Journal of Sustainable Engineering: Proceedings Series 1(1) 2019 doi:10.35793/joseps.v1i1.9

# Review of Tide and Wind Affect to Currents Pattern in Amurang Bay, North Sulawesi, Indonesia

**Tommy Jansen**[1]

[1]Sam Ratulangi University, Dept. of Civil Engineering, Indonesia

**Abstract.** Winds, tides and river discharges largely drive coastal currents. The strength of tidal currents, river runoff, meteorological conditions, shoreline configuration, water depth and topography are the factors that affect coastal water circulation. Generally currents are the flowing of water mass caused by wind, difference of density or tide moving. The existence of currents direction to nearshore of Amurang Bay was studied with using computer model tools as the hydrodynamic model by determine currents speed and its direction.

The study took place in Amurang Bay as the province of North Sulawesi Indonesia with the geography position around 1012'16.16" N-124027'04.33" E to 1015'43.80" N-124032'01.06"E. The bathymetry and tide data used in this research from Indonesian Coastline Environmental map of year 1995 with scale 1:50.000 from BIG (Badan Informasi Geospasial) with a satellite data from Google earth of year 2018 and LANTAMAL Manado, the wind and current data was obtained from BMKG Bitung. Time simulations are taken from 25 November to 23 December 2016 as a wet season and 25 Mei to 23 Juni 2016 as a dry season. As analytical tools, MIKE3 hydrodynamic mode are used. The currents pattern play an important role in sediment transport process, so the study of the currents pattern become to be important as well.

The result of this study indicate that in the wet season the combination of tide wind in surface and bottom layer of sea the currents direction close to nearshore dominant to East with current speed average 0.18 m/s, in dry season the combination of tide wind in surface layer of sea the currents direction close to nearshore dominant to South-East with current speed 0.12-0.24 m/s, in bottom layer the currents direction dominant to South-East with current speed average 0.2 m/s. Some of interesting point in research's area show that current by tide make the current direction seaward and landward, but tide combination wind change the direction of current. It can be said that the tide influenced to current make the currents direction seaward and landward follow the pattern of tide, but combination tide and wind change its direction.

## 1. Introduction

Tidal current of water flows into or out of bays and harbors caused by the rise or fall in sea level as a tide crest approaches and passes. Water rushing into an enclosed area because of the sea level rise as a tide crest approaches is called a flood current. Water rushing out because of the fall in sea level as the tide trough approaches is called an ebb current. Tidal currents reach maximum velocity midway between high tide and low tide. Slack water, a time of no currents, occurs a short time after high and low tides when the current changes direction.

Winds, tides and river discharges largely drive coastal currents. The strength of tidal currents, river runoff, meteorological conditions, shoreline configuration, water depth and topography are the factors that affect coastal water circulation. Generally currents are the flowing of water mass caused by wind, difference of density or tide moving. As winds and runoff increase, coastal currents intensify (Gross,1990).This situation likely leads the currents carry the sediment along nearshore or longshore currents affect the sedimentation process in the nearshore environment of Amurang Bay.

## 2. Study Area

The area of study is in Amurang Bay as the province of The North Sulawesi Indonesia with the geography position around 1⁰12'16.16" N-124⁰27'04.33"E to 1⁰15'43.80" N-124⁰32'01.06"E.

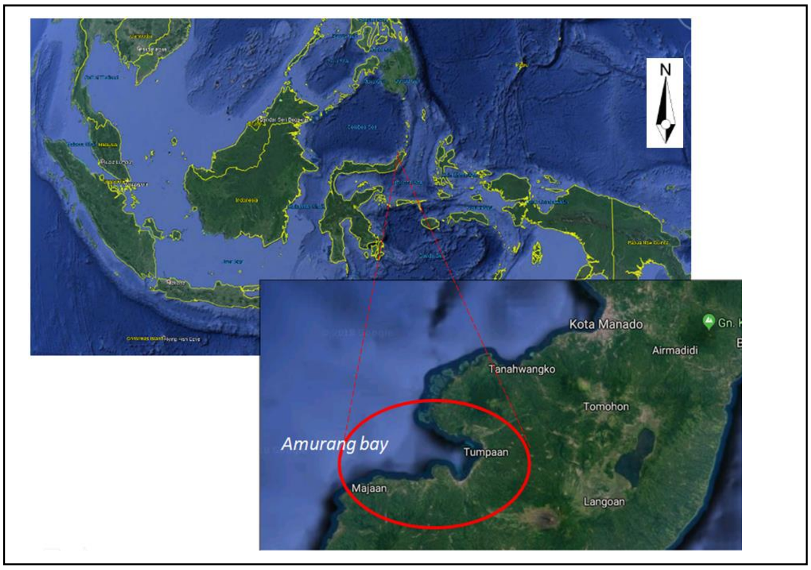


Figure 1: Location of Amurang bay (Source: Google Earth)

