Journal of Marine Science and Technology; Vol. 17, No. 3; 2017: 279-291
DOI: 10.15625/1859-3097/17/3/10592
http://www.vjs.ac.vn/index.php/jmst

IMPACTS OF THE VUNG TAU - GO CONG SEA DYKE ON HYDRODYNAMIC FLOW REGIME

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Received: 3-4-2017

ABSTRACT: The low-lying terrain in downstream area of Sai Gon - Dong Nai river is mostly affected by natural disasters such as flooding, saltwater intrusion causing difficulties in process of socio-economic development. The project of building Vung Tau - Go Cong sea dyke with a length of 32 km was proposed to solve these problems, particularly creating a reservoir for storing water and preventing saltwater intrusion, expanding urban space, industrial parks, tourism, services, shelter for boats from the storm, reserving fresh water in the future. However, hydrodynamic regime in this area would be altered by the construction of Vung Tau - Go Cong sea dyke, causing sedimentation in estuaries, changing salt marsh ecosystems. The comparison between hydrodynamic regimes with two scenarios before and after construction of sea dyke will be mentioned in this paper. In this study, MIKE 21 model was used to simulate hydrodynamic regime in study area. The computed domain is described as follows: Latitude: 1080000 - 1160000 (9º44N - 10º32N); Longitude: 670000 - 770000 (106º33E - 107º33E). The grid which was used in computation was unstructured mesh because it met the requirement of accuracy and detailed computation. Exported data from MIKE 11 model was used as input data for discharge boundary of model. The observed water level data of Vung Tau station and global tide prediction data were used for model calibration and validation. Duration time of model calibration and validation for the research site was from 17/10/2000 to 20/10/2000 and from 21/10/2000 to 24/10/2000 respectively. The calibrated parameter was seabed roughness. The application of model is considered in two scenarios: Without sea dike and with sea dike. Both scenarios show semidiurnal tidal regime in Go Cong - Vung Tau area. Moreover, those confirm that current is mainly influenced by tide and flow of estuaries in coastal area. The construction of sea dike creates two distinct areas: The first area-reservoir including main dike, branch dike and Soai Rap estuary; The second area - Ganh Rai bay containing Long Tau, Thi Vai estuaries and branch dike. There is a significant change in hydrodynamic regime between two scenarios inside reservoir, for example considerable differences in phase, fluctuation amplitude of water level/current. Except for inside the reservoir, there is a small change in phase, fluctuation amplitude of water level/current outside reservoir.

Keywords: Vung Tau, Go Cong, sea dike, hydrodynamic regime.

INTRODUCTION

The downstream area of the Dong Nai river and the Vam Co river covering 10000 km^2 plays an important role in the society and the economy of Vietnam (fig. 1). This area includes Ho Chi Minh city, Dong Thap Muoi (belonging to Mekong Delta river), Vung Tau - Go Cong area and Tien Giang, Long An provinces with dense populations and concentration of business as well as intensely agricultural productions.

Fig. 1. Vung Tau - Go Cong sea dyke project (*Source:* Google Earth 2010)

The relatively low elevation of this area in combination with the increasing extraction of drinking water and the flooding problem from the effect of sea level rise as well as salt intrusion are now of the primary concern of these areas. In short, in the present situation, the study area is located in a complicated system of many estuaries which consist of intensive rivers and channel networks; therefore, it is strongly affected by tide from the sea.

The study area is affected by two main directions of wind: Southwest monsoon and Northeast monsoon and strongly affected by tide from the East Sea, the monsoon as well as flow regime in the Mekong and Sai Gon - Dong Nai rivers. The total flow includes tidal flow, ocean current, river flow and coastal drift. The tidal regime is semi-diurnal tidal, tidal range is 3.5 - 3.6 m. The velocity of flood tide is 0.8 - 0.9 m/s, up to 1.2 m/s and velocity of ebb tide is 1.5 - 1.8 m/s. In the area, topography is flat plain with the average elevation of (+0.7 - +0.8), the highest elevation of (+1.3 - +1.4), the lowest elevation of (+0.4 - 0.5) [1].

With the aim of solving the tidal flooding and salt intrusion (which are the most important problems of the study area), the Ministry of Agriculture and Rural Development (MARD) has proposed to construct a 32 km long dyke system connecting Go Cong and Vung Tau (fig. 1). However, the sea dike could also bring about many disadvantages regarding the environment and navigation. One of the issues is the change in hydrodynamic flow regime in the area in case of having the project. Therefore, this research, will focus on how the dike impacts to the hydrodynamic flow in research site.

METHODS

This study area is complex due to mentioned characteristics such as low elevation, located near large estuaries, influenced by tidal flooding, impacted by flood from Sai Gon - Dong Nai river basin... In order to simulate the hydrodymic flow regime in Go Cong - Vung Tau area in case of having sea dyke, the main method is to use numerical model. The methods applied in this research could be mentioned: a) To analyze marine, meteorological, hydrological data in Go Cong - Vung Tau area; b) To apply a mathematical model to simulate hydrodynamic flow in Go Cong - Vung Tau area; c) To compare differences in the hydrodynamic flow regimes before and after having sea dyke.

HYDRODYNAMIC MODELS

After reviewing several available models, three models were selected for further consideration. The Delft3D was developed by the Deltares Academy; MIKE 3 and MIKE 21 were developed by DHI Water and Environments. One of these models will be chosen in this paper. Finally, MIKE 21 HD FM has been selected.

Governing equation

The basic equations of hydrodynamic mechanism consist of continous equation and momentum equation in *x*-direction and *y*-direction as follows:

$$\frac{\partial h}{\partial t}+\frac{\partial \bar{u}}{\partial x}+\frac{\partial h\bar{v}}{\partial y}=hS \qquad (1)$$

$$\frac{\partial h\bar{u}}{\partial t}+\frac{\partial \bar{u}^{2}}{\partial x}+\frac{\partial h\bar{u}\,\bar{v}}{\partial y}=f\,\bar{v}h-gh\frac{\partial \eta}{\partial x}-\frac{h}{\rho_0}\frac{\partial p_a}{\partial x}-\frac{gh^2}{2\rho_0}\frac{\partial p}{\partial x}+\frac{\tau_{sx}}{\rho_0}-\frac{\tau_{bx}}{\rho_0}$$
$$-\frac{1}{\rho_0}\left(\frac{S_{xx}}{\partial x}+\frac{S_{xy}}{\partial y}\right)+\frac{\partial}{\partial x}\left(hT_{xx}\right)+\frac{\partial}{\partial y}\left(hT_{xy}\right)+hu_sS \qquad (2)$$

$$\frac{\partial h\bar{v}}{\partial t}+\frac{\partial h\bar{u}\,\bar{v}}{\partial y}+\frac{\partial h\bar{v}^2}{\partial x}=-f\,\bar{u}h-gh\frac{\partial \eta}{\partial y}-\frac{h}{\rho_0}\frac{\partial p_a}{\partial y}-\frac{gh^2}{2\rho_0}\frac{\partial p}{\partial y}+\frac{\tau_{sy}}{\rho_0}-\frac{\tau_{by}}{\rho_0}$$
$$-\frac{1}{\rho_0}\left(\frac{S_{yx}}{\partial x}+\frac{S_{yy}}{\partial y}\right)+\frac{\partial}{\partial x}\left(hT_{yx}\right)+\frac{\partial}{\partial y}\left(hT_{yy}\right)+hv_sS \qquad (3)$$

