Suspended Sediment Dispersion Originated from the Yellow River in the Bohai Sea

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1. Introduction

The Bohai Sea is simulated using numerical model. Special attention has been paid to the tidal-induced residual current (Cui and Yanagi, 2004).

The spring-neap tidal variations of the Yellow River plume in the Bohai Sea were investigated using NOAA AVHRR visible band images in 2002(Yanagi and Hino,2005) as shown in Fig.3.

The Yellow River is famous for its sediments load into the Bohai Sea. The average river discharge was 4.1×10^9 m^3 per year and the sediment load per year was 0.54×10^8 tons in 2002(Reprot of river sediment in China, 2002).

This study, we first established a numerical model of tide, tidal current and residual currents in the Bohai Sea. Then, we investigate the sedimentation processes of suspended matter supplied from the Yellow River using a three-dimensional transport model of the Bohai Sea which includes the tidal current, residual currents. The objective of our study is to qualitatively explain the suspended sediment dispersion originated from the Yellow River.

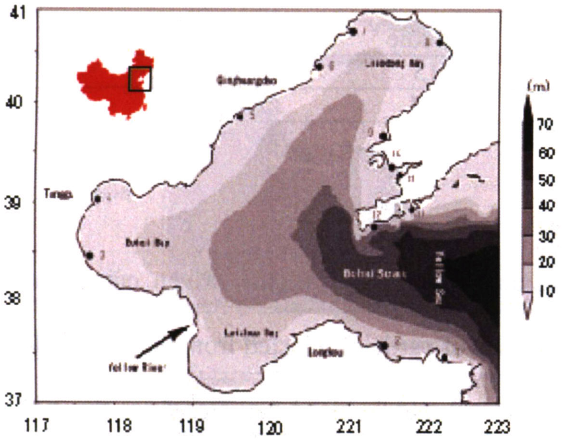

Fig. 1. Bathymetry and the model region of the Bohai Sea.

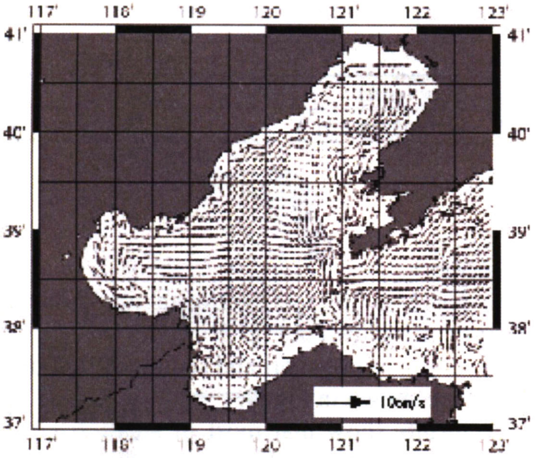

Fig. 2. Residual flows which consists of the Lagrangian tide-induced current and density driven current.

2. Model description We can track the movement of material in a numerical model of the sea using the Euler-Lanrange method (Yanagi and Inoue, 1995) where the movement of a particle is tracked in the Lagrangian sense in the current field, which is calculated in the Eulerian sense.

$$X_{n+1} = X_n + V\Delta t + \frac{1}{2}(\nabla V)V\nabla t^2 + \omega_s \Delta t + R \tag{1}$$

Where V denotes the three-dimensional velocity of tidal current. Δt is the time step. ∇ represents horizontal gradient. ω_S is the sinking velocity of suspended matter by the Stokes law.

When the suspended matter reaches the sea bottom, we judge whether it stops by applying the critical tractive force theory (Tsubaki, 1974),

$$\left.\begin{aligned} F &= \frac{\rho_\omega}{2} C_t U_b^2 \frac{\pi}{4} r^2 \\ R &= \frac{\pi}{6} r^3 \left(\rho_p - \rho_\omega\right) C_S g \end{aligned}\right\} \tag{2}$$

Where F denotes the tractive force; R, the resistance force; C_t, the drag coefficient of suspended matter; C_s, the static friction coefficient of suspended matter; U_b, the velocity of current just above the seabed.

$F > R$, The sediment matter stops moving and deposits to the position where the sediment matter reaches the sea bottom;

$F < R$, The sediment matter removes from its position.

The configurations of the model are the same as those in the tidal current experiment.

River flow rate: 130m^3/s.

River salinity: 0 psu.

On the size spectrum, the surface sediment size is less than 100 μm in Laizhou Bay. In addition, in the area around the Yellow River mouth, the sediment size is less than 16 μm (W. S. Jianget al. 2005). Thus, we injected different kind of particles (small, middle and large sizes) as shown in table 1.

We conducted two experiments which correspond to spring tide and neap tide. In the first experiment, 200 particles were injected at spring tide and tracked until next spring tide for each particle size. In the second experiment, also 200 particles were injected at neap tide and tracked until next neap tide for each particle size.

Table. 1. Particles used in model

	Small	Middle	Large
Size (μm)	4	15	50
Density(g/cm^3)	2.5	2.5	2.5

3. Result

The residual flows (Lagrangian tide-induced residual current and density driven current at the surface) are shown in Fig. 2.

The results of transport and sedimentation of suspended of particles injected from the Yellow River mouth are shown in Fig. 4.

