Application of hydrodynamic-sediment model for wave and cohesive sediment in Ciasem Estuarine Indonesia

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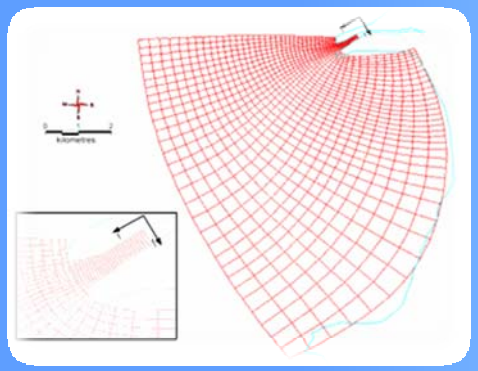

IWMO 2nd
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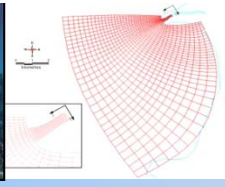
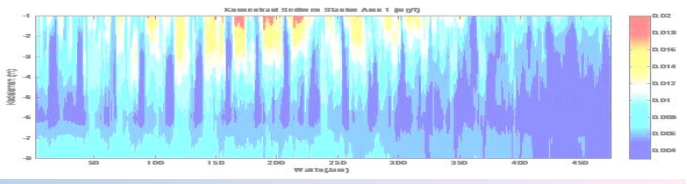
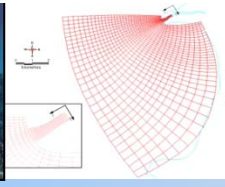
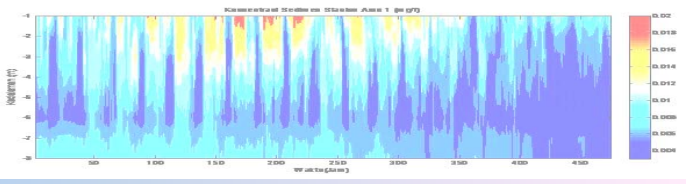



Introduction

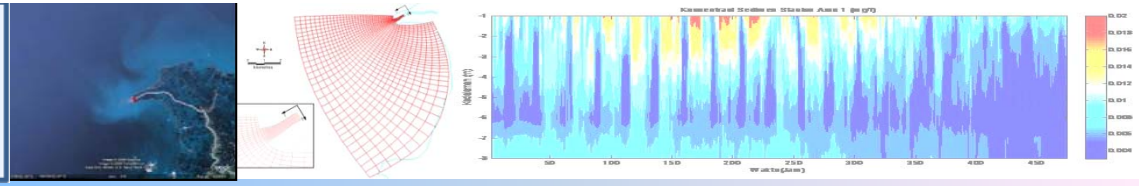
- The aims of the paper are to apply 3D Hydrodynamic-sediment model especially for cohesive sediment in real data feature in case of Ciasem Estuarine case study and Apply wave propagation model embedded
- Benefits of 3D model are vertical variation and more precisely when calibrated with field data.





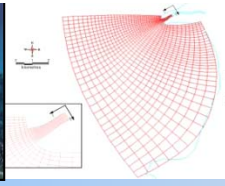
Model Outline

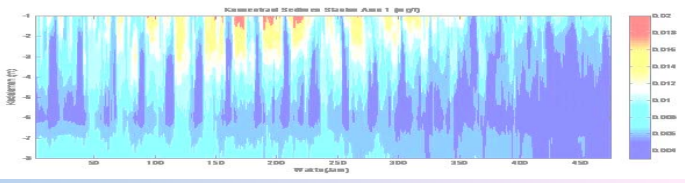
- Governing equation is transformed into curvilinear system and sigma-σ coordinate system.
- A 3D-dimensional finite difference model system for hydrodynamics and cohesive sediment transport ECOMSED solves the Navier-Stokes equation with a free surface boundary condition and the advection-diffusion equations of temperature, the salinity and any other variable



Model Outline (2)

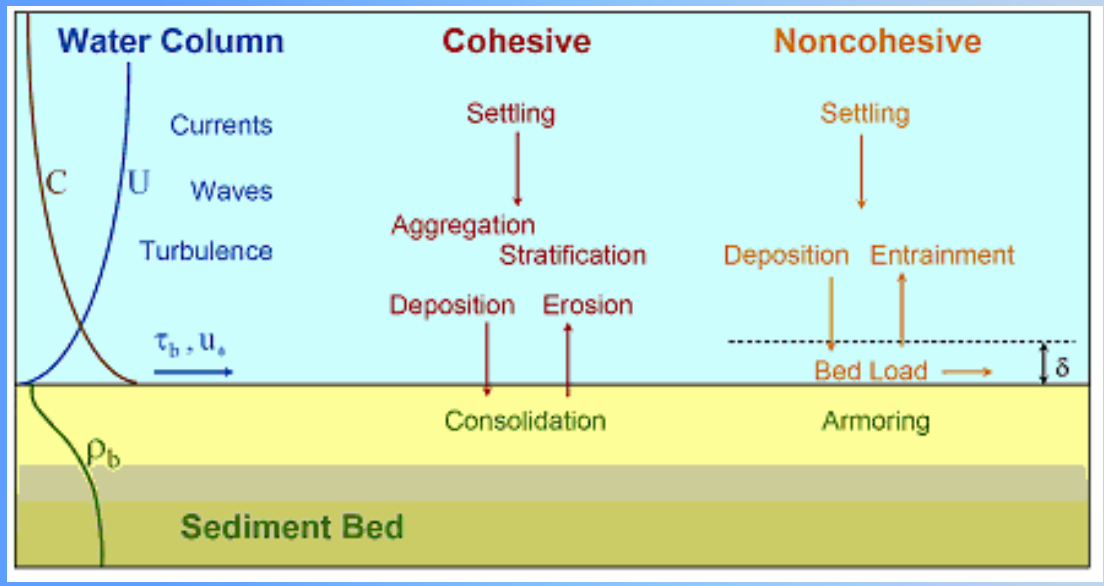
- A Wave propagation model by SWAN is implemented in order to include wave induced current effect on final result.
- In present stage, the wave model is separately process. In future, it is designed to couple model.



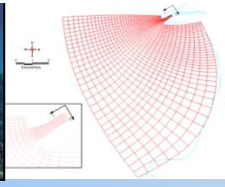
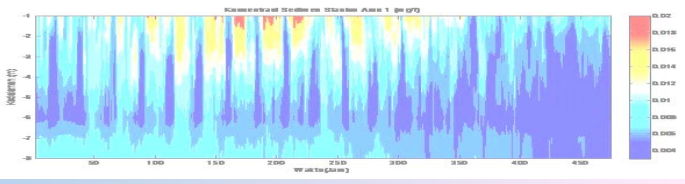


Cohesive Sediment Transport Model

- The important factors in sediment transport model are particle size and distribution, density of mass, shape, settling velocity and the resistance to erosion



Interaction process in cohesive sedimentation (*Hydroqual, 2002*)

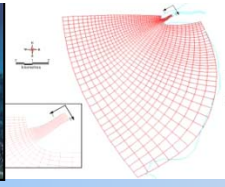
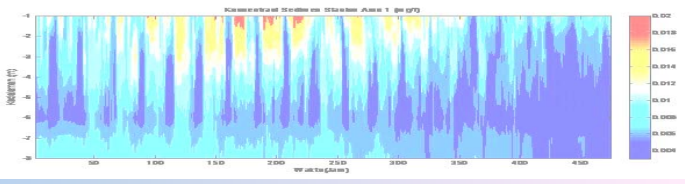




Cohesive Sediment Transport Model

- Govern Equation

$$\frac{\partial C_k}{\partial t}+\frac{\partial (uC_k)}{\partial x}+\frac{\partial (vC_k)}{\partial y}+\frac{\partial (wC_k)}{\partial z}+\frac{\partial (w_{s,k}C_k)}{\partial z}$$
$$=\frac{\partial}{\partial x}\left(A_H\frac{\partial C_k}{\partial x}\right)+\frac{\partial}{\partial y}\left(A_H\frac{\partial C_k}{\partial y}\right)+\frac{\partial}{\partial z}\left(K_H\frac{\partial C_k}{\partial z}\right)$$

Where : (Ck) is sediment concentration for class-k. (AH) is diffusion coefficient for horizontal, (KH) is eddy-diffusivity for vertical. u,v, and w are the velocities in x,y, and z -directions.

Resuspension and Deposision of Cohesive Sediment

- Resuspension

$$\varepsilon = \frac{a_0}{T_d^m}\left(\frac{\tau_b - \tau_c}{\tau_c}\right)^n$$

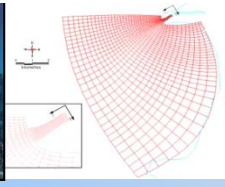
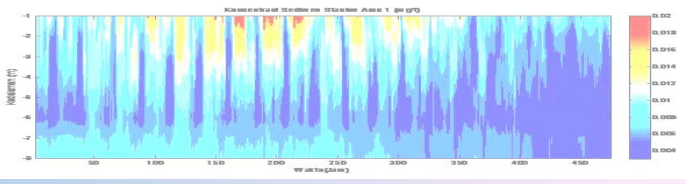
(Gailani et al., 1991)

$$E_{tot} = \frac{\varepsilon}{3600\ second}$$

(Tsai and Lick, 1987; MacIntyre et al., 1990)

$$E_k = f_k . E_{tot}$$

(Gailani et al., 1991)

Resuspension and Deposition of Cohesive Sediment

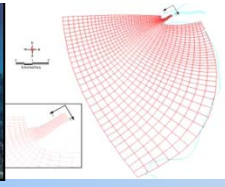
- Deposition

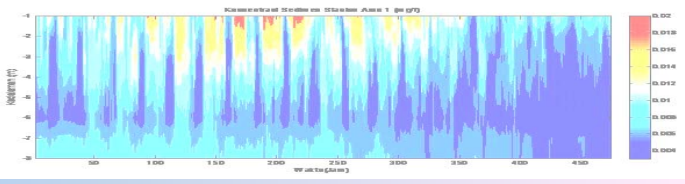
$$D_l = -W_{s,l} C_l P_l$$ Krone (1962)

Where D_l is Depositional flux (g cm-2 s-1), $W_{s,l}$ is deposition speed due to flocs (cm s-1), C_l is cohesive sediment concentration in suspension state (g cm-3), P_l is the probability of occurance for deposision

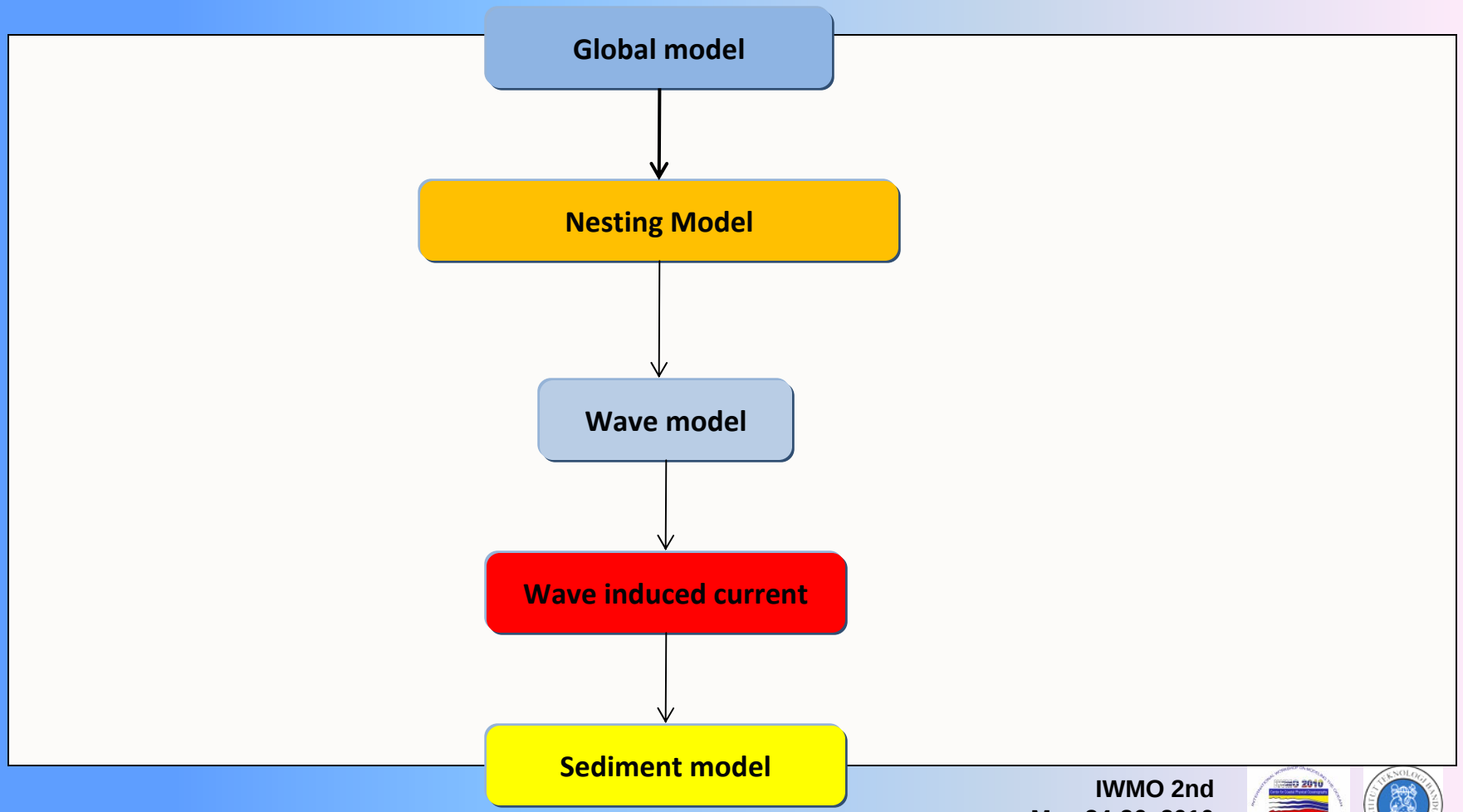
$$P_l = \begin{cases} 1 - \frac{\tau_b}{\tau_d}, & \tau_b \leq \tau_d \\ 0, & \tau_b > \tau_d \end{cases}$$ Krone (1962)

