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Shoreline change in and around the Thubon River Mouth, Central Vietnam

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Abstract: Application of GENESIS model (GENEralized model for SImulating Shoreline change) for studying the shoreline change in and around the Thubon River mouth, Central Vietnam is presented in this paper. The input parameters used are the near shore wave height, wave period and wave direction, initial shoreline positions and sediment grain size. The near shore wave parameters were estimated using SWAN model. The change in shoreline during 1997 to 1998 was estimated and compared. In general the computed shoreline positions show good agreement with measured ones, except the shoreline sections in the area of river mouth, which lives in the model boundaries and in the current dominated regions. Obtained model results give a better understanding on the changing behaviour of the shoreline of the study area.

INTRODUCTION

Thubon River joins the South China Sea at the central Vietnam coast, discharge quantity of fresh water (Q_{mean} = 665 m^3/s) during monsoon and less quantity (Q_{mean} H" 131 m^3/s) during dry season (Hung, 1995). The continental shelf off the study area is relatively narrow with 20 m depth contour occurring at 2 km, 30 m at 10 km and 50 m at 12 km away from the coast, except in the area of river mouth, where shoals are present. At about 12 km distance from the river mouth in the northeast direction, Cham Island of 8 km width is present.

Coastline consists of long sandy beaches, with medium to fine sand with median size approximately from 0.15 to 0.2 mm. The morphology of the study area was taken from the topographic map with scale of 1:100,000, issued in 1980 by the Vietnamese Navy. Topography in and around Thubon River mouth was modified using the data collected during the National Project KHCN0608 in 1998 (Trinh, 2000). The general geomorphological features of the study area are shown in figure 1.

Oceanographic conditions of the near shore waters along this region are subjected to seasonal variability with the reversing southwest (June – August) and northeast monsoon (September – May). The data on tides of this region were taken from Danang station, which are semi-diurnal with average tidal height of 0.77 m (the mean spring tidal range was 1.36 m and the neap tidal range was 0.37 m). Cyclonic storms occur at an average of 1.2 times a year in this region. The wave climate of this region is dominated by northeast monsoon and southwest monsoon.

Proper understanding of the changing behaviour of the shoreline is important for the efficient management and development of the coast. Along the central coastal region of Vietnam, especially in and around the Thubon River mouth shoreline changes have been observed. The present study was done with the following objectives

(a) Estimation of the wave characteristics along the reference depth of the shoreline sections based on the SWAN model, and

(b) Estimation of the changing shoreline in and around the Thubon River mouth during September 1997 to August 1998 using GENESIS model.

METHODS OF STUDY

SWAN model

SWAN (acronym for Simulating WAves Near shore) is a third – generation wave model (Booij, et al., 1999; Ris, et al., 1999; Holthuijsen et al., 2003) with which realistic estimates of wave parameters in coastal areas, lakes and estuaries from given wind, bottom, and current conditions can be obtained. The model is based on the wave action balance equation with sources and sinks as follows (Eq. 1)

$$\frac{\partial}{\partial t}N + \frac{\partial}{\partial x}C_x N + \frac{\partial}{\partial y}C_y N + \frac{\partial}{\partial \sigma}C_\sigma N + \frac{\partial}{\partial \theta}C_\theta N = \frac{S}{\sigma} \qquad (1)$$

The first term in the left hand side of this equation represents the local rate of change of action density (N) in time, the second and third term represent propagation of action in geographical space (with propagation velocities C_x and C_y in x and y space, respectively). The fourth term represents shifting of the relative frequency due to variations in depths and currents (with propagation velocity C_s in s space). The fifth term

