and the conservation of the mass:

$$\text{div } V = 0$$

Conditions for Calculation

1. Distance between grid points ..... 1,000 m
2. Water depth .... to be read from the chart (Fig. 2.13)
3. Tidal level .... M.W.L. ± 0.00 m
4. Boundary conditions (Amplitudes of tidal current and lag time)
   .... at the north end: 0.782 m (134.24°)
   .... at the south end: 0.615 m (125.92°)

Results of Calculation

Figure 2.14 shows the tidal current at the maximum flood tide (2-hour after low tide: 26-hour), and Figure 2.15 shows those at the maximum ebb tide (2-hour after high tide: 32-hour). These figures represent sufficiently the actual current conditions judging from the results of the observation. Both at the flood tide and the ebb tide, similar reverse patterns are noted, and the maximum velocity in both cases is about 0.6 m/sec. between Laem Pattaya and Ko Lan.

The current in the area in front of Pattaya Beach generally flow in parallel to the shoreline both at the flood tide and the ebb tide and the velocity becomes small as it approaches the beach. Near the shore, the velocity in both cases is 0.1 m/sec.

2.2.3. Water Quality

Figure 2.16 is the station map for the water quality survey and the analytical results are shown in Table 2.5 .

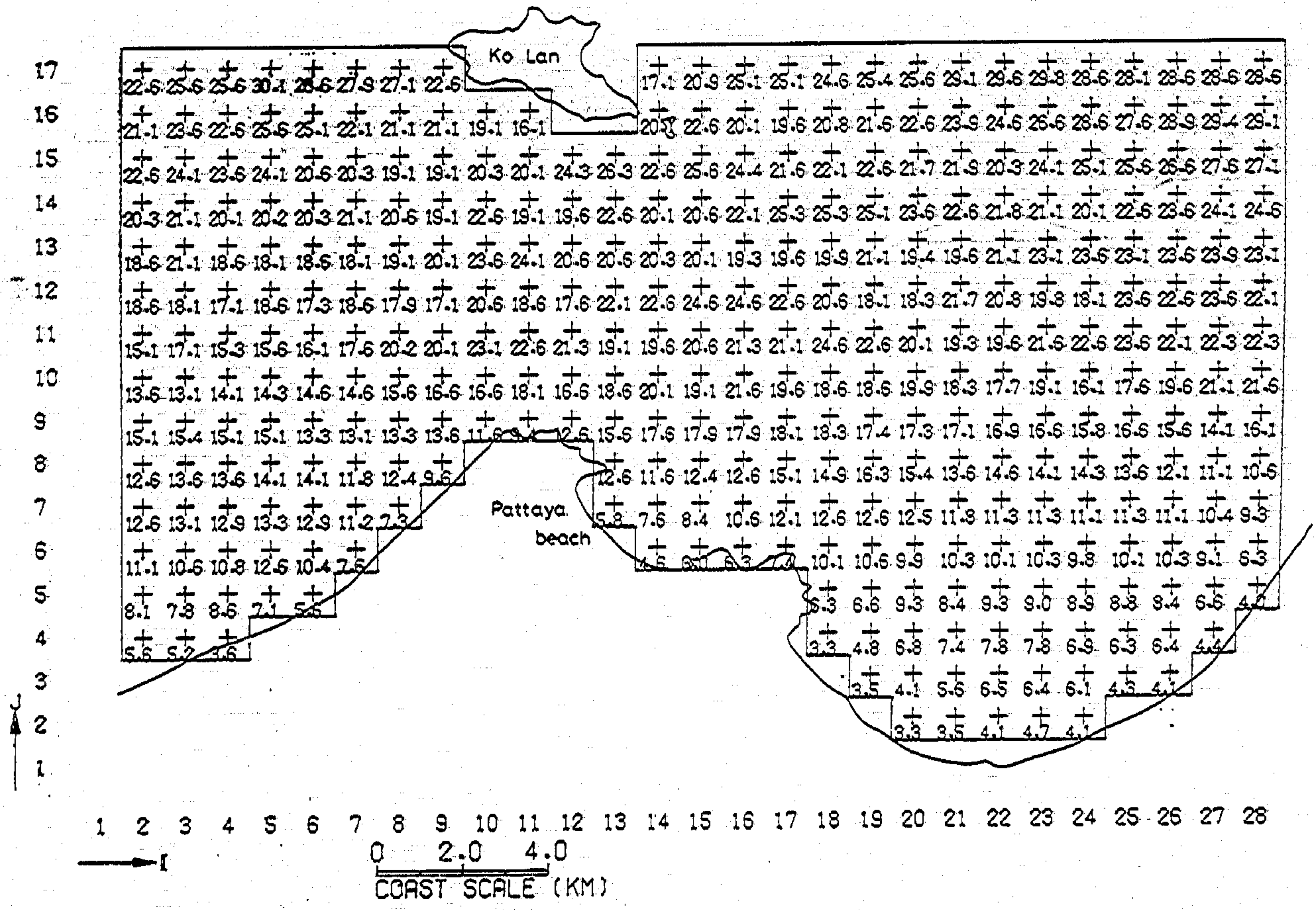


Fig. 2.13 WATER DEPTH (M)