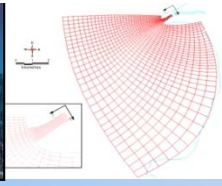
Where τ_d is bottom shear stress and τ_b is critical bottom stess (both in dynes cm-2)

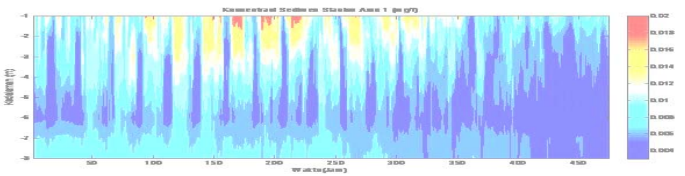




Model Design

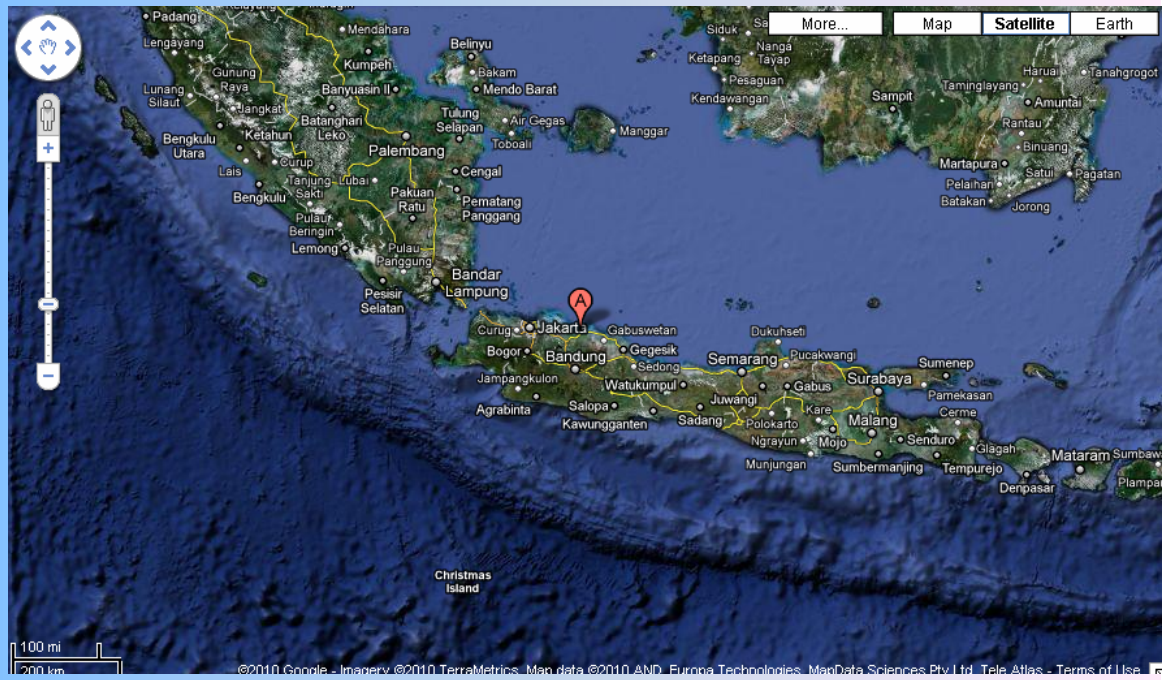




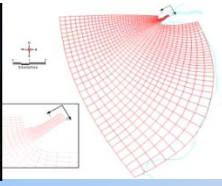
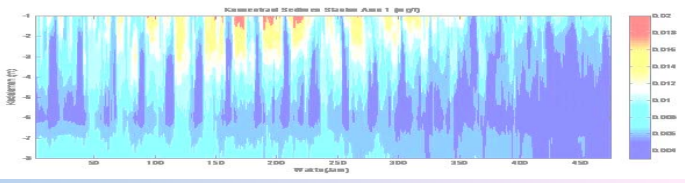


STUDY AREA

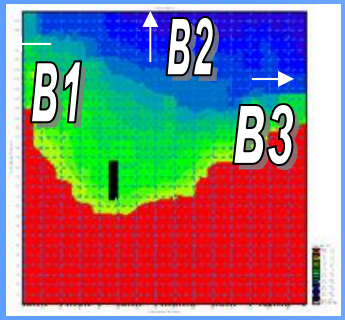
source: *Google Earth*



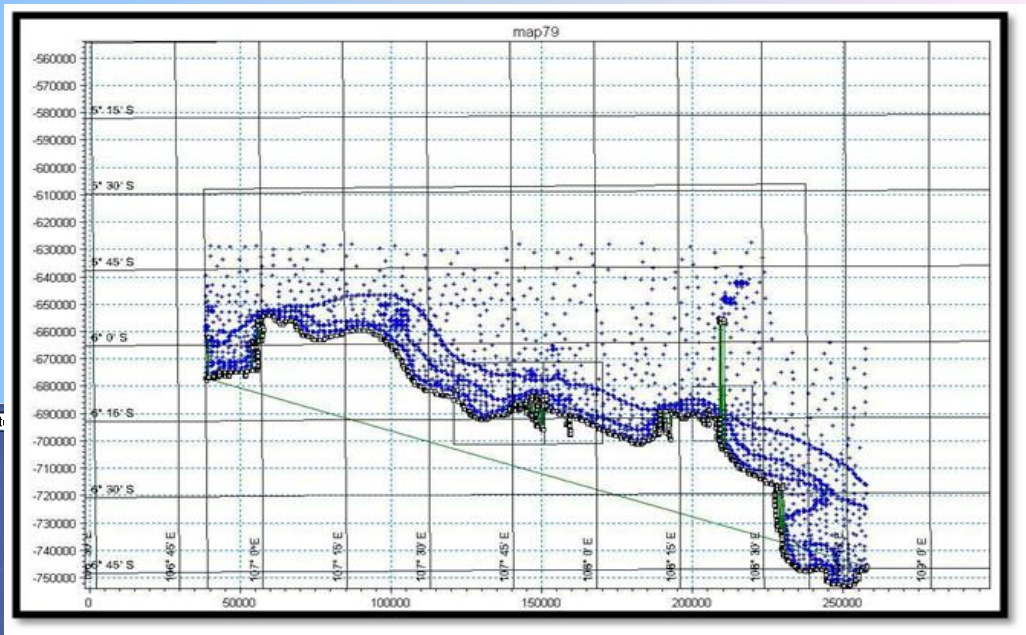
Location of Ciasem Estuarine at West of Java - Indonesia

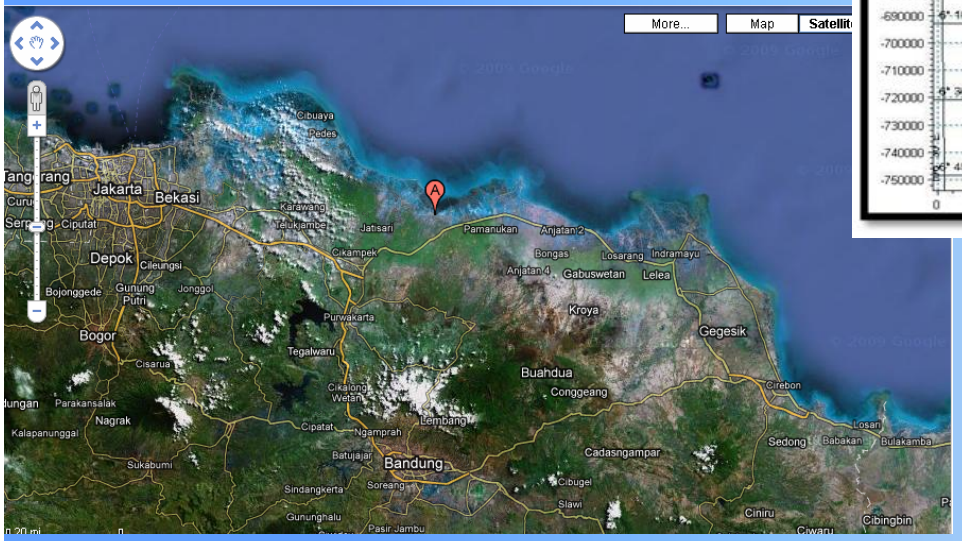
Global Model (MIKE-21)

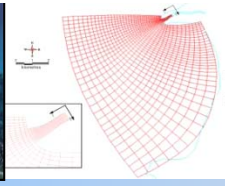


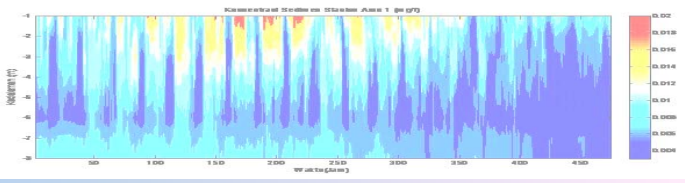
Discreetization and BC for Global model



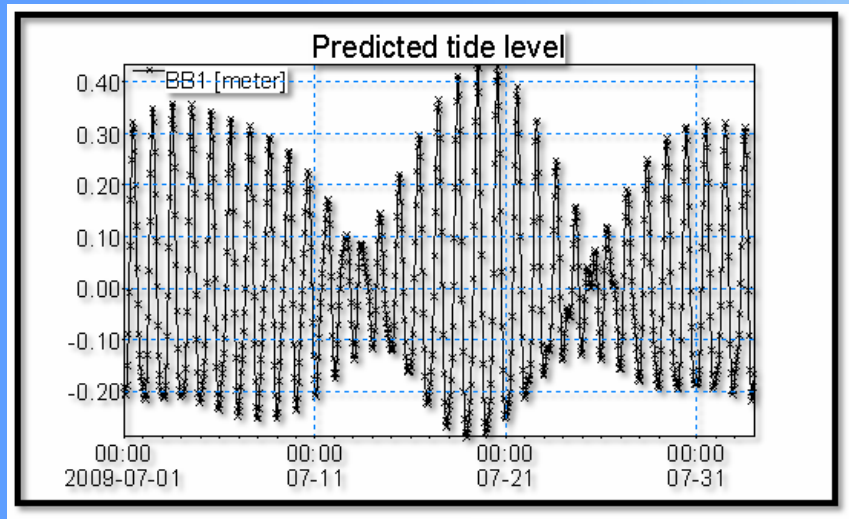
Bathymetric data for Global model

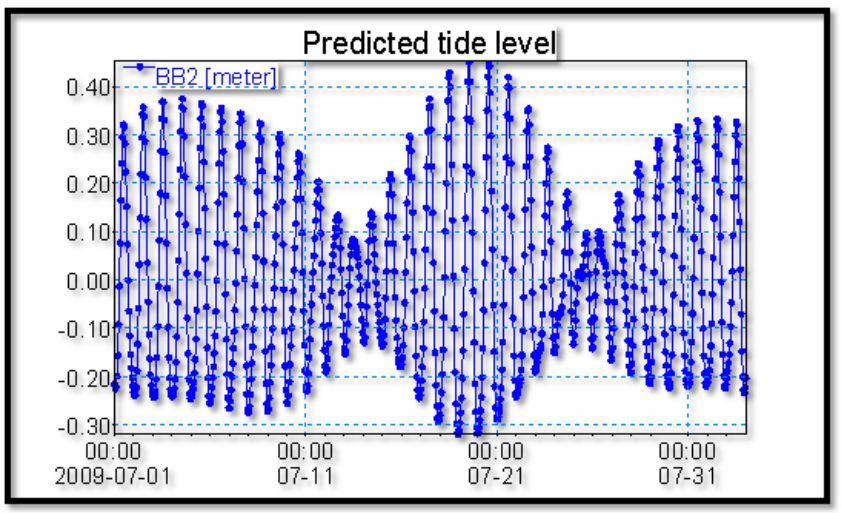


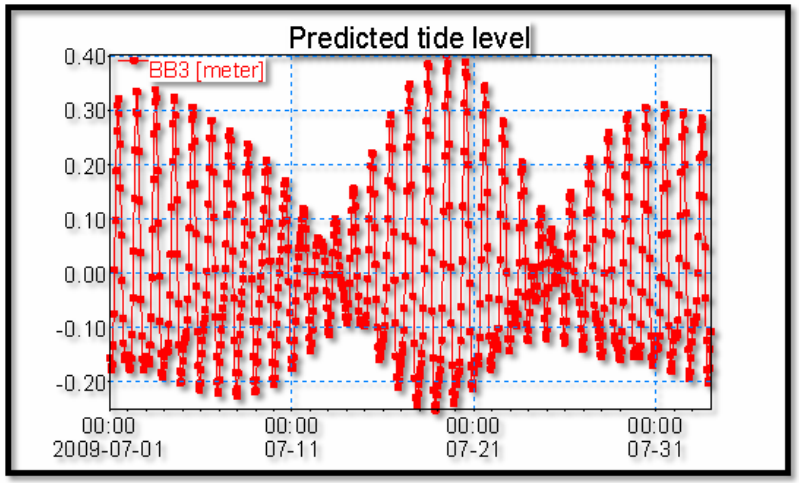


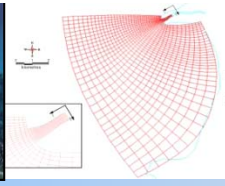


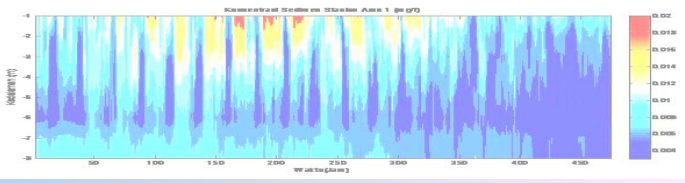
Boundary Conditions (MIKE21)



