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MOT VAI KET QUA NGHIEN CÖU SÖ THAY ÑOI ÑÒA HÌNH VUNG CÖA SONG CAI (PHAN THIET)

Vu Tuan Anh
Vien Hai Döông Hoc (Nha Trang)

TOM TAT Bai bao ñöa ra mot vai ket qua nghien cöu ve sö thay ñoi ñòa hình vung cöa song Cai (Phan Thiet).

Döa vao cac ñac ñiem ñòa hình va thuy thach ñong löc, co the chia khu vöc nghien cöu thanh 2 phan:

Phan trong song: chòu tac ñong manh cua dong trieu, dong chay cua song va dong lu, nhöng khong chòu tac ñong cua cac qua trình ñong löc bien nhö song, dong chay do song tao ra...

Phan ngoai cöa song: khong nhöng chòu tac ñong manh cua dong trieu, dong chay cua song va dong lu ma con chòu tac ñong tröc tiep cua song, dong chay do song tao ra va dong vat lieu di chuyen ngang...

Cac ket qua nghien cöu cho thay quy luat bien ñoi ñòa hình vung cöa song Cai nhö sau:

Trong ñieu kien thôi tiet bình thöông (ca mua kho lan mua lu) mot phan vat lieu ñay ñöôc ñöa ra khoi khu vöc va tham gia vao cac qua trình di chuyen khac, phan con lai cung vôi cac vat lieu ñöôc ñöa ñen bôi cac qua trình ñong löc bien khac lang ñong tai khu vöc ngoai cöa song hình thanh mot dai ñat hình vong cung.

Cuoi cung khu vöc ngoai cöa song thoat khoi tac ñong cua thuy trieu, bien ñoi dan thanh phan trong song vôi hình dang hep – nong, rong – sau xen ke.

Qua trình nay lien tuc phat trien cho ñen khi chung bò pha huy bôi cac qua trình ñong löc manh me xuat hien trong cac hien töông thôi tiet ñac biet nhö song cao, lu lôn... Chính cac qua trình ñong löc nay lam pha huy ñòa hình va vò trí cöa thoat nöôc.

SOME STUDY RESULTS OF THE TOPOGRAPHY CHANGE OF THE CAI RIVER MOUTH (PHANTHIET)

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ABSTRACT This paper gives some study results of the topography change in the Cai river mouth.

Based on the characteristics of relief and litho - hydrodynamics it is possible to separate the region into two parts:

The inner part: is influenced strongly by tides, river, and flood flows but not

by marine dynamical processes such as waves, wave-current.

The outer part: is influenced not only by actions of tides, river, and flood flows but also by direct actions of waves, wave-current, and cross materials flows.

The rule of development of Cai river mouth is as follows:

In normal weather condition (both in dry and flood seasons): A part of the materials is brought out the region and taken part in other movement processes. The remainder and materials brought by other marine dynamical processes are deposited at outer part in an arch-shaped band. At last, the bottom of the outer part escapes from influence of tide and changes into the inner part, which alternately have narrow-shallow, wide-deep shapes.

This process continuously develops until it is destroyed by strong dynamical processes happened in special weather phenomena such as high waves, floods. These dynamic processes cause the displacement of river mouth.

I. INTRODUCTION

The mouth of Cai river (Phanthiet) (Fig. 1) plays an important role in marine economy of Phanthiet city and Binhthuan province. This place is not only used for ship anchoring and repairing, sea food trading and services to fishing activity but also for sheltering of ships from storms...

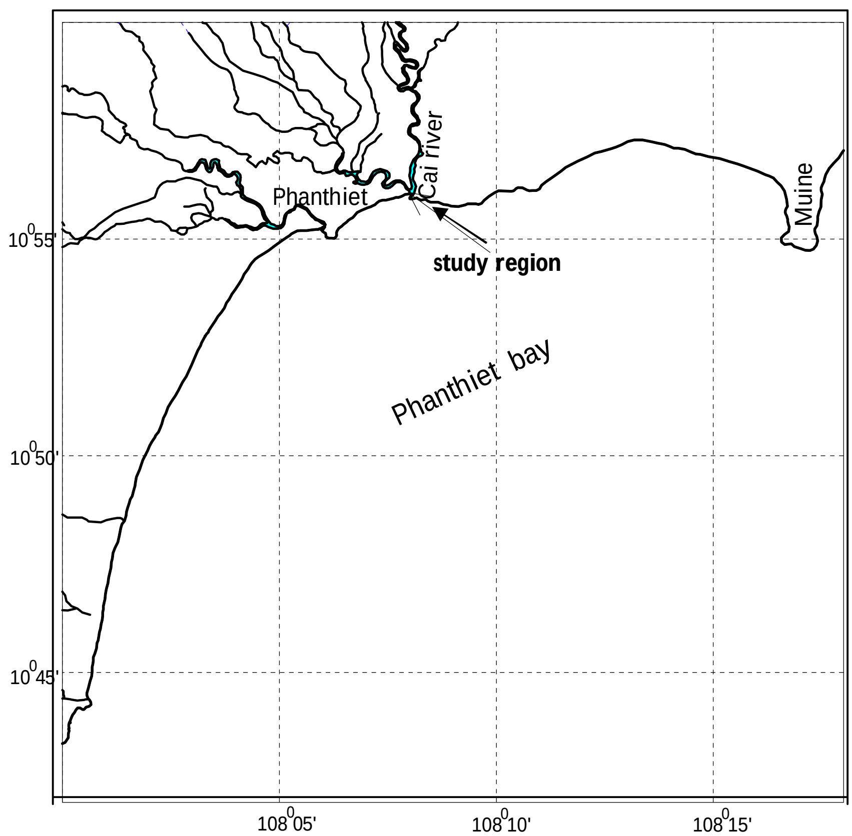

Fig. 1: Position of study region

However, resembling river mouths in central part of Vietnam, the litho - hydrodynamic processes in this place are very complex and causing at all time changes of topography. To predict the trend and intensity of them in order to avoid their bad consequences is necessary.