## 3. Research Method

As the computational tools the MIKE3 Flow Model Flexible mesh Hydrodynamic mode are used. In the model setting, a finite difference grid was developed as the model domain with the size of the triangular mesh option which each element maximum area is 100,000 m$^2$. The vertical direction z is divided into 10 layers. The position of layer 10 is in surface of seawater and layer 1 and layer 2 are close the bottom of sea. The horizontal grid mesh contains 2140 element with 1496 nodes (Figure 2).

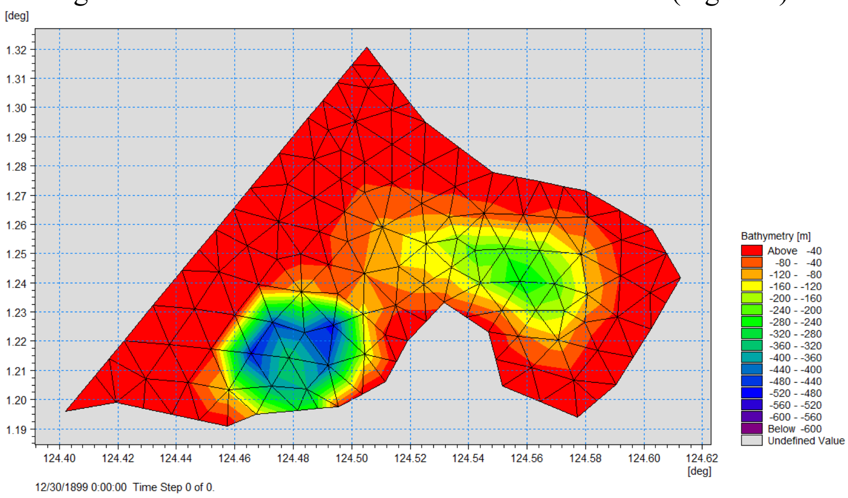


Figure 2: Unstructure Mesh and Bathymetry

Journal of Sustainable Engineering: Proceedings Series 1(1) 2019 doi:10.35793/joseps.v1i1.9

**4. Calculation Method**

The method by finite approximation for hydrodynamic equations used FEM/FVM. The model is based on the solution of the three dimensional incompressible Reynolds averaged Navier-Stokes equations, subjected to the assumption of Boussinesq and of hydrostatic pressure.

The equation of continuity is given by:

$$\frac{\partial u}{\partial x}+\frac{\partial v}{\partial y}+\frac{\partial w}{\partial z}=S \tag{1}$$

The two horizontal momentum equations for the x and y component, respectively

$$\frac{\partial u}{\partial t}+\frac{\partial u^2}{\partial x}+\frac{\partial vu}{\partial y}+\frac{\partial wu}{\partial z}=fv-g\frac{\partial \eta}{\partial x}-\frac{1}{\rho_0}\frac{\partial p_a}{\partial x}-\frac{g}{\rho_0}\int_z^\eta\frac{\partial \rho}{\partial x}dz-\frac{1}{\rho_0 h}\left(\frac{\partial S_{xx}}{\partial x}+\frac{\partial S_{xy}}{\partial y}\right)+$$

$$F_u+\frac{\partial}{\partial z}\left(v_t\frac{\partial u}{\partial z}\right)+u_sS \tag{2}$$

$$\frac{\partial v}{\partial t}+\frac{\partial v^2}{\partial y}+\frac{\partial uv}{\partial x}+\frac{\partial wv}{\partial z}=-fu-g\frac{\partial \eta}{\partial y}-\frac{1}{\rho_0}\frac{\partial p_a}{\partial y}-\frac{g}{\rho_0}\int_z^\eta\frac{\partial \rho}{\partial y}dz-\frac{1}{\rho_0 h}\left(\frac{\partial S_{yx}}{\partial x}+\frac{\partial S_{yy}}{\partial y}\right)+$$

$$Fv+\frac{\partial}{\partial z}\left(v_t\frac{\partial v}{\partial z}\right)+v_sS \tag{3}$$