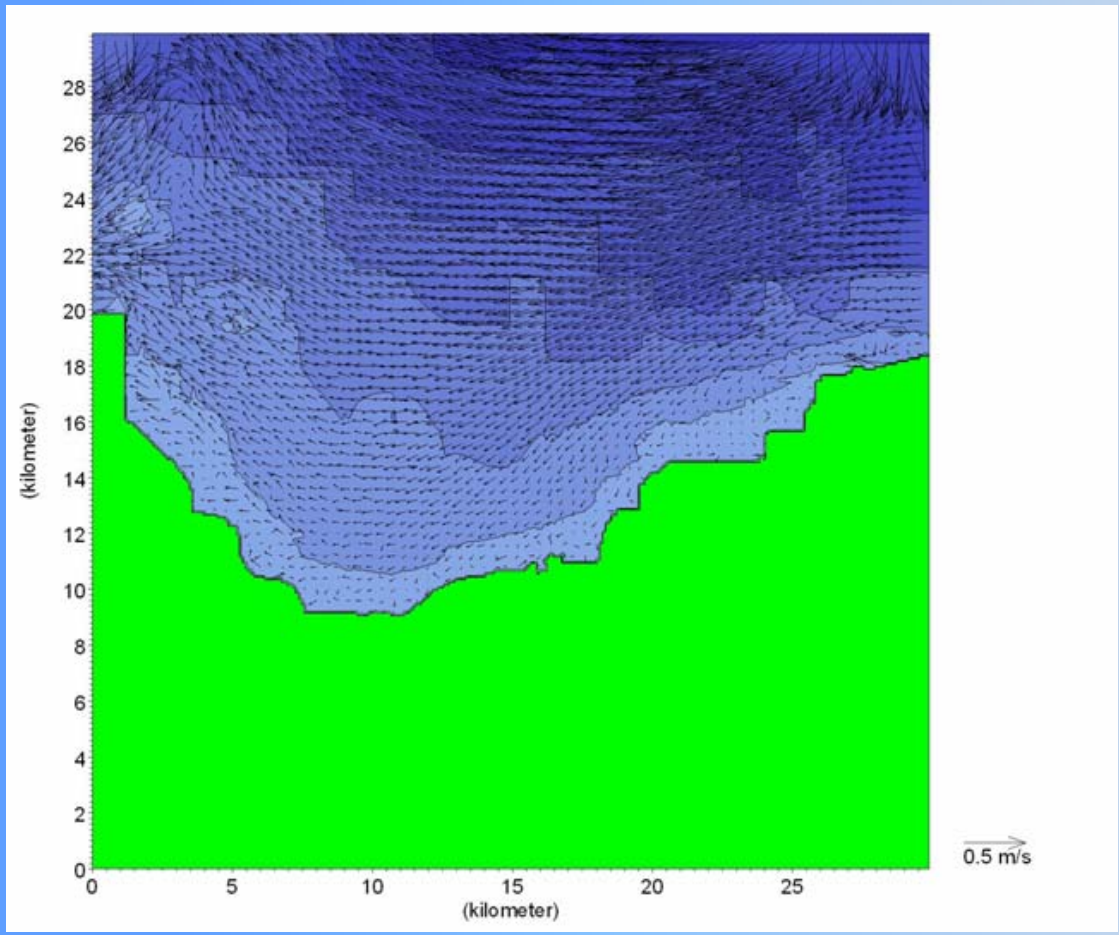




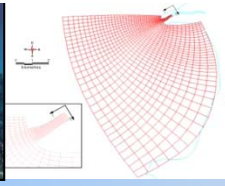


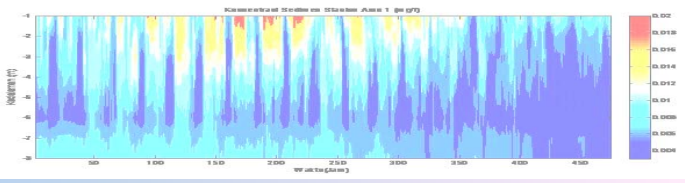


Hydrodynamic Result 1

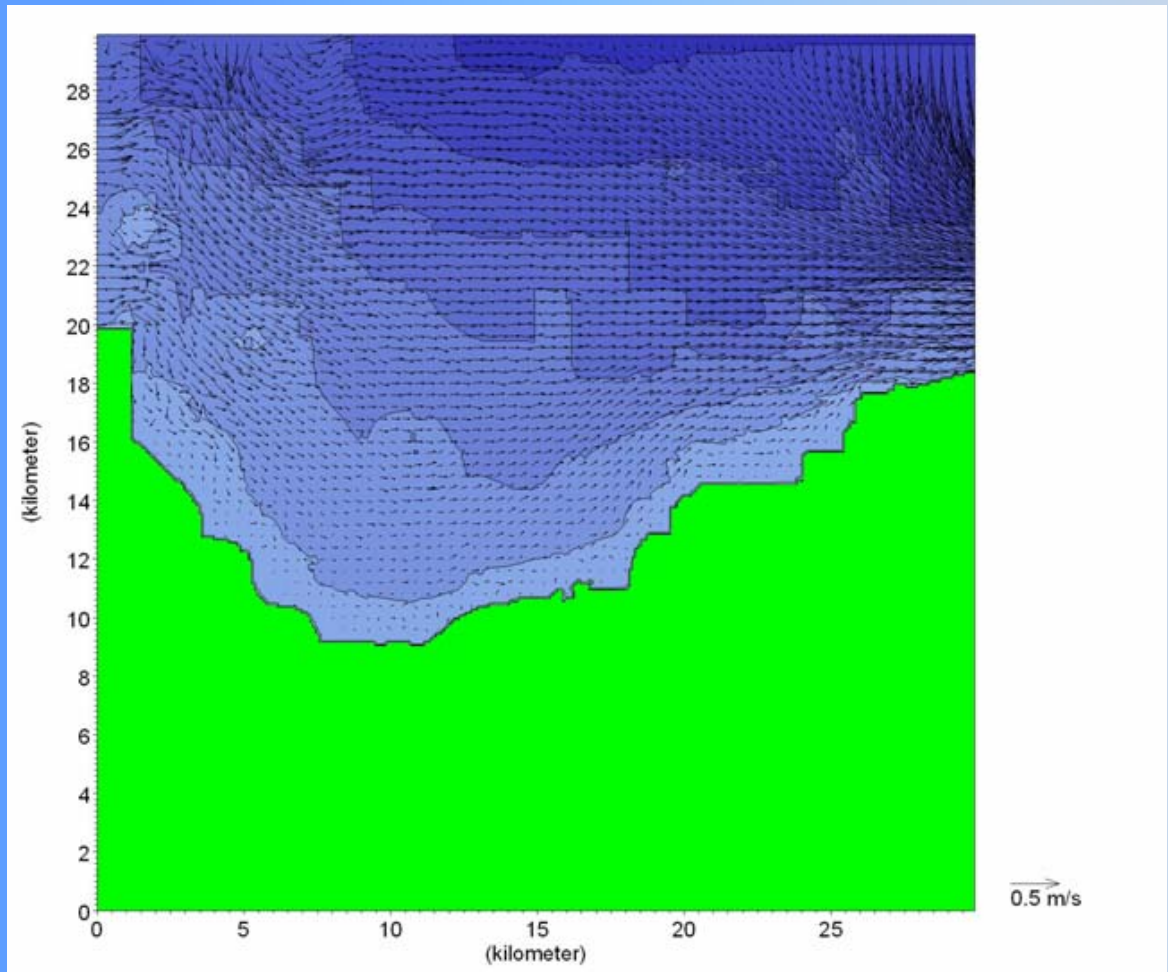


Spring tide condition

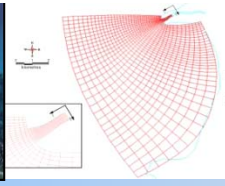


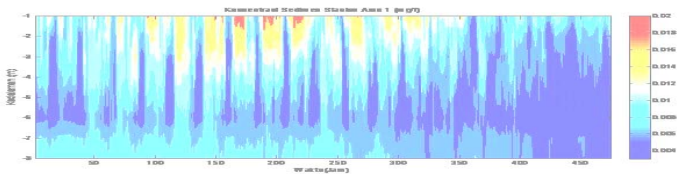


Hydrodynamic Result 2

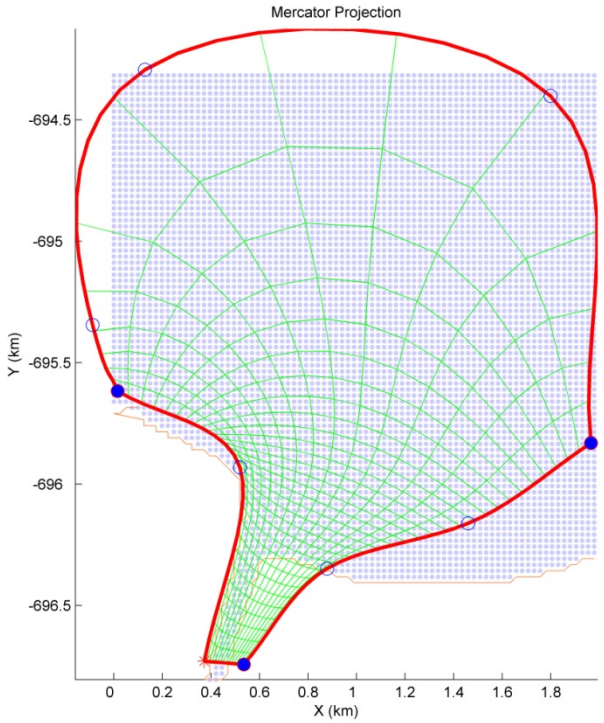


Neap tide condition

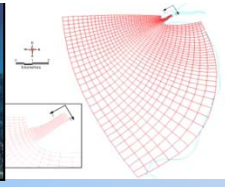


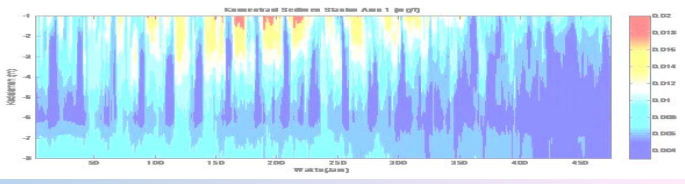


Nesting Model (ECOMSED)