Where: *t:* Time (s); *x*, *y:* Cartesian co-ordinates in horizontal plane (m); *S:* Magnitude of discharge due to point source; *η:* Water level above reference plane (m); *h:* Total water depth, $h = d + \eta$ (m); *d:* Depth below plane of reference (m); $\bar{u},\bar{v}$: Depth - averaged velocity regarding to *x*, *y* directions (m/s); *f:* Coriolis parameter (1/s); *g:* Acceleration due to gravity (m/s^2); *n:* Manning's coefficient ($m^{-1/3}.s$); ρ_a: Density of air (kg/m^3); *ρ:* Density of water (kg/m^3); ρ_0: The reference density of water (kg/m^3); τ_{sx}, τ_{sy}: The x and y components of the suface wind; τ_{bx}, τ_{by}: The x and y components of the bottom stresses; T_{xx}, T_{xy}, T_{yx}, T_{yy}: The lateral stresses, estimated using an eddy viscosity; S_{xx}, S_{xy}, S_{yx}, S_{yy}: Radian stresses; u_s, v_s: Velocity due to point source (m/s).

The discretization in solution domain is performed using a finite volume method. The spatial domain is discretized by subdivision of the continuum into non-overlapping cells/elements (DHI, 2007; DEFLT3D-FLOW manual, 2009) [2, 3].

Model setting

Study area: Based on the Vung Tau - Go Cong map and collected data of bathymetry, an area of interest was chosen. The computed domain is described as follow: Latitude: 1080000 - 1160000 (9ºN44N - 10º32N); Longitude: 670000 - 770000 (106º33E - 107º33E). The fig. 2 shows the study area picked to generate the grid calculation.

Bathymetry: Bathymetric data of the research site was collected from different sources. The measured data in the deep sea was collected from Marine Department that belongs to National Meteo-Hydrology Centre.

Mesh generation: Mesh was generated in Mike Zero, Mesh Generator tool. In this paper, unstructured mesh was used. Fig. 2 presents a picture of computational grid.

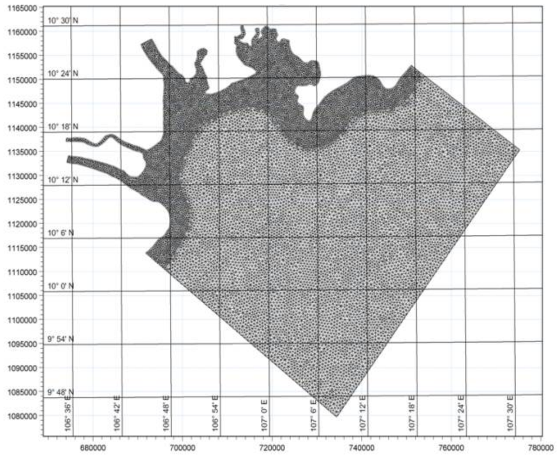

Fig. 2. Computational mesh

Water level boundaries: The northeastern edge, southeastern edge and southwestern edge were defined as open boundary. Time series of water level which was exported from Global Tide, was used by Mike 21 tool box. The fig. 3 shows the locations of 3 sea boundaries.

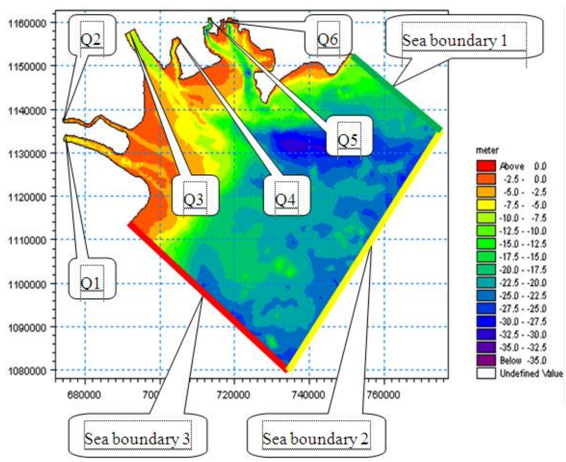

Fig. 3. Locations of river boundaries and sea boundaries

River boundaries: The discharge at river boundary was exported from MIKE 11 [4], the fig. 3 shows 6 locations (Q1, Q2, Q3, Q4, Q5, Q6) of river boundaries and the fig. 4 depicts the hydrographs at corresponding locations.

Table 1. Locations of river boundaries and Vung Tau gauge station

Name	X	Y	Notice
Q1	674560	1134163	Cua Dai river
Q2	673969	1137074	Cua Tieu river
Q3	690661	1157275	Soai Rap river
Q4	704635	1156557	Dong Tranh bay
Q5	712946	1161134	Long Tau river
Q6	716183	1160547	Thi Vai river
VT GS	726655	1142284	Vung Tau gauge station

Model calibration and validation

Model calibration and validation are necessary and critical steps in any model application. Model validation is in reality an extension of the calibration process. Its purpose is to assure that the calibrated model properly assesses all the variables and conditions which can affect model results [1].

Boundary conditions include 6 river boundaries (discharge) and 3 sea boundaries (water level). Discharge at river boundaries which were exported from Mike 11 model were showed in fig. 4 [4]. Water level at sea boundaries were exported from Mike 21 tool box. Time step interval is 5 seconds. This time step is selected so that the CFL number is less than 1 because of the stability restriction using an explicit scheme. Flood and drought is included. Horizontal eddy viscosity which is defined by Smagorinsky formulation, has constant value of 0.28 applied in the whole study area. Coriolis forcing is considered with φ=10 degrees. Initial condition: water level = 0.

