A preliminary study on the tidal effects on the Yellow Sea Bottom Cold Water and its ecosystem using a physics-ecosystem coupled model

Jae-Kwi So *, Hyoun-Woo Kang and Okhee Seo
Korea Institute of Ocean Science and Technology, Ansan, R. Korea
*jkso@kiost.ac.kr

Abstract:

A physics-ecosystem coupled model was developed to study the marine ecosystem around the Korean Peninsula. The physical module of the model uses a finite difference grid in the horizontal coordinates (C-grid) and a hybrid σ-z grid in the vertical coordinate to describe realistically the shallow and mild slope topography along with the deep and steep slope topography. The ecosystem module, which is based on the Ecological Regional Ocean Model (ERGOM) of Neumann (2000), is composed of ten variables, that is, three nutrient types (nitrates, ammonia and phosphates), three phytoplankton functional groups (diatoms, flagellates and blue-green algae), two zooplankton group (micro- and meso-zooplankton), detritus and dissolved oxygen, and it also comprises bottom detrital sediment. Tidal effects on the behavior of the Yellow Sea Bottom Cold Water (YSBCW) were tested using the developed model. In the normal experiment including tide, YSBCW is located in the central area of the Yellow Sea. In the case of the circulation experiment excluding tide, however, YSBCW is moved to the east side of the Yellow Sea, and the stratification in the latter case is weaker than in the former. The responses of ecosystem variables in the YSBCW were also investigated and be discussed for the two cases.

I. Introduction

❖ Yellow Sea Bottom Cold Water

- The southern YSBCWM is the water mass that develops in summer and decays in fall. In winter, the central area of the Yellow Sea is occupied by warm saline water (T>10℃). In contrast, from early summer to fall, under the seasonal thermocline, the central area of the Yellow Sea is occupied by cold water (T<10℃) - Zhang et al.(2008)
- In summer, the YSBCW played a sheltering role for *C. sinicus* to avoid warm surface waters above their thermal range in the southern Yellow Sea. Accordingly, a high abundance of adult *C. sinicus* occurred in the area of YSBCW(<12℃) – Wang et al(2003)
- The YSBCW plays a seasonally different role in the spatial distribution of copepods – Kang & Kim(2008)

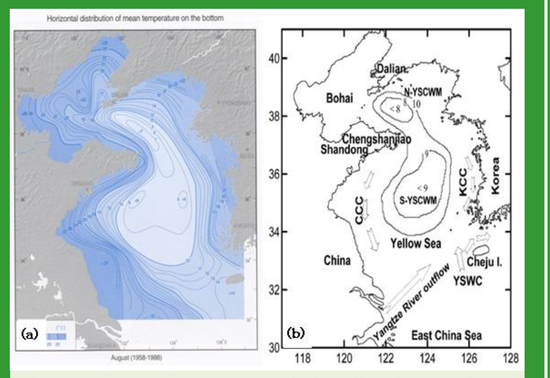


Fig. 3.1.1.7. (a) Horizontal distributions of temperature on the bottom layer in August (China Ocean Press, 1992), and (b) schematic diagrams of the cold water masses and current sysem in the Yellow Sea in summer (Zhang et al., 2008). - from KIOST(2015)

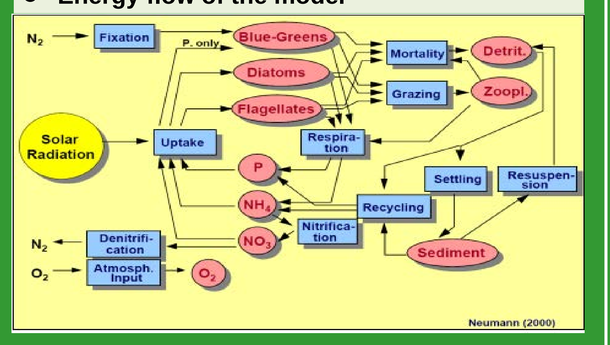
❖ Ecosystem model (ERGOM based)