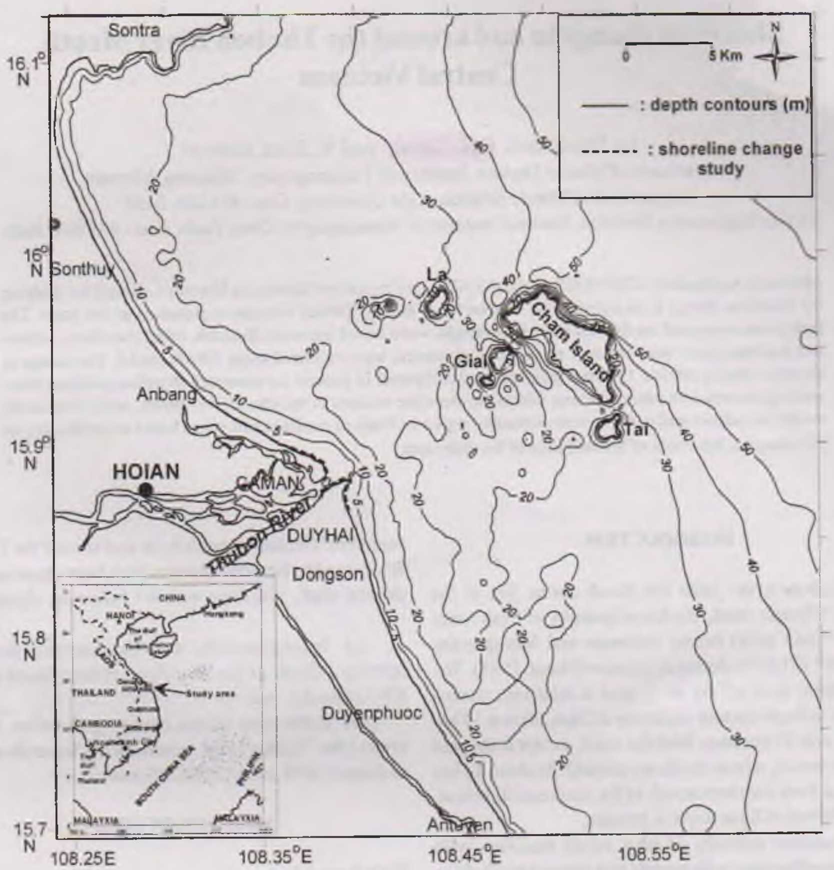

Fig.1. Map of study area.

represents depth-induced and current-induced refraction (with propagation velocity C_q in q space). The term S = S(ó,è) at the right hand side of the action balance equation is the source term in term of energy density representing the effects of generation, dissipation and nonlinear wave-wave interactions. The SWAN model accounts for shoaling, refraction, generation by wind, white-capping, triad and quadruplet wave–wave interactions, bottom friction, and depth – induced wave breaking.

GENESIS model

GENESIS simulate changes in position of the shoreline in response to wave action and boundary conditions (Hanson, 1987; Gravens, et al., 1991: Hanson and Kraus, 1991). The governing equation for the rate of change of shoreline position is formulated by conservation of sand volume as follows:

$$\frac{\partial y}{\partial t} + \frac{1}{(D_B + D_C)}\left[\frac{\partial Q}{\partial x} - q\right] = 0 \qquad (2)$$

Where,

y = shoreline position (m)
x = distance alongshore (m)
t = time interval (h)
D_B = the berm elevation (m)
D_C = the depth of closure (m)
Q = the long-shore transport rate (m^3/s)
q = the rate of source or sink of sand (m^3/s)

The empirical predictive formula for the long-shore sand transport rate (Q) used in GENESIS is given below:

$$Q = (H^2C_g)_b\,[a_1 \sin 2\theta_{bs} - a_2 \cos\theta_{bs} \frac{\partial H}{\partial x}] \qquad (3)$$

Where

H = wave height (m)
C_g = wave group speed given by linear wave theory (m/s)
b = subscript denoting wave breaking condition
q_{bs} = angle of breaking waves to the local shoreline

The non-dimensional parameters a_1 and a_2 are given by

$$a_1 = \frac{K_1}{16(\rho_s/\rho - 1)(1-p)(1.416)^{5/2}} \quad (3)$$

and

$$a_2 = \frac{K_2}{8(\rho_s/\rho - 1)(1-p)\tan\beta(1.416)^{7/2}} \quad (4)$$

Where

K_1, K_2 = empirical coefficient, treated as a calibration parameter
r_s = density of sand (taken to be 2650 kg/m^3 for quartz sand)
r = density of water (1030 kg/m^3 for seawater)
p = porosity of sand on the bed (taken as 0.4)
tanb = average bottom slope from the shoreline to the depth of active long-shore sand transport.

