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Past and present-day coastal changes between Kuala Sungai Besar and Kuala Besar, Kelantan Darul Naim

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Abstract: The Kelantan Darul Naim coast between Kuala Besar (the present outlet of the main distributary channel of Sungai Kelantan) and Kuala Sungai Besar (an abandoned outlet of Sungai Kelantan and now the mouth of Sungai Pengkalan Datu) trends northwest-southeast over some 14 km and comprises stretches of sandy beach, interrupted by small river mouths at Kuala Pak Amat and Kuala Semut Api. The stretch of beach between Kuala Sungai Besar and Kuala Pak Amat is known as Pantai Sabak, whilst that between Kuala Pak Amat and Kuala Semut Api is known as Pantai Cahaya Bulan and that between Kuala Semut Api and Kuala Besar, Pantai Mek Mas. Aerial photographs flown in 1948, 1949, 1957, 1966 and 1974 show that in the past, there has been an overall recession of the coast between Kuala Sungai Besar and Kuala Besar; this recession due to a northwest directed littoral drift that results from the oblique approach of wave-fronts from the South China Sea throughout the year, especially during the Northeast Monsoon. Breakwaters constructed on both sides of Kuala Sungai Besar between 1986 and 1987 have accentuated the effects of the littoral drift resulting in present-day accretion of sediments up-drift of the southern breakwater, but erosion and shoreline recession down-drift of the northern one. Continued erosion, especially during the Northeast Monsoon, now threatens several fishing villages and recreational facilities located along Pantai Sabak and Pantai Cahaya Bulan. Northwestward transport of the eroded sediments is resulting in present-day shoreline advance at Pantai Mek Mas and the extension of sand spits and bars in the vicinity of Kuala Besar. It is concluded that the prevailing littoral drift along any coastline has to be taken into consideration prior to the construction of breakwaters and other such engineering structures.

INTRODUCTION

Beaches are features found along the margins of bodies of water, such as the sea or a lake and can be defined as being "the body of cohesionless sediment along a coast that is subject to the effects of breaking waves". The cohesionless sediment usually means sand-sized particles, though coarser grained particles can also be included. Along sandy coasts, the landward limit of a beach is placed at the upper limit of the action of water from breaking waves or the contact between the cohesionless sediment and other material, whichever is closer to the water. The boundary on the water side is the outermost line of breakers, as determined at low tide if the body of water is subject to tidal fluctuations (Friedman and Sanders, 1978).

Several processes are operative along sandy beaches; the most important being the transport of sediments by littoral drift (on the beach) and by longshore current (in the surf zone). This along-shore transport of sediments results from the oblique approach of wave-fronts on coasts, both from swell and storm waves. Along coasts where there is seasonal or other temporal variations in the approach of wave-fronts, there can result variations in the directions of littoral drift, though there will be generally one dominant direction.

Breakwaters, piers, jetties and other engineering structures constructed at coasts where there is an oblique approach of wave-fronts have a direct impact on the along-shore transport of sediments by littoral drift and longshore current; there occurring accretion of sediments up-drift of the structures, but erosion down-drift of them. In this paper, the impacts of the construction of breakwaters at Kuala Sungai Besar in Kelantan Darul Naim are discussed in terms of the past and present-day changes that have occurred, and continue to occur, along the coast between Kuala Sungai Besar and Kuala Besar.

STUDY AREA - GEOMORPHOLOGICAL SETTING

The Kelantan Darul Naim coast between Kuala Sungai Besar and Kuala Besar, trends southeast-northwest and consists of stretches of sandy beach, some 10 to 200 m wide, whose continuity is interrupted by small river mouths at Kuala Pak Amat and Kuala Semut Api (Figure 1). The stretch of beach between Kuala Sungai Besar and Kuala Pak Amat is known as Pantai Sabak, whilst that between Kuala Pak Amat and Kuala Semut Api is known as Pantai Cahaya Bulan (formerly Pantai Cinta Berahi) and that between Kuala Semut Api and Kuala Besar is known as Pantai Mek Mas. Kuala Besar is the present-day mouth of the main distributary channel of Sungai Kelantan, whilst Kuala Sungai Besar, located some 14 km to the southeast, is the outlet of an abandoned distributary channel and now forms the mouth of Sungai Pengkalan Datu.