The results show that most of small sized particles and middle sized particles from the Yellow River transported mainly from Laizhou Bay to Bohai Bay with the coast on the left hand side, but most of the large sized particles deposited within one-day and they do not move again.

Furthermore, the spreading area during sprint tide is wider than during neap tide due to the re-suspension by the strong tidal current. This is in agreement with the results from satellite images as shown in Fig. 3.

The results of transport experiment qualitatively explain the spreading pattern of the suspended matter.

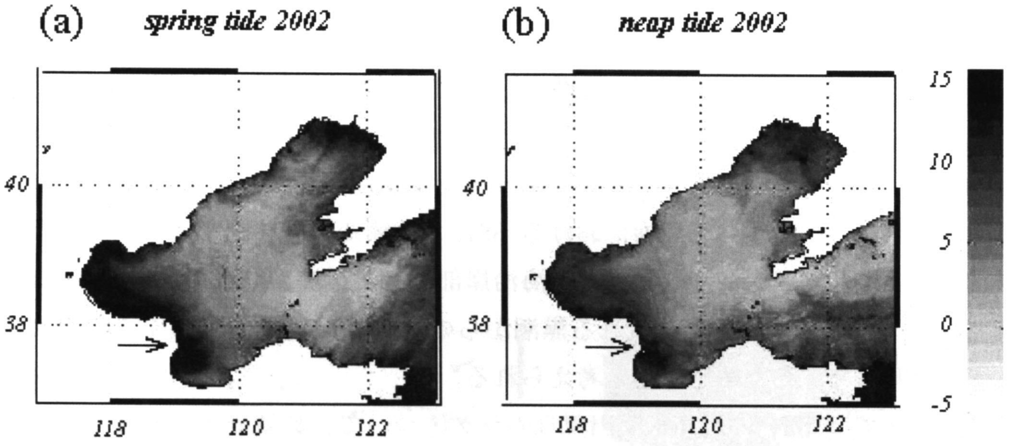

Fig. 3. The Yellow river plume spreading in spring tide (a), neap tide (b) in 2002 (Hino and Yanagi, 2004)

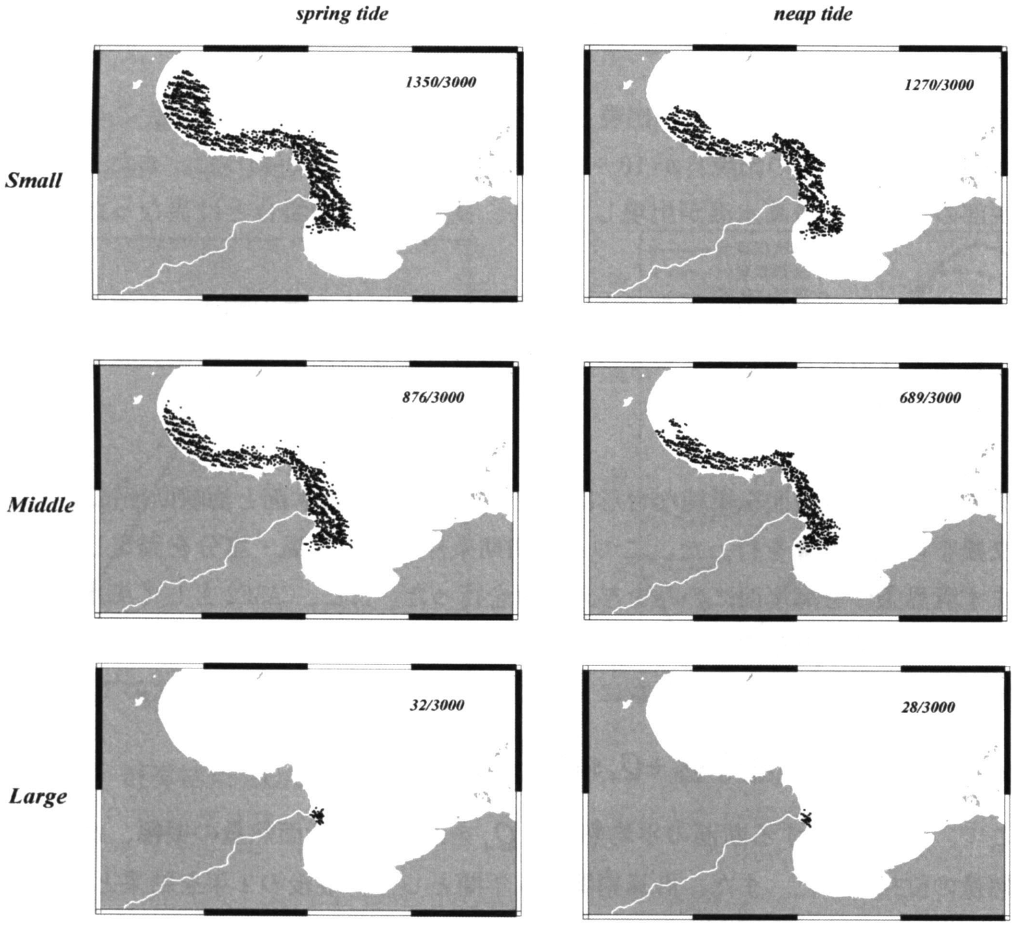

Fig. 4. Result of the calculation. Number shows the total number of moving particles and total number of particles injected from Yellow River mouth.