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Long-Shore Transport of Sediment During August and September on the Terengganu Coast

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ABSTRAK

Mengabang Telipot merupakan tanah berpaya yang terletak 10 km ke utara bandar Kuala Terengganu di pantai timur Semenanjung Malaysia. Pertukaran air laut di muara paya ini biasanya tertutup oleh tambakan benteng pasir pantai. Pada 16hb. Ogos, 1984 muara ini telah digali. Akibatnya paya dapat dipengaruhi oleh air pasang surut dan sebuah delta pasir terbentuk. Muara paya ini terbuka sehingga akhir bulan September. Kelajuan purata arus menyusuri pantai ialah 13 cm/saat menghala ke barat laut. Ini mengubahsuaikan delta dan seterusnya menutup muara tersebut. Pemendapan di sebelah tenggara delta membolehkan isipadu pemindahan pasir sepanjang pantai dianggarkan sebanyak 250 meterpadu/hari. Angka ini selaras dengan anggaran-anggaran yang lain.

ABSTRACT

Mengabang Telipot is a slough about 10 km north of Kuala Terengganu on the east coast of Peninsular Malaysia. Its mouth is normally closed to free exchange of sea water by a sand "wash-over" bar. On 16 August, 1984 the mouth was opened artificially, the slough became tidal, and a delta of sand was formed. The mouth remained open until the end of September. The long-shore current averaged 13 cm/sec toward the north-west. This modified the delta, and eventually led to the closing of the slough mouth. Deposition on the south-east side of the delta made it possible to estimate a volume of long-shore sand transport of 250 cu m/day. This is in agreement with other estimates.

INTRODUCTION

Mengabang Telipot (5 deg 25.0' N Lat., 103 deg 05.2' E Long.) is located on the South China Sea coast of Peninsular Malaysia, 10 km north-west of Kuala Terengganu and about 160 km south-east of the Malaysia-Thailand border (*Fig. 1*). The word "mengabang" is used locally to mean a slough near the sea, with no major stream flowing into it and no direct connection to the ocean. Mengabang Telipot is a slough that acts as the sump for a drainage area of about 72 sq km. The drainage into it is poorly organized, and has been further upset by development and road building. During periods of heavy runoff, the water in the mengabang will stand at about 1.8 m above sea level and almost 5 sq km are subject to inundation. This area is crossed by roads, has been developed with housing and has been used for agriculture. During the dry season the water drops to as low as 0.3 m above mean sea level and its quality tends to deteriorate, becoming a nuisance due to odor and health considerations.

The slough is separated from the South China Sea by a low sand ridge which is a storm-

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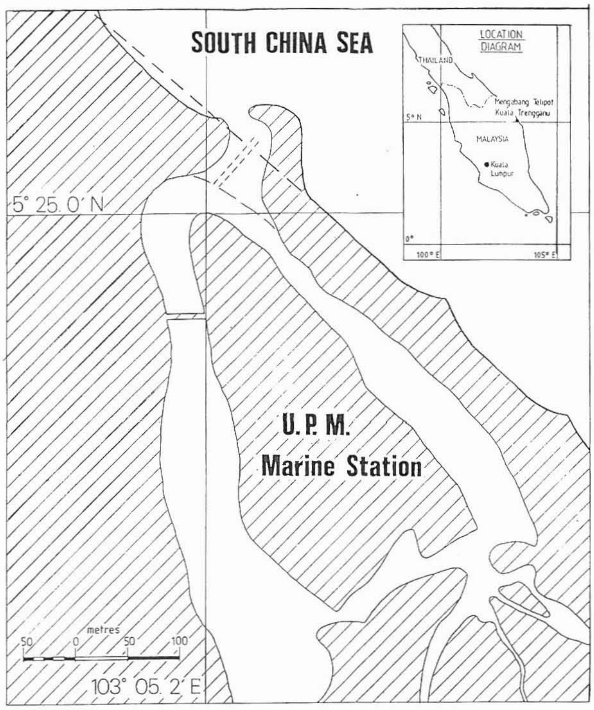

Fig. 1. Sketch map and location diagram of Mengabang Telipot, Terengganu, Malaysia. Dashed line indicates shore at time of opening.

built, or wash-over bar. This distinction is important to the development of the coastal area, since a sand dune implies wind action that builds it above the active level of the sea while a wash-over bar will be inundated by large storm waves. Fresh water draining into the slough fills it to a level as high as 2 m above mean sea level. This level is limited by seepage through the 50 m of sand which separates the slough from the sea.

