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**ORIGINAL ARTICLE**

**Satellite Images and Grains Size Analysis for Shoreline Change: A Case Study at Southern Kelantan and Northern Terengganu, Malaysia.**

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**Abstract**

Pasir Puteh and Besut are two separate districts that lie between the southern border of Kelantan and northern Terengganu. The Kemasin-Semerak Project completed in 1996 to mitigate flooding by relocating the river of Sungai Semerak 3 kilometers northward. This project was deemed to be successful. However, the coastal dynamic of this coastline was affected. This study will include the impact on the coastal environment of this project through sedimentological analysis and remote sensing. The satellite images recorded at different time (2006 to 2012) of this area were used to outline the change shoreline. The coastal processes are further investigated with grains size analysis.

**Introduction**

Malaysia is well surrounded by seas. Straits of Malacca and South China Sea engulfed Peninsula Malaysia while Celebes and Sulu Sea dominate of the east side of Sabah, Borneo. Being in such geographic setting explains that each of the coastlines in Malaysia has different coastal dynamic system. The understanding of the processes (eg: wave, tide, erosion, deposition, currents, etc) involved is prominent for a good urban planning (Davis & Fitzferald, 2004). Shifting of coastline has been a major problem since the past few decades. The roads built by the coast were buried by the landward climbing shoreline while shipyards were getting shallower.

The study area of this paper is located at the coastline along the border of two Malaysia states, Kelantan and Terengganu (Figure 1). Cities located in the study area include Tok Bali, Kelantan and Jerteh and Besut of Terengganu. Several studies on the geology had been done by Dowson, 1951, Paton, 1952, Slater, 1957 and Santokh Singh, 1960 respectively.

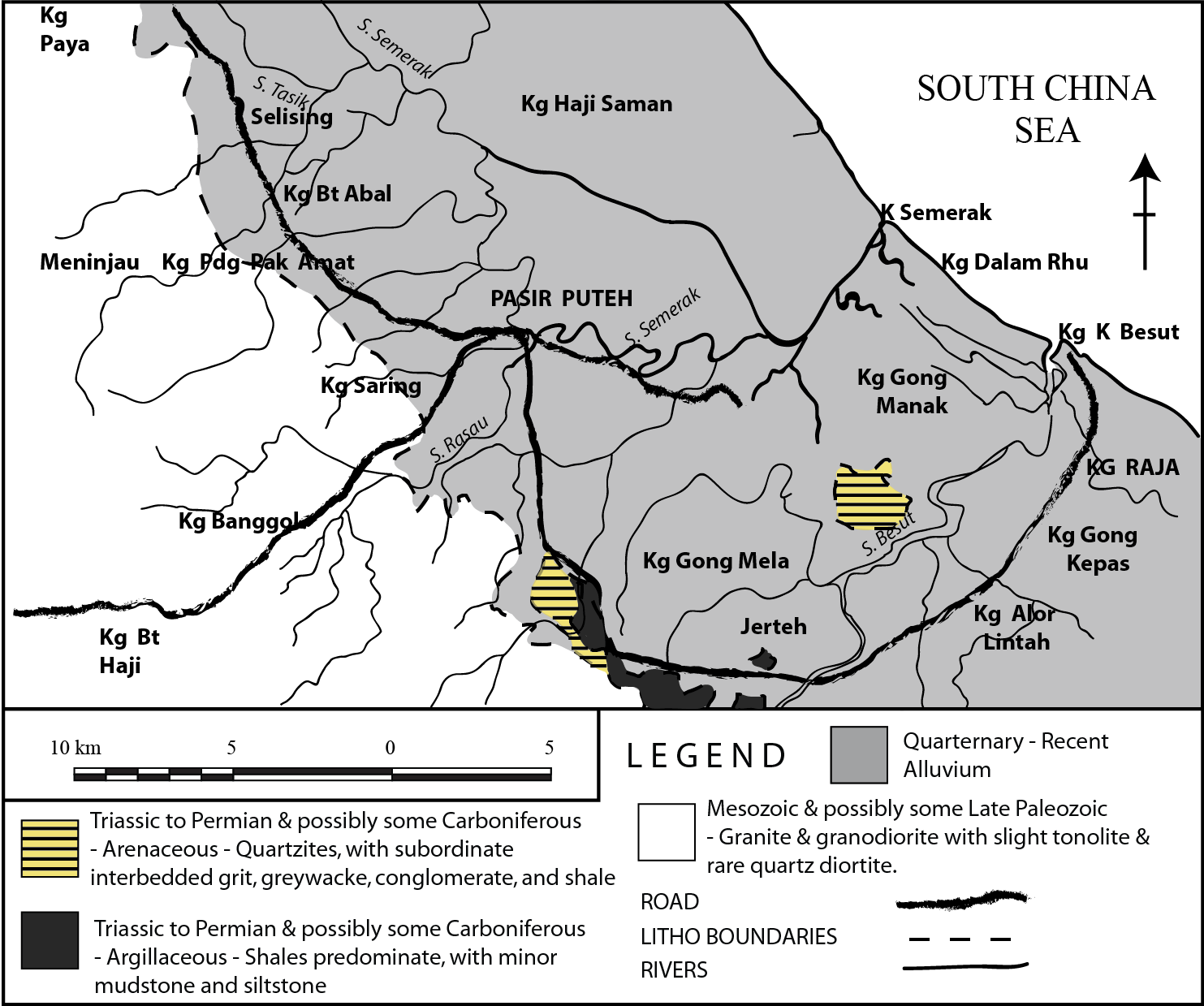
The lithology present at the study area is predominantly the quaternary to recent alluvium (Figure 2). The Triassic to Permian argillaceous and arenaceous rocks occur further inland, northeast and southwest of Jerteh, Terengganu MacDONALD, 1967). The rare occasion of these rocks which overlay the Mesozoic granite were eroded. The provenance of the recent alluvium could have derived from these older rocks.