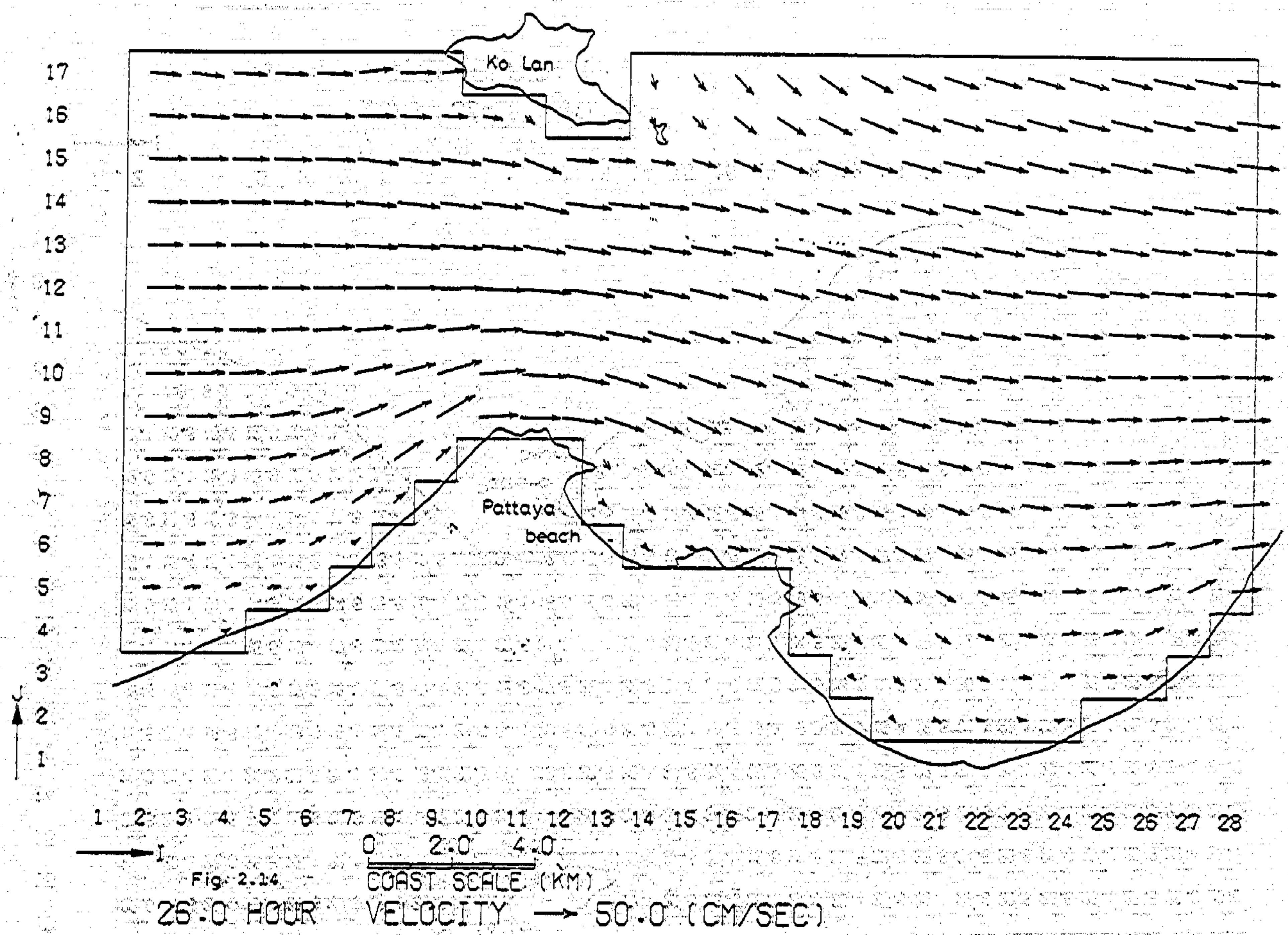


Fig. 2.14

Tidal Current at maximum flow

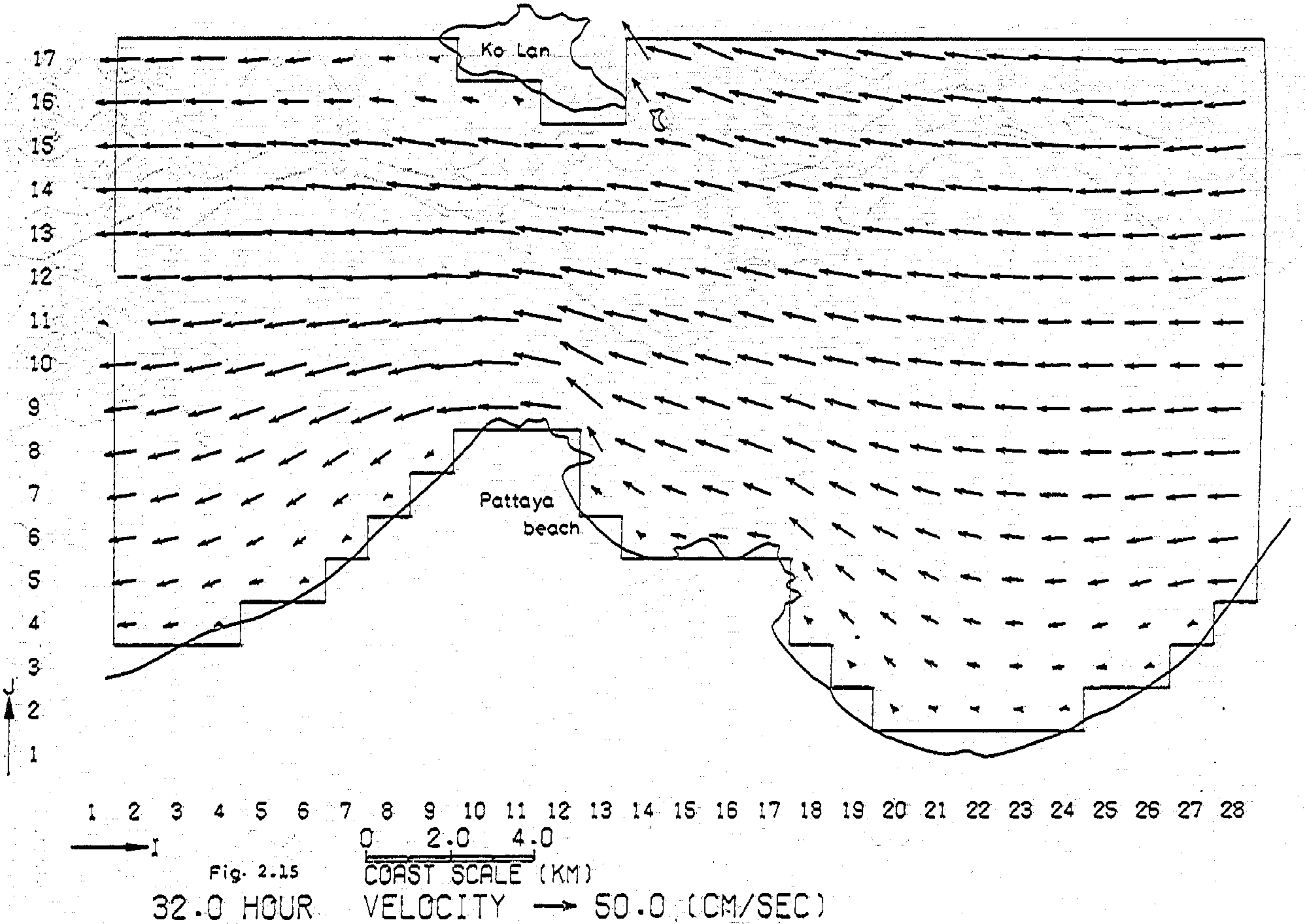


Fig. 2.15

Tidal Current at maximum flow
(2-hour after high tide)

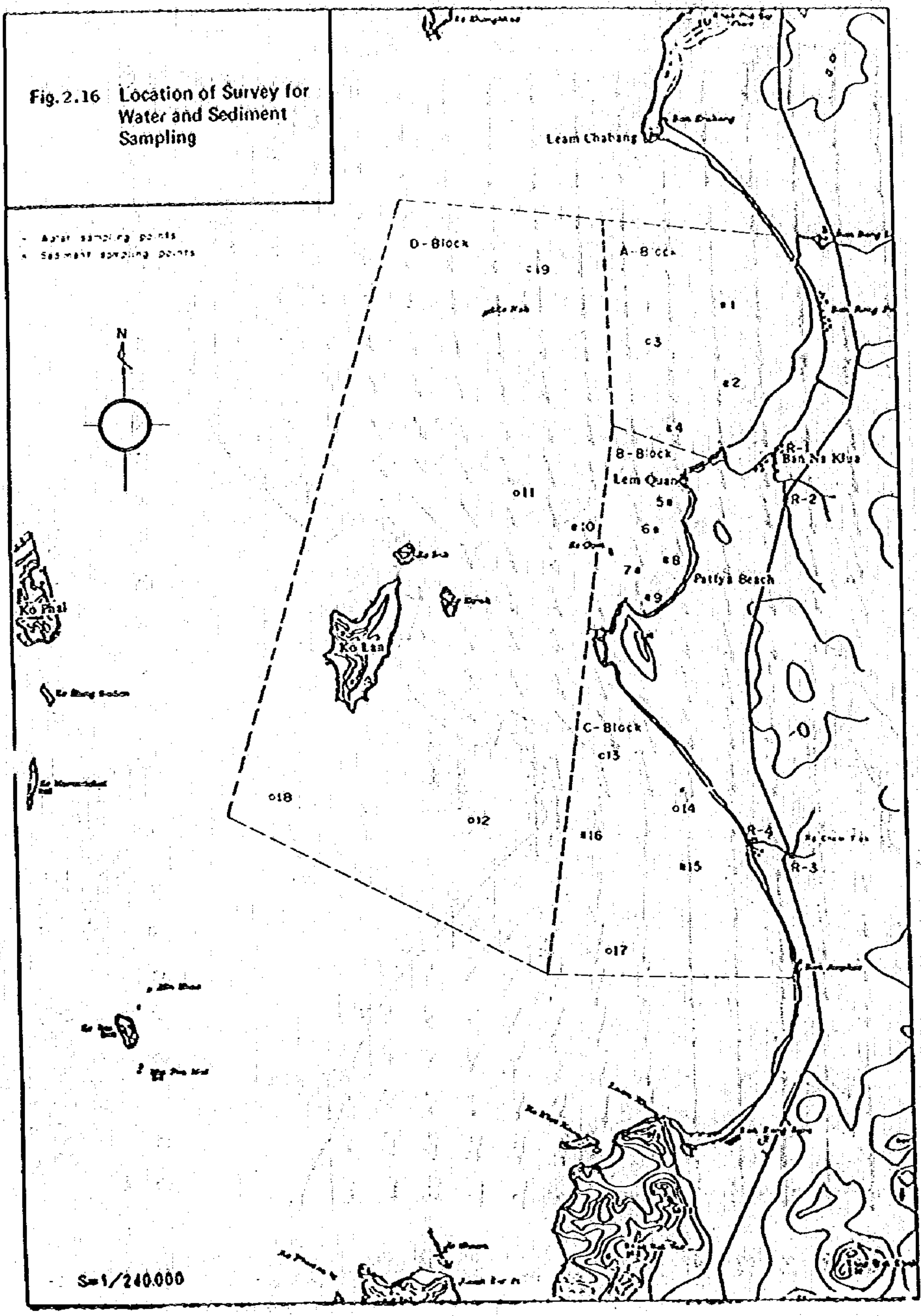


Fig. 2.16 Location of Survey for Water and Sediment Sampling

Temperature

The temperature distribution was within 29.0-30.5°C, substantially the same value as the results of the surveys conducted in the past (MPL's 1st and 2nd pollution surveys). Variation along the horizontal and vertical directions were hardly observed.

Transparency

Except for the offshore waters near Ko Lan, the transparency was low compared to the other international resorts facing the ocean.[11)13)] The waters along Pattaya Beach which is particularly popular with bathers showed a low value of less than 5.0 m.

Salinity

The comparatively low value of 28-31‰ was observed throughout the survey area, which may be considered as the characteristic feature of the Upper Gulf of Thailand and this is understandable from the past surveys. A very low value of salinity was observed near Na Klua coast, although there was a little difference between the low tide and the high one.

During the observation period, there was a small volume of river waters and because of a mild slope of the river bed, in flow of the seawater, going upstream at the bottom to a considerable distance was observed.

pH

pH was within the range of 8.20-8.47. No abnormal values were observed in the sea nor in the river waters. However, Stations 7-9 along the Pattaya Beach indicated somewhat high values of more than 8.40.

DO

The saturation rate of dissolved oxygen in seawater is the function of water temperature and salinity; the lower oxygen saturation for the higher temperature and salinity. The oxygen content was within the range of 5.5 to 6.5 ml/l and high oxygen saturation values were observed in the present survey throughout the whole area, excepting the estuaries. At the estuary of Na Klua River, the area becomes anaerobic condition during the low tide and it is considered hazardous for the biological activities.

COD

COD value was low in the study area except for the Pattaya Beach coastal waters during the high tide. Extremely high values were detected in the rivers, particularly in the upstream of Na Klua River at Station R2, the value as high as 91.8 ppm. The high values in the rivers are obviously due to the waste waters discharged from tapioca plants and due to the domestic sewage from areas along the rivers. Values exceeding the basic Japanese Standard, less than 2 ppm for bathing beaches during the flood tide, were observed in the coastal waters of Pattaya Beach, and they are assumed to have originated from phytoplankton blooms or waste water discharged into the sea, judging from the similarly high values of inorganic nitrogen and phosphate.

SS

SS values were low within the whole study area. In the river areas, no extremely high SS content was detected except at Station R2 in the upstream of Na Klua River. 592 ppm observed at Station R2 is considered to have originated from the waste water discharged from the tapioca plants during the survey period.

Nitrogen Compounds (Org-N, NO_3-N, NO_2-N, NH_4-N)

Except in Na Klua River, the values of total N were not remarkably high compared to the values observed generally in the coastal waters. However, ammonia nitrogen (NH_4-N) exceeded 80% of total nitrogen concentration, an excessively high value compared to the ordinary seawater and it is assumed that the seawater is in anaerobic condition. However, a considerably high value of dissolved oxygen suggests that recycling of nitrogen is disturbed by some reason which was not determined by the present survey.

Station R1 at the estuary during the low tide showed 710 µg.at/l and Station R2 in the upstream 1,200 µg.at/l suggesting excessive contamination of the waters by the domestic sewage and the waste water from tapioca plants. The waters along Pattaya Beach showed somewhat high inorganic nitrogen.

Phosphorus Compounds

Phosphorus compound distribution is somewhat similar to the distribution pattern of nitrogen compounds, and their values are not remarkably high for those found along the coastal areas. However, the waters in the rivers are excessively contaminated by phosphorus compounds originating from the domestic sewage and tapioca plants, in the case of nitrogen. In the waters along Pattaya Beach, PO_4-P showed somewhat high values.

TOC (Total Organic Carbon)

TOC is generally 0.1 mg/l in the oceanic waters and 5 mg/l in the coastal waters.[16] Throughout the present survey, the values were quite high; 3 mg/l-10 mg/l in the sea area. The values in the coastal waters of Pattaya Beach were somewhat on the higher side as in the case of COD.

Oil (N-hexane Extracts)

N-hexane extract was analyzed at Stations 4-9 along Pattaya Beach. It was detected only at Station 7 during the low tide. Since Japanese bathing beach standard provides that no N-hexane extract should be contained in the water, this may cause a difficulty as a bathing resort under the Japanese Standard.[16] N-hexane extracts are considered to have orginated from the waste oil, etc., of the excursion boats and fishing boats.

Coliform Bacteria

Coliform bacteria survey were conducted (Fig.2.17) two times 18th (Thursday) and 29th (Monday) of August and the results are shown in Table 2.6. The second survey showed somewhat high values because the preceding day was a Sunday. All these stations, however, were located about 200 m offshore from the shoreline. These stations were selected in order to supplement the NEB data which were observed along the shoreline. The values in the near shore area would be higher than these data because the sources of coliform bacteria exist along the shoreline.[18]

2.2.4. Sediment Conditions

Analytical results of the sediment survey are shown in Table 2.7.

