Modeling analysis of the main factures and annual cycling of new production and the microbial food loop impact in the Yellow Sea Cold Water Mass

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Main Contents

- One-dimensional coupled pelagic-benthic three-box ecosystem model
- The simulated ecosystem annual cycling
- Primary productivity and new production
- The contribution of microbial loop
- Summary and further work

Model Introduction

The Yellow Sea Cold Water Mass

- Germinate in April，come in to being in May，Reach Volume Maximum between May to June. Anon, the volume shrink along with the vertical mixing enhance, but the intensity strengthen, reach it maximum between July to August. Because of the vertical maxing, it is decline gradually whatever volume and intensity in autumn. And disappear from December to next January. It is a seasonal Cold Water Mass.

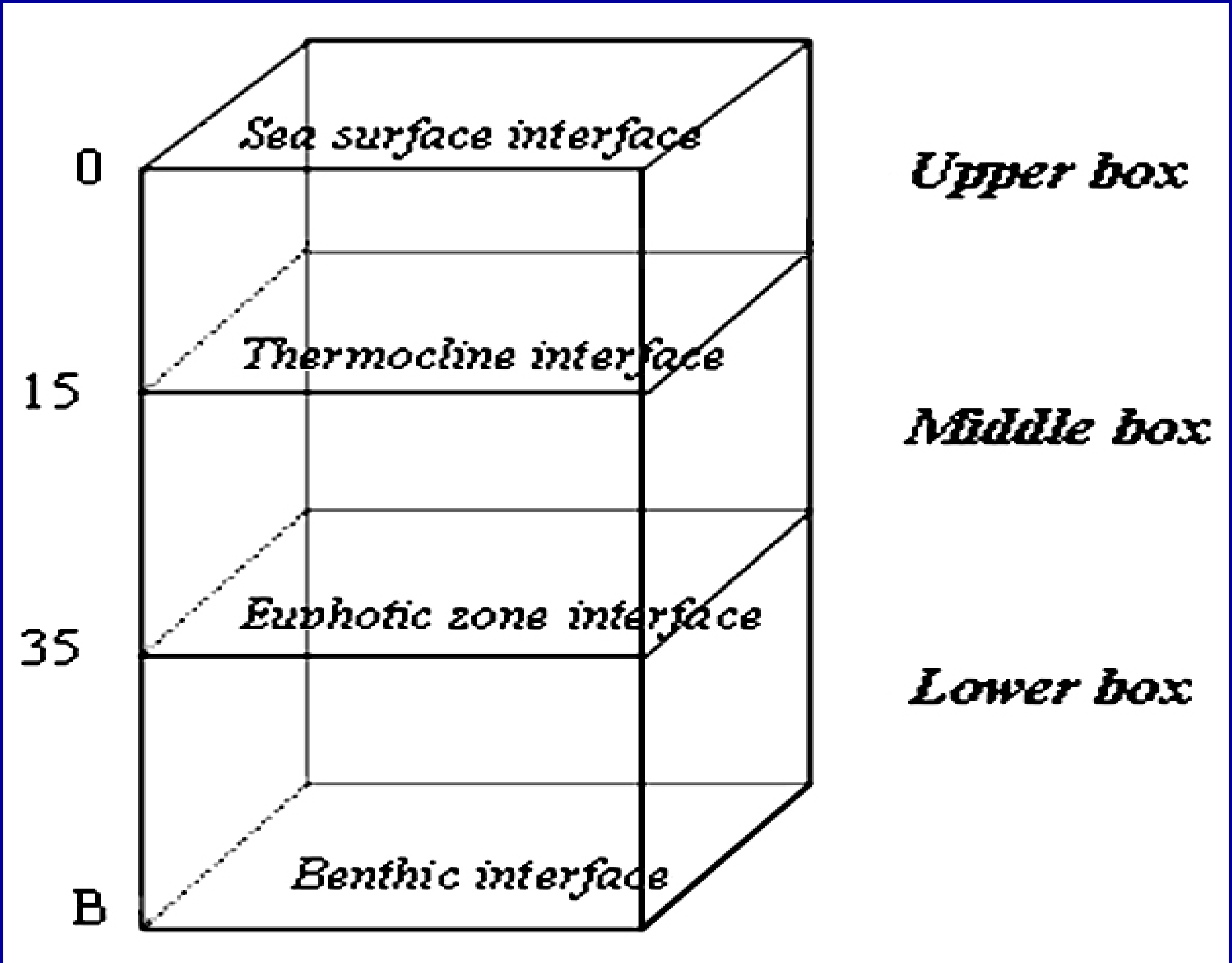
- The mean depth of the thermocline about 20 to 30m，shallow in July and August, but it can reach 40m in November （Zou *et al.*，2001）.