The factor 1.416 is used to convert significant wave height, the statistical wave height required by GENESIS, to root-mean-square (rms) wave height.

The first term in Equation (3) corresponds to the "CERC formula" (SPM, 1984). The second term is used to describe the effect of the long-shore gradient in breaking wave height. Equation (2) can be solved by either an explicit or implicit solution scheme with stability parameters (Courant number), R_s £ 0.5 or R_s £ 10 respectively.

The overall calculation flow used in the present study is shown in Figure 2.

Model simulation details

The computational grids of the SWAN model in geographical grid have size of 45.00 x 47.75 km, and resolution of 250 x 250 m which covers the area from 108.24°E to 108.645°E and from 15.695°N to 16.124°N (Fig. 1). The spectral grid with the range in frequency (f) was 0.052 – 1.0 in Hz; range in direction (è) was 0 – 360° in degree; and resolution Df = 0.1f and Dq = 10°.

The concerned shoreline in and around the Thubon River mouth is divided into three project reaches and modeled each separately. Three model reaches considered are, (i) north of the river mouth (North reach), (ii) south of the river mouth (South reach) and (iii) south bank of river (River bank reach). Figure 3 shows the details of GENESIS model reaches, and associate near shore reference depths, lateral boundary conditions.

Empirical parameters used in GENESIS (Trinh, 2000; Kraus and Harikai, 1983) are shown in Table 1.

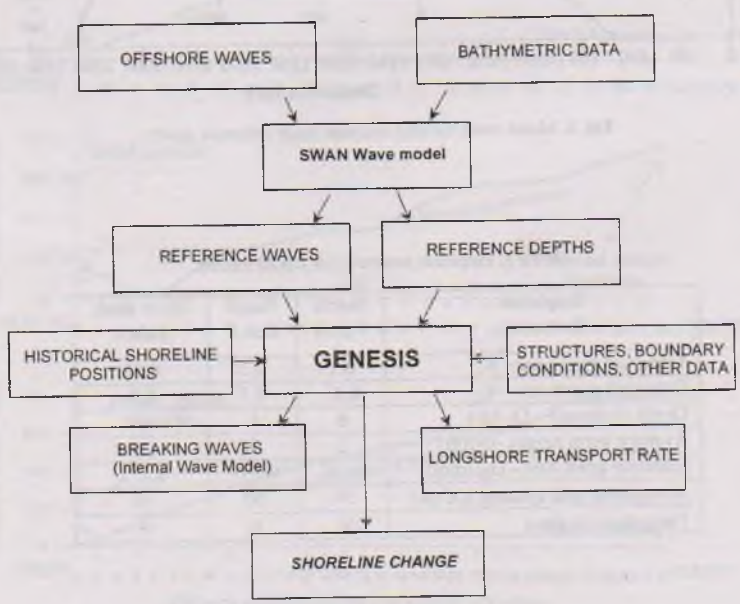

Fig. 2. Overall calculation flow used.