1) Sea Water

Table 2.5 THE RESULTS OF WATER QUALITY SURVEY

Sample No. \ Items	Date	Time	Tide	Air Temperature (℃)	Depth (m)	Transparency (m)	Water Temperature (℃)	pH	S (‰)	DO (ppm)	DO Saturation Degree (%)	COD (ppm)	SS (ppm)	Total-N (μg-at/l)	Organic-N (μg-at/l)	NO_3-N (μg-at/l)	NO_2-N (μg-at/l)	NH_4-N (μg-at/l)	Total-P (μg-at/l)	Organic-P (μg-at/l)	PO_4-P (μg-at/l)	TOC (mg/l)	n-Hexane Extract (ppm)
St. 1.H	8.23	12:37	High	28.0	8.20	3.0	30.1	8.35	28.36	4.77	101.0	1.03	5	6.6	0.11	<0.05	<0.05	6.69	1.18	0.89	0.29	4	—
1.L		07:05	Low	27.0	6.05	3.0	29.2	8.37	27.46	6.63	96.6	1.40	4	3.8	0.29	<0.05	0.05	3.51	0.98	0.63	0.30	8	
St. 2.H	8.23	13:25	High	27.2	6.00	2.7	30.0	8.37	26.90	6.88	102.8	0.97	5	3.0	0.21	0.08	0.05	3.29	0.91	0.58	0.36	6	—
2.L		07:25	Low	27.0	5.30	1.0	29.0	8.28	28.36	6.61	96.2	1.54	8	3.6	0.25	0.05	0.05	3.33	1.28	0.89	0.37	6	
St. 3.H.0	8.23	12:37	High	27.5	10.50	6.0	30.0	8.18	29.27	6.88	102.6	0.99	5	3.2	0.40	<0.05	<0.05	2.71	0.76	0.71	<0.05	6	—
3.H.5							30.1	8.32	29.81	6.24	94.0	0.88	5	2.8	0.32	0.45	0.11	1.92	0.94	0.55	0.39	5	
3.L.0		06:50	Low	27.0	8.80	4.0	29.2	8.33	28.36	6.32	92.0	1.88	4	18	0.03	0.13	<0.05	18.0	0.90	0.53	0.37	2	
3.L.5							29.1	8.35	28.54	6.63	97.1	1.54	4	4.8	0.10	<0.05	<0.05	4.70	0.98	0.54	0.44	4	
St. 4.H.0	8.23	12:10	High	28.0	11.00	6.0	29.4	8.30	29.95	6.40	98.0	1.05	5	16	0.05	0.05	<0.05	15.4	0.62	0.33	0.29	8	—
4.H.5							30.0	8.32	29.87	6.20	94.0	1.40	6	4.7	0.18	0.13	<0.05	4.38	0.08	0.61	<0.05	6	
4.L.0		06:25	Low	27.0	7.00	4.5	29.4	8.34	28.12	6.09	87.4	1.31	4	4.5	0.15	0.03	<0.05	4.30	0.74	0.44	0.32	5	
4.L.5							30.2	8.32	29.27	6.28	92.5	1.40	4	0.1	0.06	0.25	0.13	8.08	0.83	0.33	0.30	4	
St. 5.H	8.20	08:12	High	27.5	8.30	4.0	29.1	8.33	21.28	6.20	90.9	2.16	2	14	0.07	0.25	<0.05	13.7	2.03	2.00	0.63	8	<1
5.L		13:55	Low	28.0	5.10	3.5	29.6	8.30	26.92	6.65	97.4	1.68	2	6.4	0.10	0.08	<0.05	6.21	0.83	0.44	0.39	6	<1
St. 6.H	8.20	08:45	High	27.5	7.00	5.0	29.1	8.32	27.28	6.42	93.2	1.80	2	14	0.10	0.20	<0.05	13.7	0.83	0.78	<0.05	9	<1
6.L		13:38	Low	28.0	5.00	4.0	29.6	8.36	27.10	6.84	100.3	1.56	2	8.0	0.27	0.08	<0.05	7.65	0.90	0.37	0.54	5	<1
St. 7.H	8.20	08:55	High	27.5	6.70	5.5	29.8	8.44	27.28	6.07	98.2	2.18	2	14	0.01	<0.08	<0.05	13.4	1.04	0.37	0.47	7	<1
7.L		13:49	Low	27.5	5.90	4.5	29.8	8.37	27.10	6.86	100.8	1.56	2	5.5	0.19	0.05	<0.05	5.26	1.08	0.65	0.43	4	1
St. 8.H	8.20	07:50	High	27.5	4.80	4.0	29.0	8.41	27.26	6.21	90.2	2.18	2	5.8	0.06	<0.05	<0.05	5.74	1.01	—	1.60	10	<1
8.L		13:10	Low	28.0	3.90	3.5	29.7	8.42	27.28	6.66	97.8	1.74	3	2.9	0.06	<0.05	<0.05	2.88	1.04	0.56	0.49	8	<1
St. 9.H	8.20	07:38	High	27.0	4.80	4.7	29.7	8.40	27.10	6.46	94.8	1.70	2	6.7	0.03	0.10	<0.05	6.57	0.98	0.51	0.47	5	<1
9.L		13:01	Low	29.7	4.00	3.5	29.7	8.40	27.46	6.69	96.9	1.40	2	7.5	0.17	<0.05	<0.05	7.33	1.01	0.60	0.41	4	<1
St.10.H.0	8.27						30.0	8.32	31.25	6.19	94.4	1.21	2	1.9	0.18	<0.05	<0.05	1.72	0.55	0.50	<0.05	5	—
10.H.5		14:40	High	27.1	17.30	7.0	30.4	8.22	29.27	6.03	90.0	1.80	2	7.7	0.31	0.08	<0.05	7.33	0.62	0.57	<0.05	5	
10.H.10							29.9	8.21	31.63	5.55	84.3	1.07	3	0.21	0.12	<0.05	0.09	<0.05	0.66	0.51	<0.05	5	
10.L.0							30.1	8.24	29.99	6.19	93.2	1.18	2	12	0.03	0.20	<0.05	11.8	0.44	0.39	<0.05	4	
10.L.5		08:37	Low	29.0	15.30	10.0	30.0	8.32	30.89	6.09	92.1	1.33	1	13	0.05	0.05	<0.05	12.9	0.69	0.64	<0.05	4	
10.L.10							29.9	8.23	31.43	4.97	75.3	1.37	2	12	0.48	0.50	0.32	10.7	1.04	0.86	0.18	4	
St.11.H.0	8.27						30.1	8.32	30.71	6.32	96.0	0.91	1	3.0	0.03	<0.05	<0.05	2.97	0.55	0.50	<0.05	4	
11.H.5		15:10	High	27.0	21.20	8.5	30.2	8.24	31.07	6.11	93.0	1.64	2	10	<0.02	0.08	<0.05	10.0	0.76	0.71	<0.05	6	—
11.H.10							29.9	8.22	31.61	5.74	87.1	0.91	3	1.9	0.34	0.91	<0.05	0.97	0.83	0.78	<0.05	5	—
11.L.0							30.0	8.32	29.99	6.38	96.0	1.00	1	1.4	0.09	<0.05	<0.05	1.31	0.83	0.78	<0.05	4	
11.L.5		09:10	Low	27.3	18.75	13.0	29.8	8.22	29.99	6.19	92.7	1.68	1	0.52	0.27	<0.05	<0.05	0.25	0.76	0.71	<0.05	2	—
11.L.10							29.9	8.22	31.61	5.57	84.8	1.00	1	3.4	0.14	0.88	0.19	2.39	1.01	0.96	<0.05	8	
St.12	8.28	11:05	Low	27.0	17.00	9.0	30.0	8.27	31.43	6.13	93.1	1.70	2	2.4	0.09	0.05	<0.05	2.23	0.48	0.43	<0.05	4	—
St.13.H.0	8.24						30.0	8.34	30.71	6.46	97.4	1.13	14	1.3	0.14	<0.05	<0.05	1.13	0.34	0.29	<0.05	4	—
13.H.5		12:41	High	28.0	10.50	8.0	30.0	8.38	30.71	6.36	96.1	1.05	5	2.7	0.17	<0.05	<0.05	2.50	0.37	0.32	<0.05	4	
13.L.0		06:02	Low	27.0	8.85	5.0	29.4	8.29	30.55	5.67	84.6	0.40	10	2.4	0.03	0.78	0.06	1.53	0.48	0.08	0.40	5	
13.L.5							30.0	8.28	31.07	5.47	82.7	0.40	4	6.7	0.08	0.61	<0.05	6.01	0.55	0.35	0.20	7	
St.14.H.0	8.24						30.0	8.37	29.99	6.63	99.7	0.99	4	15	<0.02	<0.05	<0.05	15.3	0.62	0.57	<0.05	3	—
14.H.5		14:27	High	27.8	10.40	7.0	29.8	8.39	30.35	6.48	97.5	1.52	4	9.5	0.05	<0.05	<0.05	9.40	0.76	0.61	<0.05	5	
14.L.0		07:28	Low	27.0	9.65	7.5	29.6	8.32	29.99	5.98	89.6	0.79	4	1.2	0.02	<0.05	<0.05	1.19	0.55	0.50	<0.05	5	
14.L.5							29.7	8.37	29.27	5.82	86.6	0.47	3	2.2	0.30	0.25	0.11	1.63	0.66	0.61	<0.05	7	
St.15.H.0	8.24						30.0	8.33	30.17	6.50	97.9	1.13	5	2.0	0.22	<0.05	<0.05	1.73	0.55	0.50	<0.05	4	—
15.H.5		14:05	High	27.8	9.40	7.0	29.8	8.38	30.53	6.50	97.7	1.30	3	1.4	0.47	<0.05	<0.05	0.88	0.42	0.37	<0.05	5	
15.L.0		07:10	Low	27.0	8.35	7.0	29.6	8.33	30.53	6.05	90.7	0.73	4	1.0	<0.02	0.18	<0.05	0.88	0.69	0.38	0.31	8	
15.L.5							29.7	8.33	30.53	5.90	88.5	0.61	3	2.3	0.08	0.33	<0.05	1.89	0.73	0.35	0.38	4	
St.16.H.0	8.24						30.0	8.39	30.53	6.57	99.4	1.33	2	1.2	0.05	<0.05	<0.05	1.13	0.55	0.50	<0.05	4	—
16.H.5		13:10	High	27.8	10.10	8.0	29.9	8.39	30.71	6.57	99.1	0.86	2	1.1	<0.02	<0.05	<0.05	1.10	0.69	0.64	<0.05	5	
16.L.0		06:27	Low	27.0	5.60	>5.6	29.7	8.34	30.89	5.97	89.0	0.86	3	1.3	0.01	0.28	<0.05	0.88	0.55	0.50	<0.05	6	
16.L.5							29.8	8.25	30.89	5.85	88.3	0.57	2	5.1	0.02	0.51	<0.05	4.54	0.62	0.57	<0.05	4	
St.17.H.0	8.26						29.9	8.38	31.07	6.44	97.4	0.89	3	1.3	0.05	<0.05	<0.05	1.29	0.59	0.54	<0.05	5	—
17.H.5		13:32	High	27.5	12.10	7.0	29.7	8.38	31.25	6.26	94.4	1.39	4	4.0	0.19	<0.05	<0.05	3.76	0.69	0.64	<0.05	5	
17.L.0		06:50	Low	27.0	12.70	8.0	29.7	8.34	30.71	6.05	91.0	0.77	2	2.6	0.31	0.18	<0.05	2.06	0.98	0.58	0.40	6	
17.L.5							29.8	8.35	30.71	6.05	91.2	1.01	4	1.7	0.40	<0.05	<0.05	1.25	0.76	0.71	<0.05	4	
St.18	8.28	12:00	Low	28.7	23.50	12.5	29.9	8.31	31.62	6.14	93.3	1.33	3	0.94	0.08	<0.05	<0.05	0.81	0.34	0.29	<0.05	5	—
St.19	8.28	10:00	Low	27.2	16.20	13.0	29.9	8.22	31.62	6.26	93.7	1.07	<1	0.88	0.33	<0.05	<0.05	0.50	0.40	0.36	<0.05	4	—