In this paper, some study results on litho - hydrodynamic processes causing the change of topography in Cai river mouth are presented.

II. THE MODEL

The governing equations used in the model are as follows:

a. Currents [6]

$$\frac{\partial u}{\partial t}+u\frac{\partial u}{\partial x}+v\frac{\partial u}{\partial y}+g\frac{\partial H}{\partial x}+F_x-\Omega.v=0$$

$$\frac{\partial v}{\partial t}+u\frac{\partial v}{\partial x}+v\frac{\partial v}{\partial y}+g\frac{\partial H}{\partial y}+F_y+\Omega.u=0$$

$$\frac{\partial H}{\partial t}+\frac{\partial}{\partial x}(u.(H+D))+\frac{\partial}{\partial y}(v.(H+D))=0$$

$$F_x=\frac{g.u\left|(u^2+v^2)^{1/2}\right|}{C^2(H+D)}$$

$$F_y=\frac{g.v\left|(u^2+v^2)^{1/2}\right|}{C^2(H+D)}$$

b. The equation of bottom elevation change [4]

$$\frac{\partial z}{\partial t}=-\frac{\partial}{\partial x}\left(q_x-\varepsilon_s|q_x|\frac{\partial z}{\partial x}\right)-\frac{\partial}{\partial y}\left(q_y-\varepsilon_s|q_y|\frac{\partial z}{\partial y}\right)$$

c. The equations of sediment transport due to main current [4]

$$q_x=Q_c.u; q_y=Q_c.v$$

$$Q_c=\frac{A_c.(\tau-\tau_{cr})}{\rho.g}$$

In which:

q_x, q_y are components of rate of materials transport on a width unit caused by current in x, y directions, respectively.

x, y are, respectively, two axes in the latitudinal and longitudinal directions.

u, v are components of the current velocity in x and y directions.

H: water surface elevation above water still level.

F_x, F_y: the friction terms in the x and y directions.

$\Omega.v$ and $\Omega.u$ are the horizontal components of the Coriollis force.

$\Omega = 2.\omega \sin\phi$, where ω is the angular velocity of the earth's rotation. ϕ is the latitude of the location.

C : Chezi coefficient ($C = h^{1/6}/0.028$)

h : depth of water (h = H+D)

D: depth from the bottom to the water still level

z : the change of the bottom elevation

ε_s : constant

τ is the maximum value of the bottom shear stress in a current field, τ_{cr} is the critical shear stress for the beginning of sediment transport. A_c is a dimensionless coefficient. ρ is the density of water, and g is the gravitational acceleration. If $\tau \le \tau_{cr}$ then Q is zero.

d. Boundary conditions

- Solid boundaries: component of the current in normal direction is zero.
- Free boundaries: H, oscillation of the water level, is calculated as follows:

$H = \Sigma H_i \cos(\delta_i t - g_i)$. Here H_i, g_i are, respectively, amplitude and phase of the tidal wave, δ_i is frequency.

e. Initial conditions

t = 0; u = 0; v = 0; z = 0; H = 0.

The equations of currents and bottom elevation change were solved by different method.

The study area is divided into grid cells. Each cell has the spacing of

20 meters in x-direction and 40 meters in y-direction. The time step is 1 second.

III. THE RESULTS OF STUDY AND CALCULATION

The calculated region is the mouth of Cai river (Phanthiet) (Fig. 2). Based on the characteristics of topography and dynamics, it is possible to separate the region into two parts:

- The outer part: is under a strong influence of waves and tidal flows. The shape of this part is a wedge with wide side of 300 meters. Average depth is rather shallow (maximum depth is about 4.8 meters).

- The inner part: is not affected by waves but influenced by tide and river flows, and floods... The river axis makes up an angle of eighty degrees with the north.