In hydrodynamic model, bed resistance is one of the main factors which could impact obviously on the accuracy of results. Therefore in this article, a type of bed resistance that is Manning number is used to calibrate. Firstly, it is assigned to default value M=32 $m^{1/3}/s$, then it is assigned to other values such as: 25, 28, 30, 35, 40. Simulated water level at Vung Tau gauge station from 17/10/2000 01:00 to 20/10/2000 01:00 is used to compare with recorded water level (Location of Vung Tau gauge station is described in fig. 3). Corresponding to every Manning number, Nash-Sutcliffe coefficient is identified. If Nash-Sutcliffe coefficient is approaching 1, then result is acceptable.

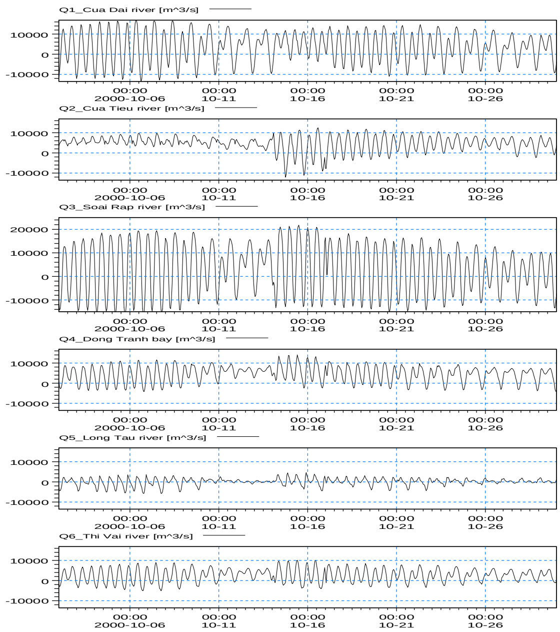

Fig. 4. Hydrographs at river boundaries

Table 2. Nash-Sutcliffe model efficiency coefficient

No	Manning number $m^{1/3}/s$	Nash-Sutcliffe coefficient	Notice
1	25	0.67	
2	28	0.80	chosen value
3	30	0.64	
4	32	-0.25	default value
5	35	-0.46	
6	40	0.61	

Table 2 shows the results in Nash-Sutcliffe coefficient. It can be seen clearly that M = 28 $m^{1/3}/s$ gives the highest Nash-Sutcliffe coefficient (it means giving the best fitness between measured and simulated water surface elevation), therefore M = 28 $m^{1/3}/s$ is a chosen factor.

From fig. 5, in general there is an agreement in phase and fluctuation amplitude between simulated and recorded surface elevation. However, there is a slight difference in fluctuation amplitude of water level. For instance, at low tide (18/10/2000 07:00) error could be up to 20%, at high tide (18/10/2000 14:00) it could be up to 17%.

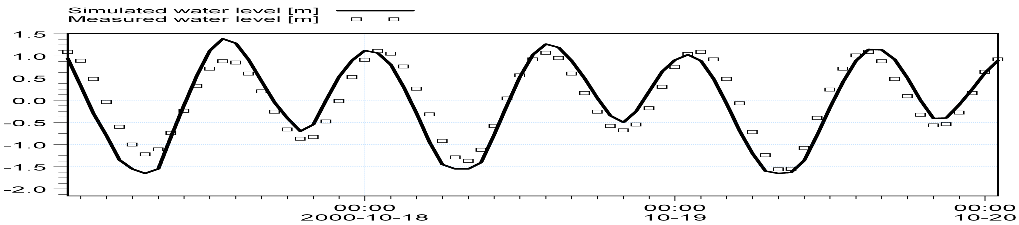

Fig. 5. Model calibration: Comparison between simulated and measured water level at Vung Tau gauge station (M = 28 $m^{1/3}$/s, 17/10/2000 01:00-20/10/2000 01:00)

In short, based on comparison between measured and simulated water level (see fig. 5) and Nash coefficient F^2=0.801 is approaching to 1, therefore parameters of the model calbration are acceptable (see table 3).

Table 3. Parameters after model calibration

Parameter	Value
Module	Hydrodynamics only
Simulation period	17/10/2000 01:00-20/10/2000 01:00
Time step	5s
Flood and drought	Included
River boundary	6 locations of discharge; Type 0 data: *.dfs0
Sea boundary	Exported global tide; Type 1 data; *.dfs1
Coriolis forcing	Included, φ = 10 degrees
Eddy viscosity	Smagorinsky formulation; Constant 0.28
Bed resistance	Manning number M=28 $m^{1/3}$/s

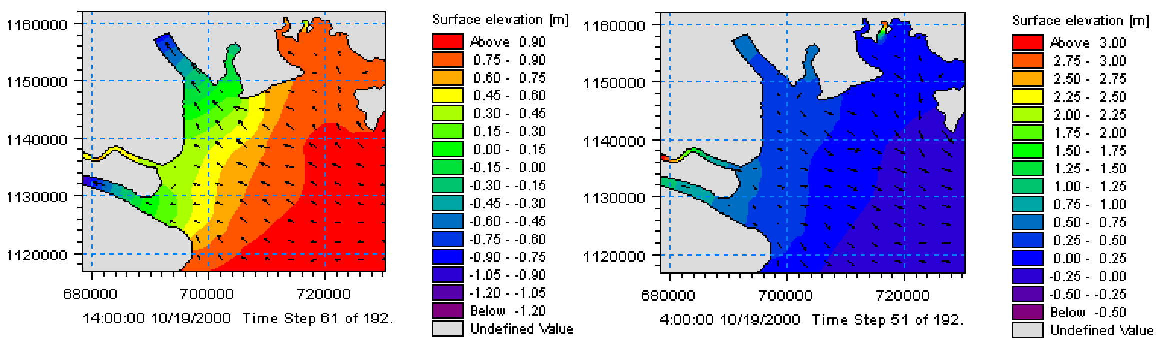

Fig. 6. Surface elevation in model calibration, 17/10/2000 01:00-20/10/2000 01:00 (left hand-flood tide; right hand-ebb tide)

In order to assess accuracy of model as well as find out appropriate parameters which are used for next scenarios, the chosen parameters after model calibration are applied to different simulation period, the so-called model validation. The simulation period in model validation is from 21/10/2000 01:00 - 24/10/2000 01:00. Simulated water level at Vung Tau gauge station is used to compare with observed surface elevation at the same simulation period. If Nash-Sutcliffe coefficient is approaching 1, then validation result is acceptable. Some main results and discussions in model validation are described as follows.