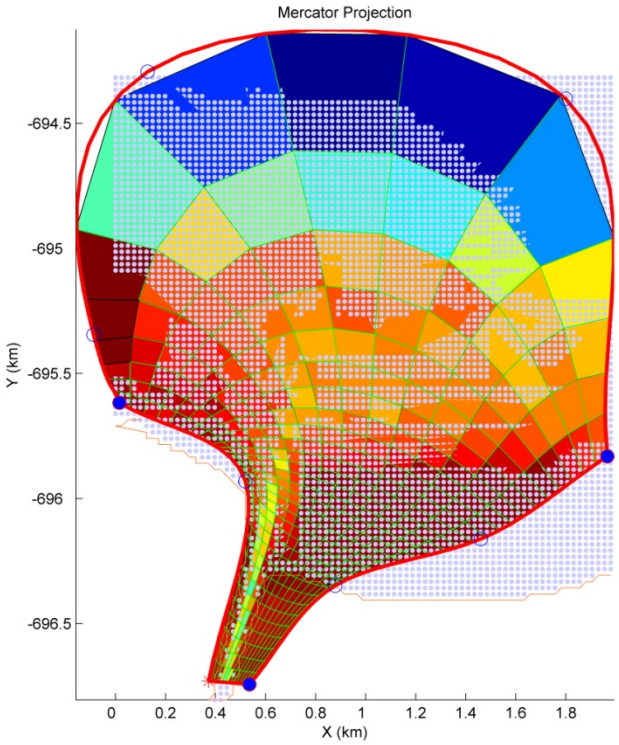


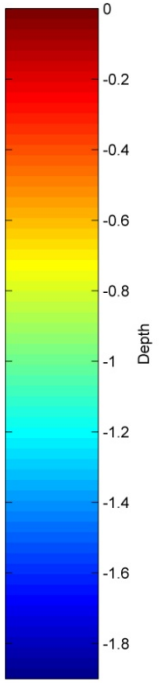
Curvilinear orthogonal Grid by Seagrid™



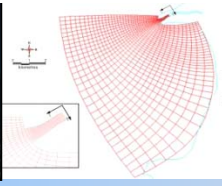


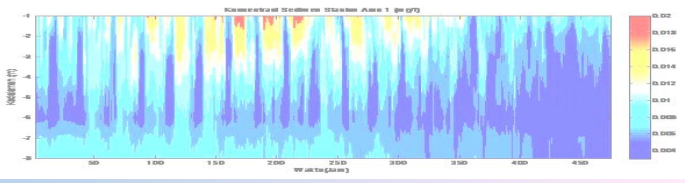
Bathymetric data



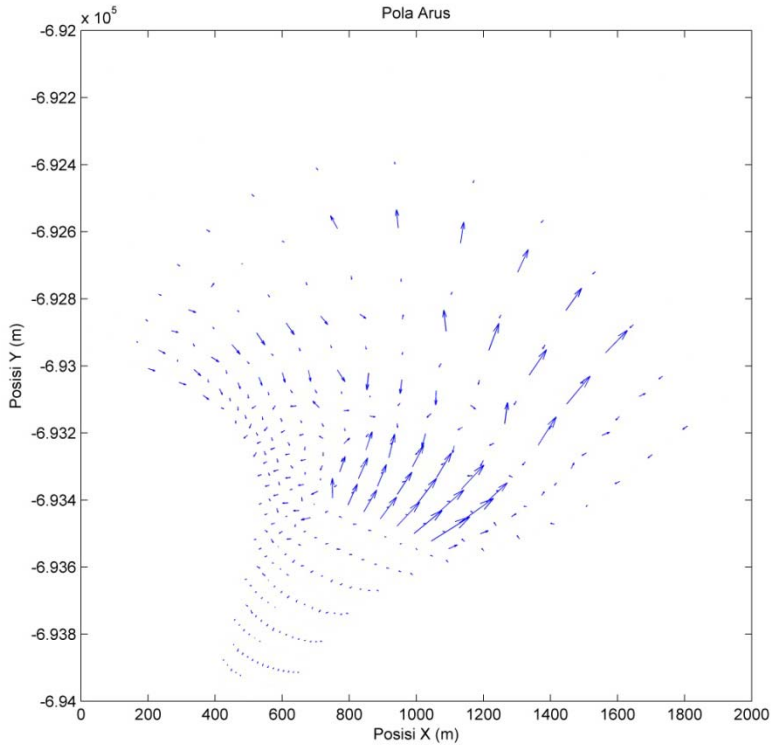


Depth (m) at ECOMSED domain

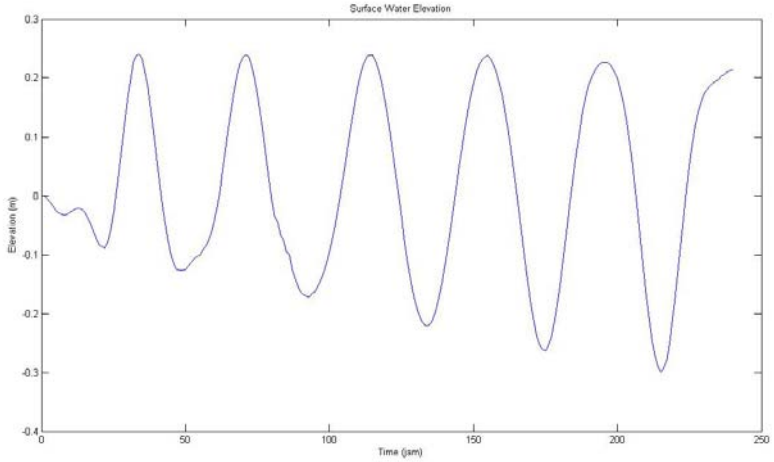




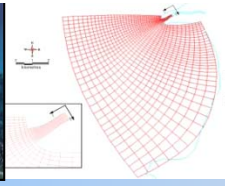
Hydrodynamic result

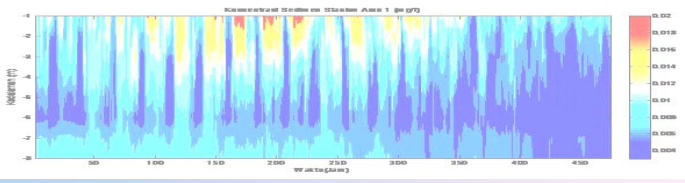


Velocity vector dominated by river

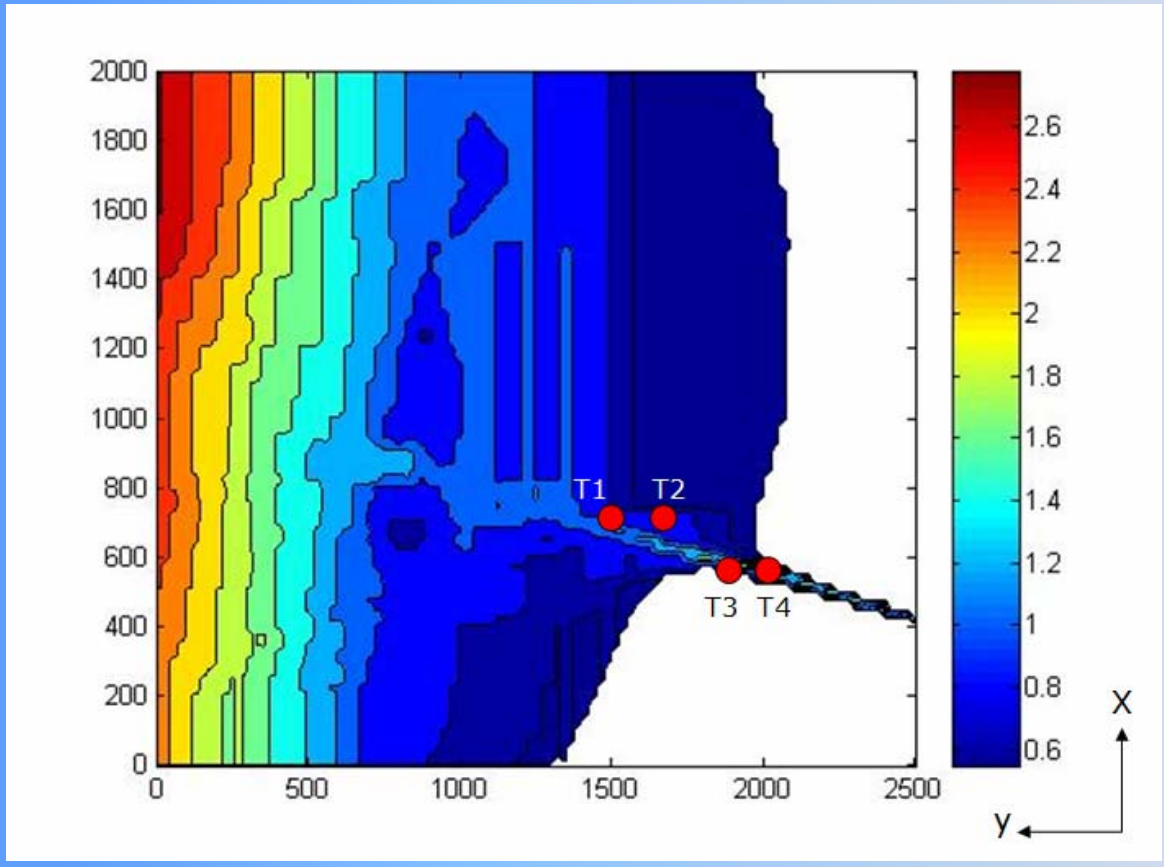


Water elevation (m) dominated by tide

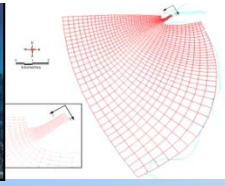


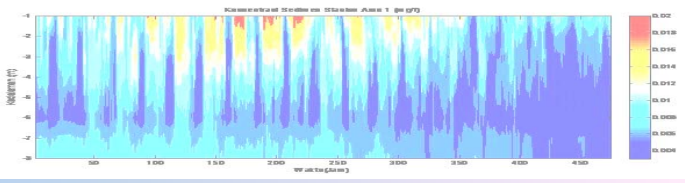


Wave Model (SWAN)

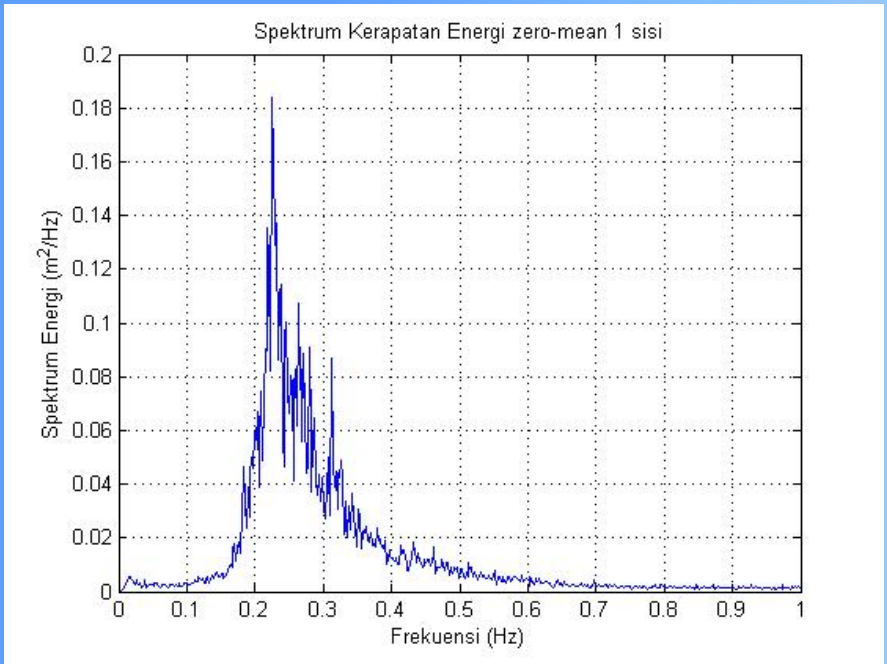


Bathymetric input data , grid system for SWAN at Ciasem Estuarine

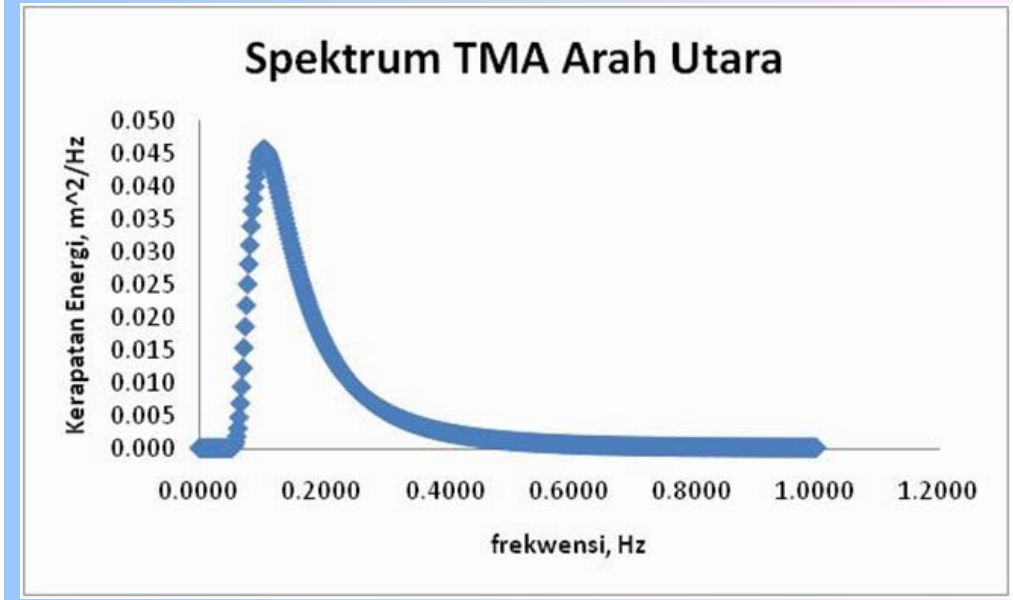




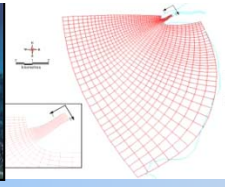
Wave offshore input (SWAN)

