RESULTS AND DISCUSSION

1. Eddy diffusion coefficient

The diffusion of pollutants in the Upper Gulf of Thailand is governed by the tidal current which will convect the pollutant back and forth while the turbulence generated by tide, wave and other flows will diffuse or spread the polluting substance in all directions. Therefore the data of flow charecteristic is very important parameter for pollution analysis.

The observed velocities of seawater had been carried out by using Sensor Data SD 6000 current meter deployed at Ao Si Racha in October 2004, May 2005 and September 2005. There are 2 tide cycles per day. Period for one cycle is about 12 hours 25 minutes. During flood tide, seawater flows northward. And during ebb tide, seawater flows southward.

Table 7 Computed diffusion coefficients in N-S and E-W direction in Ao Si Racha (β=1.0)

Period	U_E (cm/sec)	$\sqrt{u'^2}$ (cm/sec)	$\int_0^\infty R_E(\tau)\,d\tau$ (sec)	ε (cm^2/sec)
October-04-NS	18.8	65.1	9.3	11320
May-05-NS	20.5	66.5	9.1	12449
August-05-NS	23.6	68.5	11.0	17778
October-04-EW	12.1	35.3	8.6	3664
May-05-EW	13.7	35.9	7.9	3867
August-05-EW	17.1	41.6	7.3	5216

The magnitude of the diffusion coefficients in E-W direction and N-S directions at Ao Si Racha was found to be in range of 0.3-1.8 m^2/sec as shown in Table 7. However, the value of diffusion coefficient in the north-south direction was observed to be slightly higher than in the east-west direction. Hence, a better mixing could be expected in the north-south direction.

Narasimhan (1996) reported that the order magnitude of the diffusion coefficients in E-W direction and N-S directions at Sichang and Hua Hin were found to be in range of 1-5 m^2/sec. The values of diffusion coefficient in the north-south direction were observed to be slightly higher than in the east-west direction. Hence, a better mixing also could be expected in the north-south direction.

Boonchum (2005) studied the horizontal diffusion coefficient indicated how fast the dissolved or suspended substances dispersed in the water. He found that the mean diffusion coefficient computed from the experiments was 2.09 m^2/sec and the mean dispersion coefficient was 0.32 m^2/sec.

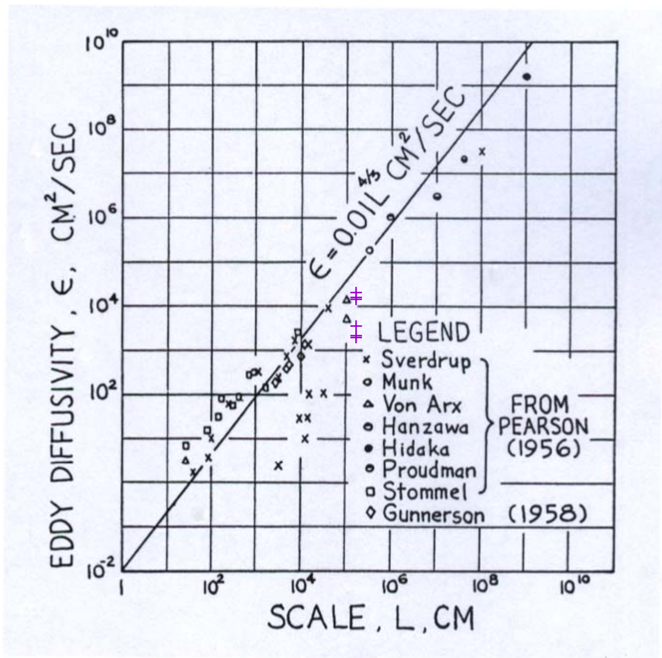


Figure 8 Measured values of eddy diffusivity in the horizontal direction in the ocean, showing increasing with scale

There are essentially two distinct ways in which mixing and suspended with seawater are brought by natural turbulence in the sea. When outfall was discharged from one of many rivers of diffuser, it has kinetic energy due to its velocity, and potential energy due to its submergence. This energy is dissipated in the turbulent mixing with the surrounding seawater. Analysis of this problem had been presented by Rawn, Bowerman and Brooks (1960)

Orlob(1958) and Pearson (1956) had given a summary of diffusion laws as relate to the ocean disposal. One thing was clear, the magnitude of the eddy diffusion coefficient increases greatly with the size of the area or volume being considered. A stream of pollutant is mixed with the seawater by irregular motions or turbulence of the seawater. Turbulent fluctuations tending to disperse the stream are superimposed on some mean motion. It will promote mixing only if the stream being dispersed is larger than the characteristic parcel or eddy size. Thus intuitively there are some grounds for believing that it is reasonable to have a diffusion coefficient which increases with the scale of that which is being mixed.