2) River Water

Sample No. \ Items	Date	Time	Tide	Air Temperature (℃)	Transparency (cm)	Water Temperature (℃)	pH	S (‰)	DO (ppm)	DO Saturation (%)	COD (ppm)	SS (ppm)	Total-N (μg-at/l)	Organic-N (μg-at/l)	NO_3-N (μg-at/l)	NO_2-N (μg-at/l)	NH_4-N (μg-at/l)	Total-P (μg-at/l)	Organic-P (μg-at/l)	PO_4-P (μg-at/l)	TOC (mg/l)
St. R. 1. H.	8.26	14:30	High	30.0	>30	33.0	8.36	8.80	7.90	125.1	2.59	15	4.5	0.15	1.42	0.43	2.50	1.68	0.86	0.82	4
R. 1. L.		07:20	Low	28.0	100	28.3	7.64	6.97	<0.01	—	16.8	37	710	23	1.66	1.06	705	54	30.0	51	31
St. R. 2. L.	8.26	07:43	Low	29.0	1.5	27.8	6.85	0.22	<0.01	—	91.8	597	1200	43	9.68	<0.05	1186	286	13.3	153	78
St. R. 3. L.	8.26	08:10	Low	27.0	135	28.2	7.34	6.03	4.86	66.3	15.4	34	39	0.43	4.21	0.96	33.6	3.43	21.8	3.25	30
St. R. 4. H.	8.26	15:00	High	28.5	>30	31.4	8.41	9.13	6.86	105.8	1.98	8	2.8	0.20	1.61	<0.05	0.78	1.12	0.97	0.15	3
R. 4. L.	8.27	07:30	Low	28.7	>30	29.7	7.81	9.30	4.53	67.9	3.31	13	1.4	<0.07	1.38	<0.05	0.05	1.58	0.90	0.08	6

Fig. 2.17 Location of Survey for Coliform Bacteria Sampling

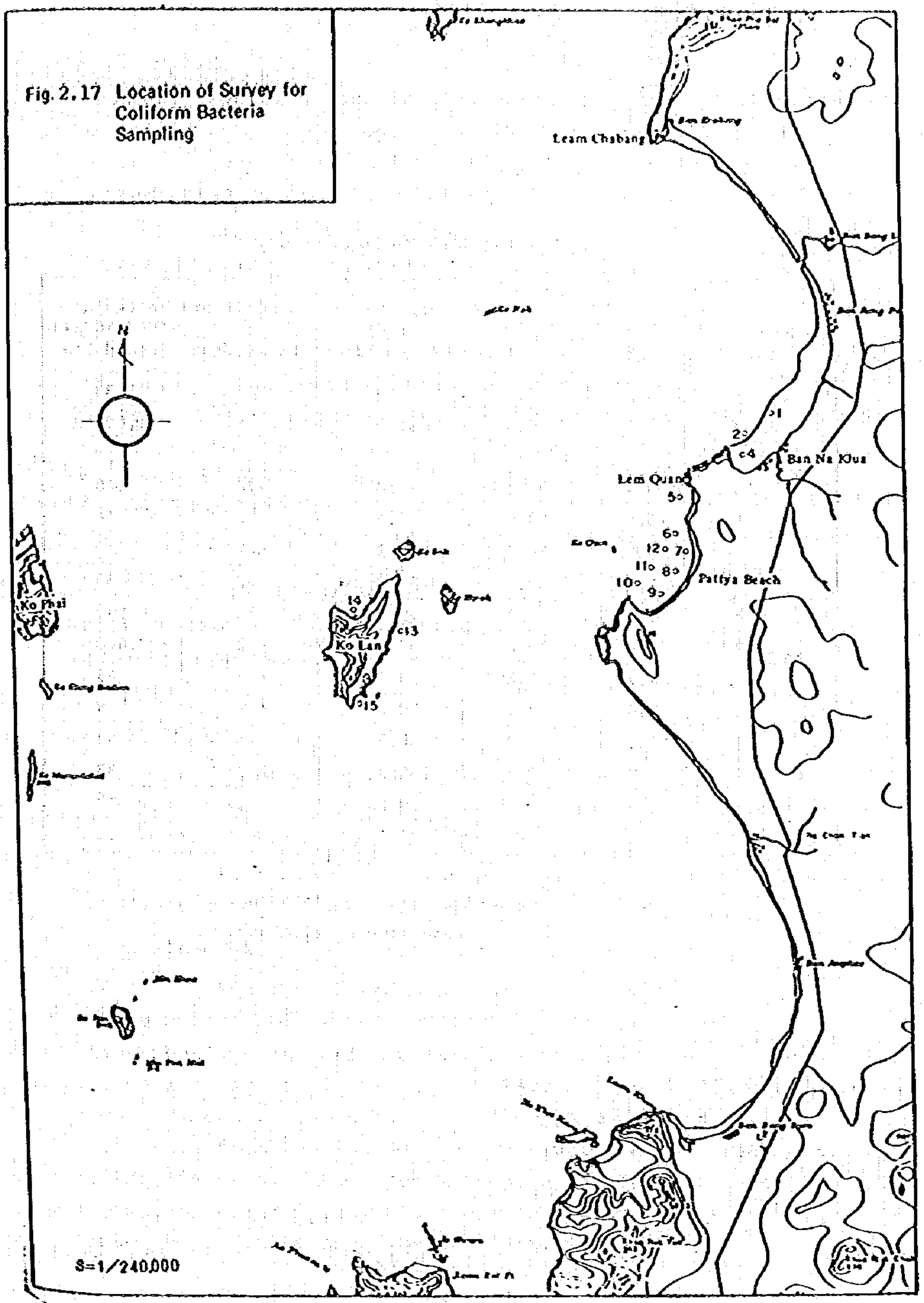


Table 2.6 The Results of Coliform Bacteria Survey

Items / Sample No.	Depth (m)	Water Temperature (°C)		Coliform Bacteria (MPN/100ml)	
		First Time	Second Time	First Time	Second Time
St. 1	1.1	30.7	30.8	2	33
2	1.4	30.5	31.0	5	1,600
3	-	-	-	-	-
4	0.9	30.8	31.0	170	540
5	3.6	30.8	30.7	< 2	46
6	3.2	30.8	30.2	< 2	49
7	1.0	30.2	30.2	22	33
8	0.9	30.9	30.4	14	540
9	0.9	30.4	30.3	< 2	> 2,400
10	4.7	30.6	30.3	< 2	49
11	4.0	30.4	30.2	< 2	9
12	4.2	30.3	30.2	< 2	33
13	2.9	30.3	30.0	280	33
14	3.0	30.7	30.1	2	11
15	3.5	30.4	30.0	2	2

Sampling Date : First Time 18th Aug.
Second Time 29th Aug.

Loss on Ignition

Ignition loss is used as an indicator to show the organic substance in sediments. Values exceeding 10% is generally considered to indicate that the sample has been contaminated by organic substances.[16]

The present survey discovered low values except at Stations 4, 10 and 16 which showed values higher than 10%.

TOC

Both the sea and the river waters showed low values of TOC. At the upstream stations, the values were somewhat higher. The increase toward the offshore waters was observed. Comparing to the deteriorated quality of the water in the upstream of the rivers, the contamination at the estuaries is not so advancing.

COD

COD showed generally low values with a distribution pattern similar to that of TOC. The stations in the offshore areas and in the upstreams of the rivers showed somewhat higher values than in the coastal areas and in the estuaries.

Total Sulfides

It is the generally accepted standard that sulfides in the sediments in some ways effect the biological activities at the level of 0.2 mg.S/g, and are detrimental at the level exceeding 1.0 mg.S/g.[11][12] In the present survey, no stations showed the values higher than 0.2 mg.S/g.

Grain Size Distribution

Samples of sediments were dried and passed through standard sieves to determine the grain size distribution. At all the stations except those located at the estuaries, about 10% of silts, clays and colloids were found in the sediments. As it has been discussed previously, these originate from the inland and the rivers, do not settle at the estuaries or near the shores because of the effects of the river flows, tide and waves, but are transported and dispersed into the offshore areas before settling finally.

Table 2.7 Analytical Data for Sediment Survey

1) Sea

Items / Sample No.	Ignition loss (%)	Total-Sulfide (mg/g)	TOC (mg/g)	COD (mg/g)
St. 1	4.6	0.03	0.5	1.5
St. 2	5.3	0.04	1.5	2.6
St. 4	10.6	0.02	2.9	2.5
St. 5	5.7	0.04	1.9	0.2
St. 6	4.3	0.04	2.0	1.5
St. 7	6.6	0.02	2.5	1.9
St. 8	2.9	0.04	0.9	1.1
St. 9	5.6	0.06	2.3	2.0
St.10	24.5	0.06	7.2	2.6
St.14	3.9	0.05	2.2	1.9
St.15	5.0	0.03	1.8	1.5
St.16	18.5	0.02	6.7	2.5

2) River

Items / Sample No.	Ignition loss (%)	Total-Sulfide (mg/g)	TOC (mg/g)	COD (mg/g)
St.R.1	0.7	0.01	0.7	0.6
St.R.2	3.1	0.08	5.8	3.0
St.R.3	2.7	0.06	2.5	2.2
St.R.4	1.1	0.02	0.3	0.5

3. Estimating Pollutants Loads in Pattaya Sea Area

3.1. Sources of Pollution

Sources of polluted waters flowing into Chonburi coastal sea area are the various industrial plants such as oil refineries, slaughter houses, sugar refineries, tapioca refineries, fish processing and wood processing plants and the domestic sewage from the local inhabitants.

Most of the major factories are located in the coastal area and the sea area near the Chonburi coast are loaded with pollutants from these factories: SS ca. 6×10^3 ton/year, BOD ca. 13×10^3 ton/year, N ca. 2×10^3 ton/year, P ca. 1×10^3 ton/year.[5)]

Table 3.1 shows SS and BOD loads originating from factories broken down by the types of factories.[5)] According to the Table, most (more than 97%) of the pollutants discharged from the factories originate from tapioca plants, and they may be rightly called the major source of pollution for the Chonburi coast.