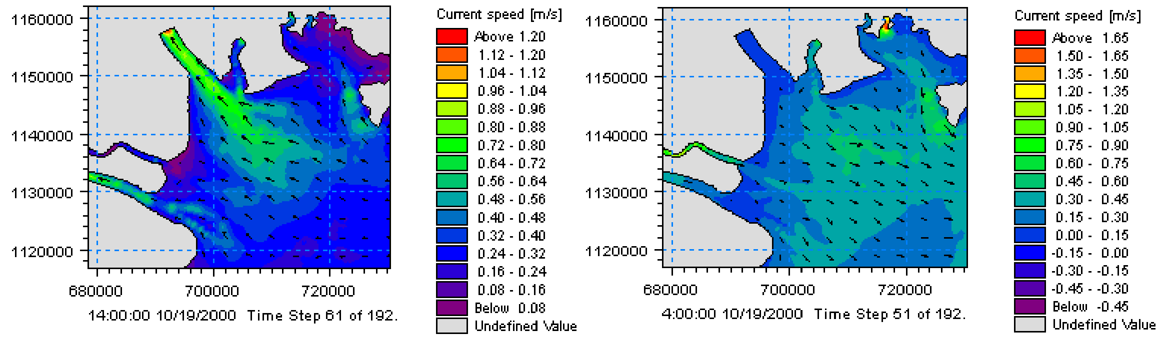

Fig. 7. Current speed in model calibration, 17/10/2000 01:00-20/10/2000 01:00 (left hand-flood tide; right hand-ebb tide)

From fig. 8, in general there is an agreement in phase between simulated and recorded surface elevation. At low tide, a slight difference between simulated and recorded water level is presented. However, there is a remarkable error at high tide, for instance, at 21/10/2000 17:00 error could be up to 20%.

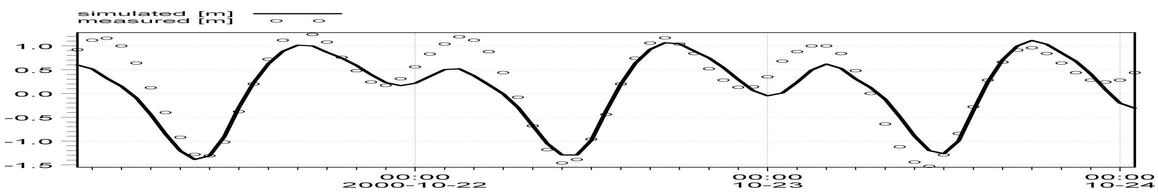

Fig. 8. Model validation: Comparison between simulated and measured water level at Vung Tau gauge station (21/10/2000 01:00 - 24/10/2000 01:00)

In brief, based on comparison between measured and simulated water level (see fig. 8) and Nash coefficient F^2=0.81 which is approaching 1, results of model validation are acceptable, therefore parameters of model are applied to calculate in following scenarios.

APPLICATION

Based on the results of model calibration and validation, the good model parameters were selected and a good model has been obtained which can be used for further application. In this paper two scenarios were considered as follows.

The 1st scenario: Without sea dike, time calculation from 17/10/2000 to 24/10/2000.

The 2nd scenario: With sea dike, time calculation from 17/10/2000 to 24/10/2000. In this paper, only one scenario of 3000 m width gate and in the main dyke is taken into account. The form of flow through the sluice is free.

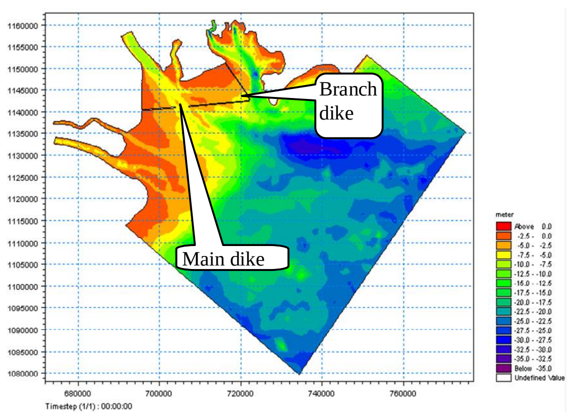

Fig. 9. Computational domain in the second scenario, with sea dike

In this research, one scenario with a gate of 3000 m wide located in main dyke was considered. In fact, there are several options of gate width such as: B=700 m; 1000 m; 2000 m that need to be simulated in order to find the best option of gate width based on current speed and other environmental conditions. In the future, these options should be done in other study (see fig. 9 and table 4).

Table 4. Design parameters of sea dike and sluice in the second scenario

No	Features	Dike	Sluice
1	Top elevation	+5 m	+5 m
2	Width	30 m	
3	Slope in river	2.5	
4	Slope in sea	3	
5	Shape	Trapezium	Rectangle
6	Width of sluice		b=3000 m
7	Form of flow		Free flow

Results and discussion

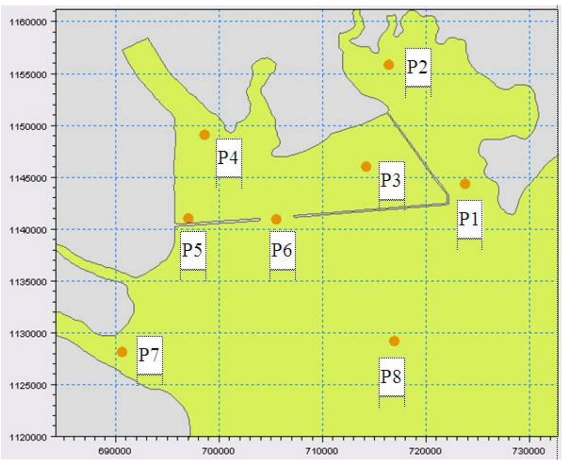

Fig. 10. Locations of exported results

The construction of sea dike creates two distinct areas: The first area - reservoir including main dike, branch dike and Soai Rap estuary; The second area - Ganh Rai bay containing Long Tau, Thi Vai estuaries and branch dike. The super sea dike has altered hydrodynamic regime in the study area. In this paper, two main factors that are of interest are surface elevation and current. These changes can be showed clearly at the first area - inside reservoir. Results were exported at points P1, P2, P3, P4, P5, P6, P7, P8 (see fig. 10).

Surface elevation

Water level elevation in two scenarios without sea dike and with sea dike is presented at fig. 11, 12, 13, 14. The similarity in two scenarios is that irregularly semidiurnal tidal regime showed in research site in which the number of days with two times of high tide and low tide in a day dominated in simulation time. The significant differences between two scenarios are the change in water level in the reservoir and the difference in water level inside and outside the reservoir in case sea dike is built.