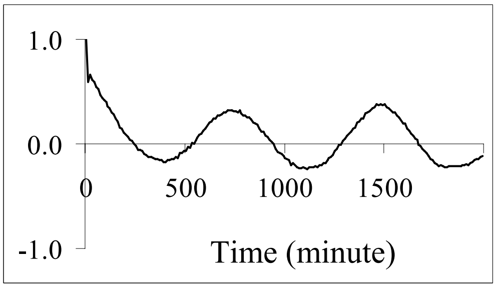
Norman (1959) had summarized the available data on eddy diffusivity for horizontal diffusion in the ocean as shown in figure 8. Several additional determinations by this experiment for the Upper Gulf of Thailand had also been plotted. If L is the scale then most of the measurements could be reasonably well represented by the equation.

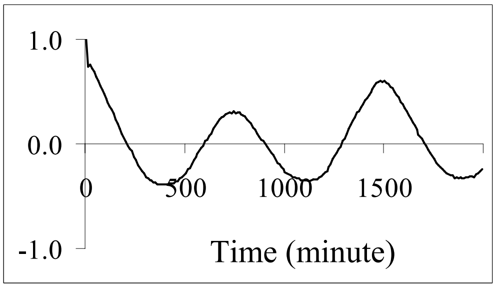
$$\varepsilon = \alpha L^{4/3} \qquad (20)$$

Where $\alpha = 0.01$ for cgs units as suggestion by Pearson (1956).

Among others, Stommel (1949) showed how the similar “4/3-law” for eddy viscosity may be deduced theoretically on the basis of the Weizsacher-Heisenberg or Kolmogoroff theories. It is assumed here that the diffusion of mass and momentum are essentially similar that order of magnitude of the eddy viscosity and eddy diffusivity are the same. The coefficient for vertical diffusion is usually several orders of magnitude less than for horizontal diffusion because of the stability caused by density stratification in the ocean (Munk, Ewing and Revell, 1949).

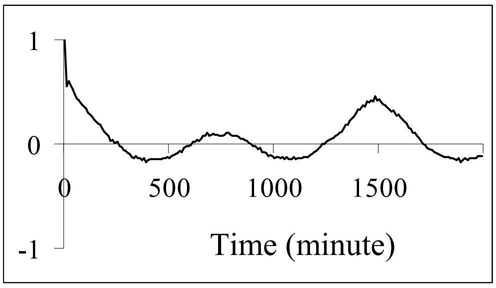
According to above mentioned, the results of computed eddy diffusion coefficients in Ao Si Racha were reliable since range of the values ε which related to L in order 10^4-10^6 cm were 10^3-10^5 cm^2/sec, respectively. The autocorrelation coefficient curves of velocity in east-west direction and north-south direction were similar pattern. They had strongly agreed relation every 12 hours 30 minutes as showed in Figure 9. The magnitudes of coefficients in North-South direction were larger than in East-West direction.