Characteristics of model

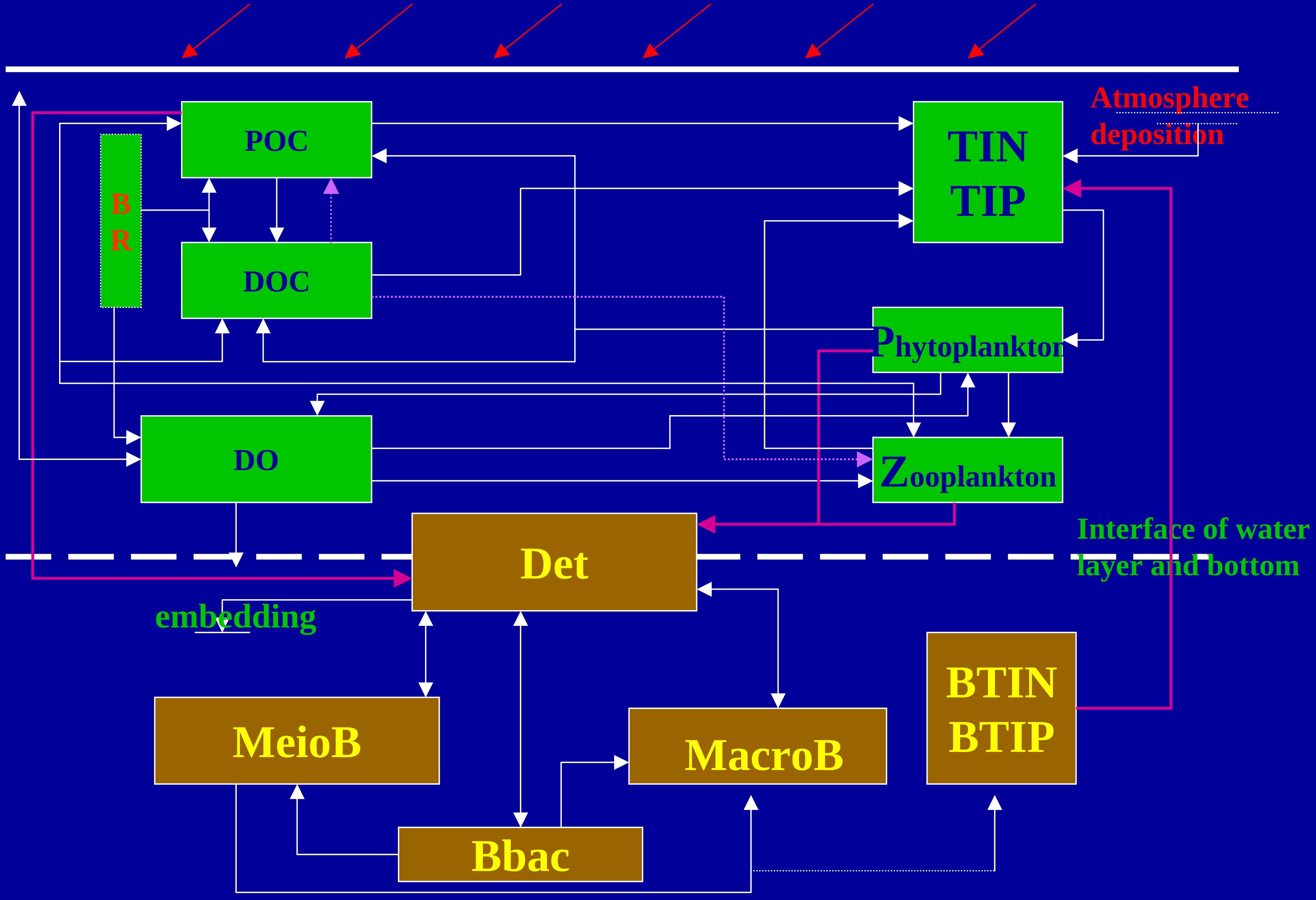
- Jiaozhou Bay model (Wu *et al*., 2001)

  Multi-box model in Bohai Sea (Zhang *et al*., 2002).
- Three boxes (vertically)
- 13 variables
- Nutrients atmosphere deposition

  Sediment ecudation
- Microbial loop



The configuration of the three boxes in the model



Configuration of energy and matters cycling in this model

Main Equations

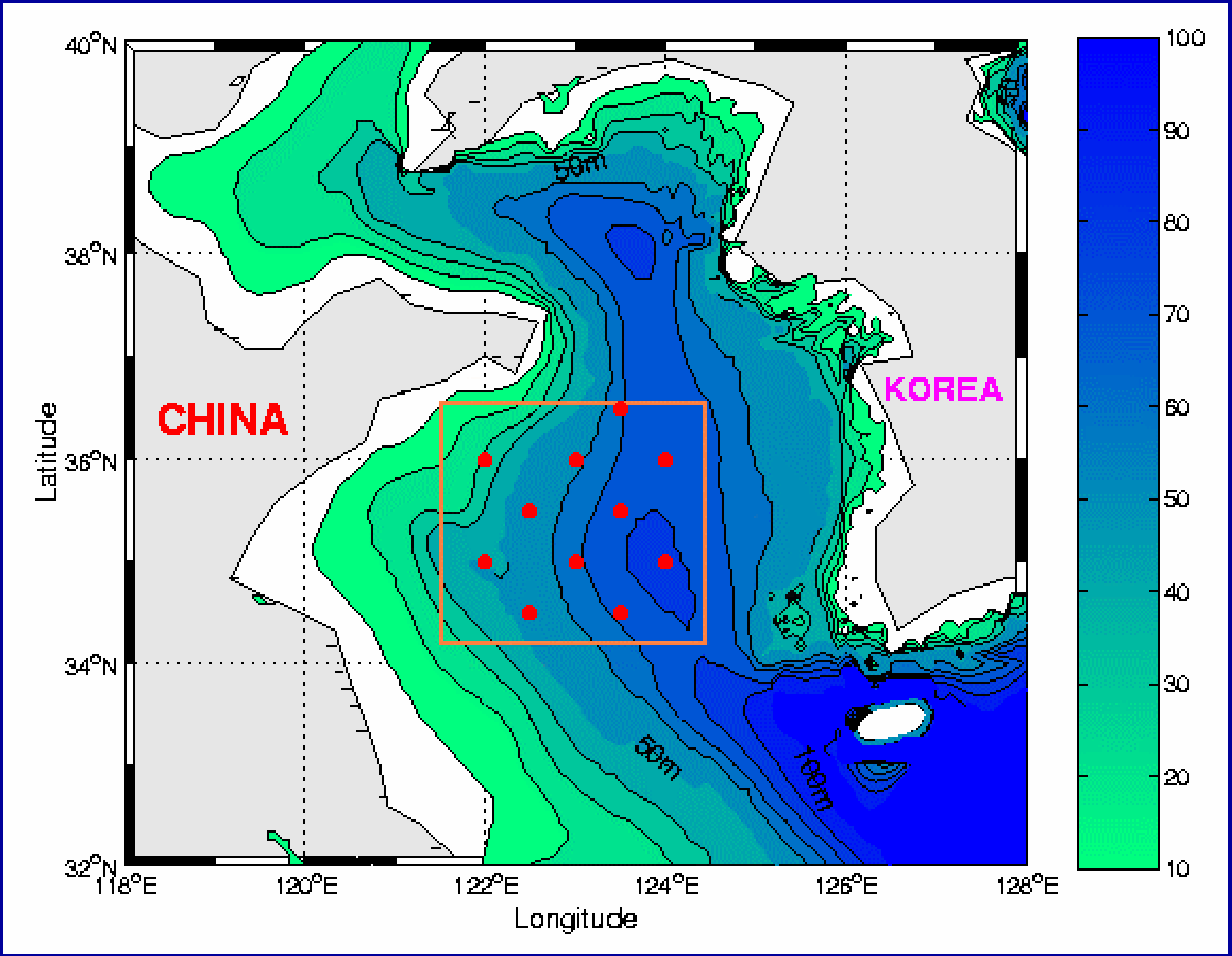
$$\frac{dP}{dt} = B_1 - B_2 - B_3 - B_4 - B_6 - B_7 + Q_v$$