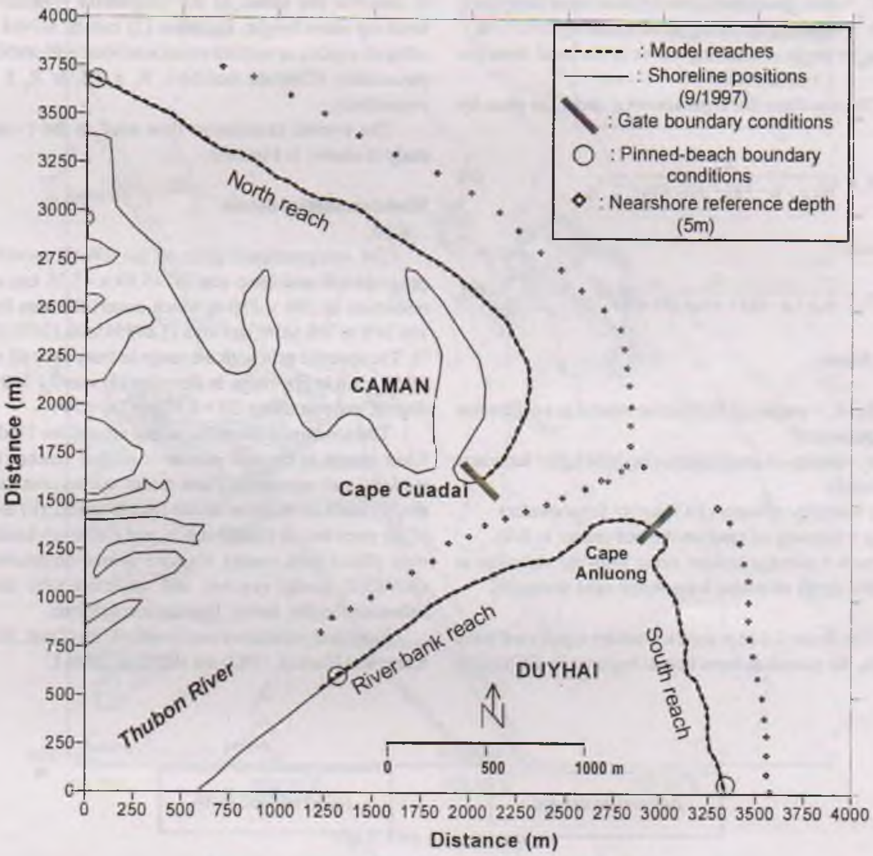

Fig. 3. Model reach systems and near shore reference depths.

Table 1. Empirical parameters at model reaches.

Empirical Parameters	North Reach	South Reach	River Bank Reach
Transport parameter - K_1	0.1	0.3	0.58
Transport parameter - K_2	0.25	0.5	0.3
Depth of closure - D_C (m)	6	6	6
Average berm height - D_B (m)	2	2	2.5
Effective grain size - D_{50} (mm)	0.175	0.175	0.175
Alongshore grid spacing ΔX (m)	50	50	50
Time step - Δt (hrs)	6	6	6

The digitized and interpolated shoreline positions (measured in September 1997) for model reaches are shown in figure 4.

RESULTS AND DISCUSSIONS

Long-shore sediment transport

Net long-shore transport rate is the net amount of material passing a particular point in the predominant direction during a specified time. The change in position of the shoreline depends on the gradient of the net long-shore transport rate. Figure 5 shows the distribution of the net long-shore sediment transport rate in the study area during September 1997 to August 1998.

At the North reach, in general, the net transport was towards north with average transport rate of 50,000 to 100,000 m^3/year, and the values increase towards

north, except the southern part (near river mouth) the net transport rate was toward south with average value of 10,000 to 50,000 m^3/year, and the values decrease further towards south.

At the South reach, the net transport rate was towards south with average transport rate of 30,000 to 80,000 m^3/year, and the values decrease towards south.

At the River bank reach, the net transport rate was towards west in most parts of the reach with average transport rate of 5,000 to 50,000 m^3/year, and the values decrease towards west, except at the eastern part, wherein the net transport was towards east.

Shoreline change

The change of shoreline in and around the Thubon River mouth during 9/1997 to 8/1998 is shown in figure 6.

At the North reach, the measured shoreline positions show that in all, the shoreline was predominantly eroding with average regression value of 25 m, and maximum value was greater than 50 m. At the southern part (near river mouth), however, the shoreline was accreting, advanced towards offshore, and river channel direction with the average distance of 70 to 100 m.

At the South reach, the shoreline was predominately accreting with average value of 15 to 20 m, especially at the northern part (Cape Anluong) the shoreline advance was much higher, approximately 50 to 70 m.