Most of the water which flows into the mengabang is rain water, though housing development has added a load of domestic waste water. The climate of the Terengganu coast is monsoonal. The year can be divided into four seasons; the south-west monsoons, the north-east monsoons, and the two transition (doldrum) periods in between. No season is without rain, but the three months of the south-west monsoons (May, June and July) have an average of approximately 120 mm/month of rainfall while the rainy season of the north-east monsoons (November, December and January) averages close to 500 mm/month (Drainage and Irrigation Division, 1977). The normal weather pattern from June through September is hot, sunny days with the build-up of convective storms with lightning, thunder and often torrential rainfall in the late afternoon and early evening. Run-off can be heavy, but brief during these afternoon storms, and the level of the slough can change by as much as 0.25 m. If the water level is high in the slough the water seeps out rather quickly, and by the next morning the level is back to the equilibrium level of about 1.8 m above mean sea-level. Even though the water level in the mengabang may be quite constant, the inundated area of the upper slough may be quite variable. The slope of the land surface is so gradual that a change of only a few tens of centimeters in the water level can cause an extensive change in the inundated area.

During the period of observation the swell of the South China Sea was small, with significant wave heights of 0.5 m or less. These waves tend to approach the coast at an angle of 10 to 15 degrees from the south-east, forming a surf zone about 2 m wide. While the details are quite variable (Table 1) the average long-shore current is 14 cm/sec from the south-east toward the north-west. It should be noted that these conditions change drastically during the months of the north-east monsoons. The coast of Terengganu has a mean spring tide range of 1.8 m. This is just at the boundary between the microtidal and mesotidal coasts of Davies (1973). The tide is mixed, with a strong diurnal component beating with a smaller semidiurnal phase. This gives rise to asymmetric tides near the springs when the tide may flood in six to eight hours and ebb over as long as 18 hours. During the neaps, a common pattern is that of a "double bottom" with the lower high water only a few tenths of a meter above the low waters. So, in

TABLE 1
Observation of waves, littoral currents, and winds at the beach of the Marine Station, Mengabang Telipot, Terengganu, Malaysia.

Date 1984	Time (−8)	Wave Hght. met	Wave Period sec	Drift Rate cm/sec	Drift Toward	Wind (Est.)	Wind From	Tide	
0801	1935	0.5	3	29	NW	light	SE	low	slack
0807	1930	0.5	3	13	NW	light	SW	mid	ebb
0810	1830	0.5	2	19	NW	light	SW	mid	ebb
0815	1935	0.2	6	10	NW	calm		low	slack
0816	1930	<.2	3.5	16	NW	light	SW	low	slack
0817	1920	<.5	6	none		light	SE	low	slack
0818	1930	<.5	4	18	NW	light	W	low	slack
0820	1930	0.5	7.5	none		calm		low	slack
0822	1940	0.1	6	3	SE	calm		mid	ebb
0825	1940	<.5	6	9	NW	3 knots	SW	mid	ebb
0826	1930	<.5	7	3	NW	calm		mid	ebb
0903	1930	<.5	6.5	none		calm		low	slack
0908	1930	0.2	2.5	43	NW	5 knots	E	high	slack
0909	1000	<.2	4.5	5	NW	calm		mid	ebb
0924	1930	0.2	3	50	NW	6 knots	S	high	flood
0925	1930	0.1	3	32	NW	4 knots	SE	high	slack

effect, the tide is low and slack for 14 to 18 hours.