Where t is the time ; x,y,z (m) are the Cartesian co-ordinates ; η (m) is the surface elevation ; d(m) is still water depth ; h=η+d is the total water depth ; u,v,w are the velocity components (m/s) in the x,y and z direction ; f=2ΩSinϕ is the Coriolis parameter ; Ω ( $^0$ )is the angular rate of revolution and (ϕ) the geographic latitude; g (m/s$^2$) is the gravitational acceleration ; ρ (kg/m$^3$) is the density of water ; $S_{xx}$,$S_{yx}$,$S_{xy}$, $S_{yy}$ (kg/s$^2$) are components of the radiation stress tensor ; $v_t$ (m$^2$/s) is the vertical turbulent (eddy) viscosity ; $p_a$(Pa) is the atmospheric pressure ; S is the magnitude of the discharge due to point sources and $u_s$, $v_s$ is the velocity by which the water is discharged into the ambient water ; $F_u$ and $F_v$ are the horizontal stress term.

The horizontal stress terms are described using a gradient-stress relation, which is simplified to:

$$Fu=\frac{\partial}{\partial x}\left(2h_t\frac{\partial u}{\partial x}\right)+\frac{\partial}{\partial y}\left(h_t\left(\frac{\partial u}{\partial y}+\frac{\partial v}{\partial x}\right)\right) \tag{4}$$

$$Fv=\frac{\partial}{\partial x}\left(h_t\left(\frac{\partial u}{\partial y}+\frac{\partial v}{\partial x}\right)\right)+\frac{\partial}{\partial y}\left(2h_t\frac{\partial v}{\partial y}\right) \tag{5}$$

where $h_t$ (m$^2$/s) is the horizontal eddy viscosity.

The surface and bottom boundary condition for u, v and w:

at $z=\eta$ :

$$\frac{\partial \eta}{\partial t}+u\frac{\partial \eta}{\partial x}+v\frac{\partial \eta}{\partial y}-w=0,\quad \left(\frac{\partial u}{\partial z},\frac{\partial v}{\partial z}\right)=\frac{1}{\rho_0 v_t}\left(\tau_{sx},\tau_{sy}\right) \tag{6}$$

at $z=-d$ :

$$u\frac{\partial d}{\partial x}+v\frac{\partial d}{\partial y}+w=0,\quad \left(\frac{\partial u}{\partial z},\frac{\partial v}{\partial t}\right)=\frac{1}{\rho_0 v_t}\left(\tau_{bx},\tau_{by}\right) \tag{7}$$

Journal of Sustainable Engineering: Proceedings Series 1(1) 2019 doi:10.35793/joseps.v1i1.9

where $\left(\tau_{sx}, \tau_{sy}\right)$ and $\left(\tau_{bx}, \tau_{by}\right)$ are the x and y components of the surface wind and bottom stresses in (Pa). The total water depth h (m) can be obtained from the kinematic boundary condition at the surface, once the velocity is known from the momentum and continuity equations.

There are some points of interesting for study from A to H spread within Amurang Bay. The geography position respectively, point A $1.24^0$ N- $124.45^0$ E ; point B $1.24^0$N-$124.53^0$E ;point C $1.225^0$N-$124.49^0$E ; point D $1.205^0$N-$124.475^0$E ; point E $1.24^0$N-$124.6^0$E ; point F $1.22^0$N-$124.45^0$E ; point G$1.21^0$N-$124.42^0$E ; point H$1.3^0$N-$124.5^0$E (Figure 3).


Figure 3: Amurang bay with spread points as the stations of study (Source: Google Earth)