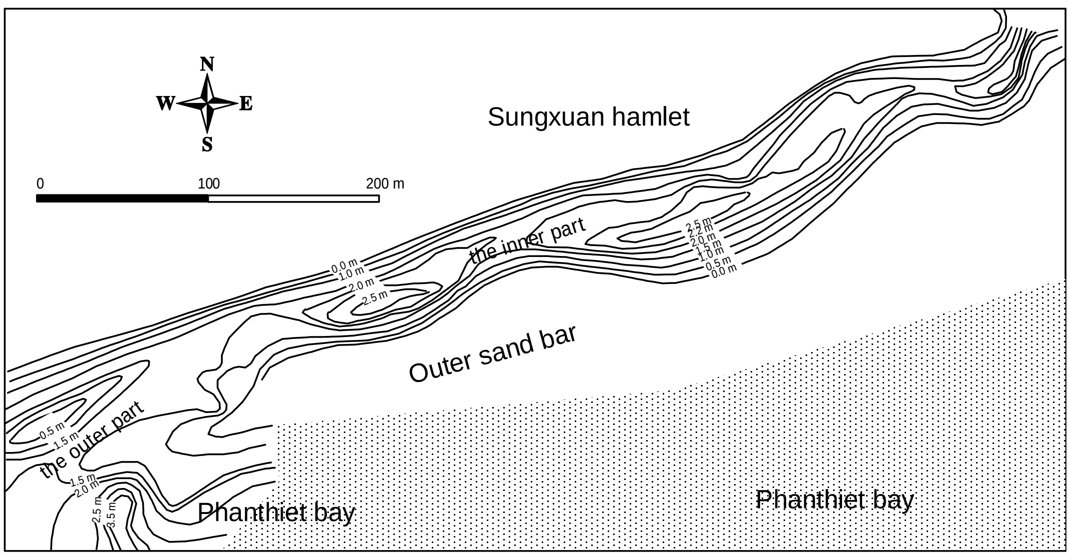

Fig. 2: Bottom topography of the mouth of Cai river (Phanthiet) (measured in 4/2000)

The whole length of study region is 1,350 meters with maximum width at outer part about 300 meters, and minimum width at inner part is 90 meters. The calculated results are as follows:

1. In dry season

1.1. Current

Calculated values for dry season show:

- In ebb tide phase:

The inner part: the flow runs along the river axis (northeast east - southwest west direction) from the river to the sea. The river in this part has special characteristics: some where the river is not only narrow but also shallow. Somewhere the river is not only wide but also deep.

Therefore, the flow is changed creating centers of high current in the places, where the river is narrow and shallow.

The outer part: because of existence of a submerged sand bar, the flow is separated into two parts with two different directions. One part continues running in the hollow canal along the coast. Other part runs in northeast-southwest direction (Fig. 3).

The module values of current are shown in table 1.

Table 1: Some calculated results of current module at the mouth of Cai river (Phanthiet) in dry season, ebb tide phase

Number	Calculation time	Maximum value (cm/s)	Average value (cm/s)	Minimum value (cm/s)
1	After 3 hours	51	6	0
2	After 6 hours	55	9	0.6
3	After 9 hours	30	4	0.1
4	After 27 hours	38	11	0.3

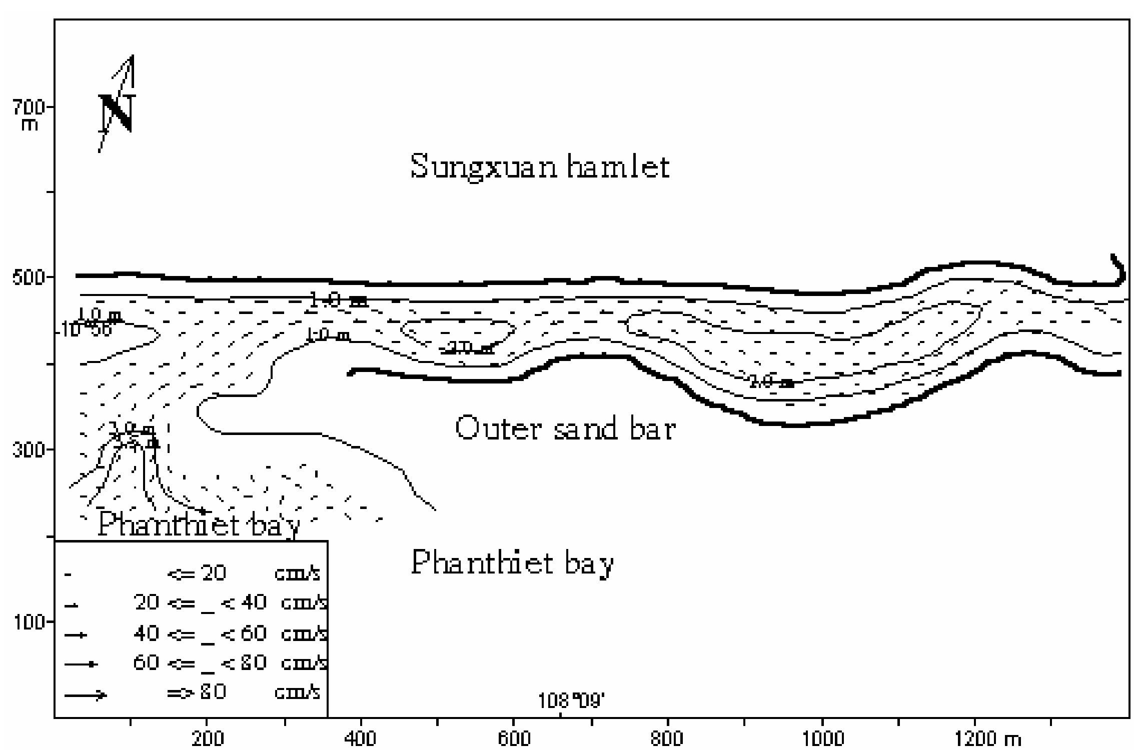

Fig. 3: Distribution of current module at the mouth of Cai river (Phanthiet) after 6 hours, in dry season, ebb tide phase

- In the flood tide phase:

In the inner part: the flow still runs along the river axis but its direction is southwest west - northeast east. Due to effects of bottom topography, there is still existence of high module centers in the places where the river is narrow and shallow (Fig. 4).