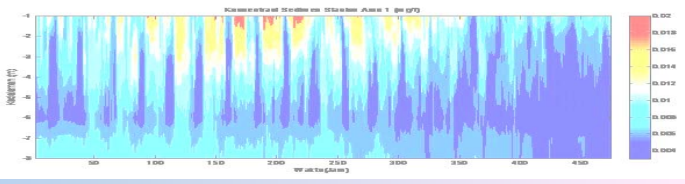


Wave real data collected at north of Java sea

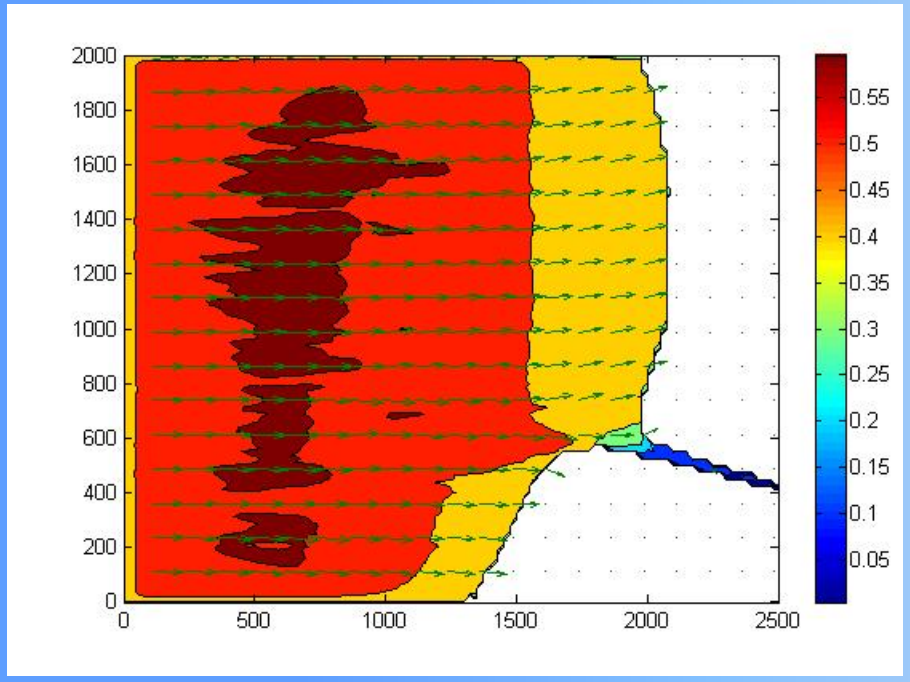


Theoretical spectrum for TMA North Direction

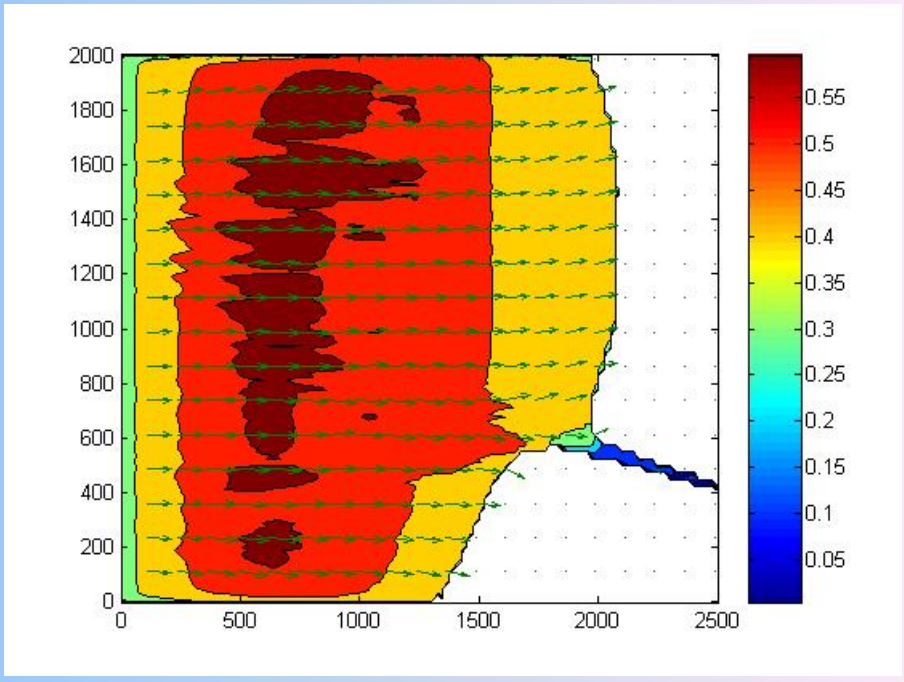




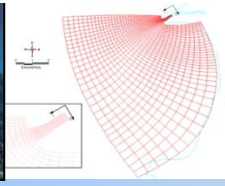
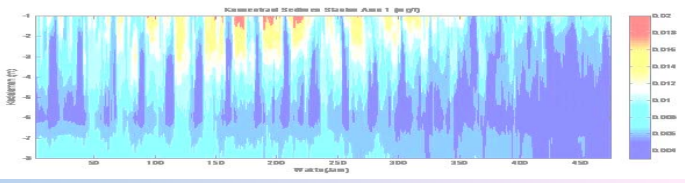
Wave Simulation (SWAN)



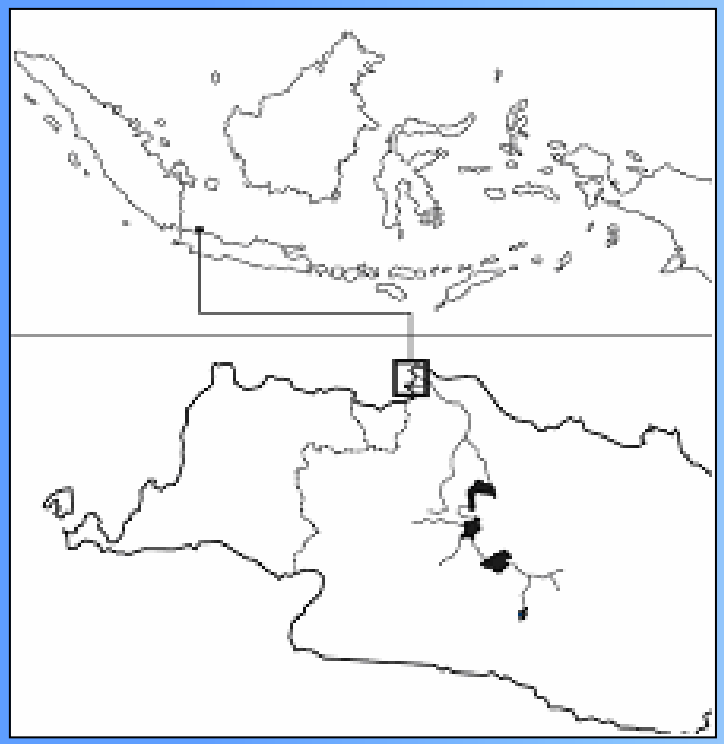
Wave distribution (m) based on Real data input



Wave distribution (m) based on TMA spectrum data input

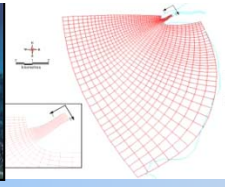




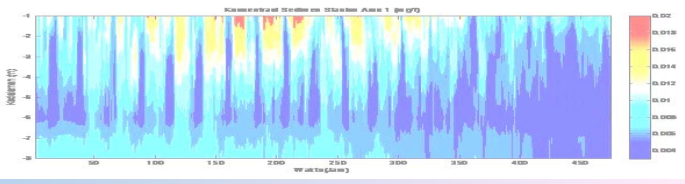
Gembong estuarine case study



Source:Poerbandono and Agung, *2007*

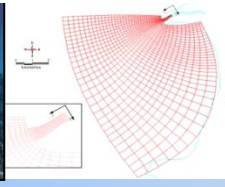
source: *Google Earth*

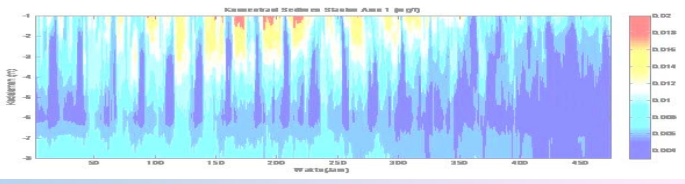




Gembong estuarine bathymetric data

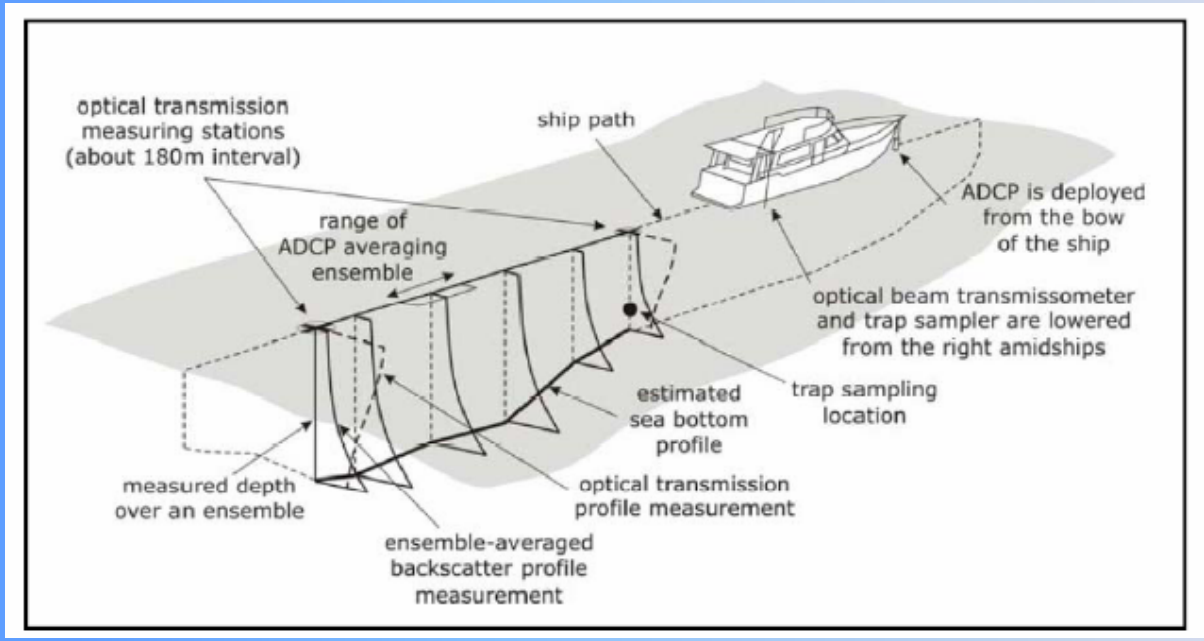
Source:Poerbandono and Agung, *2007*



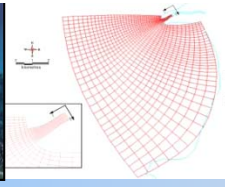
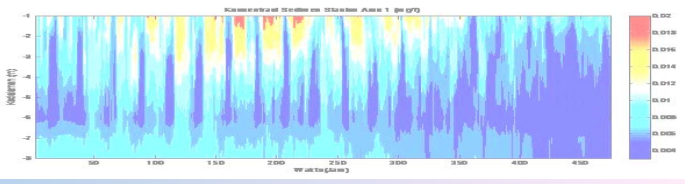


Sediment data Collection

- ADCP survey to find relation between acoustic intensity and sediment concentration.



Source:Poerbandono and Agung, *2007*

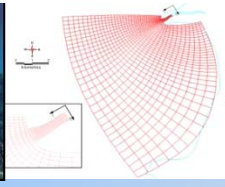




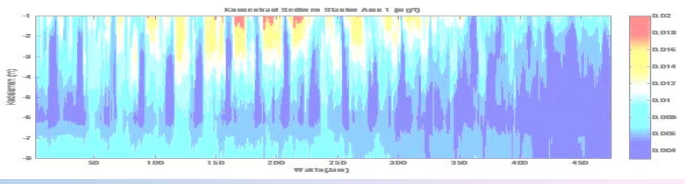
Sediment data Collection

- By using the regression method it was found that a relationship between acoustic intensity and TSS can be formulated as follows:

$$10log_{10}(c) = 0.021EI + 1.070$$

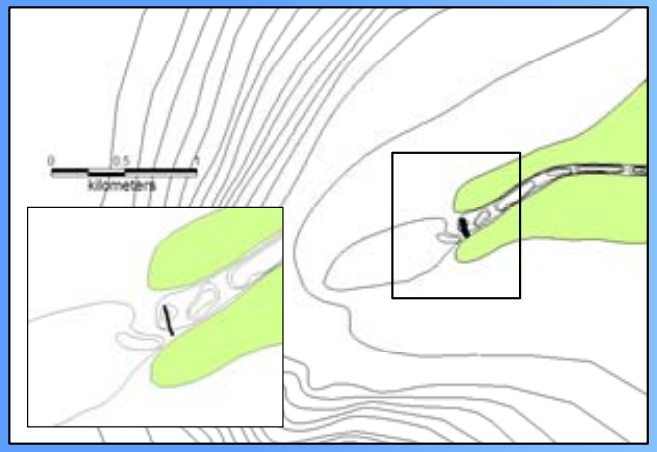
where: c is the concentration of sediment in (mg/l) and EI is acoustic intensity data. Furthermore the sediment concentration distribution was determined using this formula and then compared to numerical solution.



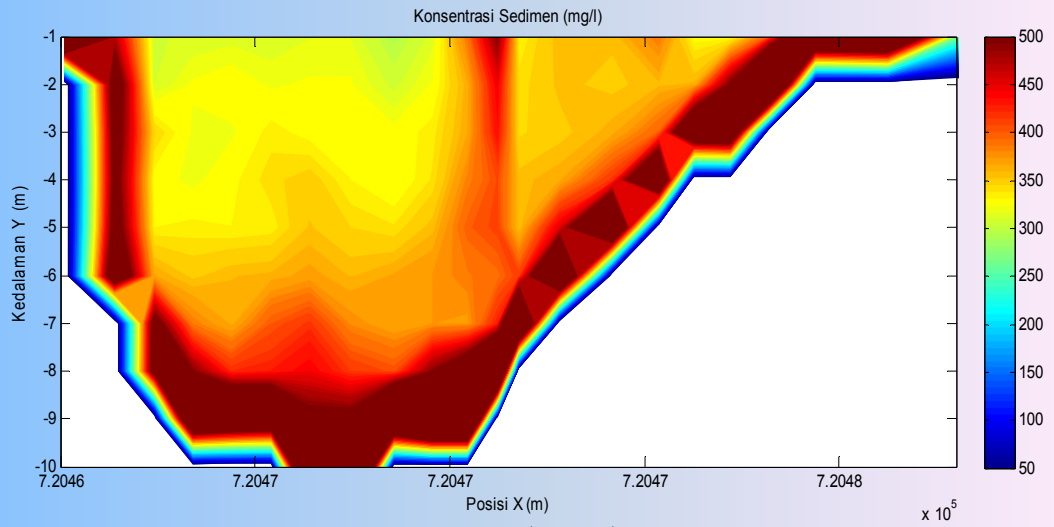


Sediment data Collection

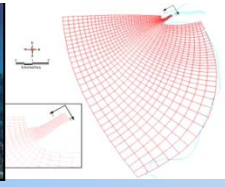
- By using the regression equation we can obtain sediment concentration data in field.