$$\frac{dZ}{dt} = B_4 + B_{Zpoc} + B_5 - B_8 - B_9 - B_{10} - B_{11} + Q_v$$

P-phytoplankton, B_1-photosynthesis, B_2-extracelular release, B_3-respiration
B_4-zooplankton grazing, B_6-mortality, B_7-deposition
Z-zooplankton, B4-graze phytoplankton, B_5-microbial loop contribution
B_8-feces, B_9-excretion, B_{10}-mortality, B11-being predation
Q_v-vertical transportation

The simulated region and period

- Latitude: 34.2ºN～36.6ºN
  Longitude: 121.6º E～124.4º E
  Mean depth: 69m
- 7 cruises in situ observation
  June, November 2000; January, April, May, June, July 2001
- 11 investigation stations
- Simulated period: 16/6/2000～16/6/2001



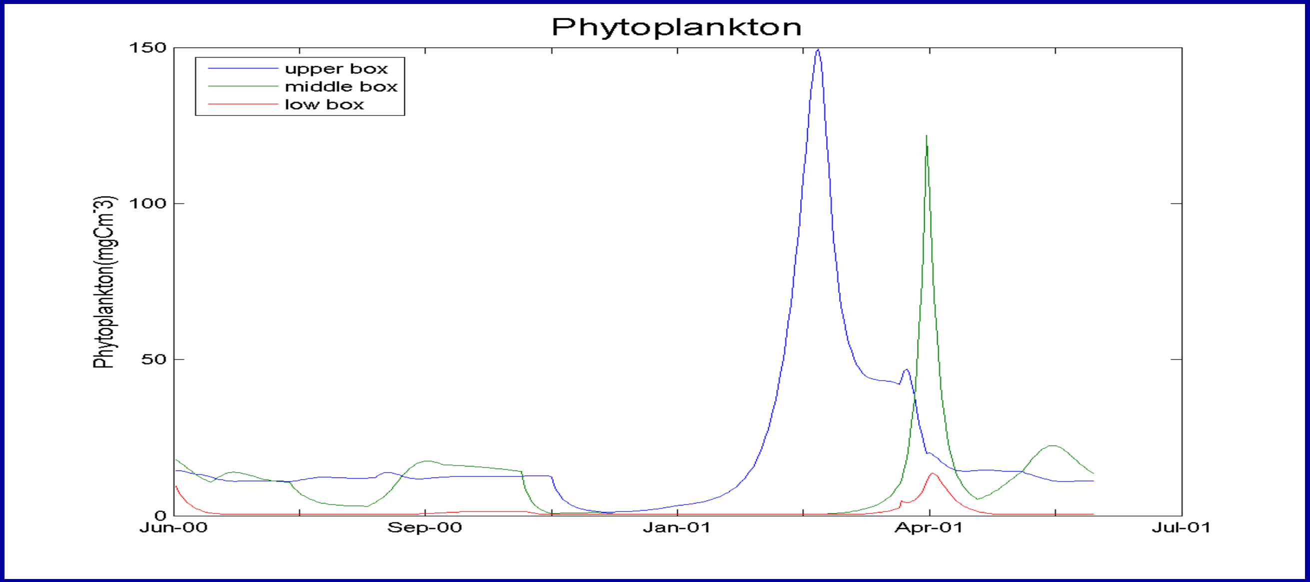
The investigation stations and the simulation region

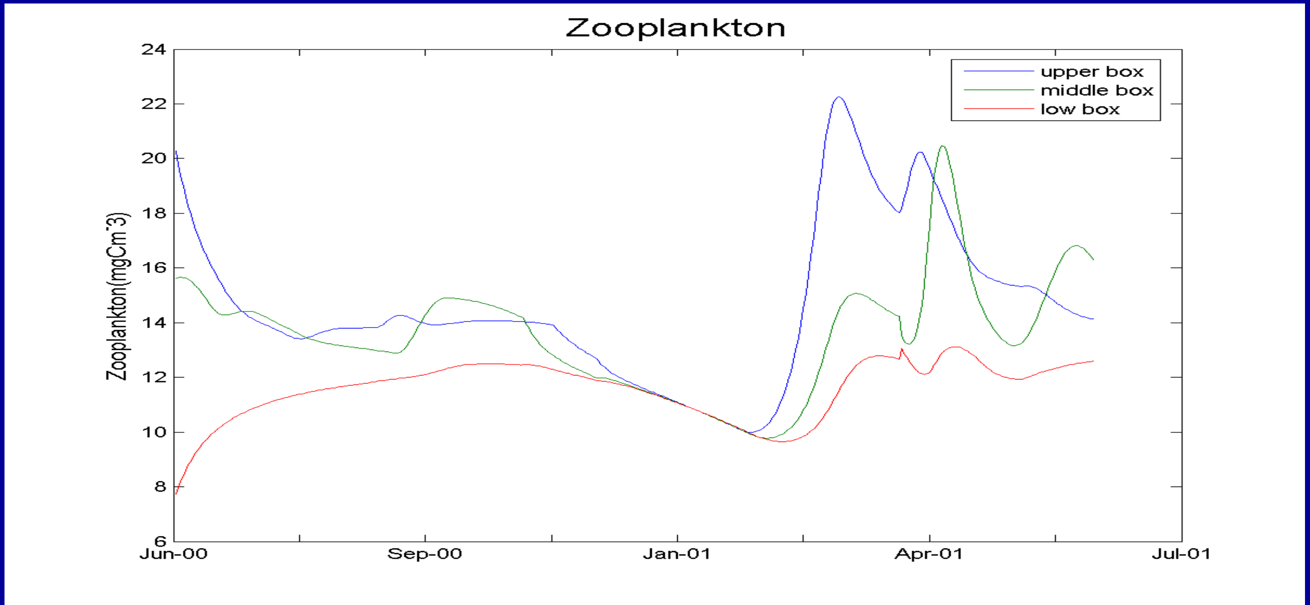
Initial values for the pelagic-benthic coupling ecosystem of the YSCWM