In the outer part: almost flow runs in a contrary direction with that of flow in ebb tide phase. A part of flow runs in southwest west-northeast east direction, other part in southwest-northeast direction (Fig. 4).

The current module results in the flood tide phase were shown in the figure 4 and table 2.

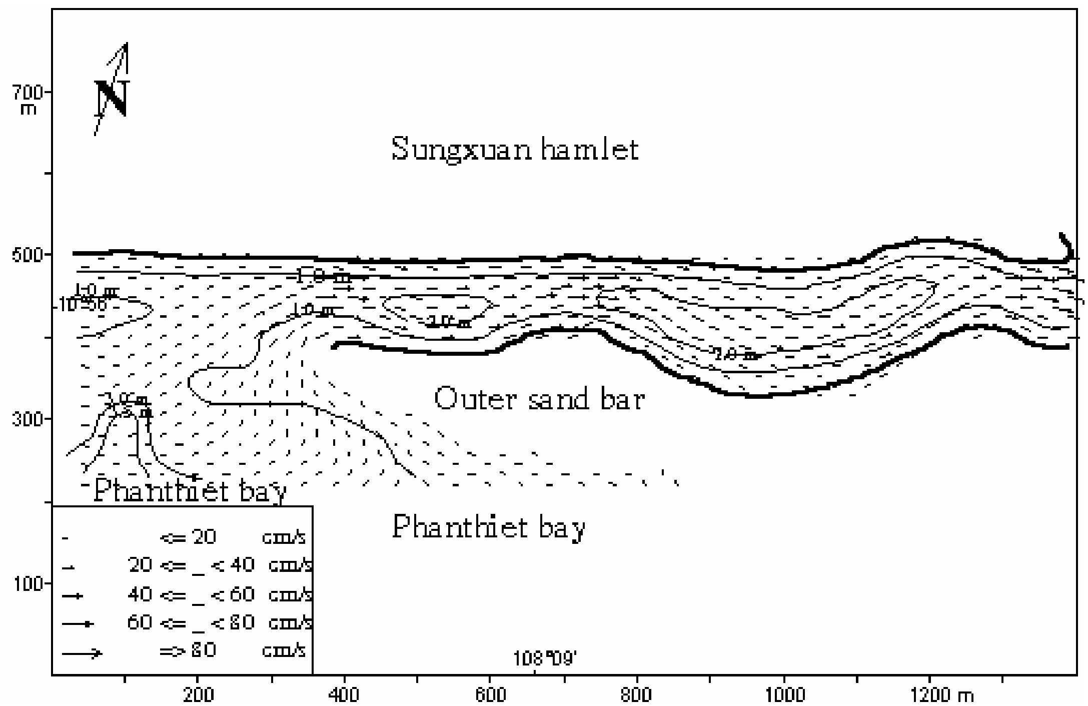

Fig. 4: Distribution of current module at the Cai river mouth (Phanthiet) after 15 hours, in dry season, flood tide phase

Table 2: Some calculated results of current module in the mouth of Cai river (Phanthiet), in dry season, flood tide phase

Number	Calculation time	Maximum value (cm/s)	Average value (cm/s)	Minimum value (cm/s)
1	After 12 hours	36	13	0.4
2	After 15 hours	47	17	0.4
3	After 18 hours	36	12	0.09
4	After 21 hours	40	14	0.8
5	After 24 hours	40	14	0.1
6	After 75 hours	24	6	0.2

1.2. The trend of topography changes under the influence of current

In dry season, and in the case of bottom with fine sand, the median diameter of grain (D_{50}) is 0.1 millimeters. The computed results show:

The inner part: because of existing of high current module centers, movement of materials changes strongly around these centers in the tide phases.

In ebb tide phases: materials are transported from the river to the sea. They cause erosion at upstream and deposition at downstream of these centers.

In flood tide phases: the processes of materials transport are in contrary to that in ebb tide phases. Flood tide flow pushes materials in direction from the sea to the river and causes the exchange of the places between eroded regions and deposited regions.

However, in the flood tide phases the flow always has higher module than that in the ebb tide phases, so it pushes a part of materials out the inner part. The process of material loss happens strongly around the centers of high current and causes erosion at riverbanks.

The outer part: erosion process always happens and makes a hollow canal closed to the shore. The shore in this part is eroded by the current running parallel and trending to press against it. A part of materials is pushed out the sea by flood current in northeast - southwest direction, which makes an outer deposit region. However, because of the influence of other processes (waves, wind currents...) materials are deposited not only there but also at submerged sand bar. After sometime, the outer part and submerged sand bar get out of the influence of tide and link with the outer sand bar that is developed due to other dynamical processes. Whole region gets out of dynamical processes such as waves, wave-currents, and cross materials flows... and the outer part of the region becomes the inner part.

Some calculated results were shown in the figure 5 and table 3.

Table 3: Some calculated results of erosion and deposition at the mouth of Cai river (Phanthiet), in dry season

Number	Calculation time	Erosion – deposition speed			
		Maximum (m)	Average (m)	Minimum (m)	Change of volume of materials (m^3)
1	After 24 hours	$+7.7.10^{-3}$	$-6.1.10^{-5}$	$-7.2.10^{-3}$	-23.2
2	After 51 hours	$+1.4.10^{-2}$	$-1.4.10^{-4}$	$-1.5.10^{-2}$	-53.3
3	After 75 hours	$+ 2.0.10^{-2}$	$-2.0.10^{-4}$	$-2.2.10^{-2}$	-77.6

Note: + deposit process; - erosion process

In dry season, during a tide period there are 20 - 25 m^3 of materials running out the calculated region.