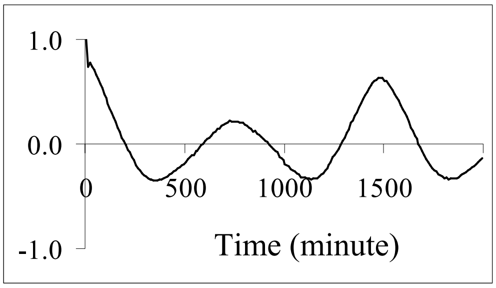




East-west direction North-south direction

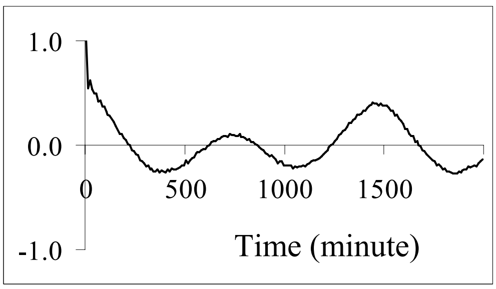
October 2004

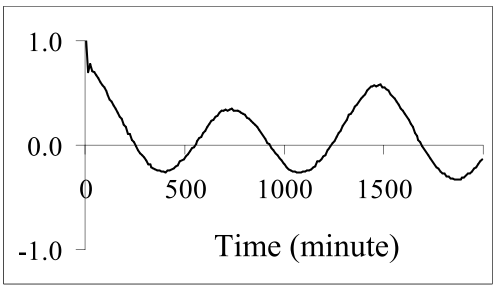




East-west direction North-south direction

May 2005





East-west direction North-south direction

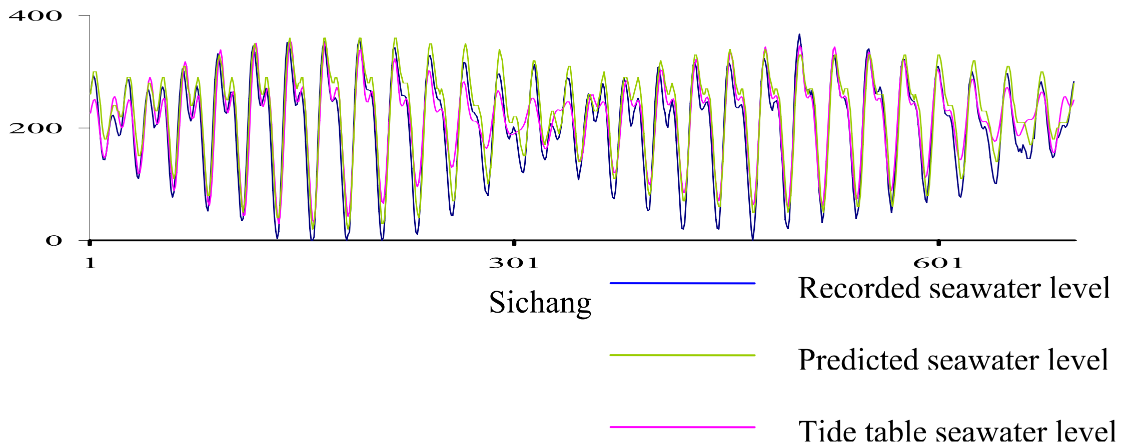
September 2005

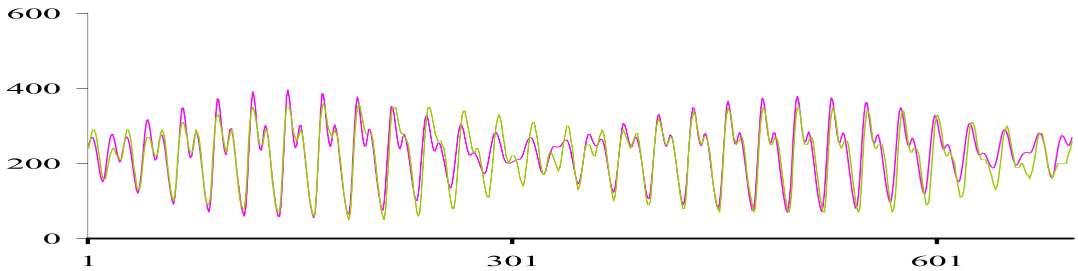
2. Tide

Seawater level at every 1 hour had been recorded by using Global water WL 15 Water Logger at Ao Si Racha (707750E, 1458474N) during May- June 2005. The results showed that recorded data and predicted data were close to tide table 2005 at Ko Sichang as shown below. Amplitude and phase of recorded data was similar to computed seawater level and data from tide table. During spring tide, tidal range was closer and more reliable than the neap tide.