At the River bank reach, the shoreline was mainly eroding with average regression value of 50 to 70 m, except the shoreline part at Cape Anluong was accreting with average value of 20 m.

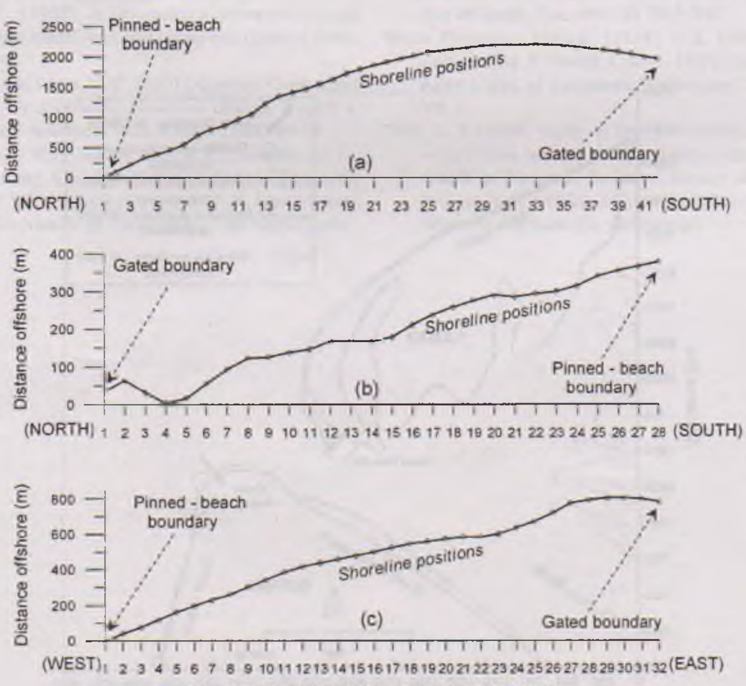

Fig. 4. Coordinate systems and grid used by GENESIS at North reach (a), South reach (b), and River bank reach (c).

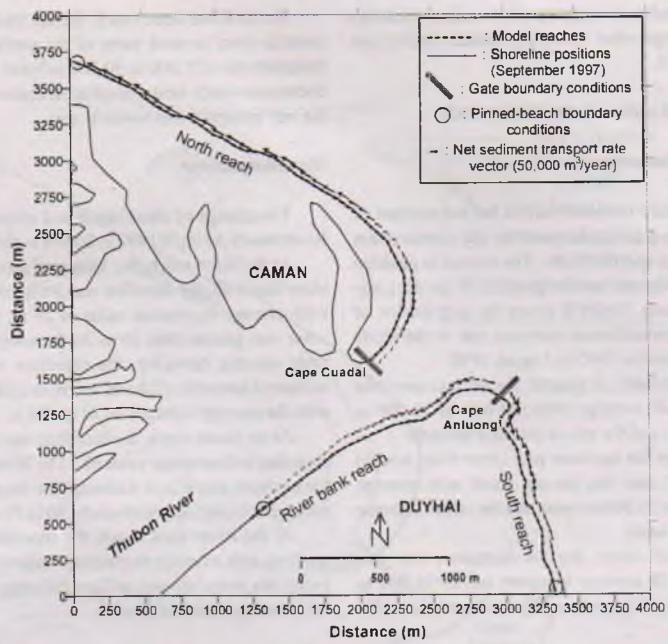

Fig. 5. Net long-shore sediment transport rate during September 1997 to August 1998.