2. In flood season

2.1. Current

The mechanism of river flow and tide transmission from the sea to the river in flood season are very complex. It causes not only the serious destruction of the riverbanks and the shore but also the violence of materials transport. In this paper we calculated for the case of the flood increasing from 0 to 0.2 meters in first 12 hours and decreasing from 0.2 to 0 meter in following 12 hours and ignoring the late phase of tide caused by flood.

In our opinion, the calculated results somewhat bring a picture of current field of region in flood season.

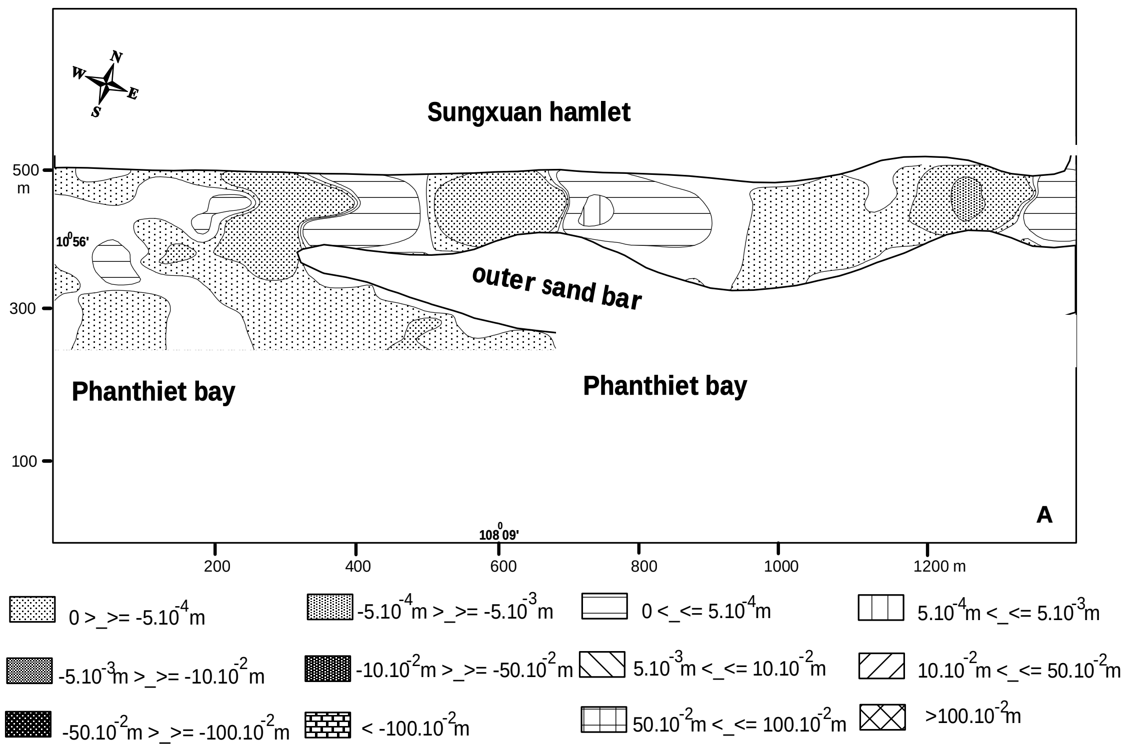

Fig. 5: Distribution of erosion and deposition at the mouth of Cai river (Phanthiet), after 24 hours, in dry season

In flood tide phase: like current field in dry season, in the inner part the current runs off from the river to the sea in river - ed axis direction. There are still the centers of high module of current in the narrow and shallow river - bed regions. In the outer part, the flow spreads out to the east more widely than that in dry season (Fig. 6). The current modules during the time of flood tide phase were showed in table 4.

In ebb tide phase: in all calculated cases currents run off from the river to the sea due to the influence of the strong flood flow. The current does not reach maximum value at the same time when the flood is the highest (after 12 hours calculating). It reaches maximum value (148 cm/s) after 15 hours of calculation (Fig. 7). After that the current velocity reduces. The current module results during the time of flood tide phase were shown in table 5.

Table 4: Some calculated results of current module at the mouth of Cai river (Phanthiet), in flood season, flood tide phase

Number	Calculation time	Maximum value (cm/s)	Average value (cm/s)	Minimum value (cm/s)
1	After 3 hours	60	19	0.3
2	After 6 hours	56	15	0.1
3	After 9 hours	83	24	0.4

Table 5: Some calculated results of current module at the mouth of Cai river (Phanthiet), in flood season, ebb tide phase

Number	Calculation time	Maximum value (cm/s)	Average value (cm/s)	Minimum value (cm/s)
1	After 12 hours	118	46	1.8
2	After 15 hours	148	59	2.2
3	After 18 hours	87	33	1.0
4	After 21 hours	61	23	0.5
5	After 24 hours	25	9.5	0

2.2. Trend of the changes of bottom topography due to current's effect

The calculation was carried out in the case the bottom materials were fine sand. The median diameter of grain is 0.1 millimeters. The calculated results show:

In outer part: there is always existence of erosion – deposition centers around the places, where the current has high module. However, in flood season the flow runs from the river to the sea in most of the time, and its velocity is higher than that from the sea to the river. Therefore, the erosion centers always exist in the upstream and the deposit centers in the downstream of the high current module centers (Fig. 8.) Materials are pushed by strong current farther than that in dry season. A part of them is deposited and the others continue to move. The part of these deposited materials and materials of other dynamical sources are deposited in an arch-shaped band at the outer part. The bottom of the region becomes shallow gradually. At last, this region escapes from tide's effect and connects with outer sand bar.