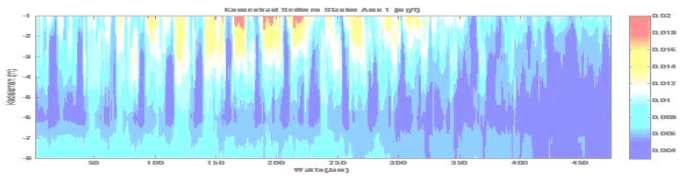


Location of survey

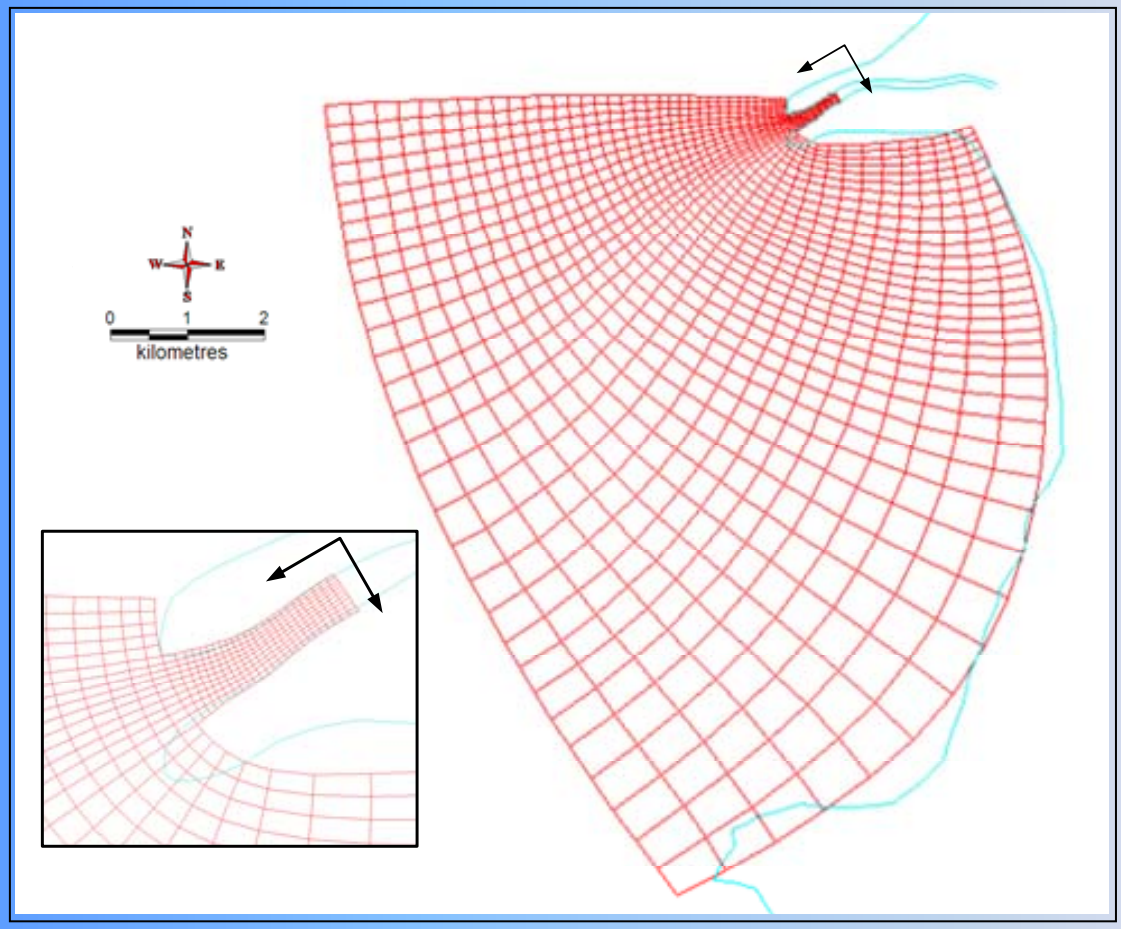


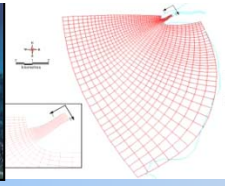
Sediment concentration in (mg/l)

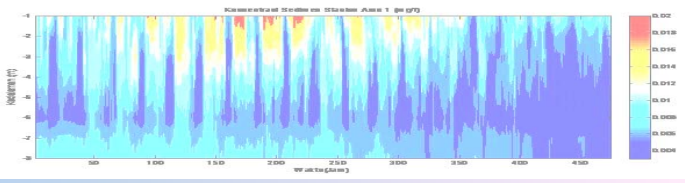




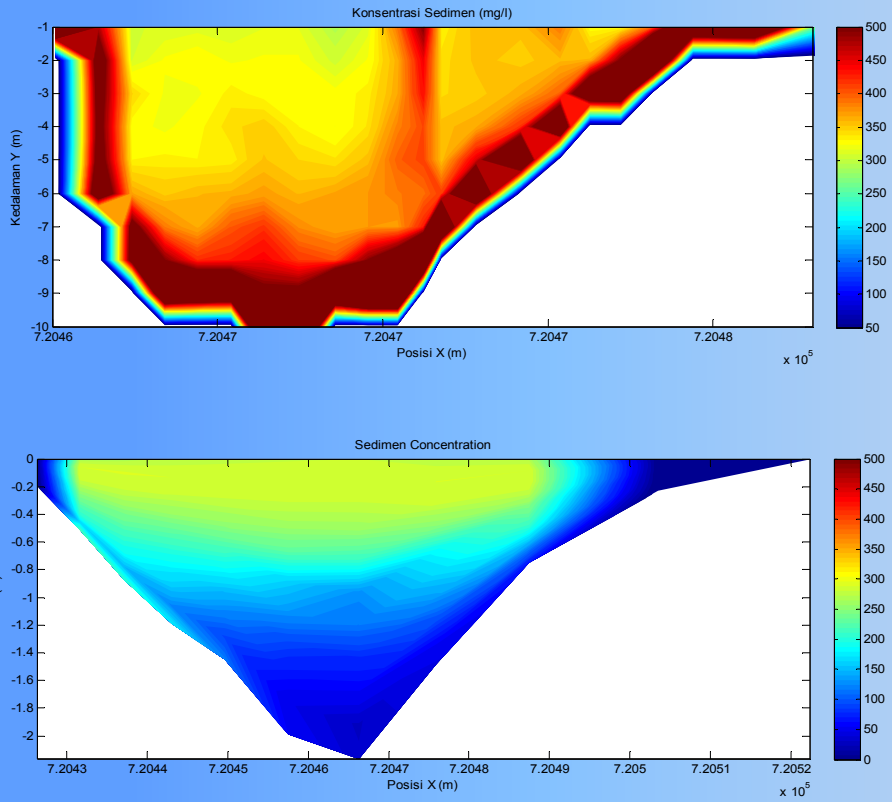
Ecomsed Hydrodynamic Model for Gembong Estuarine case

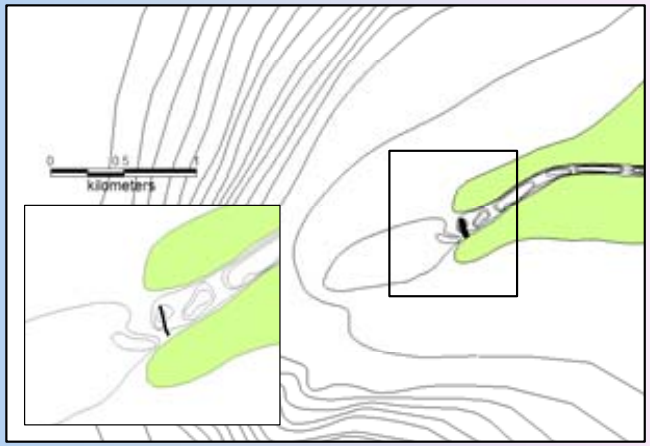




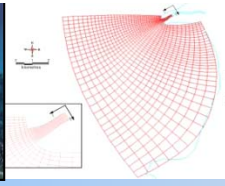
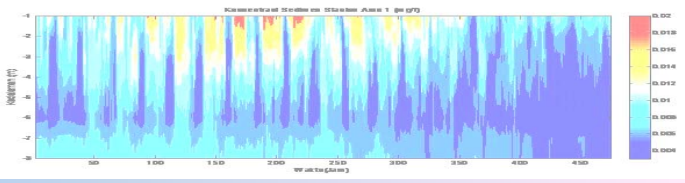


Model Calibration and verification

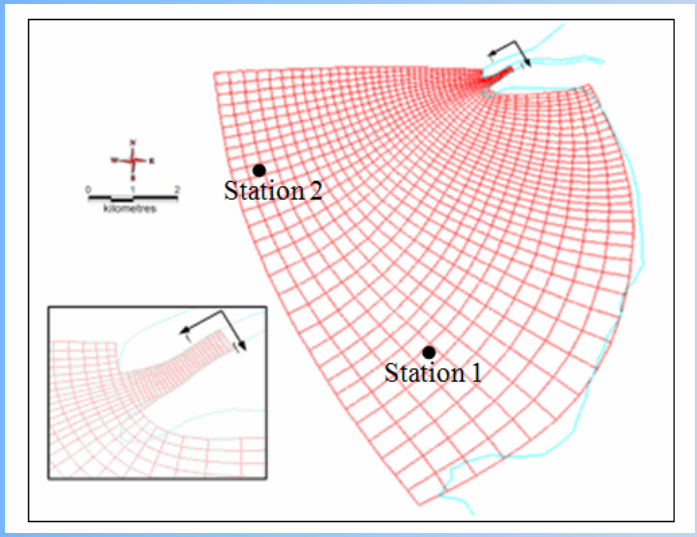


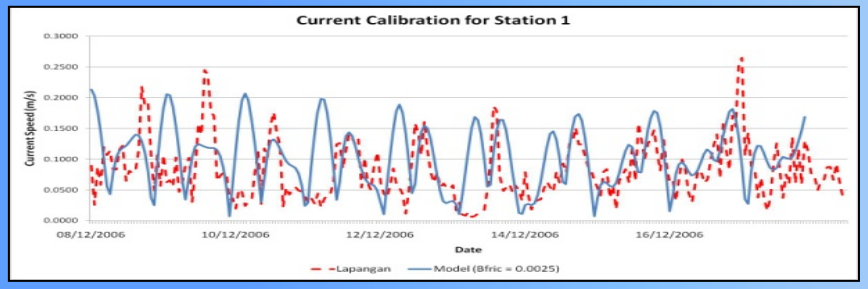


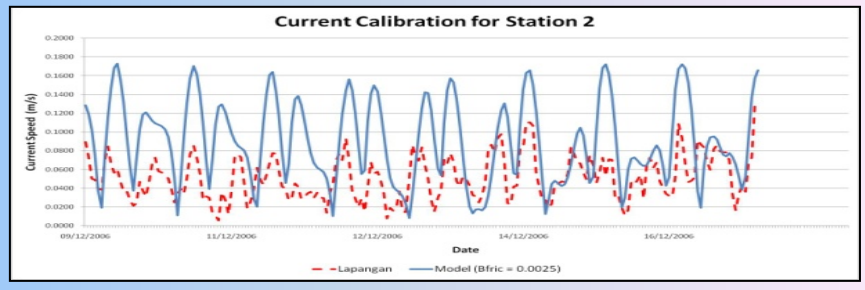
Model verification between model (lower panel) and TSS data (upper panel) at sta. 2.