	Upper Box	Middle Box	Lower Box
PC($mgCm^{-3}$)	14.5	18.0	9.5
ZOO ($mgCm^{-3}$)	20.27	15.61	7.73
POC ($mgCm^{-3}$)	183.2	172.6	169.3
DOC ($mgCm^{-3}$)	1863.2	1750.7	1659.9
DO ($mgOm^{-3}$)	6920	8020	7778
TIN ($mgNm^{-3}$)	6.86	14.18	23.66
TIP ($mgPm^{-3}$)	1.86	5.58	11.47
MacroB ($mgCm^{-2}$)	-	-	7682
MeioB ($mgCm^{-2}$)	-	-	228.99

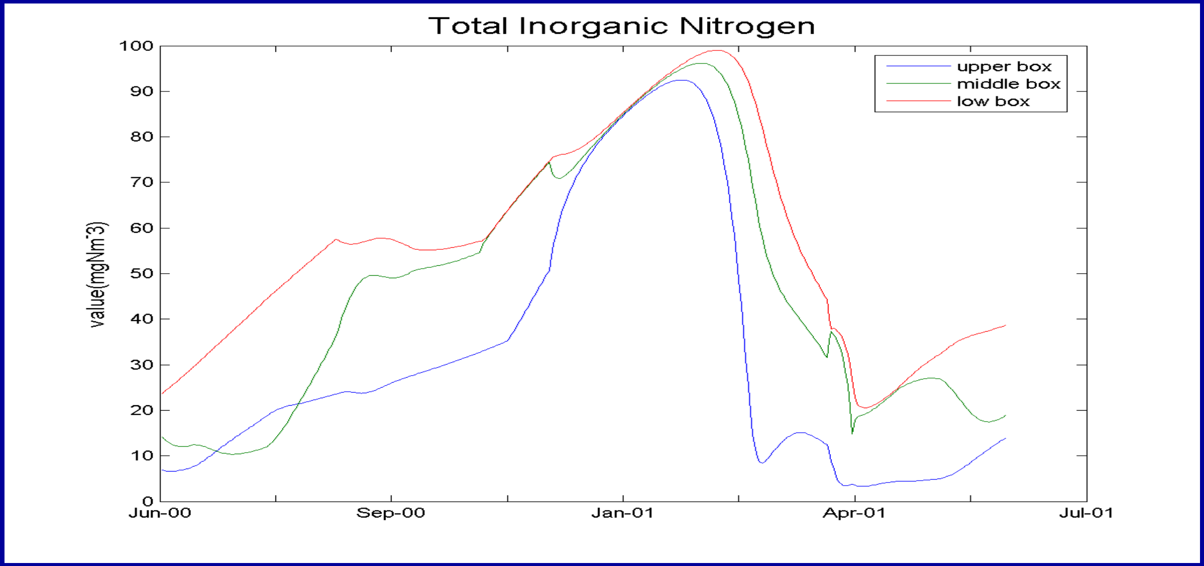
The simulated ecosystem annual cycling in the YSCWM

The annual cycling of phytoplankton and zooplankton biomass（Unit：$mgCm^{-3}$）

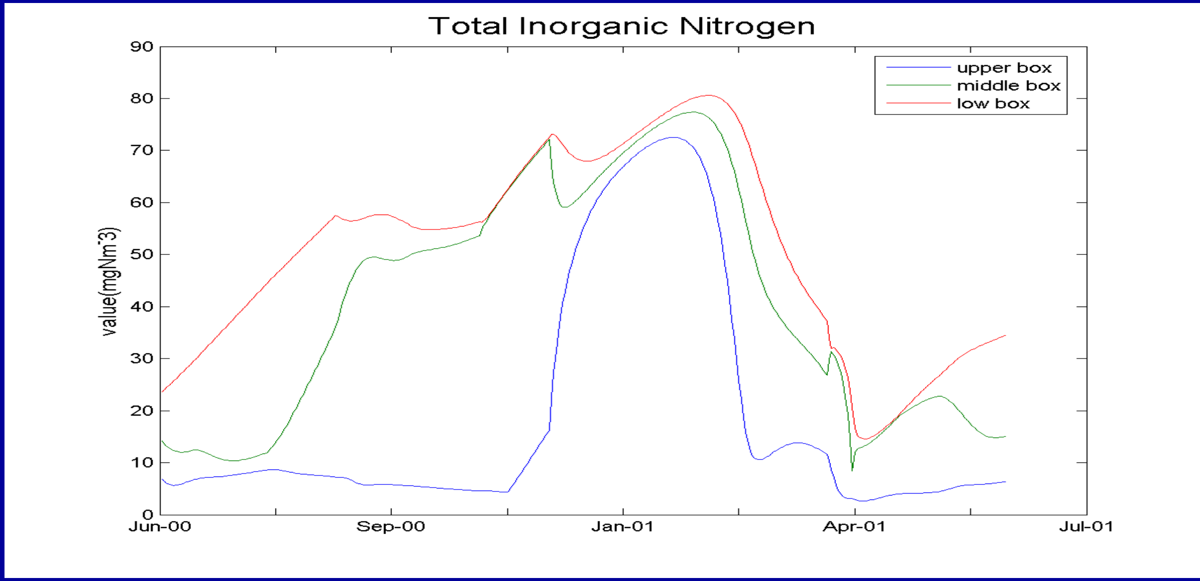




The annual cycling of TIN concentration (Unit：$mgNm^{-3}$)