**Problem Statement**

The coastline along the border of Kelantan and Terengganu has been constantly shifting. Coastal area such as the Kuala Semerak river mouth and Kuala Besut fishing port were no exception to such occasion.

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**Figure 1:** Map of Peninsula Malaysia showing the location of this research area (shaded boxes), state bourder between Kelantan and Terengganu. The research area covers the east coast coastline from Semerak River (Sungai Semerak), Tok Balik, Kelantan to Bukit Keluang, Kuala Besut, Terengganu (modified from Memoir of the Geological Survey West Malaysia, 1967).



**Figure 2:** Lithology map of the research area located at the margin of two east coast states, Kelantan and Terengganu. The research area is mainly covered by Pliocene to recent deposits (grey). Shallow environment deposits are common inland along the rivers (modified from the Geological Survey of Malaysia, 1968).

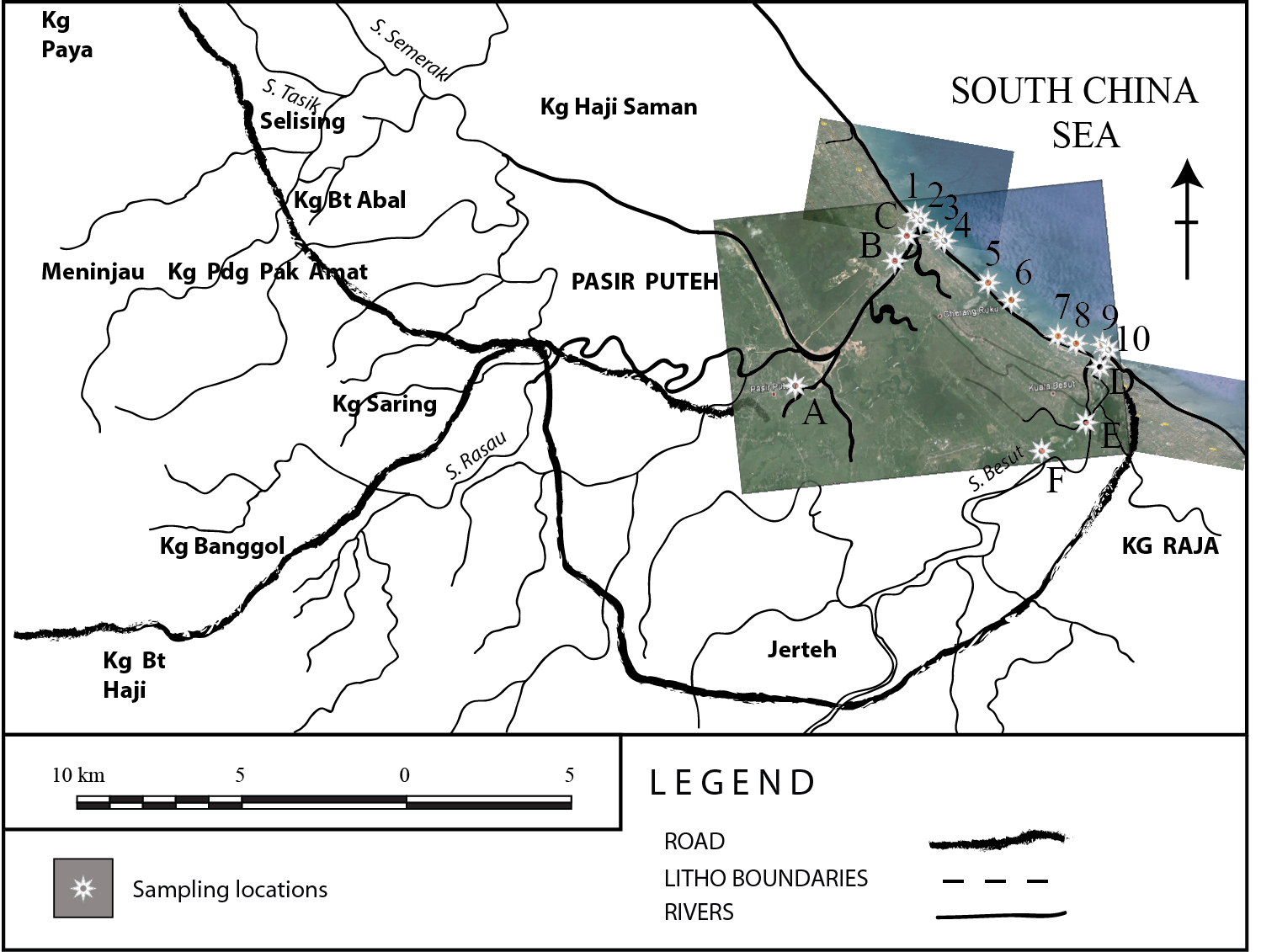
The accomplished Kemasin-Semerak Project in 1996 were listed as a major cause where in this project, the natural course of Semarak River, Tok Bali was changed along with the relocation of the river mouth. A new jetty was then built as a counter-measurement for coastal erosion. The propagating waves at Kuala Semerak have reduced in energy and the erosion ceased. However, such major development on the Kuala Semerak coastline has disrupted the natural occurring system of the adjacent areas (Marghany & Mansor, 2001; Daud, 2005). Thus, this paper will further discuss the coastal processes of Kuala Semerak and its adjacent areas.

**Aims**

In order to fully grasp onto the coastal processes of this area, this research would need:-

1) to analyze the sedimentology and architecture of the area, and,

2) to construct a shoreline change model with satellite data.



**Figure 3:** Sampling were done at the designated locations along Pantai Kuala Besut. The locations covers the whole coast stretching across the state border from Jetti Sungai Besut, Terengganu to Sungai Semerak at Tok Bali, Kelantan. Conglomerate are found in the vicinity area of Pantai Kuala Besut Bukit Keluang.