THE MENGABANG DELTA

The water level in the mengabang stood about 0.6 m above mean sea level in August 1984. The water quality was poor, with a salinity of 2 ppt, a dissolved oxygen content of 3.5 mg/l and a pH of 3.7. Mullet living in the slough were moribund. With the increase in rainfall during the end of July and early August the water level increased to a stable level of 1.8 m above mean sea level. It soon became obvious that the water would not top the bar that separated the slough from the sea, so that the only way to drain it would be to open it artificially. This was necessary because of the extensive flooding inland, the poor water quality in the slough, and the failure of septic and drainage systems due to the high water table. At about noon, on 16 August 1984 the Drainage and Irrigation Division (D.I.D.) of the Ministry of Agriculture moved a back-hoe onto the bar and cut a channel that allowed the mengabang to drain into the sea. The sand from the cut was piled on the bar text to the cut. The flowing water quickly eroded a channel approximately 35 m wide and 50 m long, graded to the bottom of the mengabang and the low tide range of the day (0.7 m below mean sea level). An estimated 4,000 to 5,000 cu m of sand were eroded, and most of it deposited as a delta at the mouth of the channel.

At about 1600 hours on 16 August a "tape and compass" survey of the delta was conducted *(Fig. 2)*. The sand had been deposited in a symmetrical semicircular delta with a radius of 45 m. The northward setting current was reflected in the slight asymmetry with a spit that was

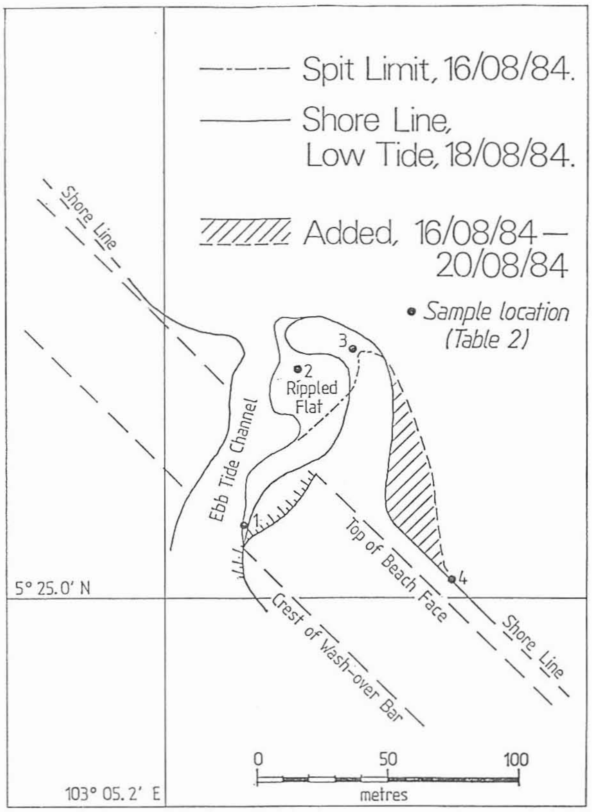

Fig. 2. Changes in the delta at the mouth of Mengabang Telipot from 16 August to 20 August, 1984.

awash on the south flank of the delta, and the main ebb-tide channel turned to the north. The outer edge of the semicircle dropped steeply to a depth of 1.5 m. The undisturbed beach profile has a rather steep beach face to a depth of 1.5 m at a distance of 4 m offshore. The volume of the delta, therefore, can be calculated as a semi-circular slab with a prism out of the shore edge.

$$\begin{aligned}\text{Volume} &= (\text{Pi} \times r \times r \times h)/2 - (2 \times r \times c \times h)/2 \\ &= (3.14 \times 45 \times 45 \times 1.5)/2 - (2 \times 45 \times 4 \times 1.5)/2 \\ &= 4438 \text{ cu m} = \text{approx. } 4500 \text{ cu m}\end{aligned}$$

This calculation indicates that the sand that was eroded from the sand bar was deposited in the delta. This is not an unreasonable conclusion, since the sand of the delta had a mean diameter of about 1.0 0 (0.5 mm; Table 2) and would only be transported by currents in the active surf zone.