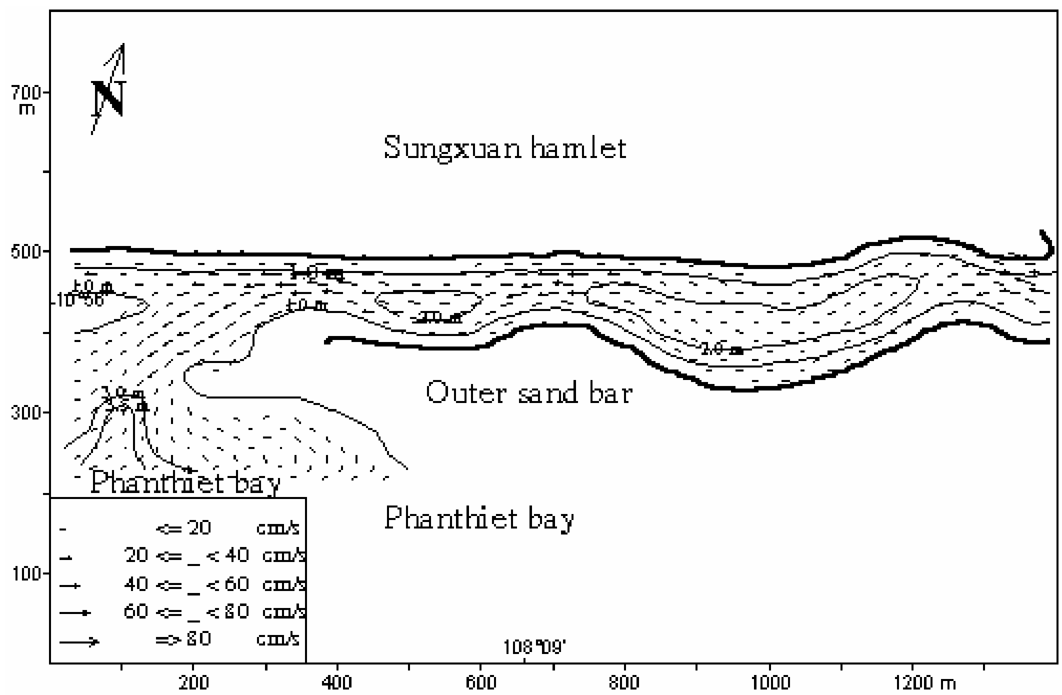

Fig. 6: Distribution of current module at the mouth of Cai river (Phanthiet) after 6 hours, in flood season, ebb tide phase

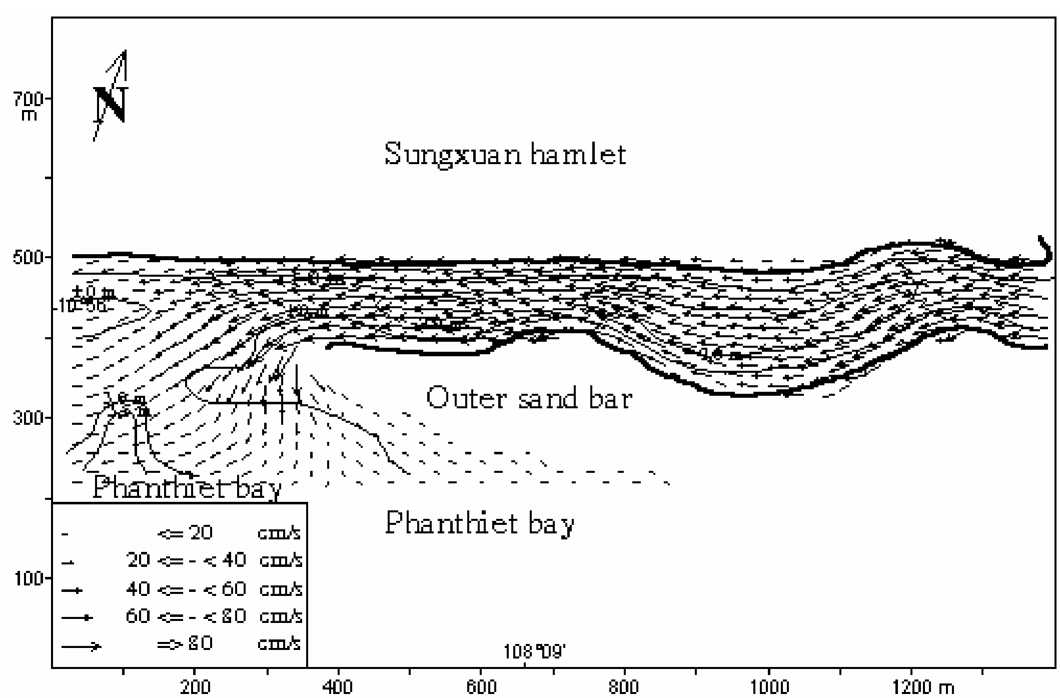

Fig. 7: Distribution of current module at the mouth of Cai river (Phanthiet) after 15 hours, in flood season, ebb tide phase

The above mentioned process happens in both dry and flood seasons having not very high intensity. It makes a cycle evolving the outer part of river mouth into new riverbed (the inner part). That is narrow-shallow and wide-deep parts alternately. However, it will be destroyed by dynamic processes in special weather phenomena such as storms, floods... Some calculated results were shown in table 6.