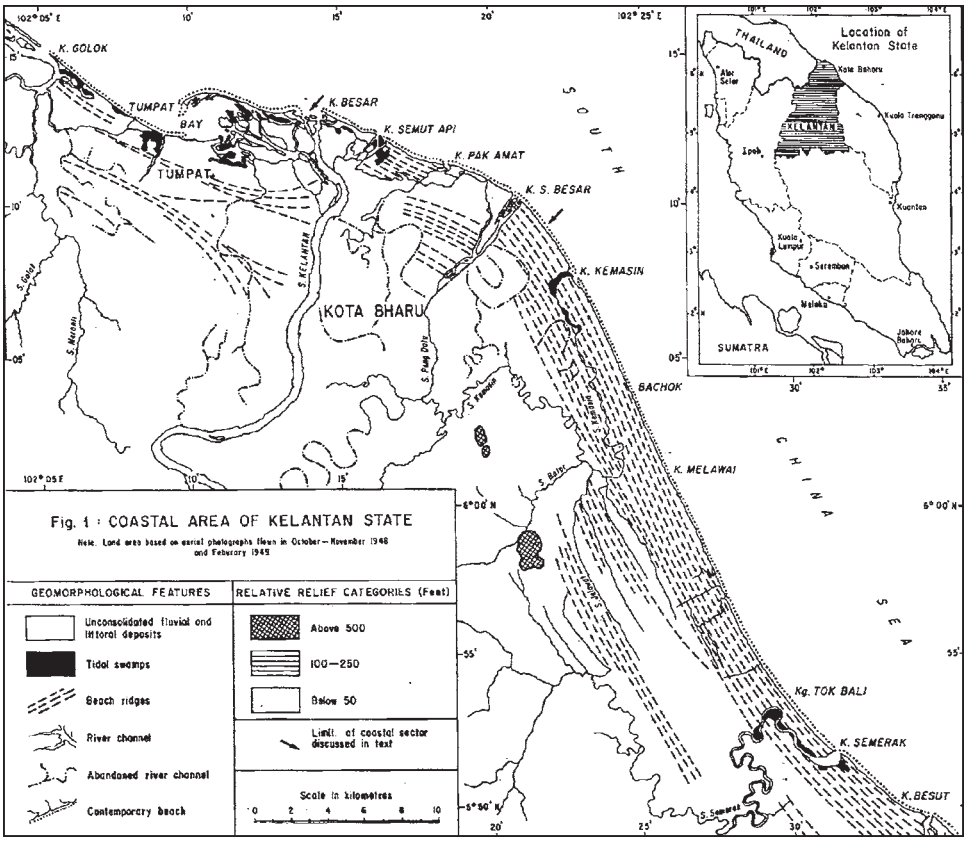

Figure 1: Location Map

There is a total absence of rocky headlands, near-shore and off-shore islands all along the Kelantan Daul Naim coast which is thus directly exposed to the South China Sea. The near-shore sea bottom gradient is a gentle one with the 10 fathom line lying some 5 to 15 km off-shore. Inland is found a broad, undulating to flat plain, underlain largely by alluvial deposits and locally covered by a series of beach ridges whose development is related to higher Holocene sea-levels (Figure 1).

STUDY AREA - ENVIRONMENTAL SETTING

The study area has a climatic regime that is primarily influenced by the Northeast Monsoon, blowing from November to March, and to a lesser extent by the Southwest Monsoon blowing from June to September. During the Northeast Monsoon, west to southwestward strong surface winds are present with heavy rainfall, whilst during the Southwest Monsoon, weak, east to northeastward surface winds are present with little rainfall. The inter-monsoon periods are also characterized by weak and variable surface winds and low rainfall.

Marine influences on the study area are directly related to the Monsoons, with maximum sea and swell conditions during the Northeast Monsoon. Between December and March, the sea state is predominantly moderate with occasional rough seas, whilst between April and May, there is a marked improvement with smooth to slight seas prevailing. As the Northeast Monsoon develops, a low to moderate northeasterly swell runs throughout the area, increasing in height as the Monsoon becomes established to reach a maximum frequency of moderate to heavy seas in December and January. From February, swell moderates progressively with increasing periods of no swell and during April and May, the swell is low and from variable directions (Dale, 1956).