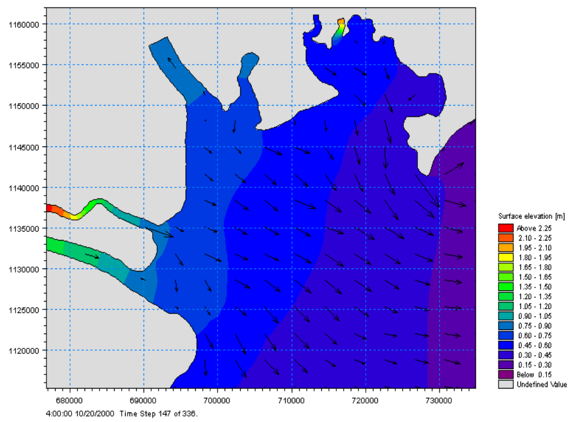

Fig. 11. Surface elevation at ebb tide, 10/20/2000 4:00, first scenario

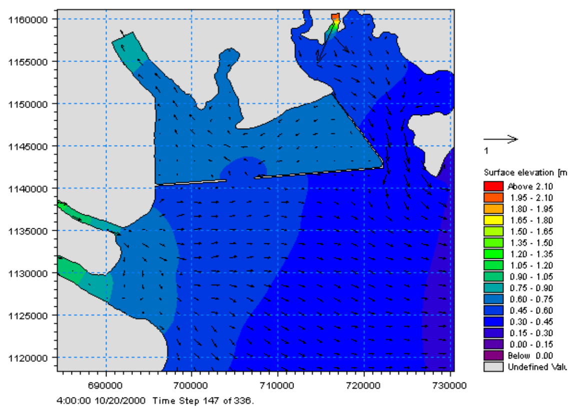

Fig. 12. Surface elevation at ebb tide, 10/20/2000 4:00, second scenario

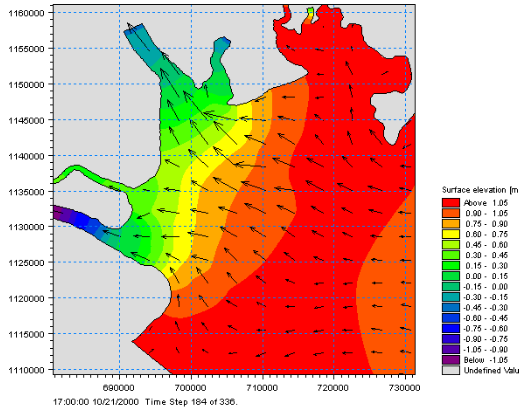

Fig. 13. Surface elevation at flood tide, 10/21/2000 17:00, first scenario

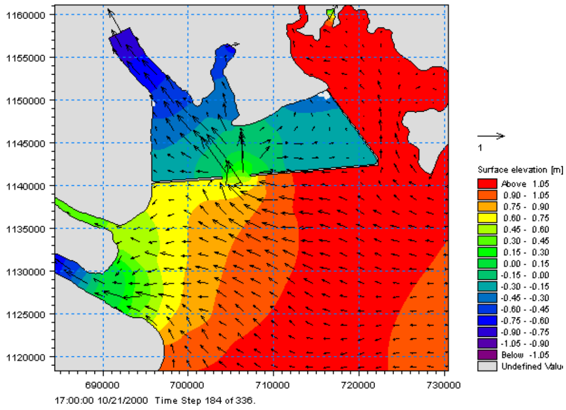

Fig. 14. Surface elevation at flood tide, 10/21/2000 17:00, second scenario

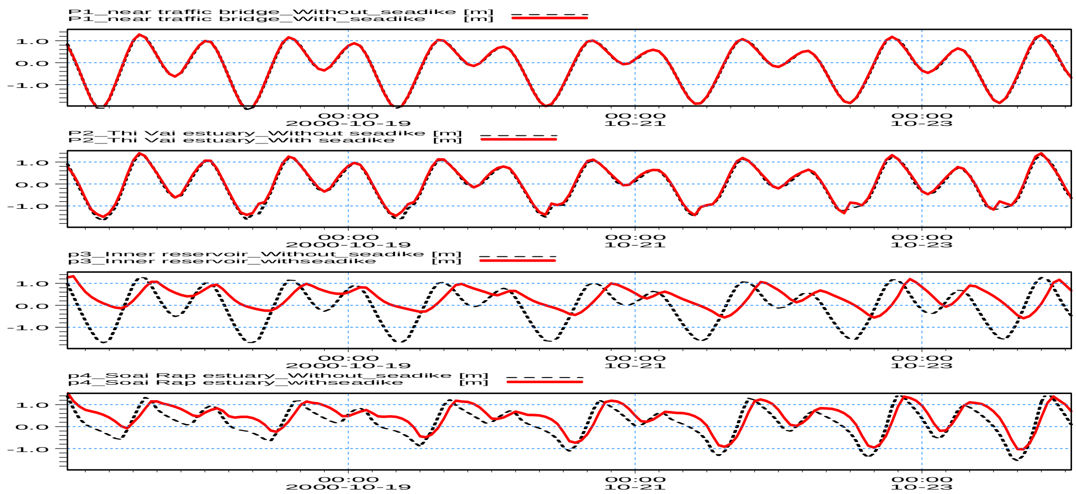

Fig. 15. Comparison of water level elevation between two scenarios at P1-P4

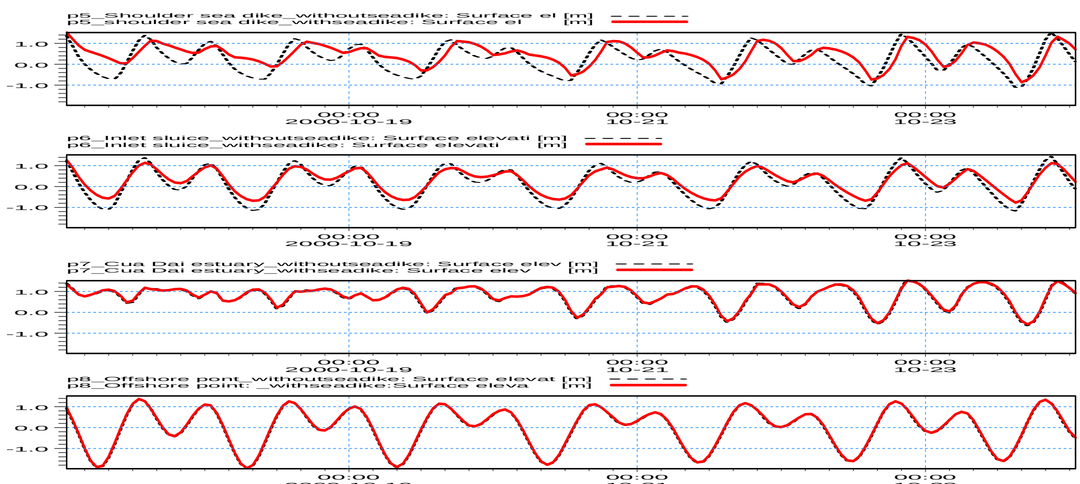

Fig. 16. Comparison of water level elevation between two scenarios at P5-P8

The view of altering surface elevation in reservoir is shown by P3-inner reservoir; P4-Soai Rap estuary; P5- Shoulder sea dike and P6-Inlet sluice (see fig. 15, 16).