The shape of the delta and the above-water bars changed systematically during the next few weeks. The spit increased in height rapidly until it was just barely awash at high tide. It extended its length and became obviously recurved so that

TABLE 2

Sedimentary analysis of sand samples from the temporary delta of Mengabang Telipot, Terengganu

Sample No.	Median ϕ_{50} (note 1)	Sorting σ_i (note 2)
1 (S. edge of ebb flow channel at washover bar)	−0.1	1.0 Moderately to poorly sorted
2 (rippled flat, behind spit)	+0.9	0.6 Moderately well sorted
3 (crest of spit)	+1.3	0.6 Moderately well sorted
4 (S. side of delta at water line)	+1.9	0.6 Moderately well sorted

notes to table 2: (1) ϕ (Phi) is the negative log to the base 2 of the diameter in mm. ϕ of 0 = 1 mm; ϕ of +1 = 0.5 mm

(2) σ_i (Sigma sub I) is the Inclusive Graphic Standard Deviation of Folk (1966):

$$\sigma_i = \frac{(\phi_{84} - \phi_{16})}{4} + \frac{(\phi_{95} - \phi_5)}{6.5}$$

it was restricting the mouth of the mengabang two days after it formed. The inflow of fresh water and the tidal prism were great enough to give current velocities as high as 100 cm/sec at the mouth, which kept a channel open to a depth of 0.6 m. There was a broad channel mouth bar formed where the water flow was slowed by the sea. The geomorphic landforms that developed in the delta and adjoining bay were a miniature version of the typical forms found in estuaries along a mesotidal coast (Boothroyd, 1978). It made an ideal teaching laboratory.

When the estuary was first opened, the salinity measurements revealed a stratified situation, with the sea water flowing in along the bottom and warmer fresh water flowing out over it with little mixing. Later, the water flow within the estuary was strongly affected by the tide. During a rising or high tide the salt water flowed well into the mengabang, and could be detected up to 1 km from the mouth. The water would be typically mixed, with little change in salinity from the surface to the bottom. With the falling tide, the inflow of fresh water would displace the salt water and flow out over the top of it, so that a typical salt wedge estuary would develop. There was no evidence for the formation of an inner-estuarine bar upstream from the mouth.

With time a spit formed across the mouth of the estuary, sand accumulated on the south side of the delta, and was eroded from the beach north of it. As a result, the channel draining the estuary became more and more nearly parallel to the coast *(Fig. 3)*, and the original sharp semicircular shape of the delta was modified to blend with the beach. By mid September the spit had grown so that it extended 150 m north-west of the original opening and effectively forced the flow to follow a longer path with a less steep gradient from the mengabang to the sea. Finally, on the spring tides of September 28 and 29 the sand carried over the spit filled the channel. The flow of fresh water into the mengabang was unable to keep the channel open. It closed, and within two weeks the spit migrated inland to merge with the original wash-over bar.

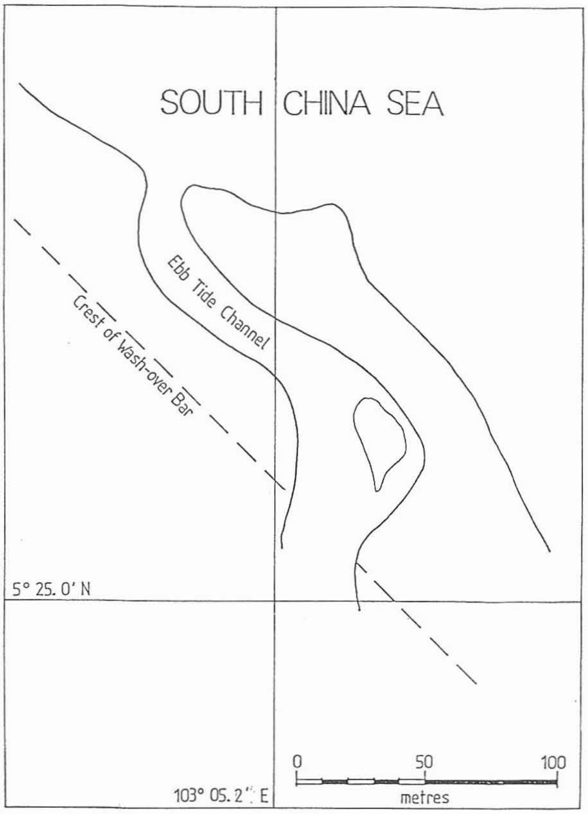

Fig. 3. The delta at the mouth of Mengabang Telipot on 3 Sept. 1984.