The domestic sewage originating from coastal urban area directly flow into the sea via brooks and ditches, and are likely causes for public health hazard as they contain enterobacterceacae, representative of which is coliform bacteria, and for the seawater loaded by SS, BOD and nutrient salts.

3.2. Effects of Industrial Waste Waters on the Sea

Major portion of pollutant loads in the Chonburi coastal sea area is the waste water discharged from tapioca refineries and they can roughly be classified into two types; namely those discharged from outlets of the flumes in the slurring and washing system for raw materials, and those discharged from outlets of the separator in the separation and refining system for the starch. Those out of the flumes contain soil, chips of tapioca and other particles, and their BOD concentration is comparatively low. On the other hand, the waste water from the separator contains a great deal of dissolved protein and sugar, and consequently is of a high BOD concentration. At the refineries the waste water from the flume and the separator are admixed and processed. Approximate concentrations of the raw

Table 3.1

Total Annual BOD and Suspended Solids Loads Discharged by Chonburi's Coastal Industries to the Marine Environment

	Annual kg S.S.	% of Total	Annual kg BOD	% of Total
Dried fish + squid	29,652	0.47	74,280	0.56
Slaughter houses	474	0.01	1,356	0.01
Suger refinery	96,416	1.54	77,132	0.58
Oil refineries	-		54,884	0.41
Fish sauce	9,374	0.15	4,493	0.03
Hardboard and Shaving Board	22,344	0.35	12,912*	0.09*
Tapioca A	546,169	8.71	1,027,706	7.73
Tapioca B	5,571,712	88.77	12,070,132	90.59
TOTAL	6,276,141	100.00	13,322,895	100.00

* In terms of COD

Tapioca A - First grade starch, produced by centrifuge, seiving and spray drying.

Tapioca B - 2nd grade starch, produced by seiving, settling and flat plate drying.

Source - Coastal water pollution survey of Chonburi Province July 10, 1973 by AIT.

waste waters are BOD 3,000 ppm, SS 2,000 ppm, N 140 ppm and P 60 ppm respectively.[12]

The processing method used for the industrial waste water in Pattaya area is anaerobic pond. Most of soil, chips from the raw materials and other particles are removable by this method, the removal ratios for BOD and SS being as low as 25-35% and 30-40% respectively and hardly any N or P removed.[12] As the waste water flows into the river, these concentrations diminish by dilution and regeneration of the river water and also as they are trapped by the river. However, excessive amount of the waste water degrade environmental condition, greatly affecting the river ecology.

When the polluted river water flows into the sea, it is gradually diluted through diffusion and advection. Organic matters (dissolved organic matters: DOM, and particulated organic matters: POM), if abundant in the water, are decomposed by bacteria, and consume a great deal of dissolved oxygen in the seawater and thus degrade the seawater. The particulated organic matters precipitating on the sea bottom would then decompose and consume the dissolved oxygen at the bottom layer, and then further decompose anaerobicly and form such harmful substances as sulfide (H_2S, etc.) and basic nitrogen compounds[11)14] (ptomaine, etc.). This will lead to the environmental deterioration in the sea and bottom.

On the other hand, the nutrient salts would accelerate eutrophication and increase phyto- and zoo-planktons, one of the causes for red tides.[14]

Figure 3.1 shows the behavior of organic matters after they enter the sea via rivers while Figure 3.2 shows process of eutrophication with waste water at the estuaries.

3.3. Pollutant Loads in the Study Area

Total pollutant loads from the inland area (the industrial waste water + domestic sewage) were estimated in respect of the coastal waters from Lem Kra Bang to Ban Sare with Pattaya Beach located in the center.

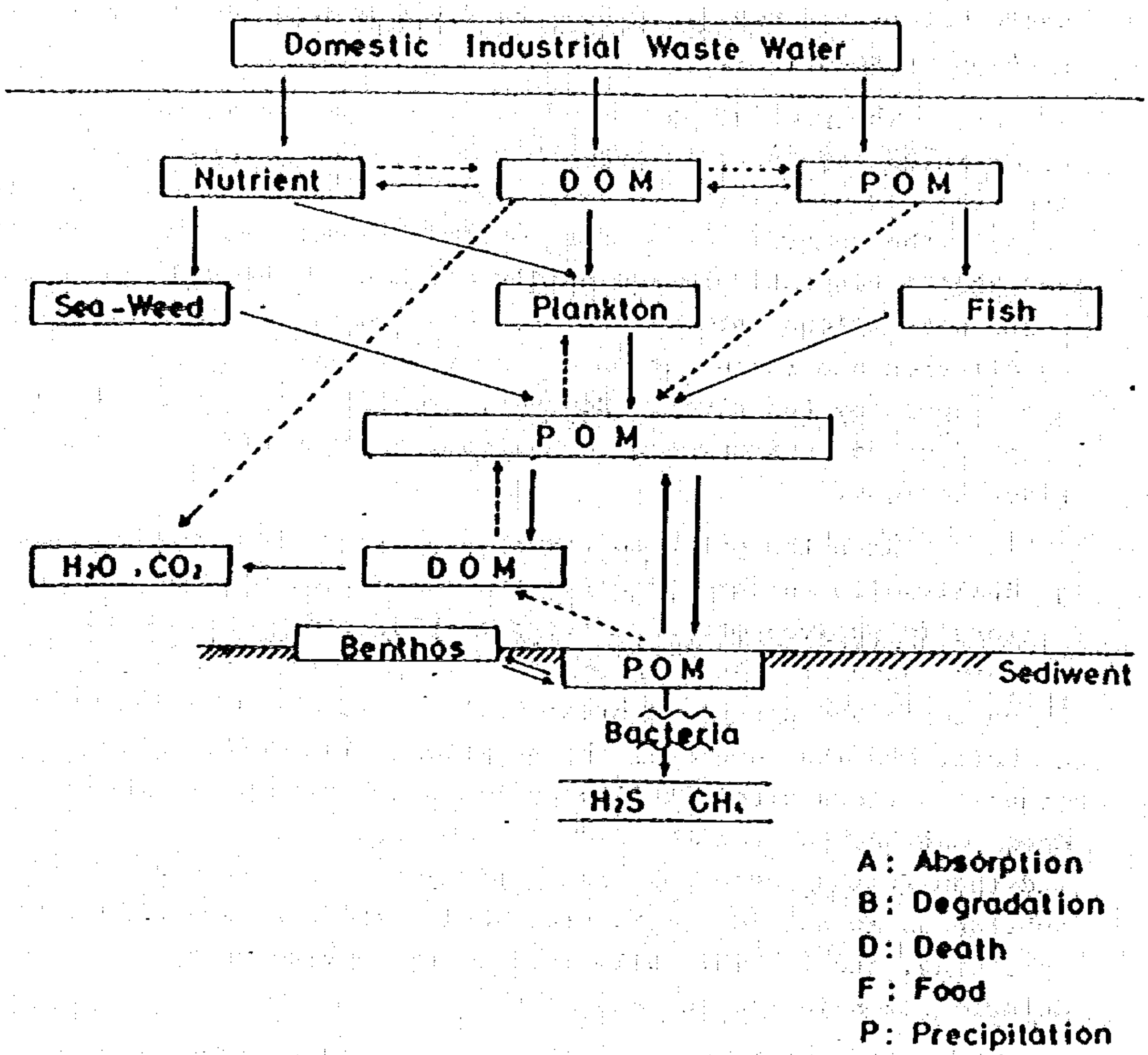


Fig. 3.1 Waste water behavior in the Sea

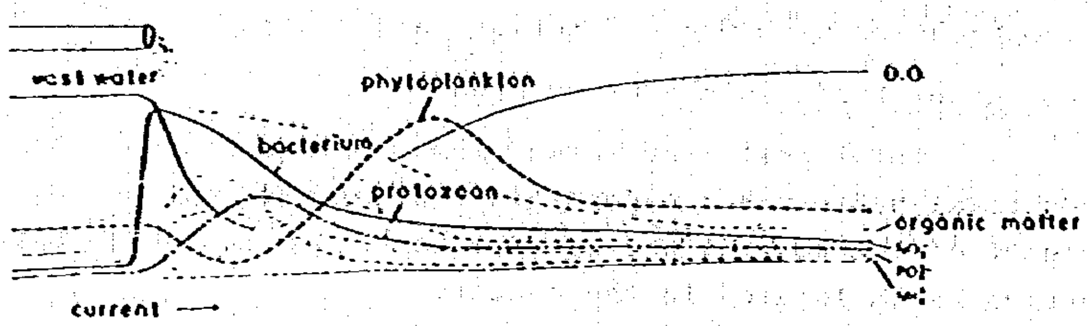


Fig. 3.2 Process of eutrophication with wast water

Industrial Waste Water

Monthly loads of SS and BOD originating from the industrial waste waters in Chonburi coastal area are shown in Table 3.2 while Figures 3.2 and 3.3 show the annual loads of pollutants broken down by the areas.[5)] Table 3.3 shows the monthly pollutant loads originating from the industrial waste waters in the study area calculated from Table 3.2. Here N and P values were respectively estimated based on an assumption that all the pollutant loads originate from tapioca starch refinery plants.