At P3, water level phase in second scenario is slower than in first scenario nearly 2-3 hours. On the other hand, water level fluctuation at this point has also changed obviously, in detail, in the first scenario fluctuation amplitude between low tide and following high tide is remarkable nearly 3 m, meanwhile in the second scenario this amplitude is merely 1.5 m. Moreover, at the same point, the speed of falling surface elevation in the second scenario is smaller than in the first one. The changes in phase, amplitude fluctuation, and speed of falling water level due to the sea dike construction will create a reservoir with functions: water detention and regulation.

Unlike inner reservoir point P3 where remarkable alteration in phase and amplitude of surface elevation occurs, other points inside reservoir such as: Soai Rap estuary P4, shoulder sea dike P5 and inlet sluice P6 witness a slight change in amplitude and phase. Similar to P4, P5 and P6, other points outside reservoir such as: Cua Dai estuary P7 and offshore point P8 witness the same situation of phase and amplitude of surface elevation between two scenarios.

As mentioned above, there is a considerable difference in surface elevation between inside and outside reservoir in two scenarios. Fig. 17 shows that in the first scenario, water level at P3 (inside lake) and P2, P8 (outside lake) is slightly different. In contrast, in the second scenario water surface inside lake is often higher than outside lake and water phase inside lake is slower than outside lake. At low tide in the second scenario, the difference in surface elevation between inside and outside lake could be up to 1.5 m (see fig. 18).

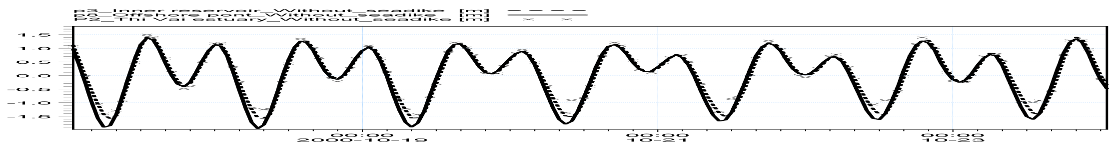

Fig. 17. Comparison of water elevation between inside and outside reservoir, without sea dike scenario

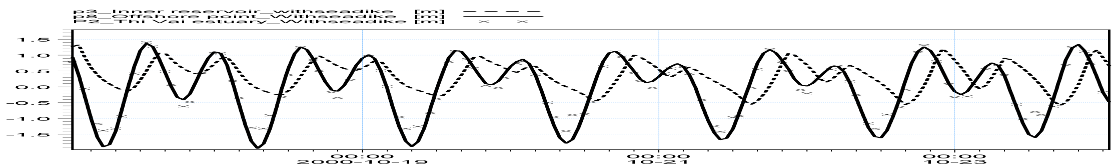

Fig. 18. Comparison of water elevation between inside and outside reservoir, with sea dike scenario

Table 5. Comparison of extreme water level between two scenarios at P1-P8

Locations	Water Level (m)	Without sea dike	With sea dike	Up/down (%)	Locations	Water Level (m)	Without sea dike	With sea dike	Up/down (%)
P1. Near traffic bridge	H_{max}	1.56	1.41	-10%	P5. Shoulder sea dike	H_{max}	1.86	1.93	4%
	H_{min}	-1.98	-1.89	-5%		H_{min}	-1.24	-1.21	-2%
P2. Thi Vai estuary	H_{max}	1.63	1.54	-6%	P6. Inlet sluice	H_{max}	1.75	1.70	-3%
	H_{min}	-1.53	-1.39	-9%		H_{min}	-1.67	-1.18	-30%
P3. Inner reservoir	H_{max}	1.65	1.80	9%	P7. Cua Dai estuary	H_{max}	1.96	1.84	-6%
	H_{min}	-1.62	-0.90	-45%		H_{min}	-0.62	-0.59	-5%
P4. Soai Rap estuary	H_{max}	2.05	2.02	-1%	P8. Offshore point	H_{max}	1.51	1.47	-3%
	H_{min}	-2.00	-1.43	-29%		H_{min}	-1.95	-1.94	0%