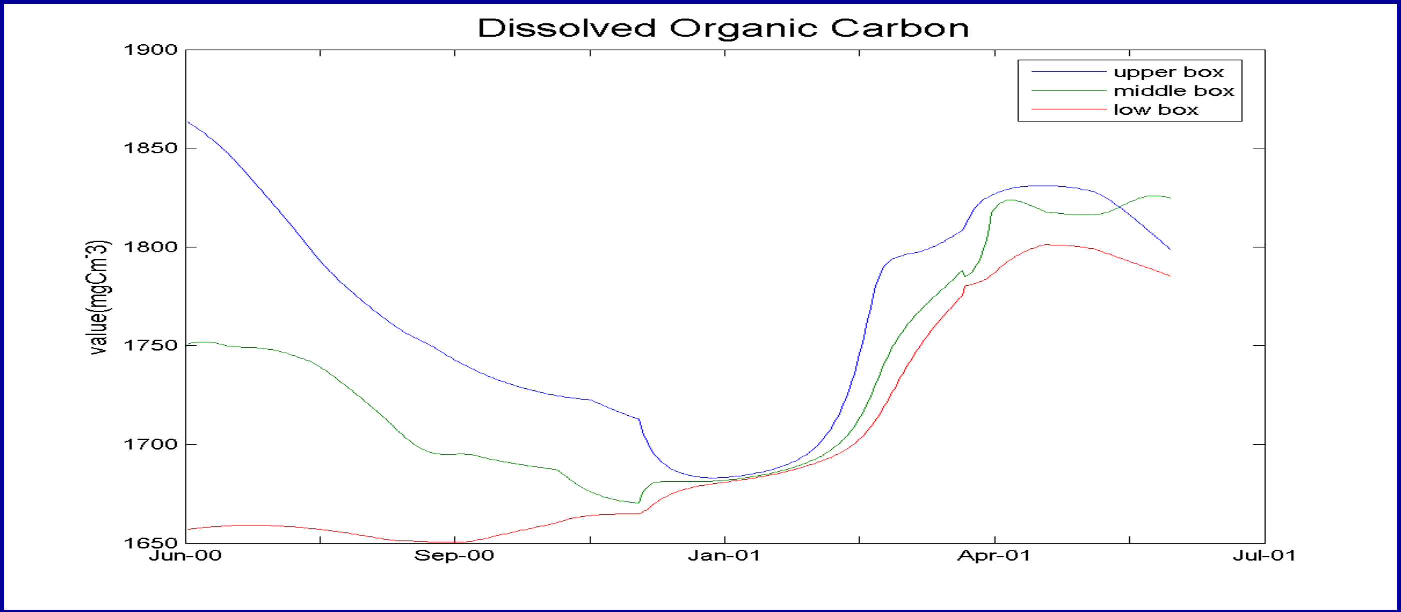


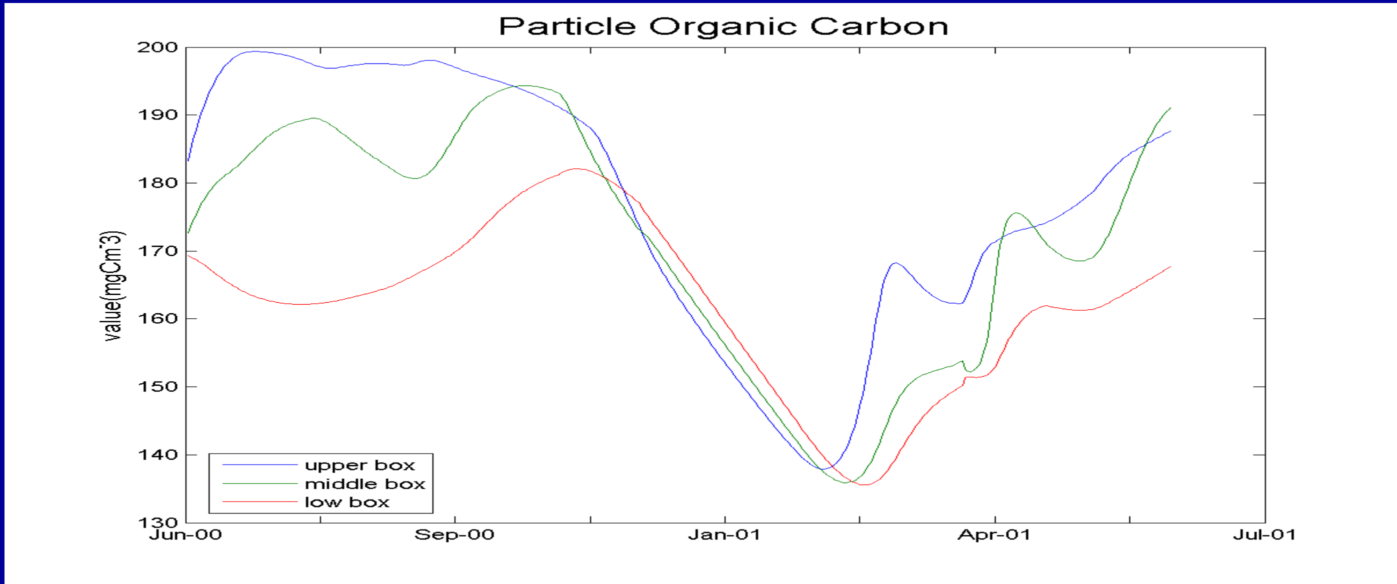
With atmosphere nutrients deposition



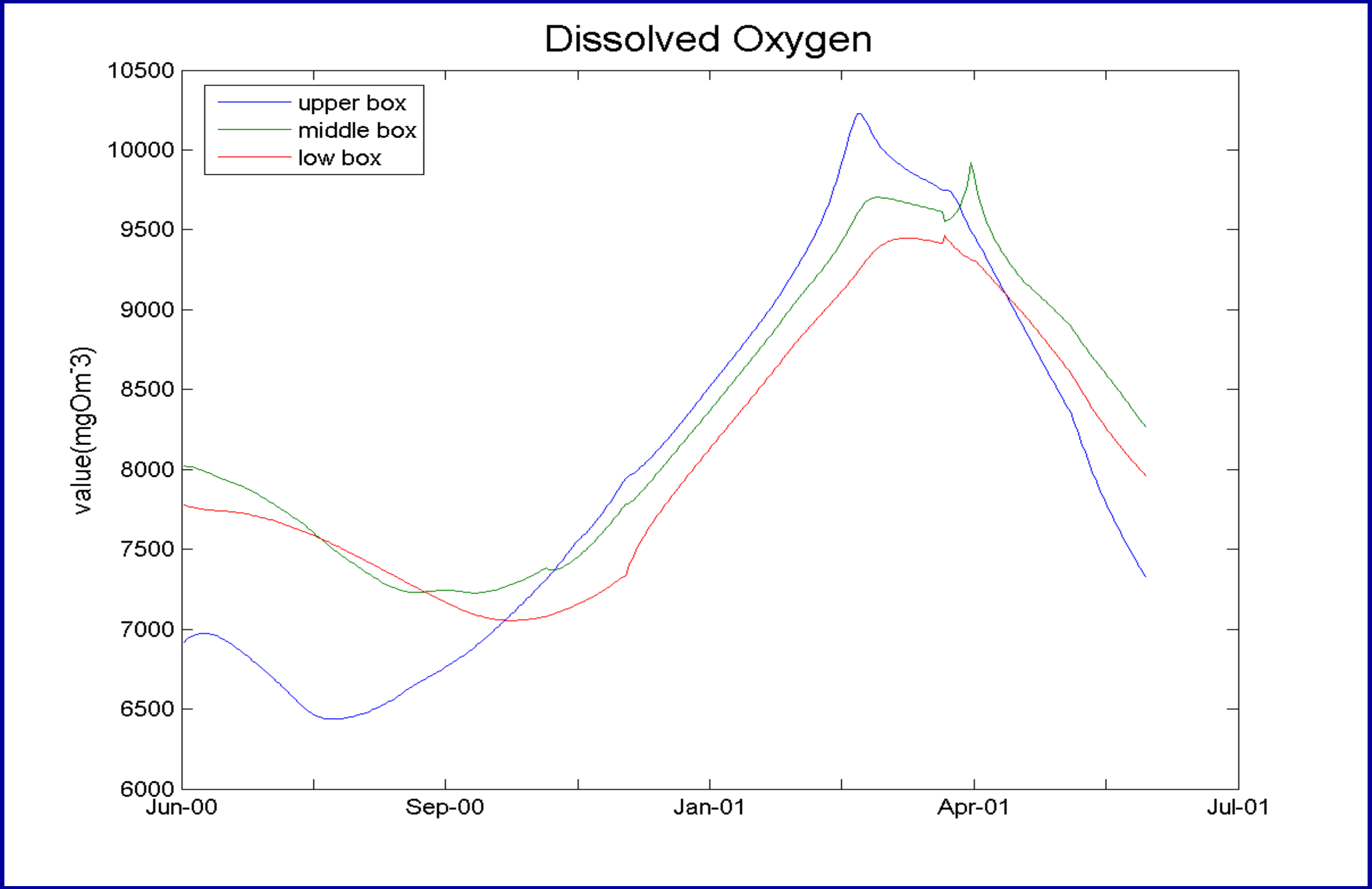
Without atmosphere nutrients deposition