Table 3.2 Monthly Discharge of Industrial Waste Waters along the Chonburi Coast by Tapioca Factories[5)]

Month	Suspended Solids		BOD	
	Tapioca A	Tapioca B	Tapioca A	Tapioca B
Jan	86203	763232	186390	1739328
Feb	64768	381616	140029	869664
Mar	72323	-	156634	-
Apr	27387	-	59211	-
May	12403	-	26825	-
June	52222	457939	112904	1043596
July	28796	457939	62264	1043596
Aug	18847	610585	40757	1391462
Sept	28285	610585	61196	1391462
Oct	50292	763232	105746	1739328
Nov	39272	763232	84978	1739328
Dec	65371	763232	141340	1739328

kg/month

Table 3.3

Monthly Total Waste Water Discharge Along the Coast of Study Area

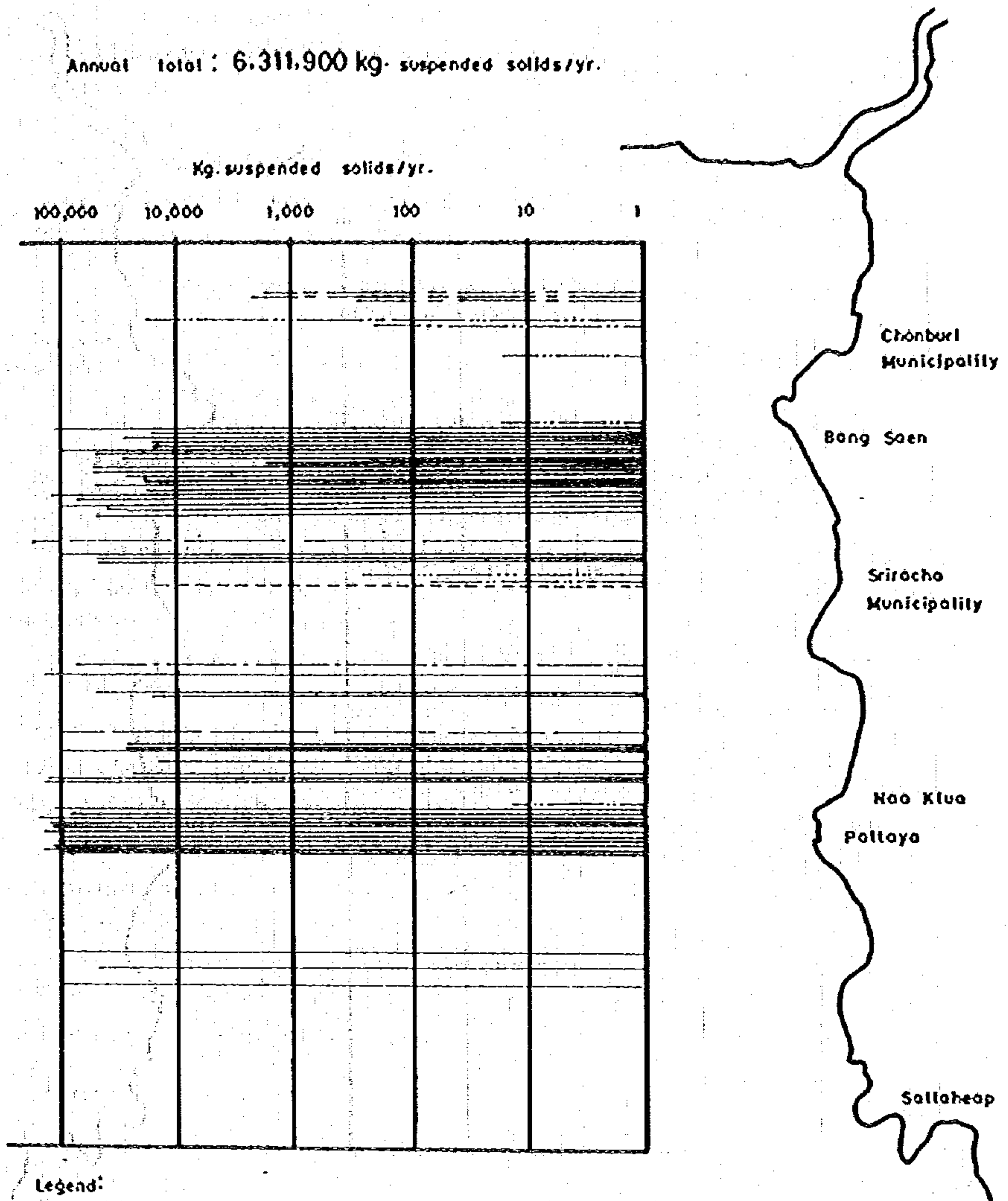
(ton)

Month	Item			
	Suspended Solids	BOD	N	P
January	340	720	110	55
February	210	430	64	32
March	30	53	4	2
April	27	28	2	1
May	23	28	1	1.5
June	230	470	68	34
July	220	450	66	33
August	290	610	90	45
September	270	570	84	42
October	360	770	120	59
November	350	730	110	56
December	370	790	120	60
Total	2,700	5,650	840	470

Domestic Sewage

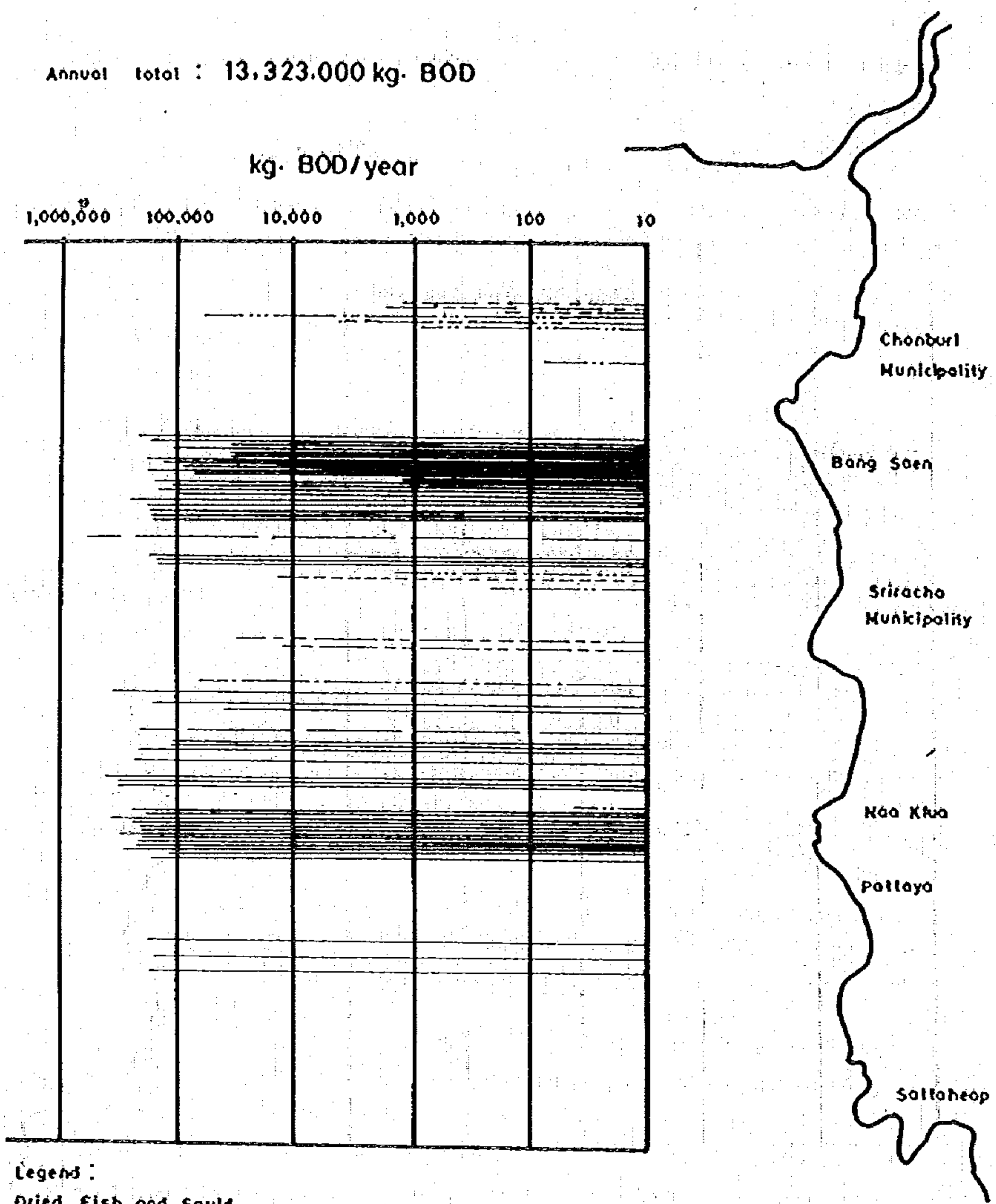
The domestic sewage are excreta and miscellaneous waste water such as from cooking and washing, the discharge amount of which does not fluctuate during the year.

Loads per person per day of excreta are estimated to be SS 10 g/person day, BOD 13 g/person day, N 9 g/person day, P 0.6 g/person day.[16] Since the population of the inland areas from which the pollutants originate is about 43,000, the load per person is multiplied by this figure to obtain the following total loads on the study area: SS 13 ton/month, BOD 16 ton/month, N 12 ton/month, and P 0.8 ton/month.



Legend:
Dried Fish and Squid
Slaughter House
Sugar Refinery
Oil Refinery
Fish Sauce
Hard Board and Shaving Board
Tapioca A
Tapioca B
Pig Farms

Fig. 3.2 Annual Industrial Pollutant Loads from the Chonburi Coast [5]



Legend :

Dried Fish and Squid
Slaughter House
Sugar Refinery
Oil Refinery
Fish Sauce
Hard Board and Shaving Board
Tapioca A
Tapioca B
Pig Farms

Fig. 3.3 Annual Industrial Pollutant Loads from the Chonburi Coast 5)

Basing the estimate on the corresponding loads in Japan and the living standard in the study area, the loads from the miscellaneous waste water were calculated and the following results obtained: SS 5 g/person day, BOD 5 g/person.day, N 0.5 g/person day, and P 0.1 g/person day.[16] As described above, the total load in the subject waters are calculated in the above described manner and the results are: SS 6.5 ton/month, BOD 6.5 ton/month, N 0.7 ton/month and P 0.1 ton/month.

Accordingly, the total loads originating from the domestic sewage (excreta + miscellaneous waste water) in the study area are: SS 20 ton/month, BOD 23 ton/month, N 13 ton/month, and P 1 ton/month.

When these pollutants flow into the sea area via rivers, the loads entering the rivers do not necessarily become the loads entering these sea area. The rivers have their own characteristic discharge rates and those flowing through the dry area have lower rate while those flowing through the wet area a higher rate. Assuming from the discharge rate of the rivers in Japan (N 0.4 and P 0.26), the discharge rate of the rivers in the study area are assumed to be N is 0.5 and P is 0.3.[12] The loads of the domestic sewage flowing into the study area are 20 ton/month for SS, 23 ton/month for BOD, 6.5 ton/month for N, and 0.5 ton/month for P.

Table 3.4 shows the total monthly loads in study area. It is known from the Table that the figures for December (SS 305 ton/month, BOD 770 ton/month, N 120 ton/month, P 60 ton/month) are highest while those for the three months from March to May were negligibly small. This has to do with the harvesting season of tapioca.

Table 3.4

Monthly Industrial Waste Water Discharge Along the Coast of Study Area

(ton)

Month	Item			
	Suspended Solids	BOD	N	P
January	320	700	110	55
February	190	410	64	35
March	10	20	4	2
April	7	5	2	1
May	3	5	1	0.5
June	210	450	68	34
July	200	430	66	33
August	270	590	90	45
September	250	550	84	42
October	340	750	119	59
November	330	710	112	56
December	350	770	120	60
Total	2,500	5,400	840	420

4. Conclusion

4.1. Seasonal Changes in Water Quality

As has been discussed above, the currents in the Upper Gulf of Thailand have two patterns depending on the season. Thus, the water quality in Pattaya is expected to change correspondingly.

During the period from December to April, the waters of Pattaya area is under the influence of the high saline waters flowing from the Gulf of Thailand. This is caused by the counter clockwise current during the northeast monsoon and also by the smaller discharge from the rivers[1] (Table 4.1) during the dry season.