With the onset of the Southwest Monsoon, the swell is consistent with the wind and from June to September, is predominantly from the southwest quadrant. April to September are the months of least swell, with a mean frequency of 90% of low or no swell state. In October, conditions deteriorate with a moderate westerly swell, but this is short-lived and by November, there is slowly increasing swell from the northeast (Ritchie, 1958).

Surface drift currents in the South China Sea, close to the study area, are also related to the Monsoons, with a southeast setting drift from November to May, but a generally northwest setting drift from June to October, except in July, when a northeast setting drift is present (Dale, 1956). Tides at Geting (Tumpat), some 26 km west of Kuala Sungai Besar, are mixed with the diurnal component dominant. The ratio between diurnal and semi-diurnal tides is 1.5:1; diurnal irregularity is high and often there is one high and one low water in a day. The maximum tidal range is 1.2 m and the mean spring tidal range of 0.6

m is the lowest recorded in Malaysia. Analysis of tidal records from 1987 to 1992 show that the mean sea level is strongly influenced by the Northeast and Southwest Monsoons, achieving its maximum height in November/ December and dropping to its lowest level in June/July; the mean difference in sea levels being about 52 cm (Teh and Shamsul Bahrain, 1995).

PAST COASTAL CHANGES

Aerial photographs of approximately 1:25,000 scale have been flown over the study area between 1948-49, 1966 and 1974-75, and of approximately 1:60,000 scale in 1957. Topographic maps of different scales and dates of compilation also cover the study area. As these photographs and maps show the distribution of land and sea areas at different times, they were used by Raj (1985, 1986) to identify the changes that have occurred between 1948 and 1975 along the Kelantan Darul Naim coast.

Figures 2 and 3 show the shoreline changes that have occurred between Kuala Sungai Besar and Kuala Besar from 1948 through 1949, 1957, 1963 and 1966, to 1974. It is to be noted that the limits of the land areas of the different years were interpreted from aerial photographs flown in October 1948, February 1949, August 1957, July 1966 and June 1974, except for that of 1963 which is based on a 1:63,360 topographic map published in 1967 (but with field revisions dating back to 1963).

From Figures 2 and 3, it can be seen that there has been an overall recession of the shoreline between 1948 and 1974, with sites of erosion predominating, though there have also been sites of accretion. These changes are dependent upon time of year for Hill (1966) has shown that in northeast Johore, there is a tendency for erosion of beach sediments during the Northeast Monsoon, but a tendency for deposition during the remainder of the year. In the case of the Sungai Kelantan delta furthermore, Koopmans (1972) has noted that the high velocity, onshore blowing winds during the Northeast Monsoon result in plunging breakers that lead to erosion of the upper beach and deposition at off-shore bars. During the remainder of the year, however, the lower velocity and frequently off-shore blowing winds result in constructive breakers that lead to the deposition of sediments (from the off-shore bars) against the upper beach.

Superimposed upon the simple pattern of erosion during the Northeast Monsoon and deposition during the remainder of the year is the lateral transport of beach sediments by littoral drift (Zakaria, 1975; Raj, 1985). This littoral drift, however, is only important along coastal sectors that trend obliquely to the generally northwest-southeast to north-south trending wavefronts of sea waves and swell approaching from the South China Sea (Ritchie, 1968). This influence is clearly seen in the study area where the northwestward extension of sand spits and bars over the years clearly indicates the presence of a northwest directed littoral drift. In view of this northwest directed littoral drift, Raj (1985) predicted that there would be continued erosion of the coast between Kuala Sungai Besar and Kuala Besar with recession of the shoreline (Figure 3).

Koopmans (1972) has also noted that there is large variability in the discharge of Sungai Pengkalan Datu, with maximum values during the Northeast Monsoon, when there is sometimes overflow from the Sungai Kelantan. Variations in the discharge of Sungai Pengkalan Datu will have a direct impact on the northwest directed littoral drift in the study area, as large discharges will prevent the development of sand spits and bars at Kuala Sungai Besar. The variations in discharge will also influence their bed loads and thus directly affect the supply of sediments to the beaches between Kuala Sungai Besar and Kuala Besar. Figures 2 and 3 show that there have variable impacts on littoral drift by variations in the discharge of Sungai Pengkalan Datu. During a single season of the Northeast Monsoon for instance, between 4th October 1948 and 23rd February 1949 (Figure 2), there was no impact of the discharge as there was an extension of the sand spit at Kuala Sungai Besar. During other times, however, as on 27th July 1966 (Figure 3), ther appears to have been little discharge from Sungai Pengkalan Datu; the river mouth blocked by a broad sand spit resulting from the northwestward littoral drift.