- ERGOM : developed by Neumann(2000), for the Baltic Sea research
- Nitrogen cycle (**one energy currency : Nitrogen**)
- **12 ecosystem variables**
- **4 nutrients** : ①Ammonia, ②Nitrate, ③Phosphate, ④Silicate
- **3 phytoplankton functional groups**: ⑤Diatoms, ⑥Flagellates, ⑦Blue-green algae
- **2 zooplankton groups**: ⑧Micro-zooplankton group, ⑨Meso-zooplankton
- ⑩Detritus, ⑪Dissolved Oxygen, ⑫Detrital sediment
- **Normalized unit** : N_{norm}=4.5$\frac{mmol}{m^3}$, O_{norm}=375$\frac{mmol}{m^3}$

● Phytoplankton functional groups

diatoms	①larger cell, ②grow quickly in nutrient rich conditions, ③sinking fast to the bottom
flagellates	①smaller cell, ②neutrally buoyant cells, ③have an advantage at lower nutrient conditions
blue-greens	①smallest cell, ②nitrogen fixation (a nitrogen source for the system). ③positive buoyancy

● Energy flow of the model



II. Numerical modeling

❖ Model setup

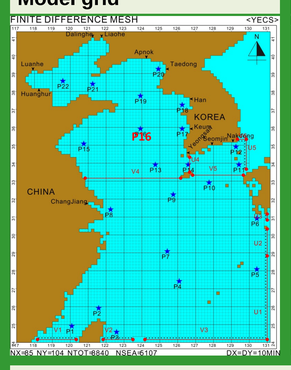
● Model

- Horizontal : finite difference mesh of equally spaced by 1/6° (Nx=85, Ny=104)
- Vertical : total 37 layer with the upper 14 σ-layer
- Vertical eddy viscosity/diffusivity – algebraic formula by Pacanowski & Philander(1981)
- Advection::UNO(Upstream Non-Oscillatory) scheme

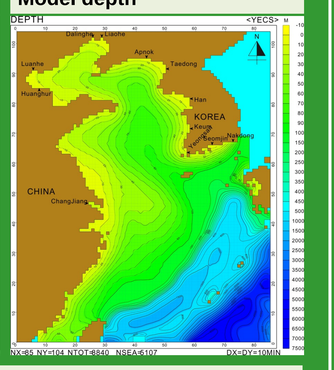
● Input data

- Tide : TPXO8
- Air-sea : ERA-Interim SST, Wind, Atm. Pressure (monthly), TCC (6 hourly))
- Open boundary : HYCOM results (Elev, Vel, Tem & Sal), WOA2009 (ecosystem variables)
- River boundary : GRDC (flux), Global NEWS (nutrients)
- Experiment : 10 years (1999-2008)

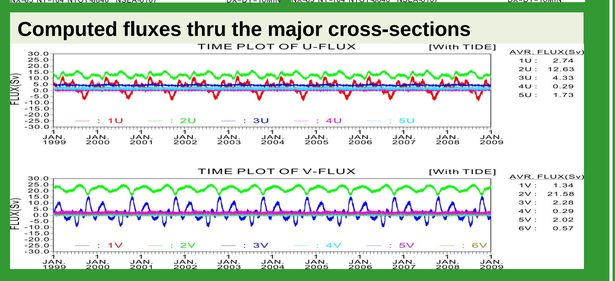
Model grid



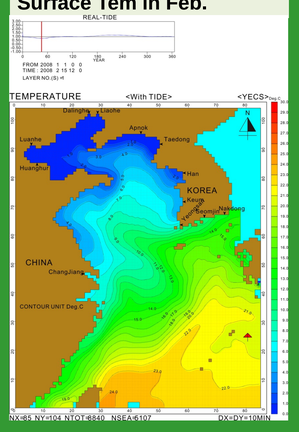
Model depth



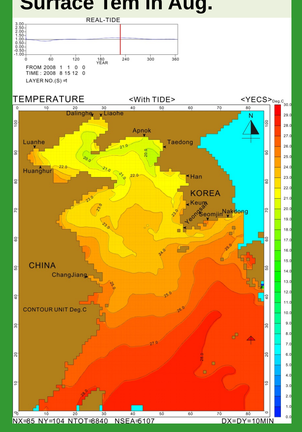
Computed fluxes thru the major cross-sections



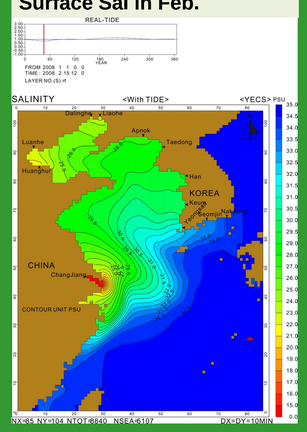
Surface Tem in Feb.