On the contrary, during the period from June to September of the southwest monsoon season, the Pattaya area is under the strong influence of the fresh waters from northern end of the Upper Gulf of Thailand. This influence is stressed by the clockwise current during the rainy season.

The total pollutant loads, originating from the domestic sewage and the waste water discharged from tapioca plants, are bigger during the period from June to next February and are very small from March to May. The load during the months of August and September is somewhat smaller than that of December when the load is at maximum. Lower salinity is one of the conditions favorable for increase of phytoplanktons and a higher potential for eutrophication become higher during the summer[15], and thus this might generate red tides.

Judging from the above, it is concluded that during the period of August and September when the Japanese Team surveyed, the influence of the rivers discharge and the pollutant loads are quite excessive, and it is also the period when phytoplanktons are most active. Thus, the water quality in this period is considered to be the worst throughout year. On the contrary, the period of December to March is considered to be most favorable as they are under the influence of oceanic water caused by counter clockwise current.

Table 4.1

Average Monthly River Discharge

River	Month											
	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
Macklong	276.0	176.0	148.6	126.8	198.9	768.8	1,517.5	2,625.3	2,305.8	1,843.1	837.3	445.1
Chao Phraya	612.0	541.0	614.0	545.0	721.0	1,157.0	1,598.0	2,774.0	4,512.0	5,245.0	2,667.0	1,166.0
Pasak	39.6	33.5	30.7	26.3	43.2	51.5	98.2	170.8	640.1	901.2	145.9	50.7
Bang Pakong	343.1	317.3	356.7	315.0	308.9	487.1	769.0	1,045.8	1,344.4	1,171.7	568.1	422.0
Total	1,270.7	1,067.8	1,150.0	1,013.1	1,272.0	2,464.4	3,982.7	6,615.9	8,802.2	9,161.2	4,218.3	2,083.8

(Unit : $m^3 \times 10^6$)

4.2. Contamination of Water Quality

Both AIT[5] and Dr. Ludwig[1] have studied respectively, on the water pollution in the Upper Gulf of Thailand and estimated the mean BOD value in the Upper Gulf based on the flushing time, which was calculated from the salinity, good indicator for mixture of the seawater and fresh water
According to their studies, BOD value was about 2 ppm.
The Japanese Team's survey observed about 1 ppm COD value in the sea area off Pattaya Beach including Ko Lan. Correlation between BOD and COD is not clearly known, but it may be said that the contamination of the Upper Gulf is not advancing.

The contamination by the pollutant loads coming from the inland area near Pattaya is considered to come from the domestic sewage such as excrete and the waste waters discharged from tapioca plants. According to the analytical results of the water quality performed by the Japanese Team, COD which is an excellent indicator for organic pollutant, is low while TOC which is also a good indicator for the same purpose is high. SS is also low. These results suggest that colloidal, suspended or dissolved organic matters, which are hard to decompose, originating from tapioca plants, are found present in a considerable amount, and they have dispersed into a wide area extensively because of their small falling velocity. The rivers, through which these pollutants enter the sea are highly polluted. Among them, Na Klua River is in such a state that dissolved oxygen content is 0 ppm and all the pollutants show abnormally high index values. There is an apprehension that this river is becoming "death river" rapidly. However, the phenomenon was observed particularly at the river mouth, and no direct effects were seen on the sea. This is considered to be due to the fact that the river discharge during the survey period was very small so that most of pollutants were carried away by the tides and dispersed very quickly into the sea. Sediments in the Pattaya sea area were in good conditions, because the water undergoes actively the regeneration as the temperature of the water is high and the dissolved oxygen is at high saturation rate.

However they consist of mostly sand, contained silt, clay and colloid. Most of colloids are considered to originate from the suspended material discharged from tapioca plants. Pollutants in the sea bottom sediments were somewhat higher than those in the rivers. Those at the estuaries were lowest and they increased toward offshore. The possible cause for this phenomenon are:

1) Suspended matters discharged from the tapioca plants are very fine and difficult to decompose and difficult to precipitate near the estuaries and the shorelines by the river flows and waves, and then they are carried away into the offshore and they gradually precipitated on the seabottom.

2) Some of the silts are discharged from the big rivers in the Upper Gulf and other artificial pollutants tend to be carried by the clockwise current when the Upper Gulf is subject to the southwest monsoon.

These two reasons are conceivable but not sufficient to elucidate the phenomenon fully.

4.3. Suitability as the Ocean Resort

Recently, there are many problems of the marine environmental pollution in the world, and the oceanic recreational activities cannot escape from the impact of the pollution. In many countries, the criteria for ocean resort have been established for the purpose of preserving the water quality and various measures are being taken for this purpose. Regrettably, there is no standard for the criteria established in Thailand. The present discussion will be based on the standards in other countries and on the suitability of Pattaya as an oceanic resort area.

Pattaya is easily accessible from Bangkok, the climate is tropical and the scenery is beautiful. For its future development as an international beach resort, it is necessary to preserve its marine environment.

Water quality criteria for ocean resort in Hawaii,[10] Rio de Janeiro,[9] Australia,[8] USA[7] and Japan[12)16] are shown in Table 4.2 - 4.6. In most of these countries, the standard for coliform counts is 1,000 MPN/100 ml while at Pattaya Beach many of the past investigations observed values exceeding this value at a number of locations.

Quite often values exceeding 10,000 MPN/100 ml were observed in the waters in front of Pattaya downtown. This area is clearly unsuitable for recreational activities such as bathing, because the water quality and the sediments are clearly to be polluted. It is urgent that some kind of measures are taken to cope with this particular area.

DO in the study area is close to saturation. But Na Klua River, particularly at its estuary, is anaerobic condition and requires some kind of urgent measures, even though the river is not used for recreational purposes presently.

According to Japanese criteria, the sea area where n-Hexane is detected is not suitable for water contact recreation. In the sea water in front of Pattaya Beach, however, 1 ppm of n-Hexane was detected, which is supposedly a result of oil discharge from excursion boats and fishery boats. In immediate future some measures might be necessary for controlling oil discharge in this area.

In respect of other matters, the water in the study area contains rather high amount of nutrient salts. Particularly in the sea area in front of Pattaya Beach, eutrophication is in progress and a careful monitoring will be required for the future.

An overall review of the various subjects discussed above, indicates that the quality in the waters in front of Pattaya Beach and in the vicinity of Ko Lan, which are now being utilized for recreational activities, is somewhat inferior comparing with, the quality of the water in other resorts such as Hawaii, Mediterranean Sea, etc.[13)16] This is partly due to the unprocessed domestic sewage, the waste water discharge from tapioca plants, and partly due to the fact that the Upper Gulf of Thailand is an inland type bay with low salinity. When the seawater characteristics are compared with the oceanic type resorts, the seawater itself may be inherently inferior. However, this is not necessarily a negative factor for recreational activities. There is a need to start countermeasures for preserving the water quality and sediments, because there are some part in front of Pattaya Beach where pollution is advancing. Solid wastes (such as plastics, polyethylene bags, papers) which necessarily accompany the recreational activities would harm the aesthetic beauty of the beach and therefore require measures for cleaning and disposing them.

Table 4.2 Water Quality Standards in Hawaii[10)]

Class	Item / Purpose of utilization	Special Standard				
		Total-Phosphorus (ug. at/ℓ)	Total-Nitrogen (ug.at/ℓ)	Dissolved Oxygen (mg./ℓ)	pH	Coliform (Cell/ 100 mℓ)
AA	Oceanographic research propagation of shell fish and marine life conservation aesthetic enjoyment	0.65	7.1	6.0	8.0 - 8.5	Mediam 70 230 anytime
A	Recreational, including fishing, swimming bathing and other contract sports and aesthetic enjoyment	0.80	10.7	5.0	7.0 - 8.5	Mediam 1,000 10% 2,400 Fecal Coliform 200 for 30 day period 10% 400
B	Small boat harbours commercial shipping and industrial bait fishing aesthetic enjoyment	0.97	14.3	4.5	7.0 - 8.5	Fecal Coliform 400 for 30 day period 10% 1,000

Table 4.3 Water Quality Standard in Rio de Janeiro[9)]

Recreational Zone: Coliform

Extending 300 meters offshore from the beaches.

Coliform less than 1,000 MPN/100 mℓ

No objectional floating material

Table 4.4 Australian Water Quality Criteria[8)]

Recreational Water Quality : Fecal Coliform less than 200/100 mℓ

pH .... 6.5 - 8.3

Table 4.5

U.S. Water Quality Criteria [7)]

Recreational Zone : Temperature .... 26.0 - 35.0

pH .... 6.5 - 8.3

Table 4.6

Japanese Standard of Coastal Water Quality [12)16)]

Category	Item / Purpose of Utilization	Standard Values				
		pH	Chemical Oxygen Demand (COD)	Dissolved Oxygen (DO)	Number of Coliform Groups Bacteria	N-hexane Extracts
A	Fishery, class 1: bathing conservation of natural environment and uses listed in B-C	7.8 - 8.3	2 ppm or less	7.5 ppm or more	1,000MPN/100m/ or less	Not detectable
B	Fishery, class 2: industrial water and uses listed in C	7.8 - 8.3	3 ppm or less	5 ppm or more	-	Not detectable
C	Conservation of environment	7.0 - 8.3	8 ppm or less	2 ppm or more	-	-

* With regard to the quality of fishery, class 1 for planting oysters, the number of coliform groups shall be less than 70 MPN/100 m/.