PRESENT-DAY COASTAL CHANGES

As a part of the Kemasin-Semerak Project to alleviate flooding of low-lying areas, breakwaters were constructed between mid-1986 and 1987 on the south, and north, sides of Kuala Sungai Besar. The southern breakwater extended some 300 m with a northeast trend, whilst the northern breakwater was some 150 m long and extended in an easterly direction. Inland of the northern breakwater was to be located a fishing harbour protected by an 80 m strip of land. Design considerations were a breakwater life of 30 years, deepwater waves with a recurrence period of 30 years and a wave period of 9 seconds; extreme conditions for the Northeast Monsoon being used (Teh and Shamsul Bahrain, 1995). Sands to the beach, immediately northwest of Kuala Sungai Besar, i.e. Pantai Sabak, were considered to be supplied by Sungai Pengkalan Datu.

In the design stage, it was envisaged that erosion would be initiated behind the northern breakwater (along Pantai Sabak) and that the coast here would experience shoreline recession. These changes have been discussed in detail by several workers (especially Teh and Shamsul Bahrain, 1994; 1995) who noted that following construction of the breakwaters, there resulted the classical pattern of accretion up-coast, and erosion down-coast, of the introduced structures, which acted as a barrier to littoral drift. Erosion started in 1988 during the first Northeast Monsoon after completion of the breakwaters. Beach nourishment was carried out to protect the boat harbour, but this was unsuccessful and the harbour breached in