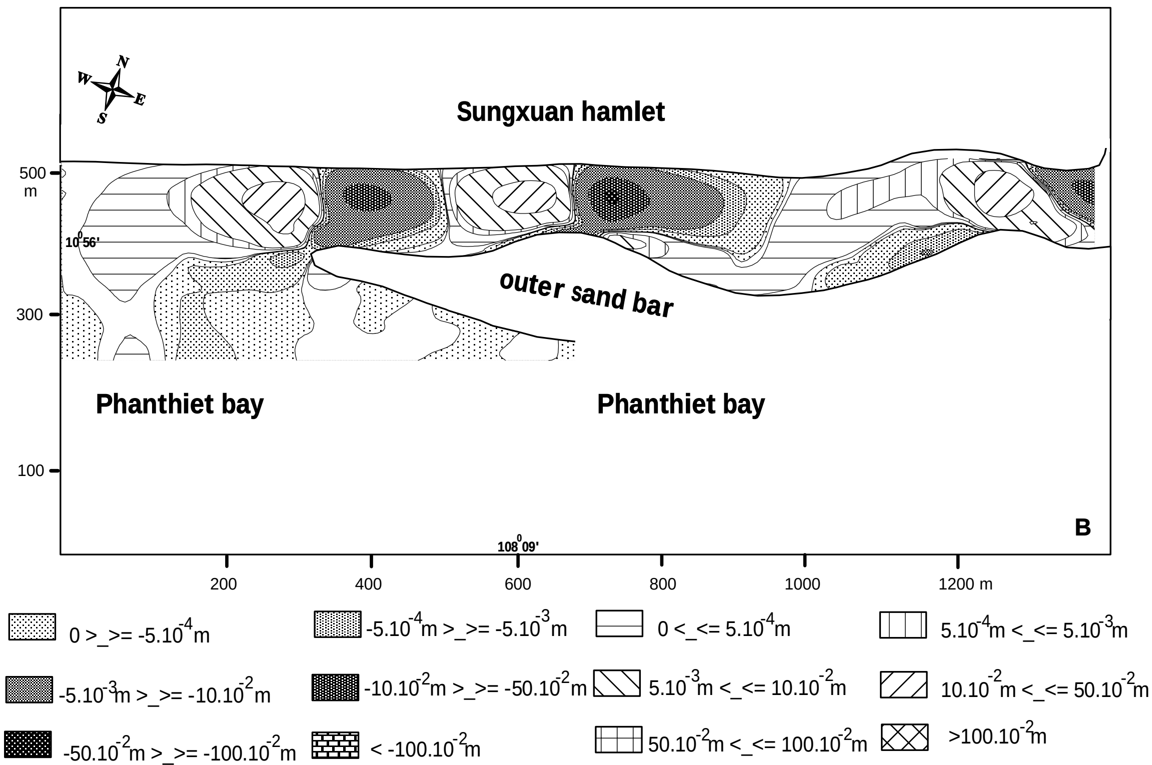

Fig. 8: Distribution of erosion and deposition at the mouth of Cai river (Phanthiet) after 24 hours, in flood season

3. In special weather conditions

Figure 9 (following the map named SHEET 6630 IV, 1974, scale 1:50.000, data of 1970) shows that the river mouth shape in 1970 is similar to that in the present. However, the existence of an old river mouth is clear. The submerged sandbars at two banks of an old canal were the track of an old river. Figure 10 (following the map named U.T.M 6630 Ñ.B. 1997, scale 1:25,000, data of 1995) shows a new river mouth opened after all outer sand bars were destroyed by floods and strong waves.

Table 6: Some calculated results of erosion and deposition at the mouth of Cai river (Phanthiet), in flood season

Number	Calculation time	Erosion – deposition speed			
		Maximum (m)	Average (m)	Minimum (m)	Change of volume of materials (m^3)
1	After 3 hours	$+2,07.10^{-3}$	$-1,73.10^{-5}$	$-2,19.10^{-3}$	6
2	After 9 hours	$+1,41.10^{-2}$	$-5,77.10^{-5}$	$-1,21.10^{-2}$	21
3	After 18 hours	$+9,70.10^{-2}$	$-8,22.10^{-4}$	0.10	313
4	After 21 hours	+0,10	$-8,86.10^{-4}$	0.11	337
5	After 24 hours	+0,10	$-9,01.10^{-4}$	0.11	343