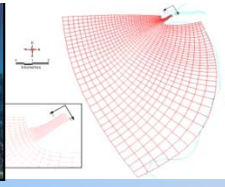
Model Calibration and verification

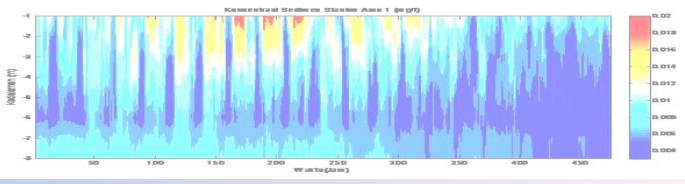




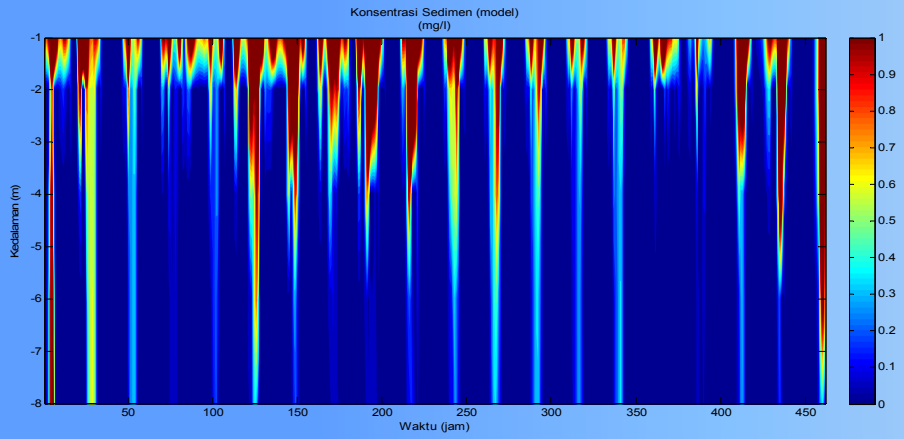


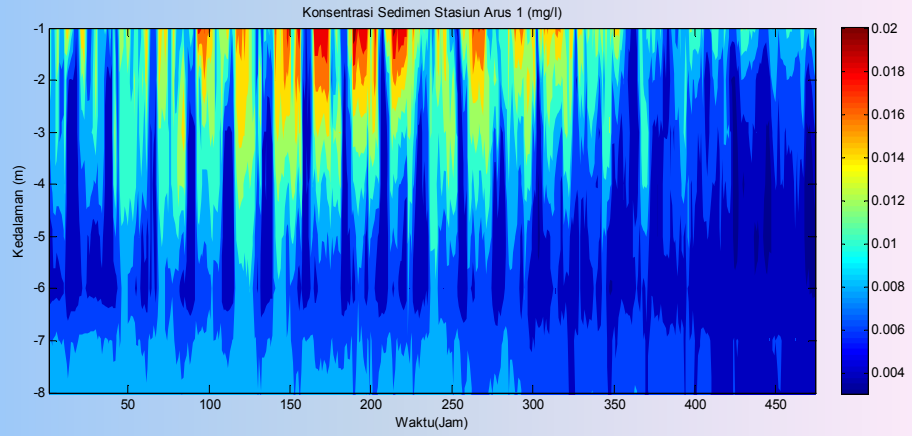
Model calibration between model result (line) and the velocity data (dot-line) for both stations (left panel: at station 1 and right panel: at station 2).



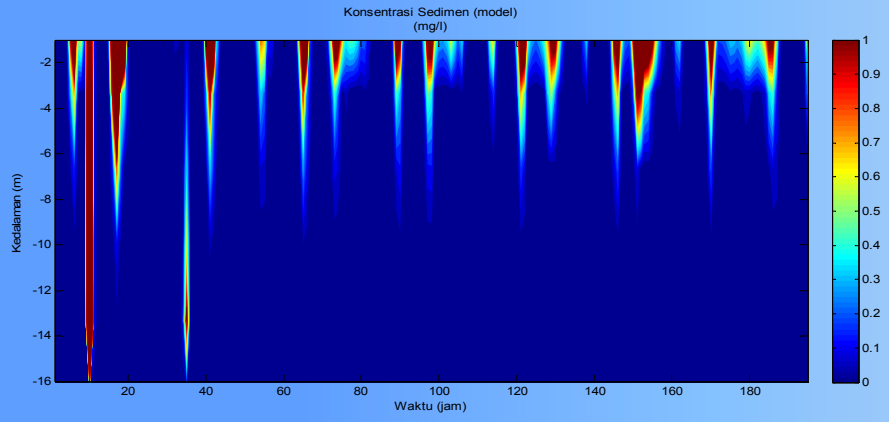


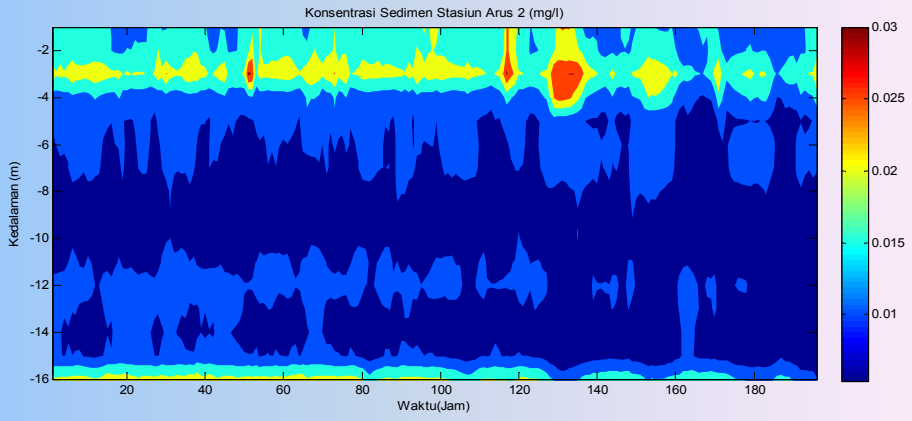
Model Calibration and verification



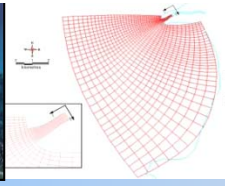


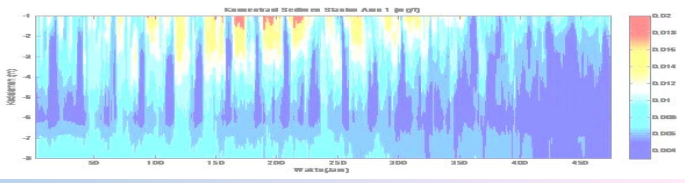
Model verification between model (left panel) and TSS data (right panel) at sta. 1.



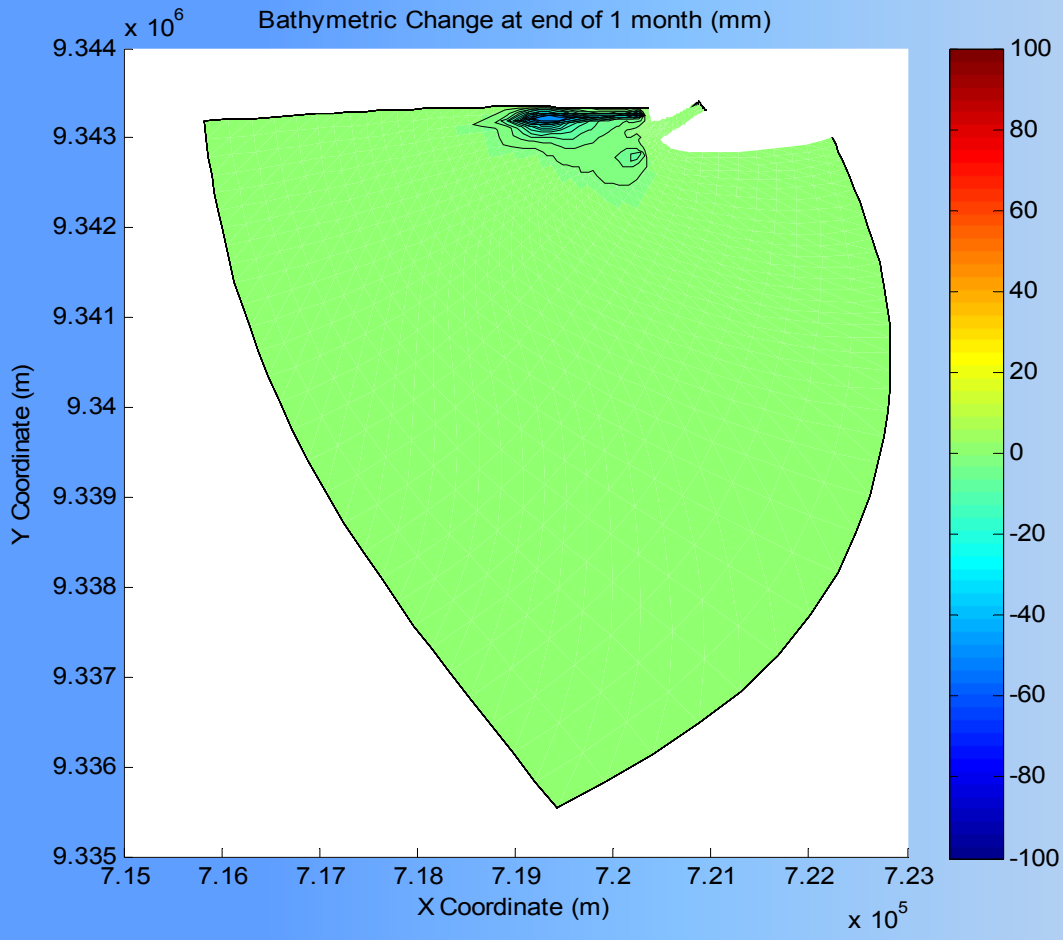


Model verification between model (left panel) and TSS data (right panel) at sta. 2.

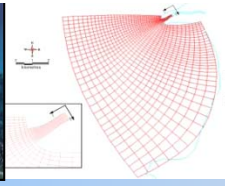
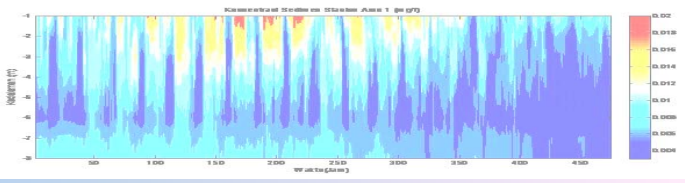




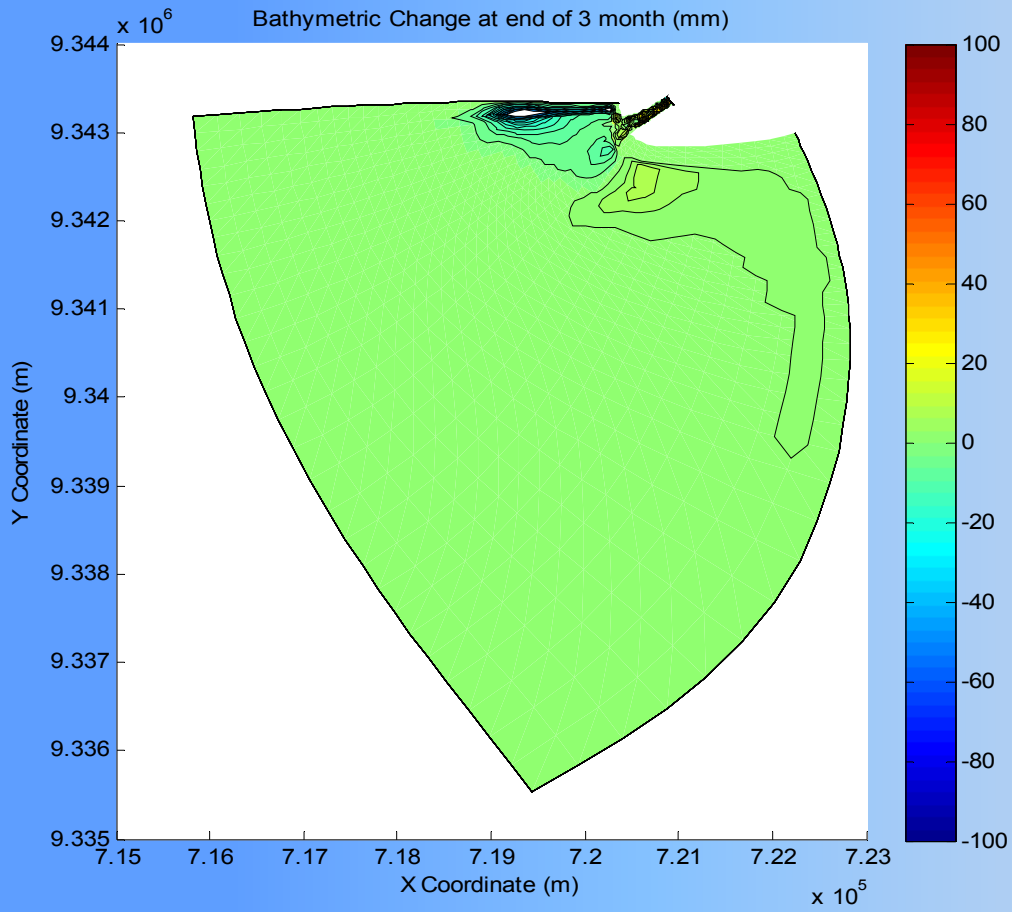
Cohesive Sediment Deposition and Bathymetric Change