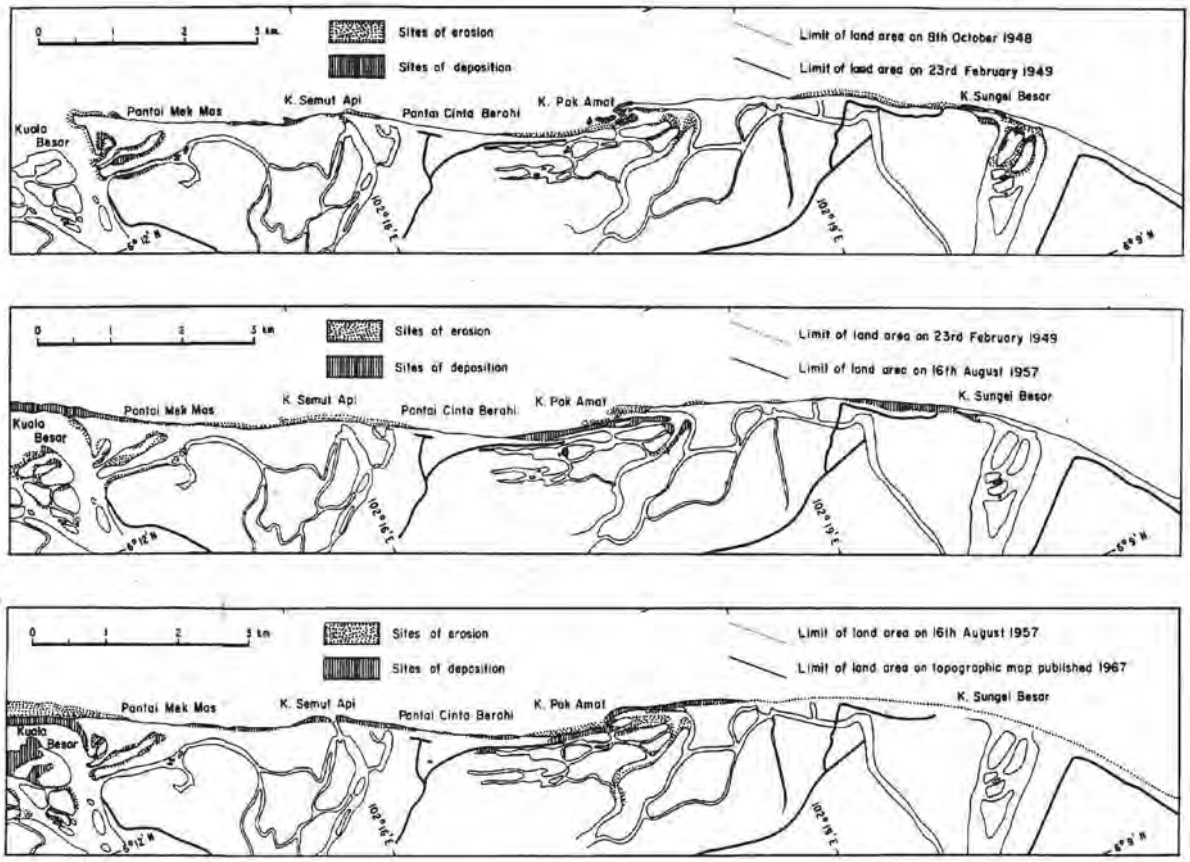

Figure 2: Coastal changes between 1948, 1949, 1957 and 1963 (Raj, 1985).

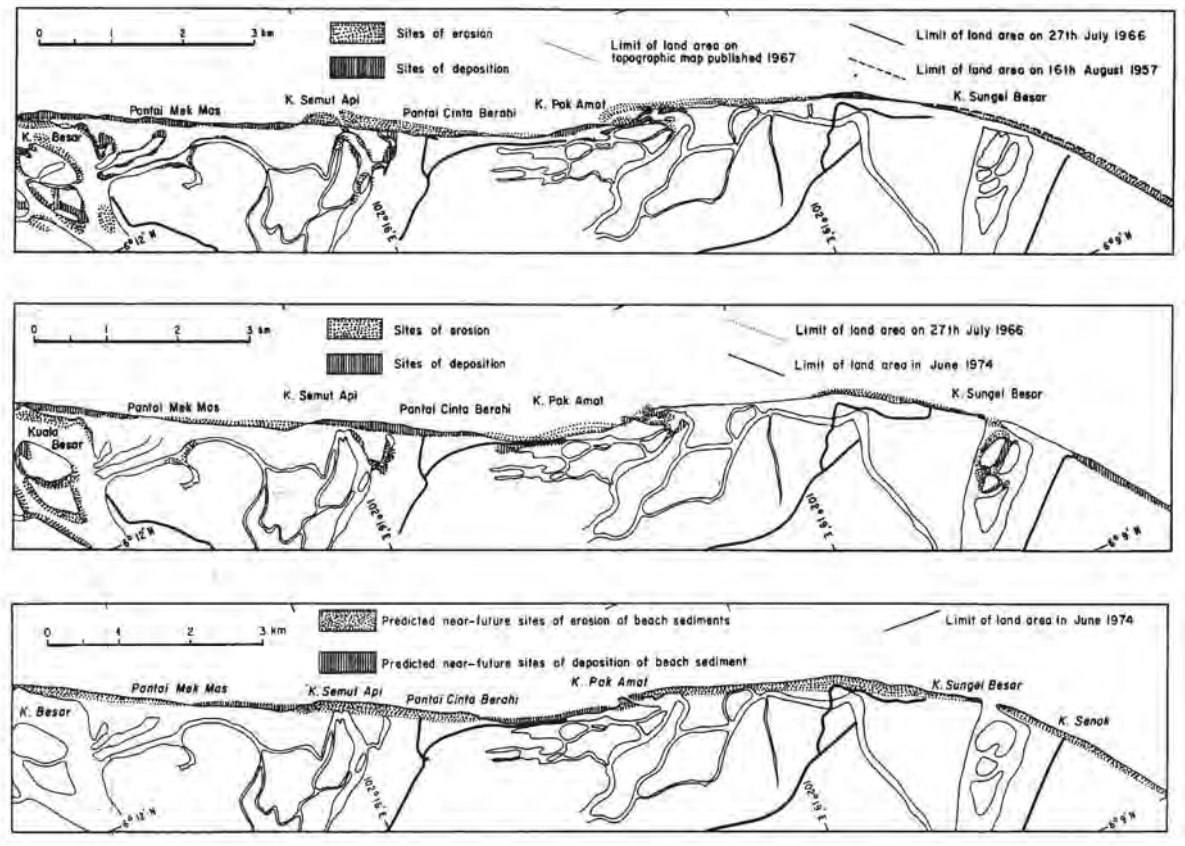

Figure 3: Coastal changes between 1957, 1963, 1966, 1974 and predicted near future coastal changes (Raj, 1985).