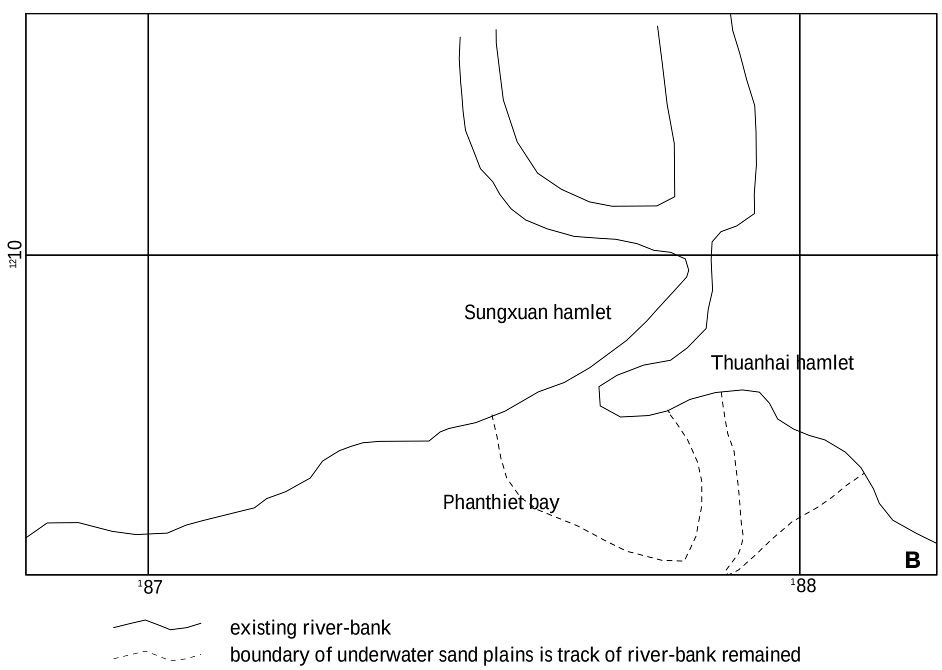

Fig. 9: Form of riverbanks at the mouth of Cai river (Phanthiet) (1970)

This fact indicates that the topography of the Cai river mouth could be destroyed by strong dynamical processes in the special weather conditions.

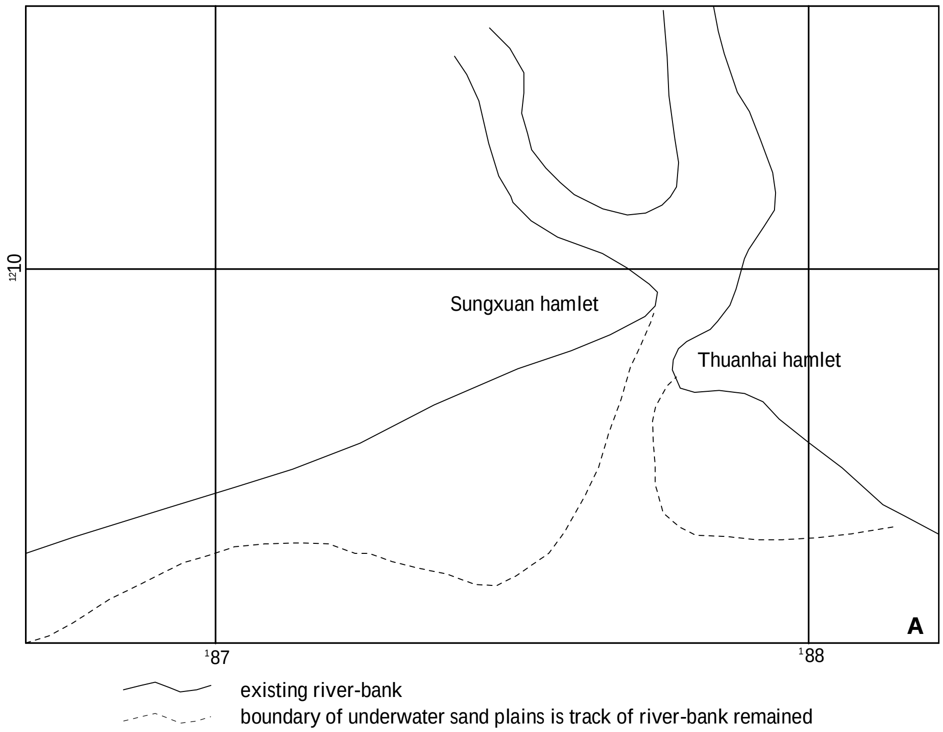

Fig. 10: Form of riverbank at the mouth of Cai river (Phanthiet) (1995)

IV. CONCLUSIONS

Based on the characteristics of the form of relief and litho – hydrodynamics, it is possible to separate the region into two parts:

The inner part: is influenced strongly by tide, river, and flood flows but not by marine dynamical processes such as waves, wave-currents....

The outer part: is influenced not only by actions of tide, river, and flood flows but also by strong direct action of waves, wave - currents, and cross materials flows.

In the inner part, there are always high current module centers at the place, where river-bed is narrow and shallow, so there is always existence of regions, where the material movement depends strongly on the tide phases.

The rule of the development of the mouth of Cai river is as follows:

In normal weather condition (in both dry and flood seasons) materials in the river are pushed from the river to the sea by river and flood flows. A part of them is brought out the region and taken part in other movement processes. The remainder and materials brought by some dynamical processes such as waves, wave-currents...are deposited. They make the bottom of the region be shallow gradually. At last, bottom of the region escapes from influence of tide and the outer part changes into the inner part, which alternately has narrow-shallow, wide-deep shapes. This process continuously develops until it is destroyed by strong dynamical processes happened in special weather phenomena such as high waves, floods.

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