**Methodology**

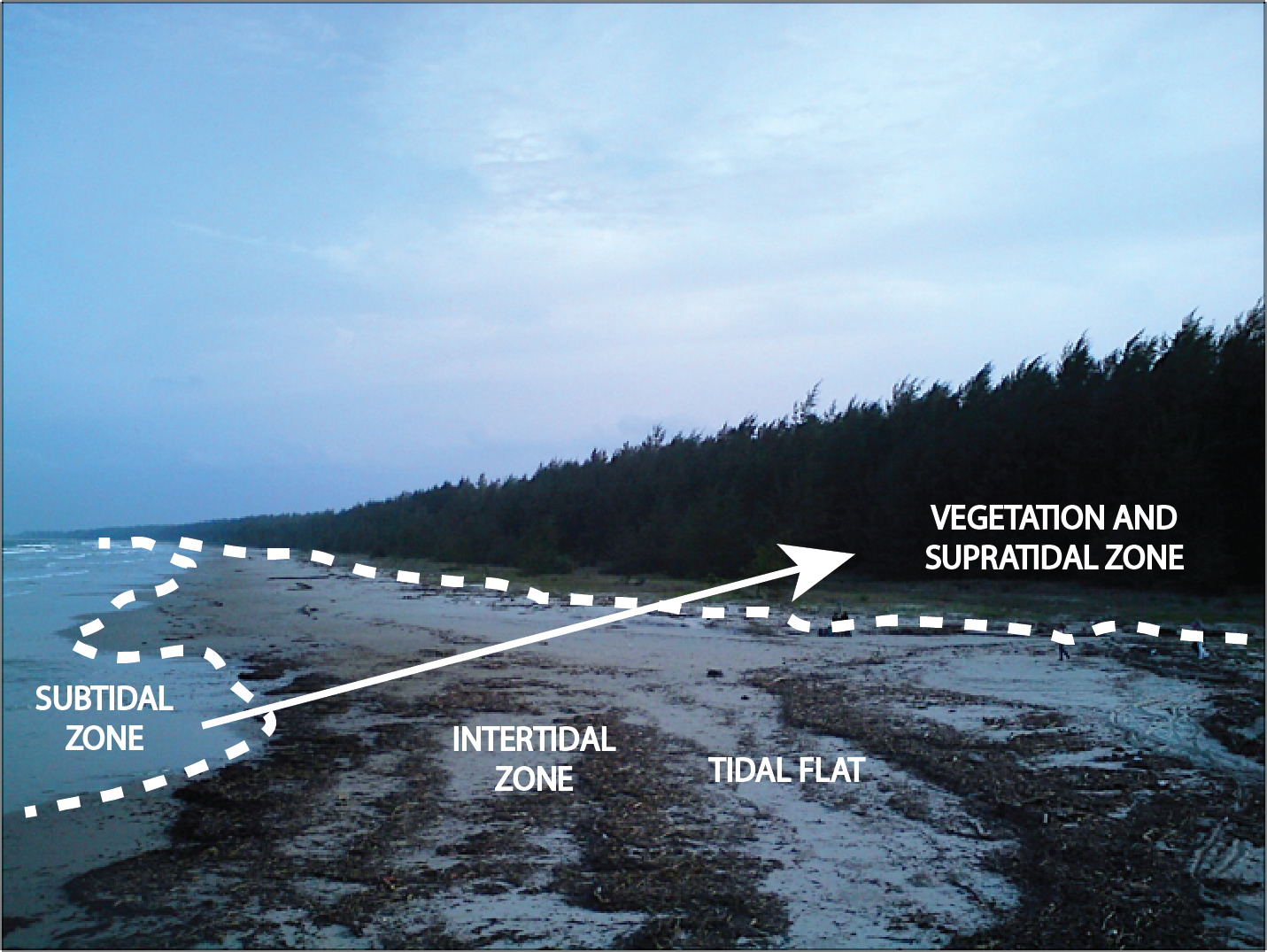
In order to investigate the shoreline change situation, spatial data comprising SPOT-2005 and SPOT-2011 (system for earth observation) satellite images, tidal data from Malaysia Meteorology Department, sedimentology and grains analyses on the collected samples (Figure 3)(Krumbein, 1934; Krumbein, 1938; Blott & Pye, 2001), and topography maps from Geoscience and Minerals Department were processed. A shoreline change model was constructed through the implementation of DSAS (Digital Shoreline Analysis System). This model arranges the variables of *x*, *y* and *z* (time) in a linear mode (Prukpitikul et al., 2012).

**Results and Discussion**

Over 30 sand samples were collected from 10 different localities located along the coastline of the study area. The samples were then sieved with the standard method from Krumbein (1934). The mean, kurtosis and skewness were calculated (Krumbein, 1938). Two grain size distribution trends could be deduced from this analysis; 1) the coarsening upward, and, 2) the fining upward trend, from subtidal environment to supratidal zones (Figure 4).