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Survey on Composition Analysis

of Solid Waste

Appendix 3.3 Survey on Composition Analysis of Solid Waste

Project: Pattaya Tourism Development (Phase II)
Location: Solid Waste was taken from Beach and Road Thrash Can
Carrier: Open Dump Truck #5 (Isuzu), Yellow
Date: July 10, 1978 Dumping Time: 08.00 hrs Collecting Time: 08.15 hrs

COMPOSITION ANALYSIS OF SOLID WASTE

Sample No.	Cat. 1		Cat. 2		Cat. 3		Cat. 4		Cat. 5		Cat. 6		Cat. 7		Cat. 8		Total	
	Kg	%	Kg	%	Kg	%	Kg	%	Kg	%	Kg	%	Kg	%	Kg	%	Kg	%
5/1	5.985	18.8	6.061	19.1	3.632	11.4	2.273	7.2	1.353	4.2	1.819	5.7	0.205	0.6	10.472	33.0	31.710	100
5/2	4.435	16.1	6.116	22.2	3.966	14.4	1.652	6.0	1.515	5.5	1.689	6.1	0.087	0.3	8.099	29.4	27.550	100
5/3	6.917	18.0	10.145	26.4	4.188	10.9	1.574	4.1	2.960	7.7	1.498	3.9	0.192	0.5	10.951	28.5	38.430	100
Average		17.6		22.5		12.2		5.8		5.8		5.2		0.5		30.4		100

Cat 1: Food Waste (Fruits)
Cat 2: Food Wate (Others)
Cat 3: Paper
Cat 4: Yard Waste and Wood
Cat 5: Plastic, Rubber and Leather
Cat 6: Metal and Glass
Cat 7: Textiles
Cat 8: Miscellaneous

MOISTURE CONTENT

Description		Sample No. 5/1	5/2	5/3	Remarks
Weight of Sample in Wet Condition (W_w)	Kg	2.533	1.480	1.695	
Weight of Sample After Air Bathing (W_d)	Kg	1.538	0.795	0.822	
Moisture Content (C) $C = \frac{W_w - W_d}{W_w} \times 100$	%	39.3	62.4	51.5	
Average Moisture Content	%		51.0		

Project: Pattaya Tourism Development (Phase II)

Location: Solid Waste was taken from Na Klua Area

Carrier: Mercedes Benz #2

Date: July 10, 1978 Dumping Time: 10.30 hrs Collecting Time: 10.35 hrs

COMPOSITION ANALYSIS OF SOLID WASTE

Sample No.	Cat. 1		Cat. 2		Cat. 3		Cat. 4		Cat. 5		Cat. 6		Cat. 7		Cat. 8		Total	
	Kg	%	Kg	%	Kg	%	Kg	%	Kg	%	Kg	%	Kg	%	Kg	%	Kg	%
2/1	0.754	5.3	4.603	32.4	3.565	25.1	1.421	10.0	0.966	6.8	0.128	0.9	0.440	3.1	2.329	16.4	14.206	100
2/2	1.240	7.5	4.959	30.0	2.397	14.5	2.744	16.6	1.355	8.2	0.560	3.4	1.140	6.9	2.131	12.9	16.530	100
2/3	0.672	5.4	4.415	35.5	2.667	21.4	1.565	12.5	0.873	7.0	0.130	1.0	0.587	4.7	1.532	12.5	12.441	100
Average		6.1		32.7		20.3		13.0		7.3		1.8		4.9		13.9		100

Cat 1; Food Waste (Fruits)
Cat 2; Food Wate (Others)
Cat 3; Paper
Cat 4; Yard Waste and Wood
Cat 5; Plastic, Rubber and Leather
Cat 6; Metal and Glass
Cat 7; Textiles
Cat 8; Miscellaneous

MOISTURE CONTENT

Description	Sample No. 2/1	Sample No. 2/2	Sample No. 2/3	Remarks
Weight of Sample in Wet Condition (W_w) Kg	1.720	2.044	1.557	
Weight of Sample After Air Bathing (W_d) Kg	0.660	1.030	0.838	
Moisture Content (C) $C = \frac{W_w - W_d}{W_w} \times 100$ %	61.6	49.6	46.2	
Average Moisture Content %		52.5		

Project: Pattaya Toursim Development (Phase II)

Location: Solid Waste was taken from Hotels (Orchid Lodge — Nipa Lodge)

Carrier: Toyota #1

Date: July 10, 1978 Dumping Time: 11.40 hrs Collecting Time 11.45 hrs

COMPOSITION ANALYSIS OF SOLID WASTE

Sample No.	Cat. 1		Cat. 2		Cat. 3		Cat. 4		Cat. 5		Cat. 6		Cat. 7		Cat. 8		Total	
	Kg	%	Kg	%	Kg	%	Kg	%	Kg	%	Kg	%	Kg	%	Kg	%	Kg	%
1/1	15.500	58.4	1.088	4.1	0.265	1.0	2.521	9.5	1.035	3.9	1.566	5.9	0.186	0.7	4.379	16.5	26.542	100
1/2	11.050	51.0	1.310	6.0	0.265	1.2	3.268	15.0	0.387	1.8	1.620	7.5	0.052	0.2	3.710	17.1	21.662	100
1/3	10.467	42.0	1.968	7.9	0.847	3.4	2.592	10.4	1.073	4.3	2.766	11.1	-	0	5.207	20.9	24.920	100
Average		50.5		6.0		1.9		11.6		3.3		8.2		0.3		18.2		100

Cat 1; Food Waste (Fruits)
Cat 2; Food Wate (Others)
Cat 3; Paper
Cat 4; Yard Waste and Wood
Cat 5; Plastic, Rubber and Leather
Cat 6; Metal and Glass
Cat 7; Textiles
Cat 8; Miscellaneous

MOISTURE CONTENT

Description		Sample No. 1/1	1/2	1/3	Remarks
Weight of Sample in Wet Condition (W_w)	Kg	2.663	3.385	2.103	
Weight of Sample After Air Bathing (W_d)	Kg	1.752	1.585	0.842	
Moisture Content (C) $C = \frac{W_w - W_d}{W_w} \times 100$	%	34.2	53.1	60.0	
Average Moisture Content	%		49.1		

Project: Pattaya Tourism Development (Phase II)

Location: Solid Waste was taken from Ko Lan Village

Carrier: Hand Carry, Cart

Date: July 10, 1978 Dumping Time: - Collecting Time: 15.30 hrs

COMPOSITION ANALYSIS OF SOLID WASTE

Sample No.	Cat. 1		Cat. 2		Cat. 3		Cat. 4		Cat. 5		Cat. 6		Cat. 7		Cat. 8		Total	
	Kg	%	Kg	%	Kg	%	Kg	%	Kg	%	Kg	%	Kg	%	Kg	%	Kg	%
K1-4	0.418	2.4	9.822	57.0	1.140	6.6	0.645	3.7	1.152	6.7	0.480	2.8	0.240	1.4	3.333	19.4	17.2	3

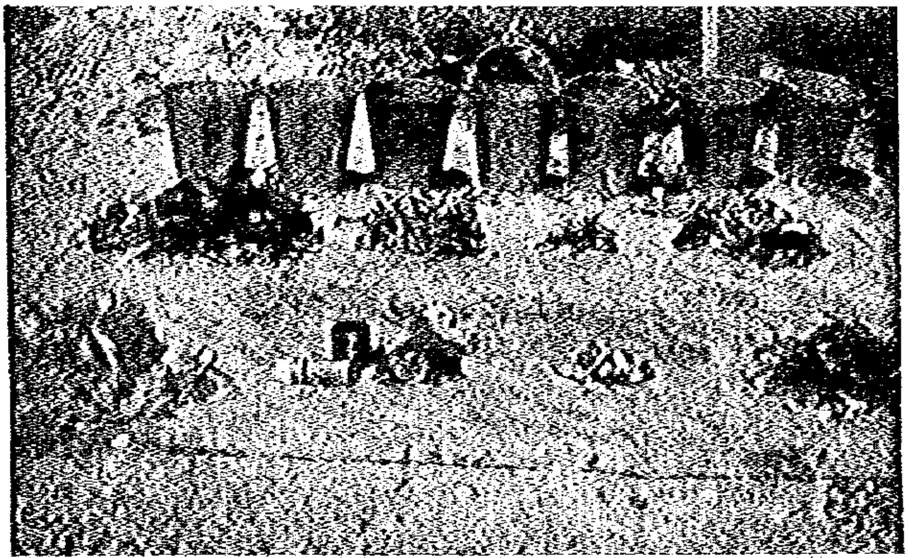
Note: Sample K1-4 was made by mixing sample #K1, #K2. #K3 and #K4 Due to piles of solid waste were separately dumped.

Cat 1; Food Waste (Fruits)
Cat 2; Food Wate (Others)
Cat 3; Paper
Cat 4; Yard Waste and Wood
Cat 5; Plastic, Rubber and Leather
Cat 6; Metal and Glass
Cat 7; Textiles
Cat 8; Miscellaneous

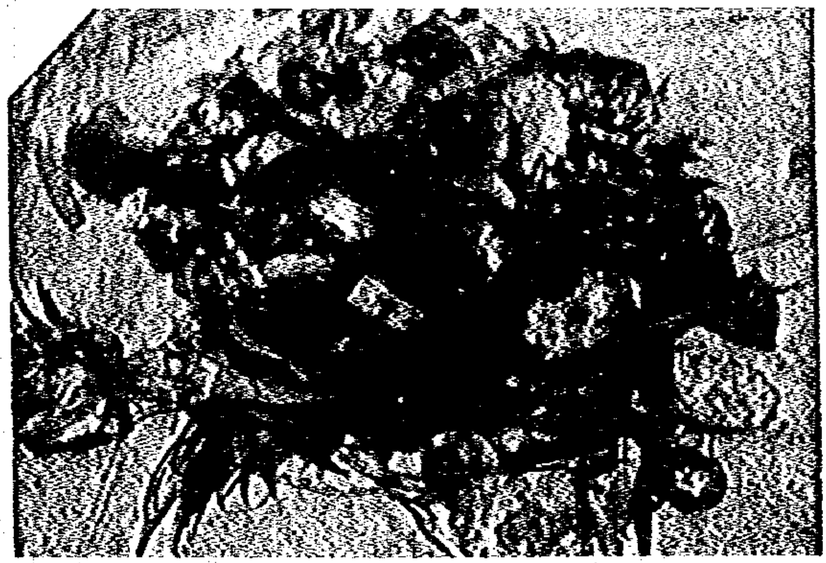
MOISTURE CONTENT

Description		Sample No.			Remarks
		K1-4			
Weight of Sample in Wet Condition (W_w)	kg	2.287			
Weight of Sample After Air Bathing (W_d)	Kg	0.798			
Moisture Content (C) $C = \frac{W_w - W_d}{W_w} \times 100$		65.1			
Average Moisture Content					

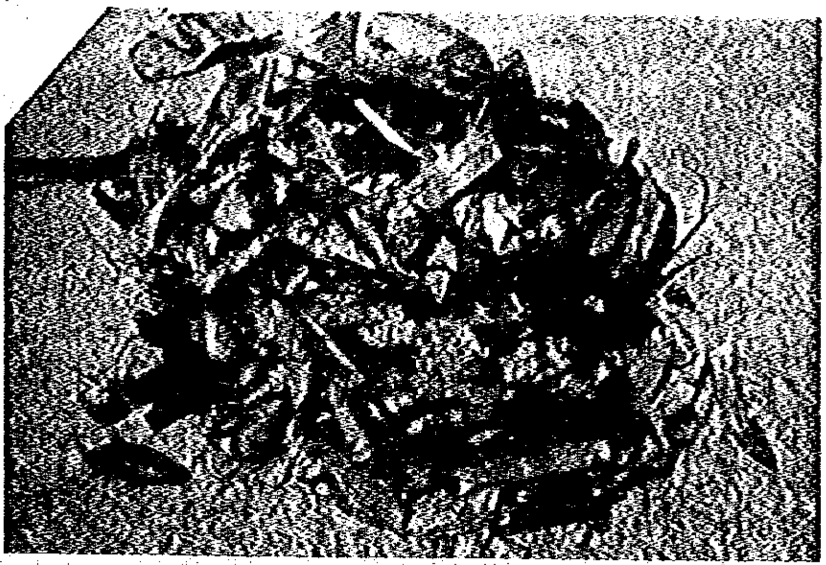
In land



Cat 1



Cat 2



Cat 3