The annual cycling of DOC and POC concentration （Unit：$mgCm^{-3}$）

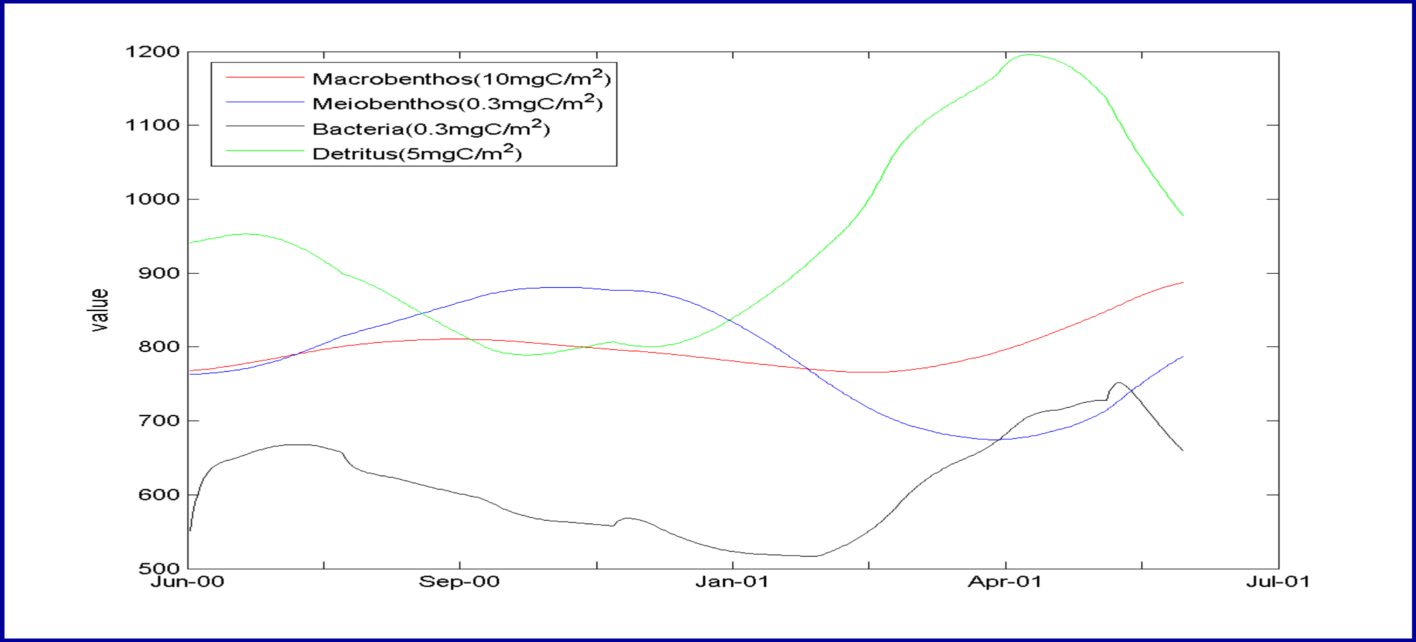


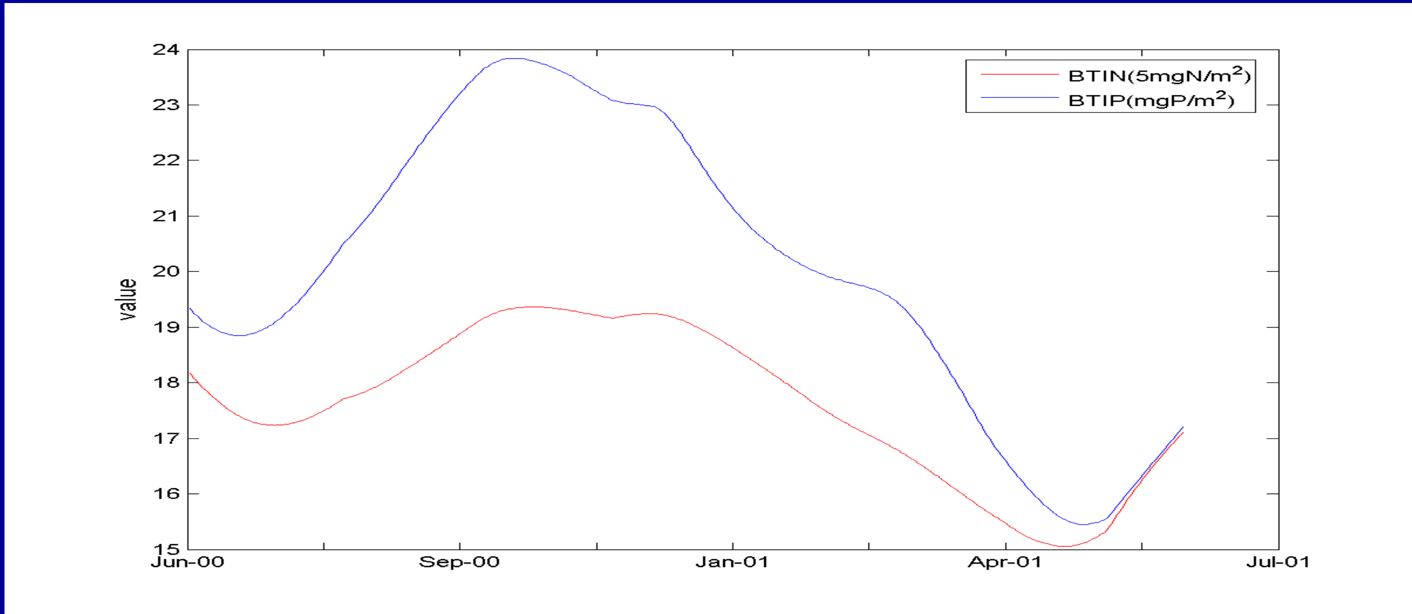


The annual cycling of DO concentration (Unit: $mgOm^{-3}$)