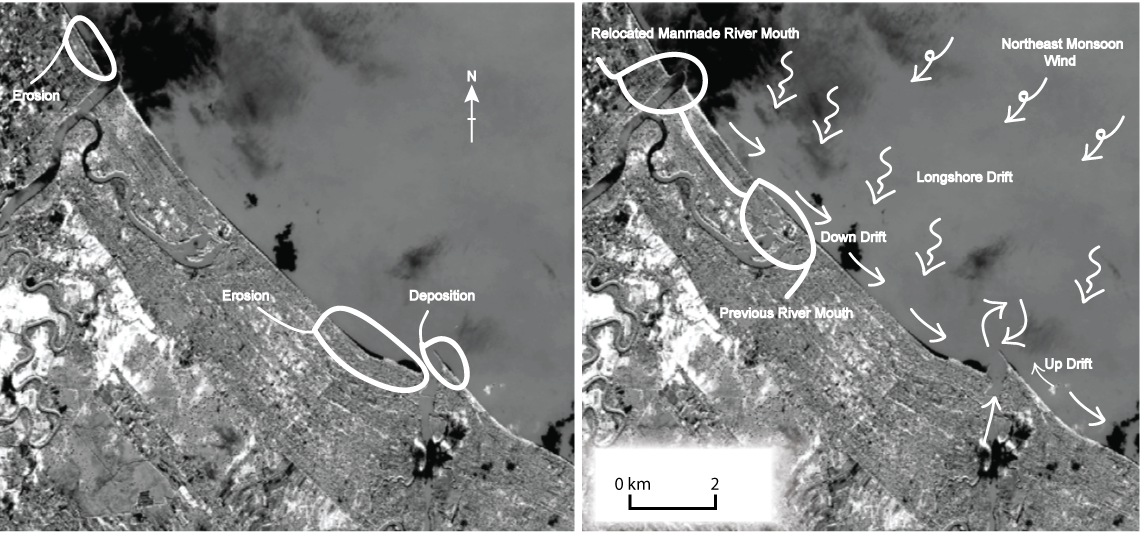
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| --- | --- | --- |
| Grain Size Distribution from Subtidal to Supratidal Zone | Locality | Discussion |
| Coarsening Upward | 1, 2, 9 & 10 | Coarse sands are deposited at the backshore (by the littoral drift?). |
| Fining Upward | 3, 4, 5, 6, 7 & 8 | The coarse grains at these localities are being redistributed to adjacent areas. The beach is fining inland. |

**Table 1:** Summary of the grain size distribution result from subtidal zone to supratidal zone for the samples collected from different localities along the shoreline of the study area.



🡨 **Figure 4:** The tidal zones of Kuala Tok Bali, Kelantan.