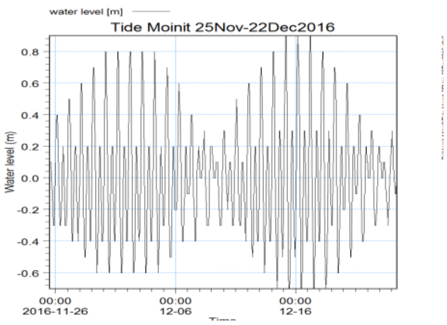


Figure 4: Tide 25Nov-23Dec 2016

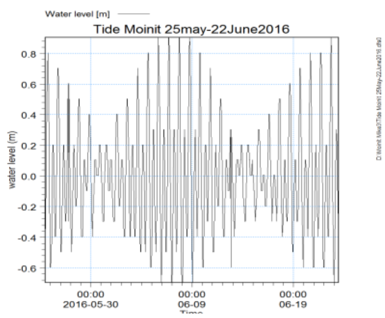


Figure 5: Tide 25May-22June 2016

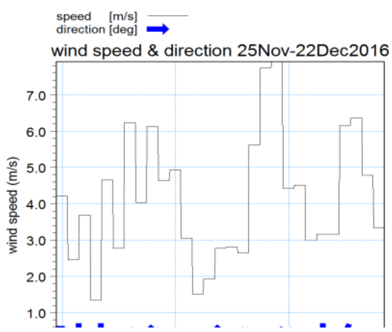


**Figure 6:** Wind speed & direction 25Nov-22Dec2016

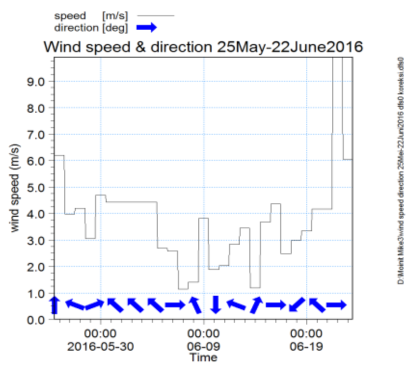


**Figure 7:** Wind speed & direction 25May-22June2016

Journal of Sustainable Engineering: Proceedings Series 1(1) 2019 doi:10.35793/joseps.v1i1.9

The input data for the numerical model as the hydrodynamic mode are divided by the tide data and wind data and combination by tide and wind data, and bathymetry data. The simulations consist by tide and tide-wind, then comparing the both combination. Comparing the simulation result between tide-wind effect and data can be depicted in Figure 8 and Figure 9 to Figure12.

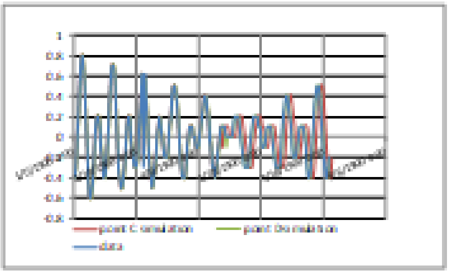

**Figure 8:** Comparing water level between data and simulation at point C and point D

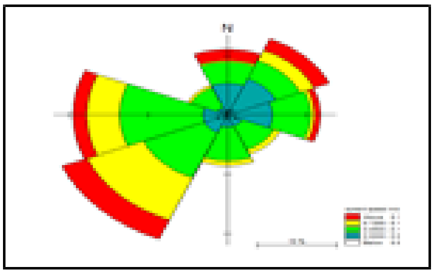

**Figure 9:** Current rose simulation 25 Nov-14Dec 2016

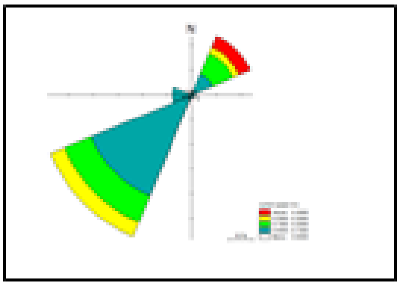

**Figure 10:** Current rose data 25 Nov-14Dec 2016

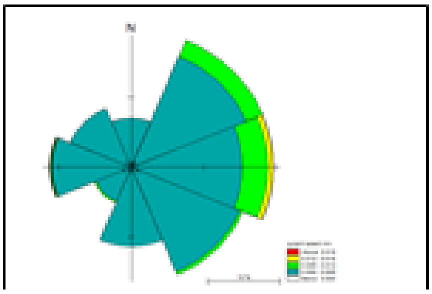

**Figure 11:** Current rose simulation 25May-26June 2016

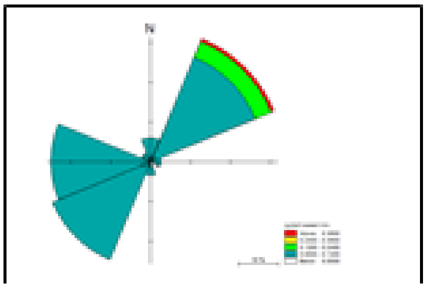

**Figure 12:** Current rose data 25May-26June 2016

The computer model has been compared with the data at dry season in range 25Nov-14Dec 2016 and wet season in range 25May-26June2016 of water level and current rose, it can be seen in Figure 8 to Figure12. Comparing the result of water level between simulation in point C and point D with the water level data, it can be seen in Figure 8. The results are comparable with in good results between data and simulation results.