Current

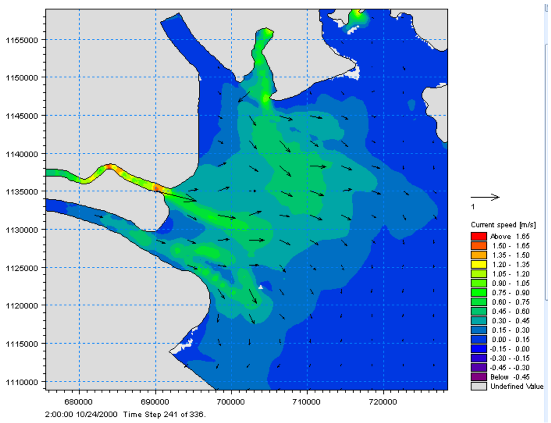

Fig. 19. Current speed at ebb tide, 10/24/2000 2:00, first scenario

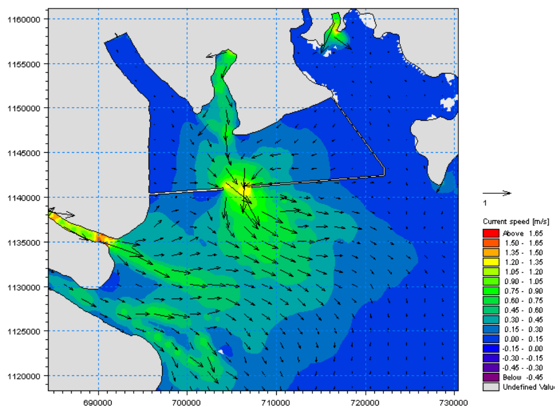

Fig. 20. Current speed at ebb tide, 10/24/2000 2:00, second scenario

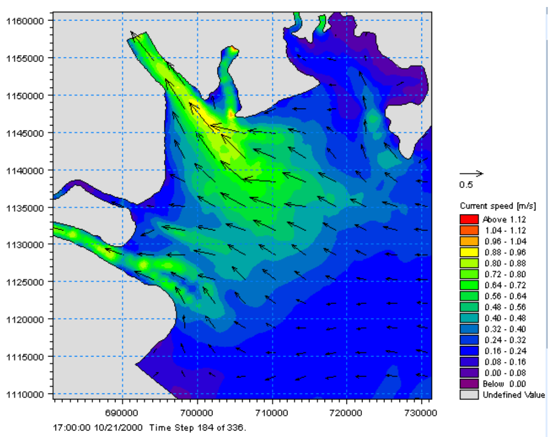

Fig. 21. Current speed at flood tide, 10/21/2000 17:00, first scenario

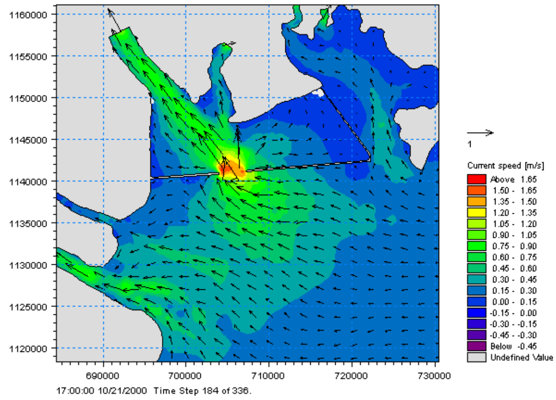

Fig. 22. Current speed at flood tide, 10/21/2000 17:00, second scenario

The current at flood tide and ebb tide in two scenarios is shown at fig. 19, 20, 21, 22. The similarity in two scenarios is that in coastal area, the current is influenced mainly by tide and flow of estuaries. The differences of speed and direction of current between two scenarios in the reservoir are shown at points: P3 - inner reservoir; P4 - Soai Rap estuary; P5 - shoulder sea dike and P6 - inlet sluice (see fig. 23, 24).

The marked change in current is presented at inlet sluice P6 where current is most concentrated in with sea dike scenario. At this point, current speed in the second scenario which is twice that in the first one could be up to 1.69 m/s. The dominant direction is Northwest-Southeast (see fig. 24 and tab. 6).

Unlike inlet sluice point P6 where only a change in current speed occurs and there is no alteration in current phase, at inner reservoir point P3 a remarkable alteration occurs not only in phase but also in current amplitude. In without sea dike scenario, this location belongs to interference region between flows from Ganh Rai bay and Soai Rap estuary; therefore current speed is quite low, about 0.3 m/s. However, in the second scenario the current speed declines to 0.15 m/s. This low current speed and enormous volume of alluvium from upper stream could lead to a high risk of deposition at inner reservoir region.

One of interesting places is the coastal line from Soai Rap estuary to shoulder of main sea dike (near to P5). In reality, soil erosion often occurs in this area. According to Hung (2011) [5], the main cause is the flow at Soai Rap estuary. The current from north to south results in soil erosion, brings sediment to area that is an interference region between Soai Rap estuary and Cua Tieu with low current speed, resulting in deposition. The construction of sea dike would create low circular current speed and small phase fluctuation at this location, therefore coastal erosion could be diminished. (see fig. 24, point P5).

Outside reservoir, one location that should be mentioned is near traffic bridge P1. In case sea dike is built, cross section at this area would be reduced, therefore current speed would be increased. From fig. 23 and table 6, it could be up to 1.11 m/s (up to 21%). The increase in current speed could lead to the risk of erosion of seabed at this region.

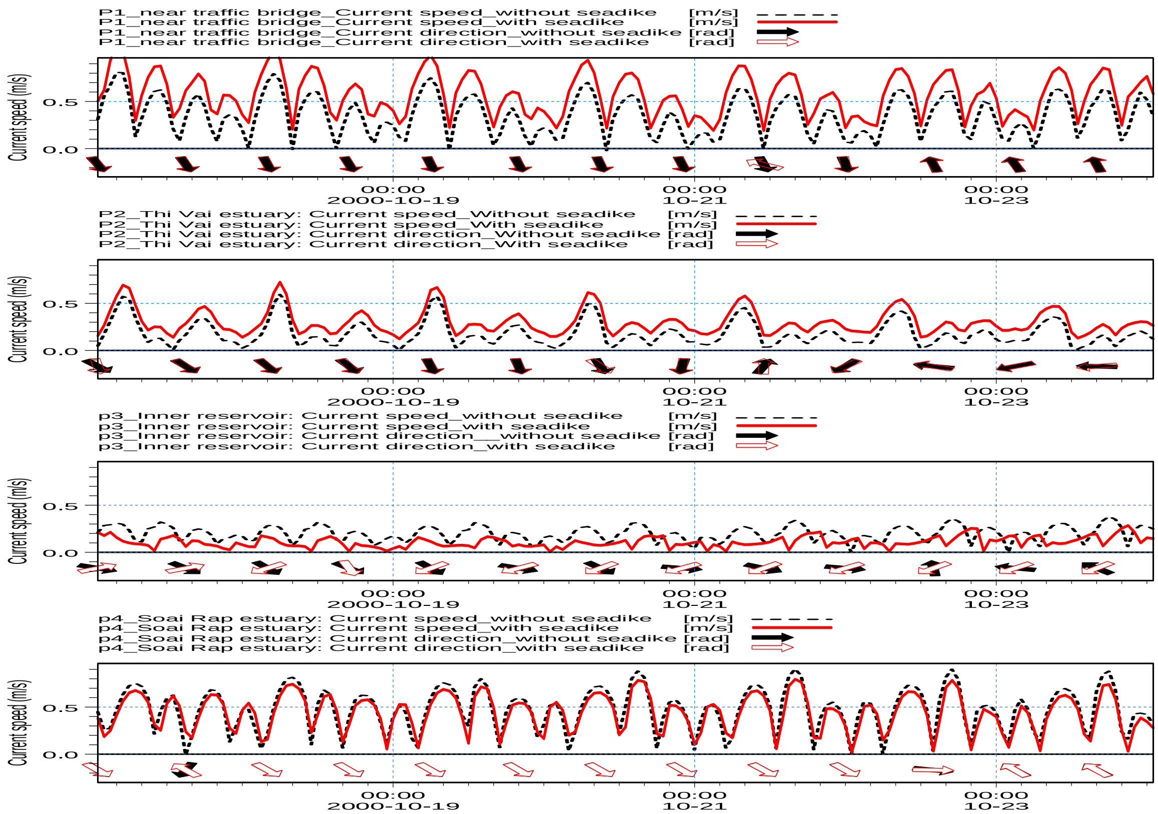

Fig. 23. Comparison of current between two scenarios at P1-P4

Table 6. Comparison of extreme current speed between two scenarios at P1-P8

Locations	Current Speed (m/s)	Without sea dike	With sea dike	Up/down (%)	Locations	Current Speed (m/s)	Without sea dike	With sea dike	Up/down (%)
P1. Near traffic bridge	V_{max}	0.92	1.11	21%	P5. Shoulder sea dike	V_{max}	0.38	0.24	-37%
P2. Thi Vai estuary	V_{max}	0.61	0.65	7%	P6. Inlet sluice	V_{max}	0.86	1.69	96%
P3. Inner reservoir	V_{max}	0.43	0.45	5%	P7. Cua Dai estuary	V_{max}	0.85	0.83	-2%
P4. Soai Rap estuary	V_{max}	0.92	0.80	-14%	P8. Offshore point	V_{max}	0.61	0.61	0%