The benthic sub-model variables annual cycling





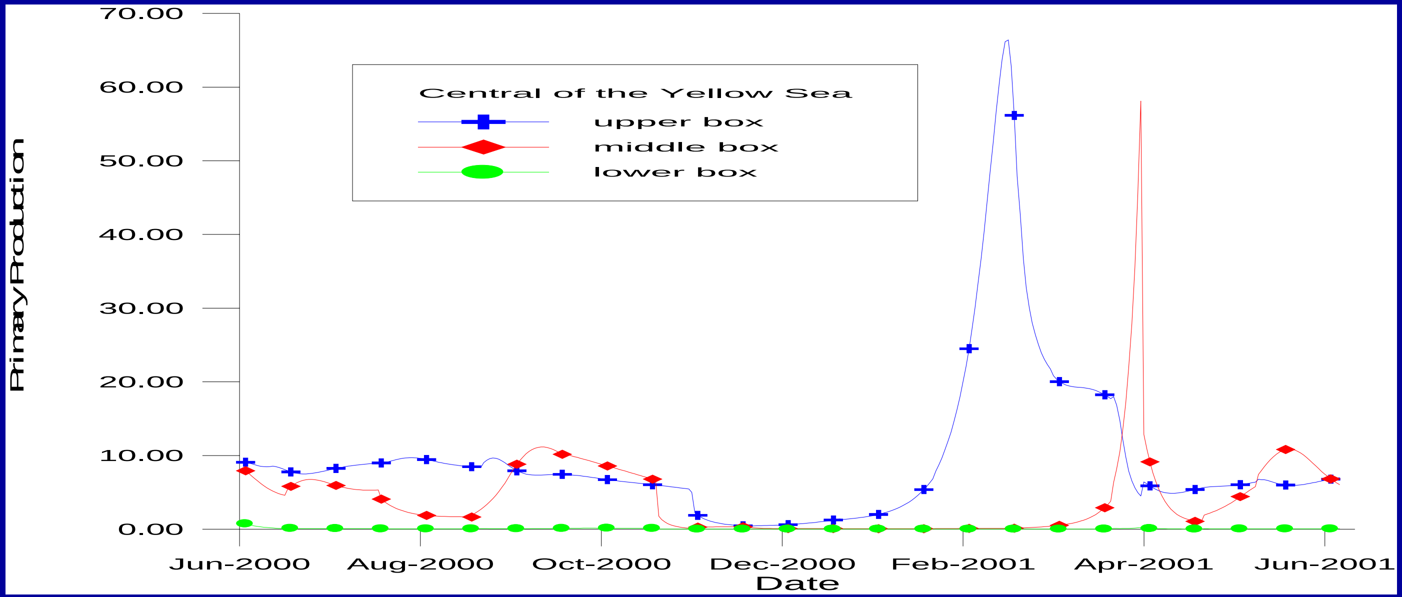
Primary productivity and new production

Annual cycling of the primary productivity （Unit：$mgCm^{-2}d^{-1}$）

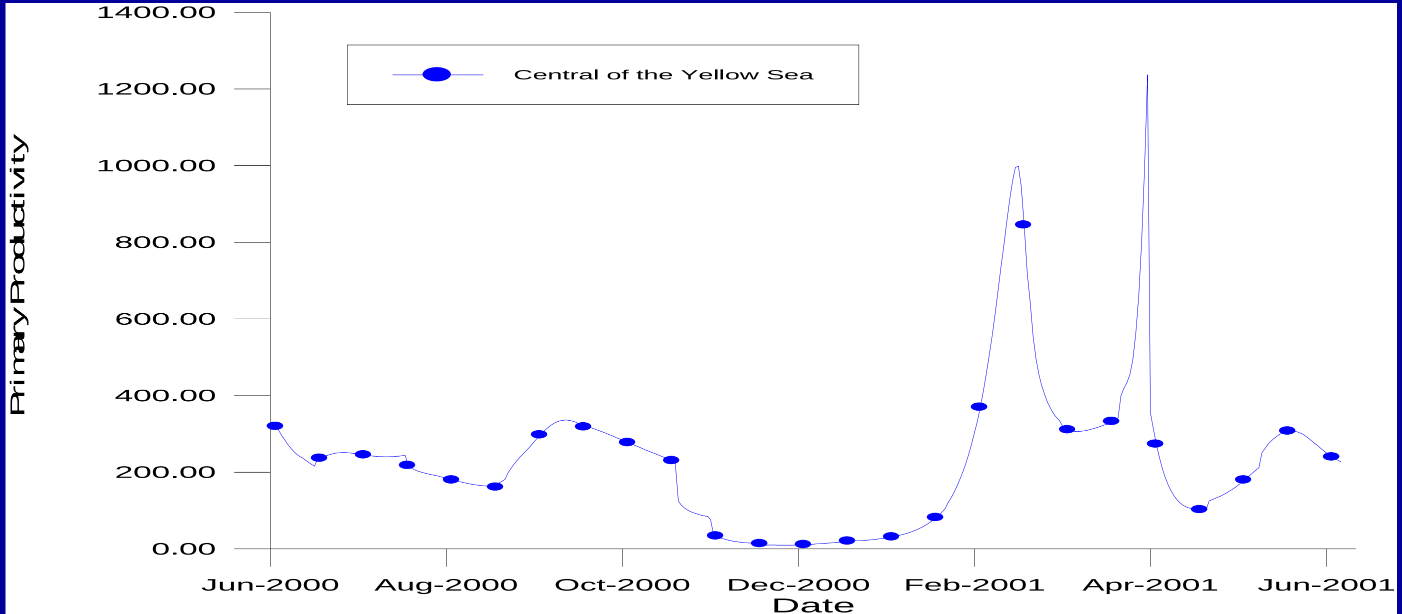
	In situ Obs. YS*	Result of Simu. YSCWM
Spring	623	399.96
Summer	596	258.33
Autumn	368	257.26
Winter	111	36.86
Whole year	425	239.10

* Aug. Nov. 1984, Feb. May 1985， in situ Obs., Ning *et al*. （1995）

The annual cycling of Primary Productivity



（Unit：mgCm^{-3}d^{-1}）



（Unit：mgCm^{-2}d^{-1}）

Analysis

The reason of low PP：

1）Region and period difference between simulated and observation (because of data limited)

- **Date 1984～1985, most region of the Yellow Sea, 200～500. Zhu *et al.*（1993）**
- **Date 1993～1994, the East China Sea and surrounding region, 220～350, seasonal variation remarkable 68～1500. T. Hama *et al.*（1997）**