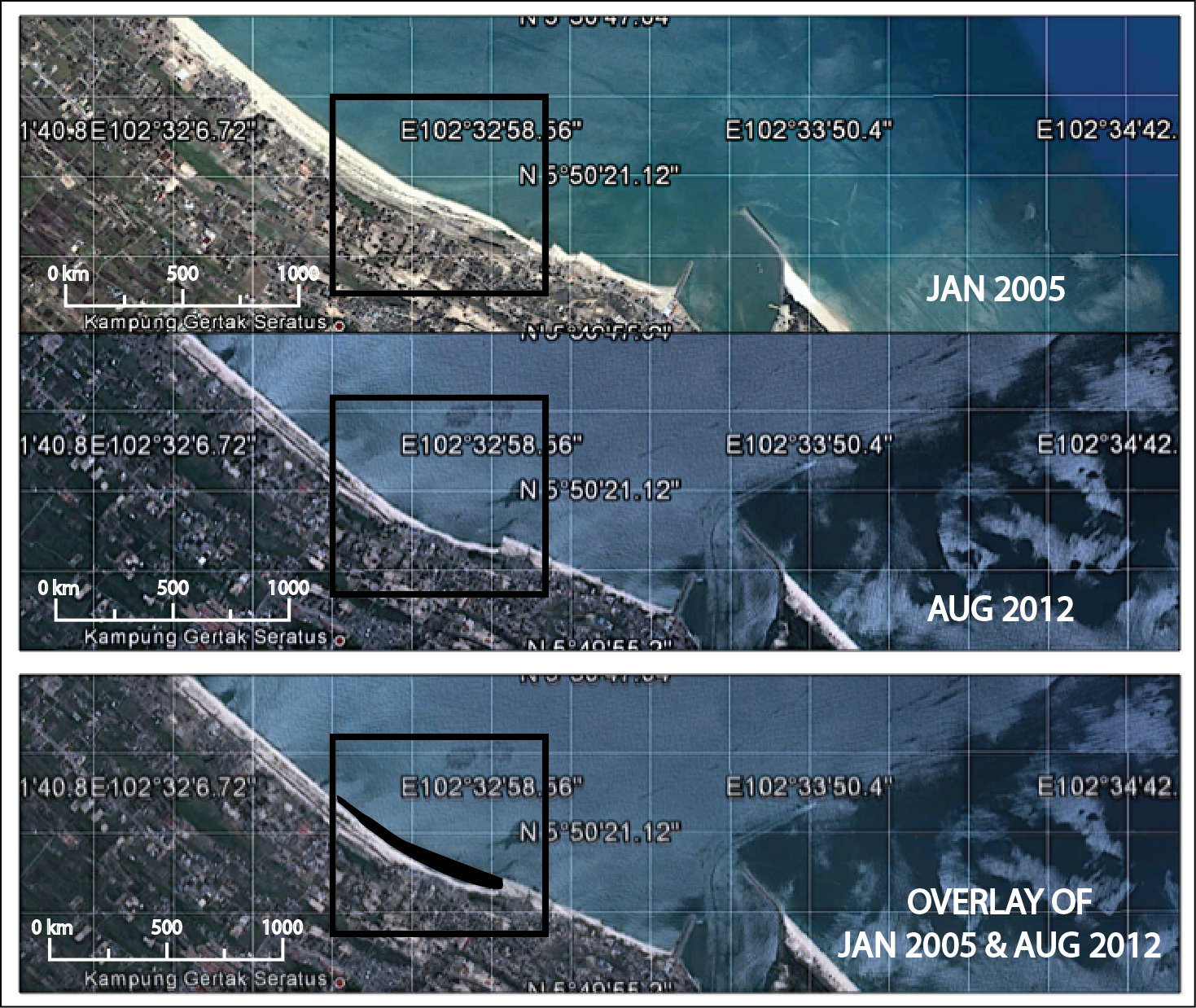
The coarsening upward grains size distribution trend basically explains that the sands are coarsening inland, where coarse sands are deposited during high tide and storms (Table 1). Likewise, the waves would be low in energy during low tide at subtidal zone. The transportation of grains are much dependent on the wave energy (Selley, 2000; Reineck & Singh, 1975; Pettijohn et al., 1972).



**Figure 5:** Satellite image from SPOT satellite based on DSAS (Digital Shoreline Analysis System) of Sungai Semerak and Sungai Kuala Besut, indicating the shift of shoreline between 2005– 2011. (Left) The left image shows the areas affected by erosion and deposition. (Right) The right image shows the coastal processes (eg: propagation of currents) involved (modified from SPOT 2011).

Coarser sands would need more energy when compared to the finer sands. Thus, at the localities (1, 2, 9 & 10) (refer to Figure 3) where coarsening upward occur, coarser sands are deposited at the supratidal zones (inland).

Localities that have fining upward trend in grains size distribution indicate the coarse sands are deposited at subtidal zones, where energy is highest during low tide. This high energy condition enable the deposition of coarse grains but it also removed the finer sands. Erosion would happen if the removal rate of finer sands is more dominant. This trend could be seen at localities 3, 4, 5, 6, 7 & 8 erosion occurred (Figure 5 & 6).



**Figure 6:** (Top) The top statellite image shows the situation of the coastline during January 2005. (Middle) The middle image shows an inland shift of the coastline in August 2012. (Bottom) The bottom image is an overlay of the top and middle image. It shows the differences occurred at similar location, Tok Bali, Kelantan from two time periods.

**Conclusion**

The Kemasin-Semerak Project caused the change in coastal dynamic in this area. The erosion at the river mouth of Sungai Semarak has shifted southward towards Besut. The constructed jetty has also altered the natural flow of drift current along the shoreline. The sands are transported to a lower energy condition where waves are blocked by the jetty. In time, the adjacent area, south of the jetty, would get muddy and shallow.

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