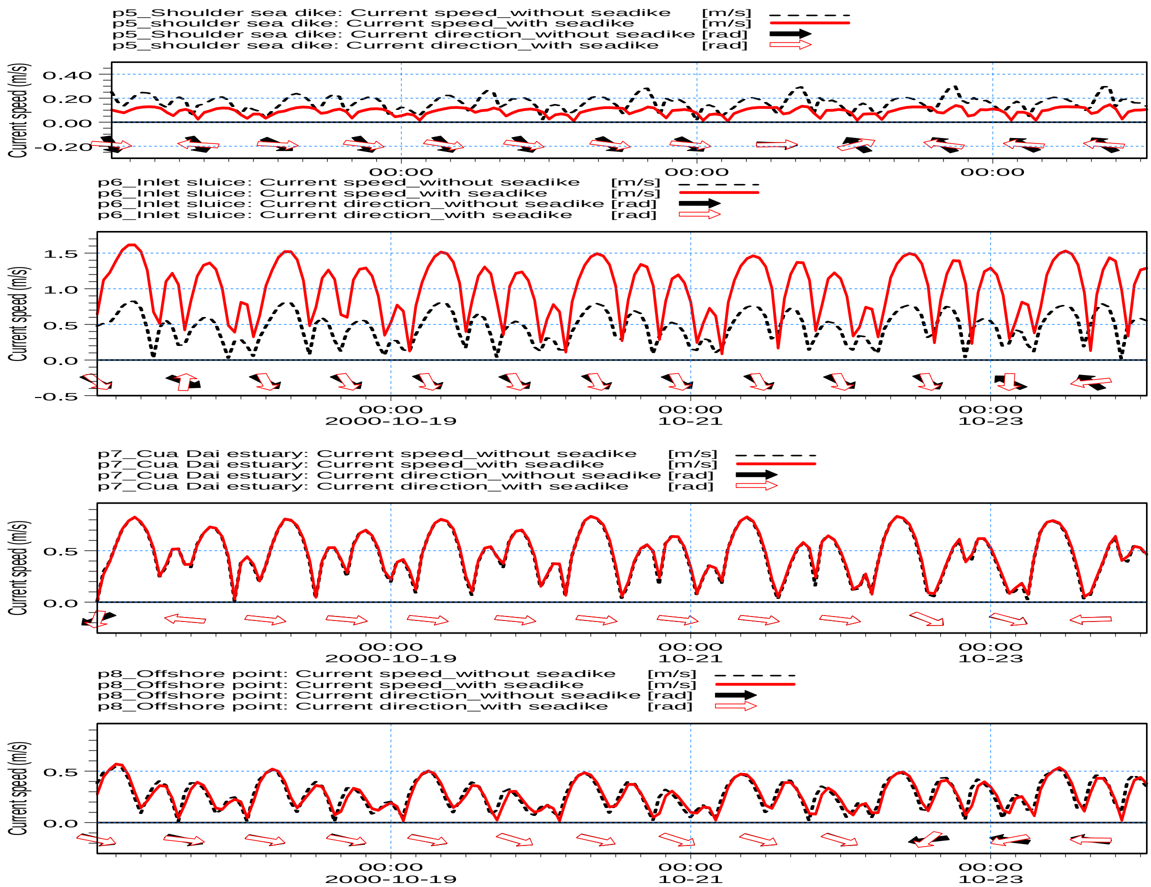

Fig. 24. Comparison of current between two scenarios at P5 -P8

In other locations such as Cua Dai estuary P7, offshore point P8, a small change in phase, speed, and direction of current is presented (see fig. 24).

CONCLUSIONS AND RECOMMENDATIONS

Conclusions

Some results are taken into account:

The paper has reviewed the estuaries that are influenced by tide in Mekong delta and the related researches on the lower area of Sai Gon - Dong Nai river basin. Moreover, hydrodynamic models are reviewed.

The paper used MIKE 21 HD FM model to simulate hydrodynamic processes in Go Cong - Vung Tau area (surface water, current and tide) corresponding to two scenarios: Without sea dike and with sea dike.

The result of model calibration and validation of water level at Vung Tau gauge station is quite good, therefore we can use this model to quantify hydrodynamic flow regime in Go Cong - Vung Tau area. Some assessments are considered:

Two scenarios both presents irregularly semidiurnal tidal regime in Go Cong - Vung Tau region.

From result of current, both scenarios show that current is mainly influenced by tide and flow of estuaries in coastal area.

There are considerable differences in phase, fluctuation amplitude and speed of falling water level at inner reservoir between two scenarios.

The construction of sea dike creates two distinct areas: The first area - reservoir including main dike, branch dike and Soai Rap estuary; the second area - Ganh Rai bay containing Long Tau, Thi Vai estuaries and branch dike. There is a significant difference in surface water level between inside and outside reservoir in with sea dike scenario.

The marked change in current is presented at inlet sluice in the second scenario, it could be up to 1.69 m/s.

The construction of sea dike would create low circular current speed and small phase fluctuation at shoulder of main sea dike or at inner reservoir, therefore coastal area that is adjacent to Cua Tieu estuary could be less eroded in one hand, the sedimentation at inner reservoir would occur in other hand.

The branch sea dike could lead to a decrease of cross section near traffic bridge. As a result, an increase in current speed could cause erosion in seabed at this region.

Except for inside the reservoir, there is a small change in phase, speed, and direction of current at offshore region.

Recommendations

In order to obtain comprehensive impacts of sea dike on natural condition, the other studies such as: Water quality, salt intrusion, sedimentation transport,... need to be conducted.

In reality, mangrove exists at coastal line from Soai Rap estuary to Ganh Rai bay. The appearance of mangrove could impact on tidal current, for example delaying phase of tidal current. In this article, the boundary of model has not yet described the role of mangrove. The following research could concern this issue to get more accurate results.

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