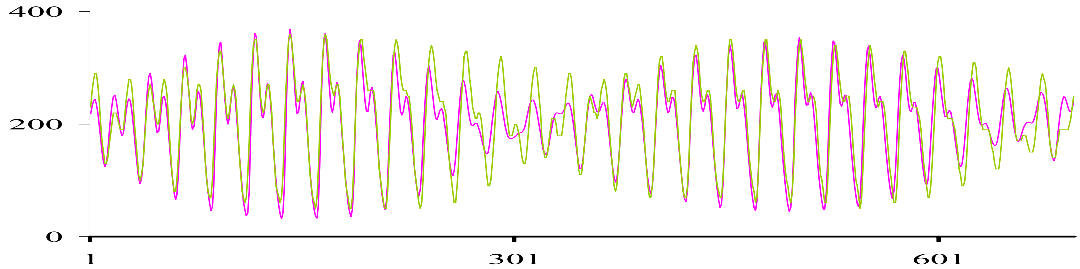
The comparative of predicted seawater level at Ko Sichang with recorded data and computed seawater level was shown in Figure 10. The computed seawater level was calculated by 25 constituents of tide as: S_a, S_{sa}, M_m, M_{sf}, M_f, Q_1, O_1, M_1, P_1, S_1, K_1, OO_1, $2N_2$, μ_2, N_2, ν_2, M_2, λ_2, L_2, T_2, S_2, K_2, M_3, M_4 and M_6. The lines were closely during spring tide. It meant that the computed constituents of tide were reliable to produce the initial conditions of tide to the hydrodynamic model.

The computation of tide constituents by application program at 6 stations (Sichang, Thachin, Pha Chunlachomklao Fort, Mae Klong, Bangpakong and Bangkok bar) around the Upper Gulf of Thailand was shown in Table 8. Each amplitudes and phases lag of constituents at 6 stations did not differ with each other. The co-range lines and co-tidal lines of tide in the Upper Gulf of Thailand could be representing as Figure 11 and Figure 12.

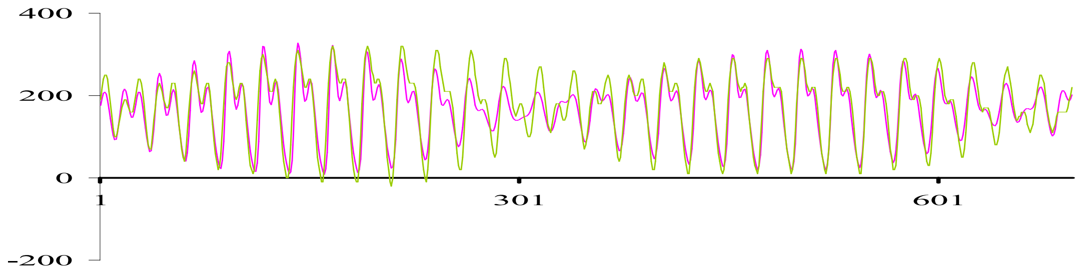




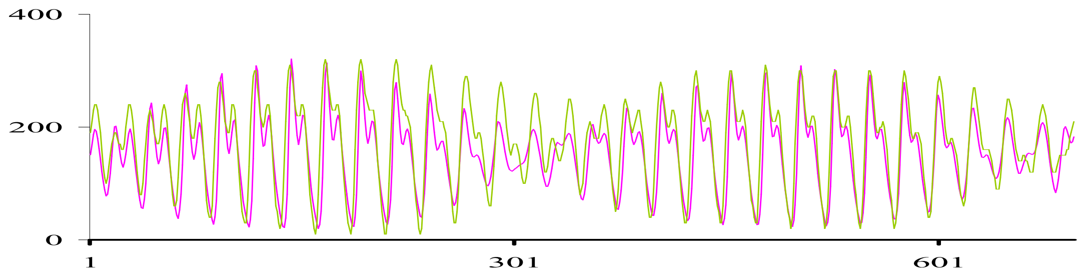
Thachin



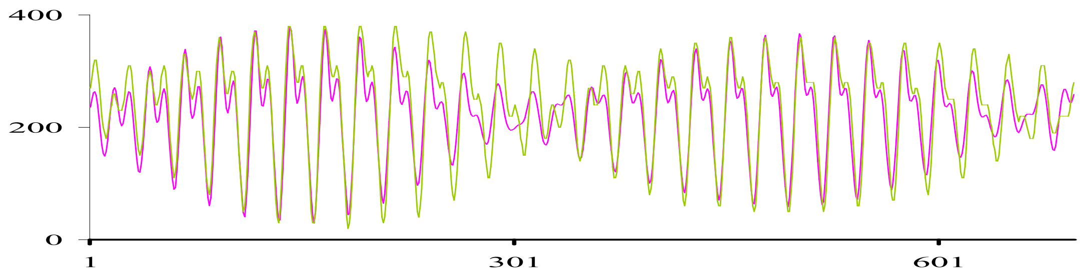
Pha Chunlachomklao Fort



Mae Klong



Bangpakong



Bangkok bar

Figure10 (Continued)