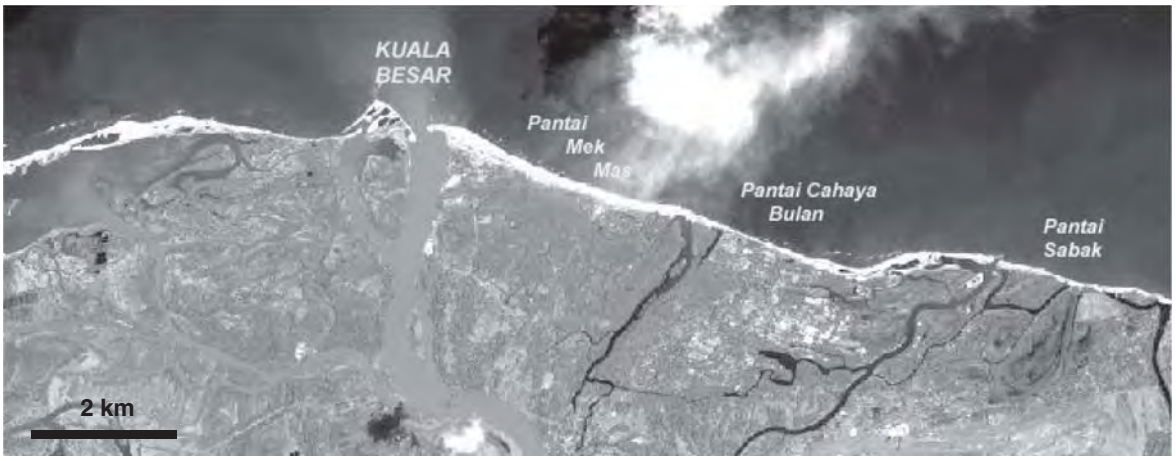

Figure 4: Pantai Sabak to Kuala Besar - 4th August 2003. IKONOS satelllite image (CRISP, 2006).

Figure 5: Pantai Cahaya Bulan and Kuala Besar, 12 July 2005. IKONOS satellite image (CRISP, 2006).

March 1989. Subsequent work, including redesign of the northern breakwater and revetment down coast of it as well as beach nourishment was carried out to reduce erosion in the early 1990's (Teh and Shamsul Bahrain, 1995).

There is little doubt that construction of the breakwaters led to erosion down-coast of them at Pantai Sabak, though it is to be noted that there was already present the along-shore transport of beach sediments by the northwest directed littoral drift. This down-coast erosion also resulted from the decreased volume of beach sediments supplied to Pantai Sabak for much of this was trapped up-coast, i.e. behind the southern breakwater at Kuala Sungai Besar. In hindsight, it also appears that the supply of sands to Pantai Sabak by Sungai Pengkalan Datu was not of any signifance to prevent erosion and shoreline recession.

In the present-day, the accentuated northwest directed littoral drift (northwest of Kuala Sungai Besar) continues to cause shoreline recession at Pantai Sabak, with northwestward transport of the eroded beach sediments (Figure 4). The accentuated northwest directed littoral drift has also now influenced the beach at Pantai Cahaya Bulan; there being shoreline recession with the eroded sediments transported northwestward and resulting in shoreline advance at Pantai Mek Mas and extension of sand spits and off-shore bars in the vicinity of Kuala Besar (Figure 4). This continued erosion now threatens several fishing villages and recreational facilities, including shops, located along Pantai Sabak and Pantai Cahaya Bulan.

CONCLUSION

In summary, it can be said that the coast between Kuala Sungai Besar and Kuala Besar in Kelantan Darul Naim has experienced, and will continue to experience, a northwest directed littoral drift; this drift resulting from the oblique approach of wave-fronts from the South China

Sea throughout the year, especially during the Northeast Monsoon. Breakwaters constructed on both sides of Kuala Sungai Besar between 1986 and 1987 have accentuated the effects of this littoral drift, with accretion of sediments up-drift of the southern breakwater, but erosion and shoreline recession down-drift of the northern one.

In the present-day, the accentuated northwest directed littoral drift (northwest of Kuala Sungai Besar) continues to cause shoreline recession at Pantai Sabak and Pantai Cahaya Bulan. Northwestward transport of the eroded beach sediments furthermore, results in shoreline advance at Pantai Mek Mas and the northwestward extension of sand spits and off-shore bars at, and in the vicinity of, Kuala Besar. In conclusion, it is noted that the construction of breakwaters and other coastal engineering structures always need to take into consideration their impact on prevailing natural processes.

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