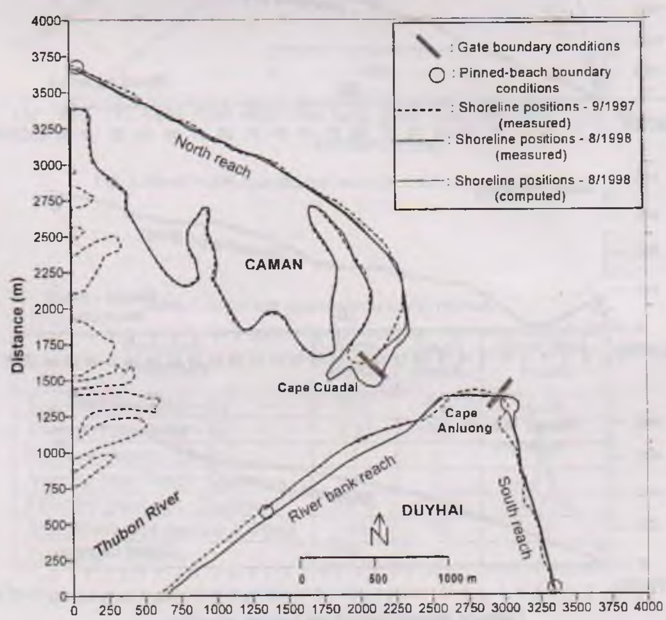

Fig. 6. Shoreline change in and around the Thubon River mouth during September 1997 to August 1998.

In general the computed shoreline positions show good agreement with measured ones, except the shoreline sections in the area of river mouth which is the current dominated regions, and falls in the model boundaries. The magnitude of erosion and accretion in the current dominated regions (accretion at Cape Cuadai, northern part of the South reach; and erosion at south bank of river) is relatively large (about 50 to 100m). The erosion was due to the landing of hurricane FRITR during September to November, 1997.

CONCLUSIONS

From the present study, following conclusions can be recorded.

The shoreline in and around the Thubon River mouth during September 1997 to August 1998 was subjected to changes with relatively large magnitude, especially in the areas of Cape Cuadai, Cape Anluong, and south bank of river (current dominated area).

In general the northern shoreline (North reach), and south bank of river (River bank reach) are subjected to erosion, whereas the southern shoreline (South reach), and the area of Cape Cuadai are subjected to accretion.

The computed shoreline positions is in good agreement with measured ones in the wave dominated regions, and the GENESIS model can be applied to predict the shoreline changes in the northern and southern shoreline of the Thubon river mouth.

References

Booij, N., Ris, R. C. and Holthuijsen, L.H., (1999). A third generation wave model for coastal regions. Model description and validation. Jour. of Geophy. Res., 104 (C4), 7649-7666.

Gravens, M. B., Kraus, N. C. and Hanson, H., (1991). Genesis: Generalized model for simulating shoreline change. Report 2. Workbook and system user's manual. Tech. Report CERC-89-19.

Hanson, H., (1987). A generalized shoreline change numerical model for Engineering use. Genesis. Lund, Sweden.

Hanson, H. and Kraus. N. C., (1991). Genesis: Generalized model for simulating shoreline change. Report 1. Technical reference. Tech. Report CERC-89-19.

Holthuijsen, L. H., Booij, N., Ris, R. C., Haagsma, IJ. G., Kieftenburg, A.T.M.M., Kriezi, E. E. and Zijlema, M., (2003). SWAN Cycle III version 40.20. User Manual. Delft University of Technology, The Netherlands.

Hung, T. D., (1995). The hydrological features in the Quangnam – Danang Province. Danang. General Publish House (in Vietnamese).

Kraus, N. C. and Harikai, S., (1983). Numerical Model of the Shoreline Change at Oarai Beach. Coastal Engineering, 7 (1), 1-28.

Ris, R. C., Holthuijsen, L.H. and Booij, N., (1999). A third generation wave model for coastal regions. Verification. Jour. of Geophy. Res., 104 (C4), 7667-7681.

Shore Protection Manual, (1984). U.S. Army Coastal Engineering Research Centre, Department of the Army Corps of Engineers, Washington, DC. USA. Vol. 1.

Trinh, L. P. (2000). Study on laws and prediction erosion – deposition habitude in the coastal zone and river mouth of Vietnam. Technical Report of National Project KHCN0608. Institute of Oceanography, Nhatrang, Vietnam. (in Vietnamese).