## 5. Result And Discussion

Figure 13 shows the variation of current speed and direction of point A,C,D,F in surface and bottom layer of sea water, shows that current direction average dominant to south-east and to south with speed average 0.12-0.24 m/s.

Figure 14 and Figure 15 show the current velocities during spring tide caused by tide and caused by tide and wind. It can be seen that the wind makes velocity of current to increase, in the deeper area velocity of currents are decrease if compared with in the shallow area. The wind is responsible to longshore current occurring along nearshore.

Journal of Sustainable Engineering: Proceedings Series 1(1) 2019 doi:10.35793/joseps.v1i1.9

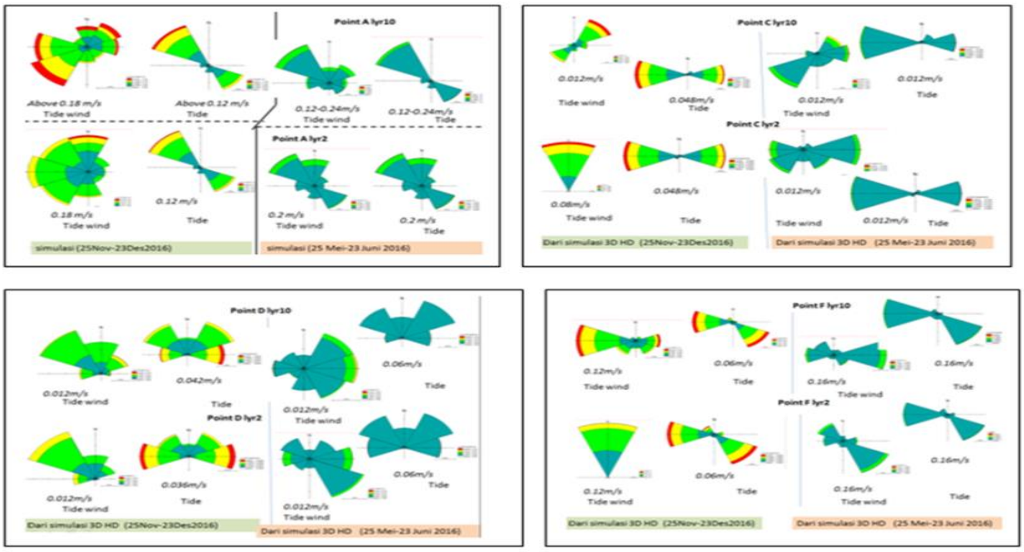

**Figure 13:** Current Rose of point A,C,D,F in surface and bottom layer at dry and wet season

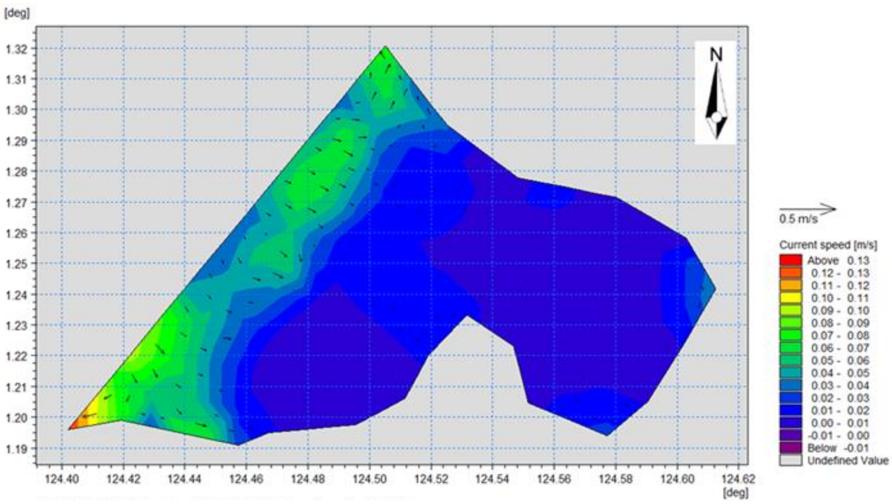


**Figure 14:** Current velocity and direction in surface layer at spring tide caused by tide

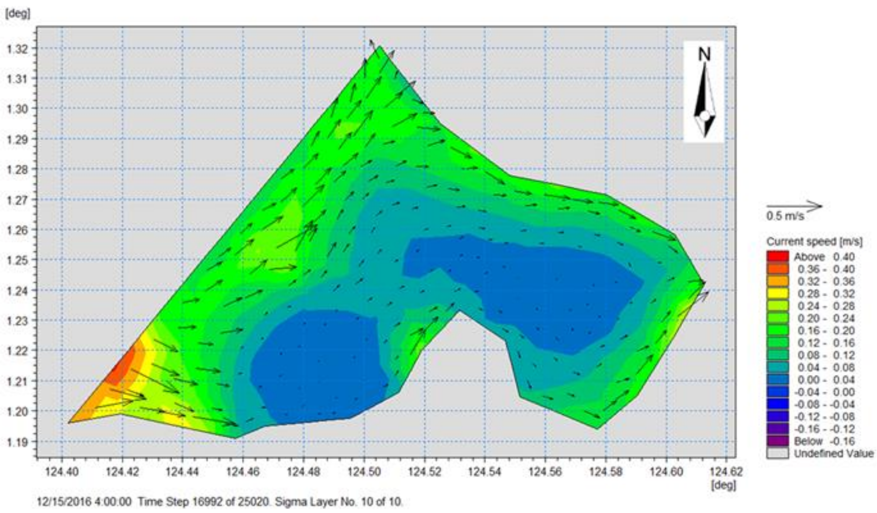


**Figure 15:** Current velocity and direction in surface layer at spring tide caused by tide and wind

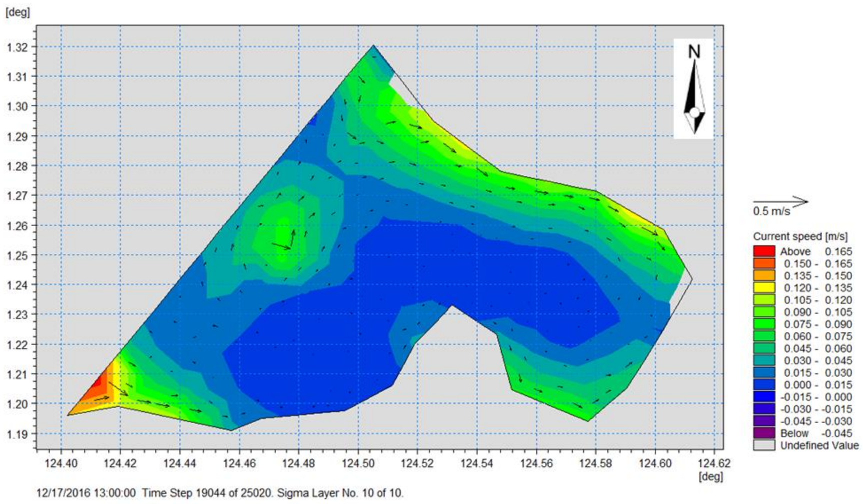


**Figure 16:** Current velocity and direction in surface layer at neap tide caused by tide and wind

Figure16 shows the current velocity and direction in surface layer at neap tide, it can be seen that the direction of current in nearshore keep moving landward even though occurring at neap tide. The bathymetry influences the direction of currents in this condition.