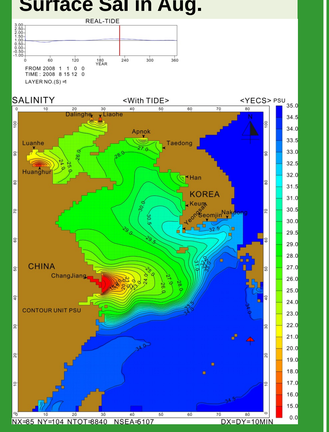
Surface Tem in Aug.



Surface Sal in Feb.

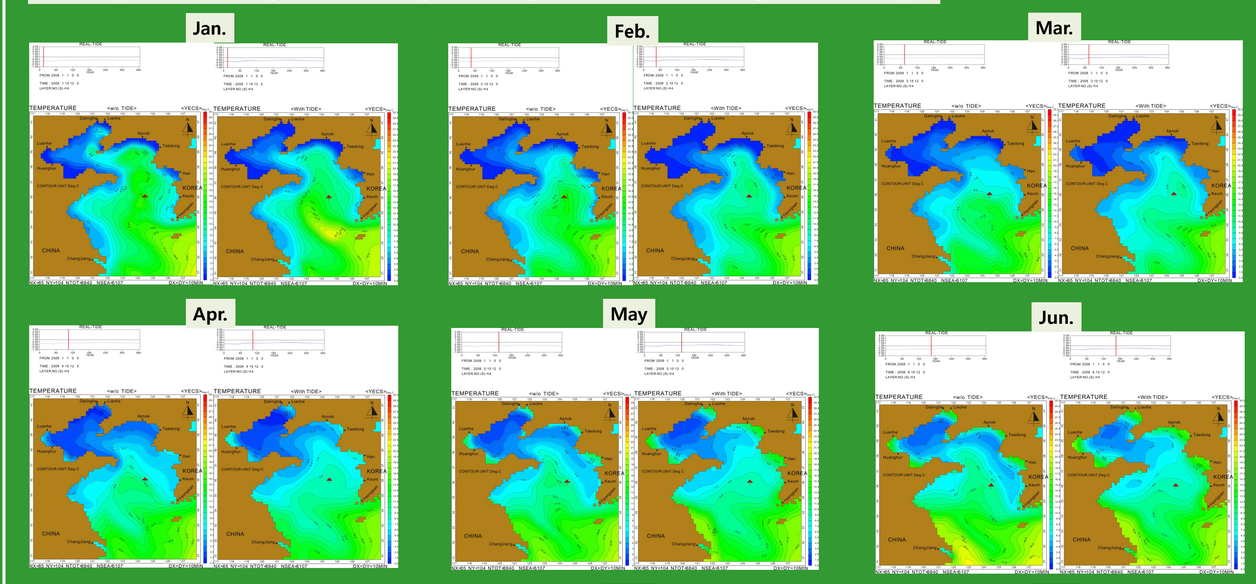


Surface Sal in Aug.



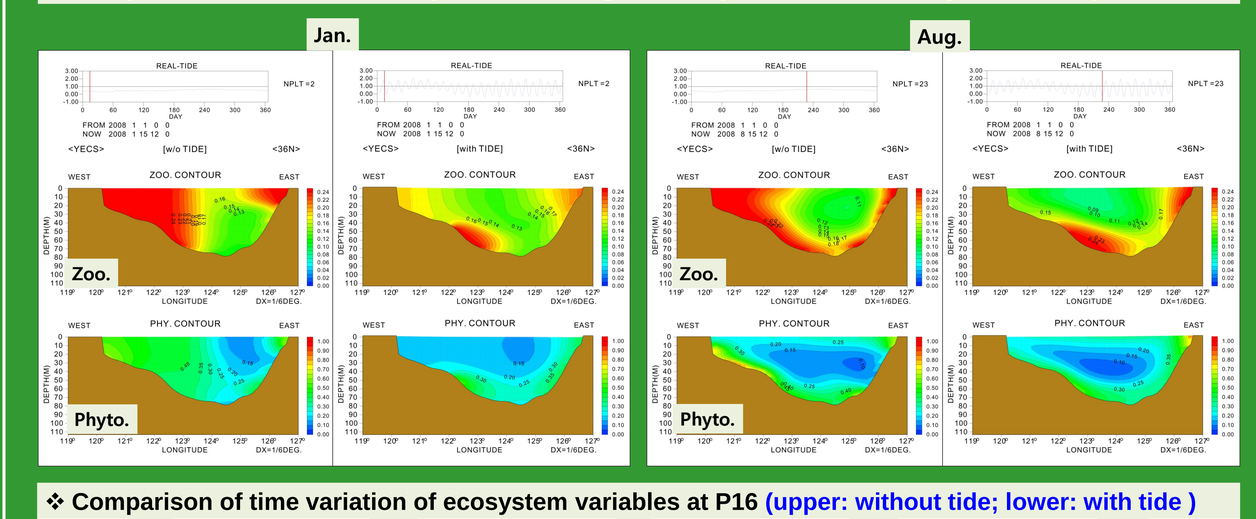
III. Tidal effects on YSBCW and its ecosystem