The evidence that the mouth had been open was almost destroyed.

MEASUREMENT OF LONG-SHORE TRANSPORT

The long straight coastline of the State of Terengganu clearly indicates that long-shore transport is an important mechanism here. Studies (Raj, 1982, Shiozawa, undated) have pointed to the magnitude of this phenomenon and its importance to engineering projects. The changes in the shape of the delta seem to offer a way of measuring this long-shore transport of sand during August and September.

For the first few days after the formation of the delta, the basic shape remained the same *(Fig. 2)*. The major changes were the filling of the area south-east of the spit, and the erosion of the beach to the north. It would appear that the delta formed a barrier to the transport of sand along the beach and caused its deposition at the south side. The resulting loss of sand in the long-shore system caused erosion north of the delta, in a pattern that is very familiar to coastal engineers. The delta seemed to be an efficient sediment trap. During the first four days, changes to the outer edge of the north side of the delta were minor. After 20 August, the sand apparently had filled the trap of the south side of the delta, and began bypassing it. The spit prograded rapidly parallel to the beach.

If it is assumed that the delta did form an efficient barrier, an estimate of the amount of sand added to it during the first four days will give an estimate of the long-shore transport in the surf zone. The added sand formed a triangular deposit *(Fig. 2)* which reached the tip of the delta, 45 m from the shore line and extended for 35 m along the coast. The slope of the seaward side of the delta and the seaward edge of the deposit were similar so the volume deposited can be calculated by assuming a triangular slab with a prism out at the beach side.

$$\begin{aligned}\text{Volume} &= (b \times r \times h)/2 - (b \times c \times h)/2 \\ &= (35 \times 45 \times 1.5)/2 - (35 \times 4 \times 1.5)/2 \\ &= 1181 - 105 = 1076 \text{ cu m} \\ &= \text{approx. } 1000 \text{ cu m}\end{aligned}$$

or approximately 250 cu m/day.

This estimate is close to that from other studies. Shiozawa (undated, 1983?), from a model study of Cendering Fishing Port, 21 km to the south, estimated the total long-shore drift at Cendering to be "500 to 700 thousand cubic metre/year, out of which about ... 11% is from the south" (pg. 23). If the northward drift is restricted to the 250 days between north-east monsoonal seasons then this averages to about 250 cu m/day.

It is difficult to correlate the drift rates given by Raj (1982) to volumetric measurements. Based on a study of changes in coastal features detected on aerial photographs, he estimated the drift at Batu Rakit (just north of Mengabang Telipot) as an "average annual rate < 5 m/y" directed to the northwest, and at Marang (south of Cendering) as 45 m/y toward the south. This ratio, $< 5/45$, is similar to that determined by Shiozawa and consistent with the figures derived here. An annual volume of 1000 cu m/y has been used in the design of the harbour at Tanjong Berhala near the southern border of Terengganu State (Danish Hydraulic Institute, Sept. 1982).

This drift is much lower than the transport that takes place during the north-east monsoons which may be higher by an order of magnitude and is one of the major factors that must be taken into account whenever work is suggested along the east coast of Peninsular Malaysia. On the other hand, 250 cu m/day is a significant amount of sediment. In this case, it closed the mouth of the Mengabang in six weeks, and defeated the drainage scheme. I am sure that it has affected other projects along the coast. It is hoped that engineers and others whose responsibility lies with structures on or modifications to the coastline will keep this high volume of drift in mind.

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