## 6. Conclusion

In this study the presentation a computer model capable of tide and wind affect to current pattern at the Amurang bay. The combination of tide and wind with condition of bathymetry can influence the currents in coastal areas.

Results indicate that tide combined with wind and the existence of bathymetry make the velocity of current increase, the current rose of some point of study show that current direction average dominant to south-east and to south with speed average 0.12-0.24 m/s, in the wet season the combination of tide wind in surface and bottom layer of sea the currents direction close to nearshore dominant to East with current speed average 0.18 m/s, in dry season the combination of tide wind in surface layer of sea the currents direction close to nearshore dominant to South-East, in bottom layer the currents direction dominant to South-East with current speed average 0.2 m/s. Some of interesting point in research's area show that current by tide make the current direction seaward and landward, but tide combination wind change the direction of current.

## References

DHI,2011,MIKE 21 & MIKE 3 Flow Model FM Hydrodynamic and Transport Model, *Scientific Documentation*, MIKE by DHI, Denmark.

Gross,M.G.,Oceanography, 1990 : *A View of the Earth*, 5th ed., Prentice- Hall, Englewood Cliff, NJ.

Kennish,M.J.,2001, *Practical Handbook of Marine Science*, CRC Press LLC,2000 N.W. Corporate Blvd., Boca raton, Florida 33431.