❖ Computed monthly bottom temperature (left: without tide; right: with tide)

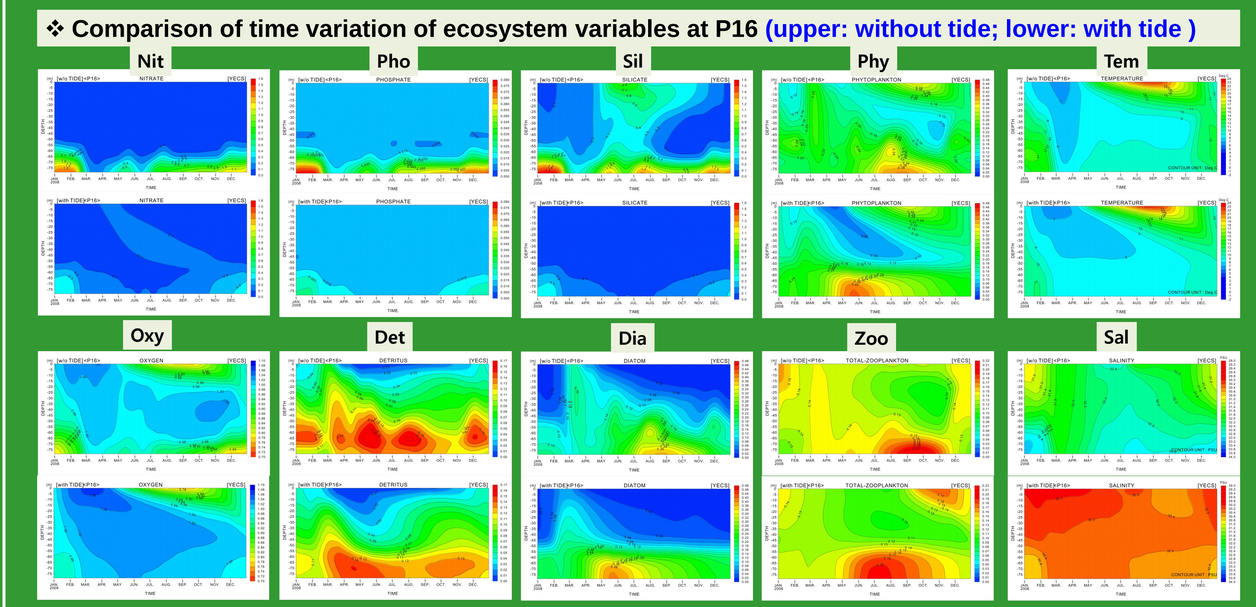


❖ Comparison of section view of T &S along the 36N (left: without tide; right: with tide)

❖ Comparison of section view of planktons along the 36N (left: without tide; right: with tide)



❖ Comparison of time variation of ecosystem variables at P16 (upper: without tide; lower: with tide)



❖ Summary

- An ERGOM-based ecosystem model was developed and coupled to the coastal ocean physical model
- Tidal effects on the YSBCW and its ecosystem are studied using the coupled model.

- Without tide, the YSBCW locates nearer to Korean Peninsula, while it locates at central part with tide.
- In case of no tide, the model results shows some different distribution pattern of ecosystem variables
- Other factors affecting the YSBCW will be studied.