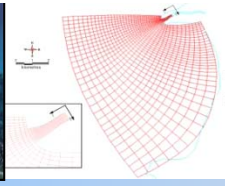
Bathymetric change at end of 1 month

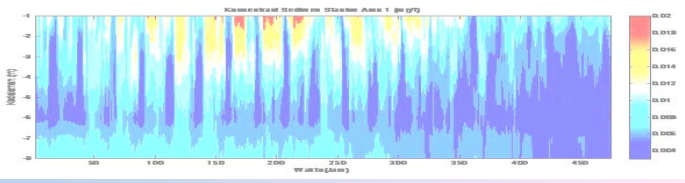




Cohesive Sediment Deposition and Bathymetric Change

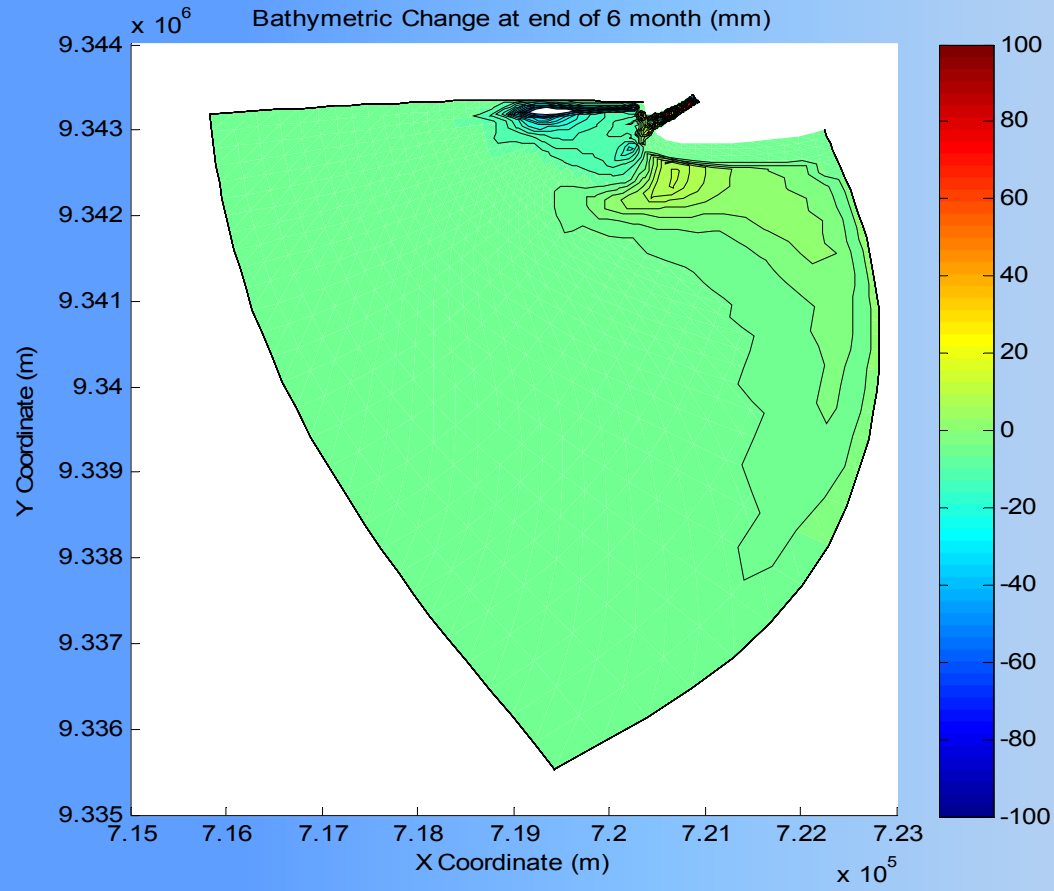


Bathymetric change at end of 3 month

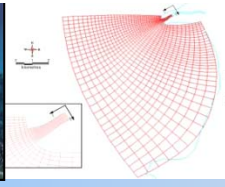
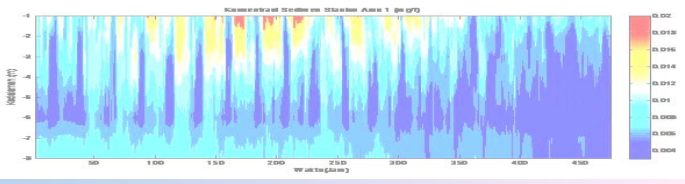




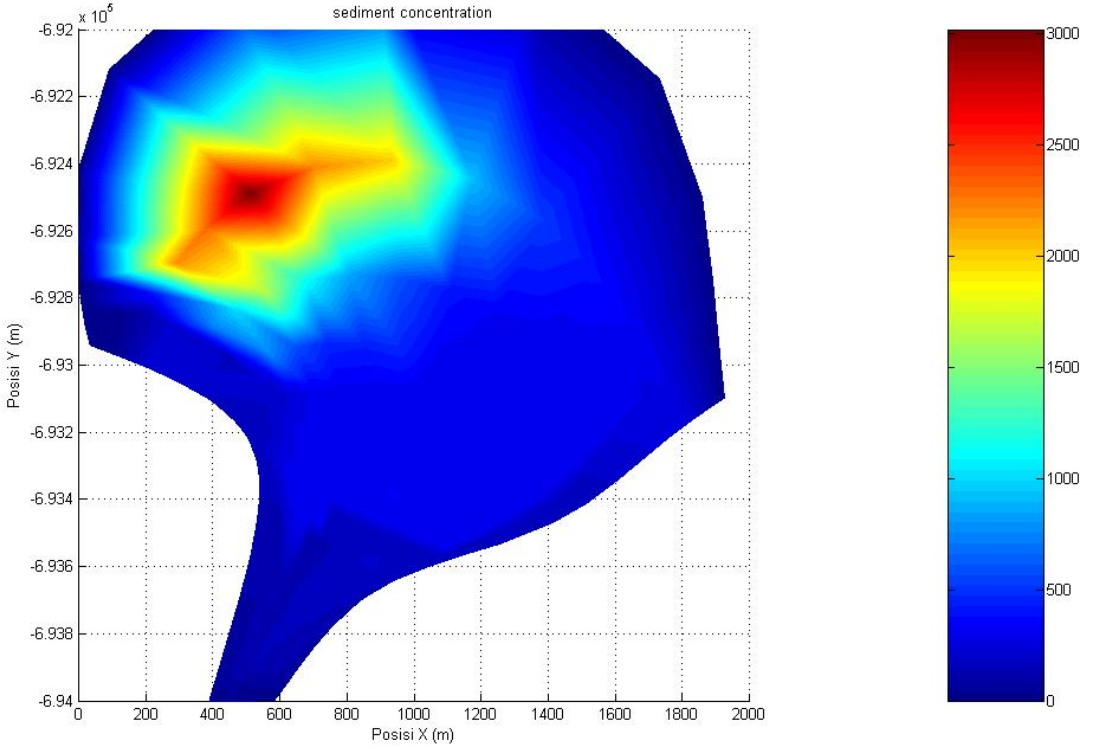
Cohesive Sediment Deposition and Bathymetric Change



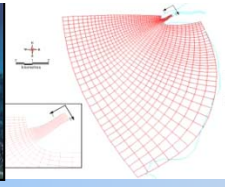
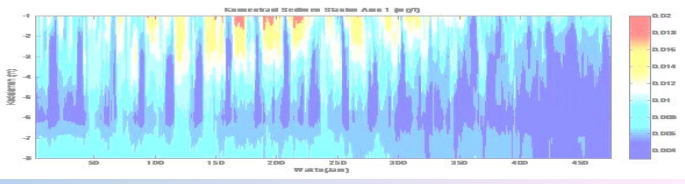
Bathymetric change at end of 6 month

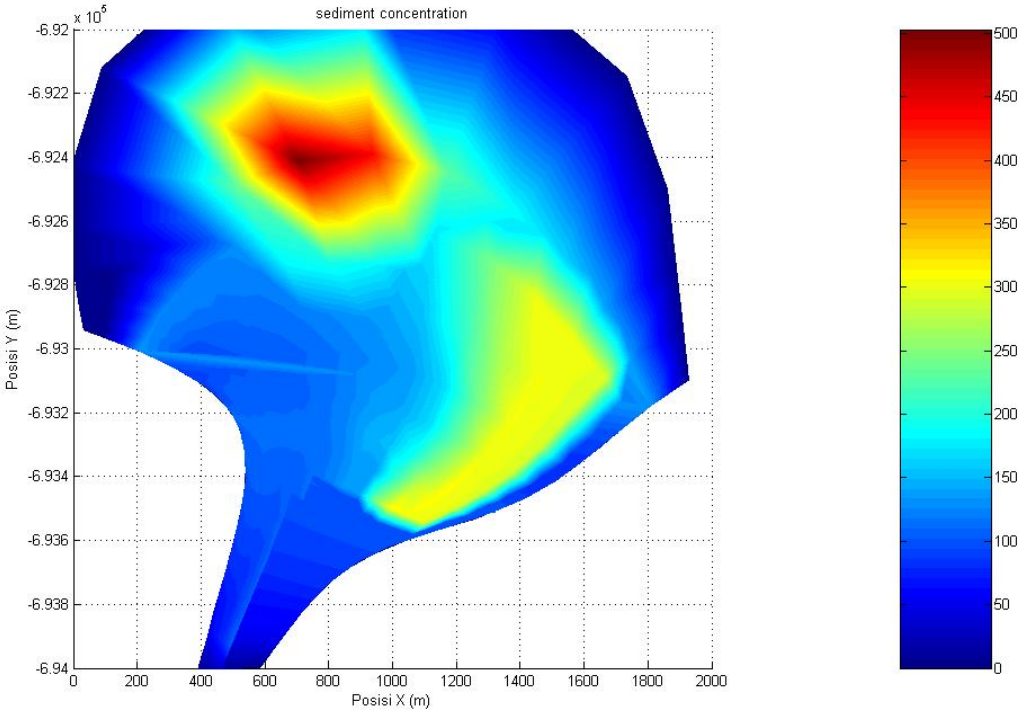
Sediment Concentration in Ciasem Estuarine



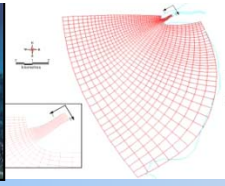
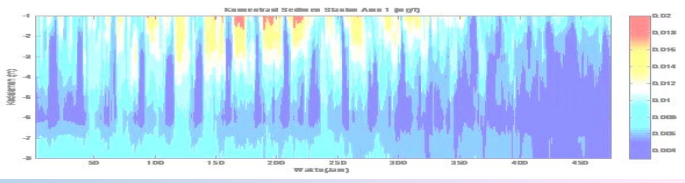
Sediment concentration in Ciasem estuarine at neap condition

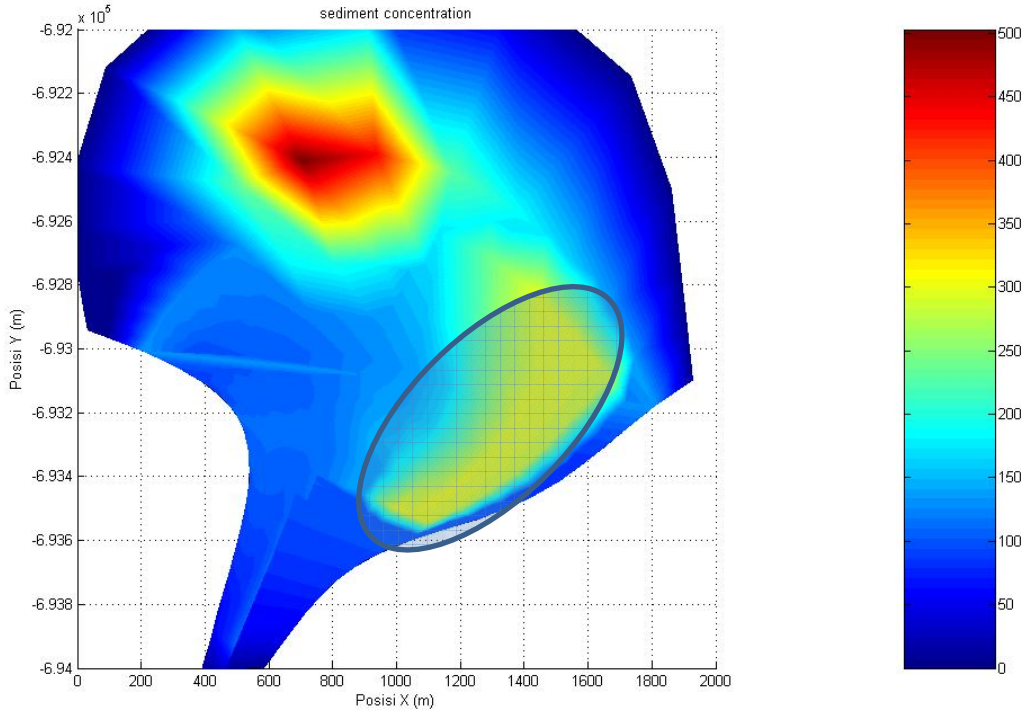
Sediment model Result for Ciasem Estuarine



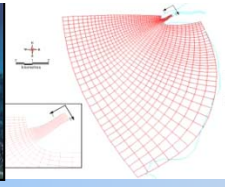
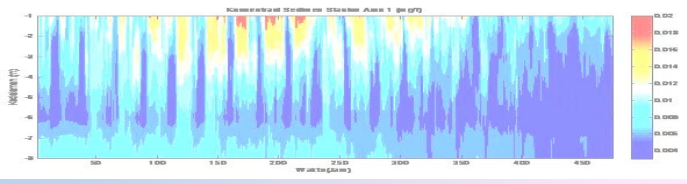
Sediment concentration in Ciasem estuarine at Spring condition

Sediment model Result for Ciasem Estuarine



At Spring condition, the sediment tend to accumulate on East nearshore of Ciasem

Conclusion

- MIKE21, and ECOMSED are suitable for application of 3D Hydrodynamic-sediment model especially for cohesive sediment in Gembong and Ciasem Estuarine which are the outlets of Citarum River in Java Island-Indonesia.
- In order to enhance the model with wave effect, it is necessary to combine the wave model (SWAN) into the Hydrodynamic model.
- The verification in Gembong estuarine shows an agreement of tendency of the magnitude between model result and data collection, however at the near botom, some descrepancy was appeared.
- The prediction of sediment deposition and bathymetric change after half year simulation was gave a clarification process of sediment accumulation at south of Gembong River-mouth.
- For Ciasem Estuarine the sediment (organic/clay dominated) tends to accumulate at west sorline of Ciasem eastuarine. futher extension studies are necessary conducted to solve this accumulation problem in the future.