- **The primary productivity of the Yellow Sea, high value in offing and low value in center area. Yang *et al.*（1999）**

2）Human activity, climate *et al.*

- **After 10 years, the mean primary productivity of the whole Bohai Sea descend from 312 to 216, and it descend from 394 to 185 in the center area of Bohai Sea. Lv *et al.*（1999）。**

3）Conclusion ： The primary productivity is descend gradually in the center area of the Yellow Sea

number unit of this page: $mgCm^{-2}d^{-1}$

New N / Regeneration N

- **Annual atmospheric deposition**

  Simulation result: 1318.1 $mgNm^{-2}yr^{-1}$

  Wang (2002): 1017.3 $mgNm^{-2}yr^{-1}$

- **Annual mean sediment ecudation**

  Simulation result: 15.9$mgNm^{-2}d^{-1}$

  Wang (2002): 14.6 $mgNm^{-2}d^{-1}$

f ratio

Simulated result : 33.0 %

Yang (1999) : <40 %

Tian *et al.* (2003): 30 %

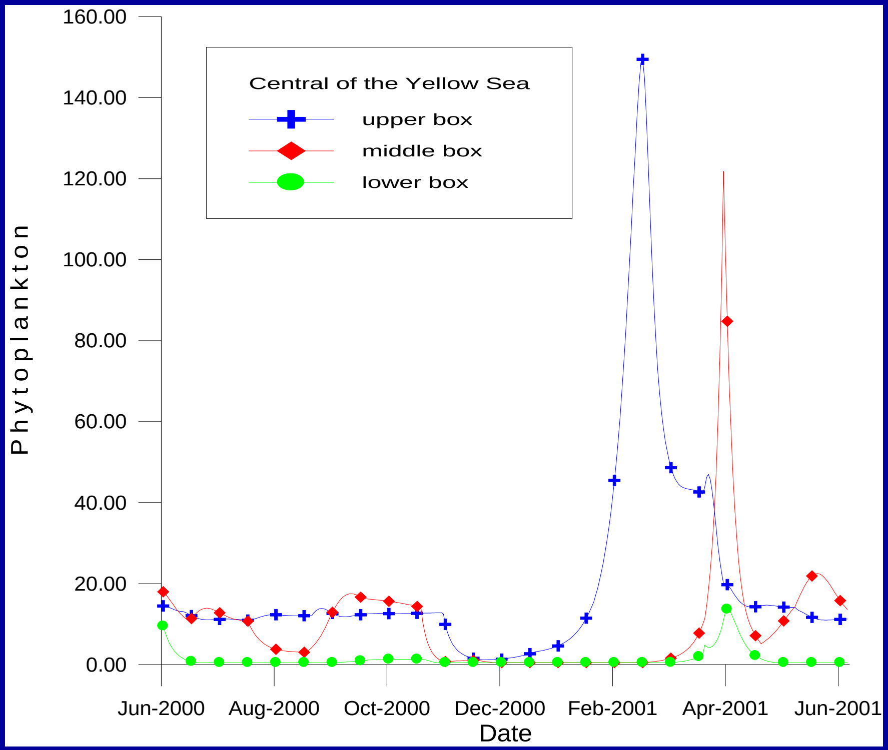
New production:

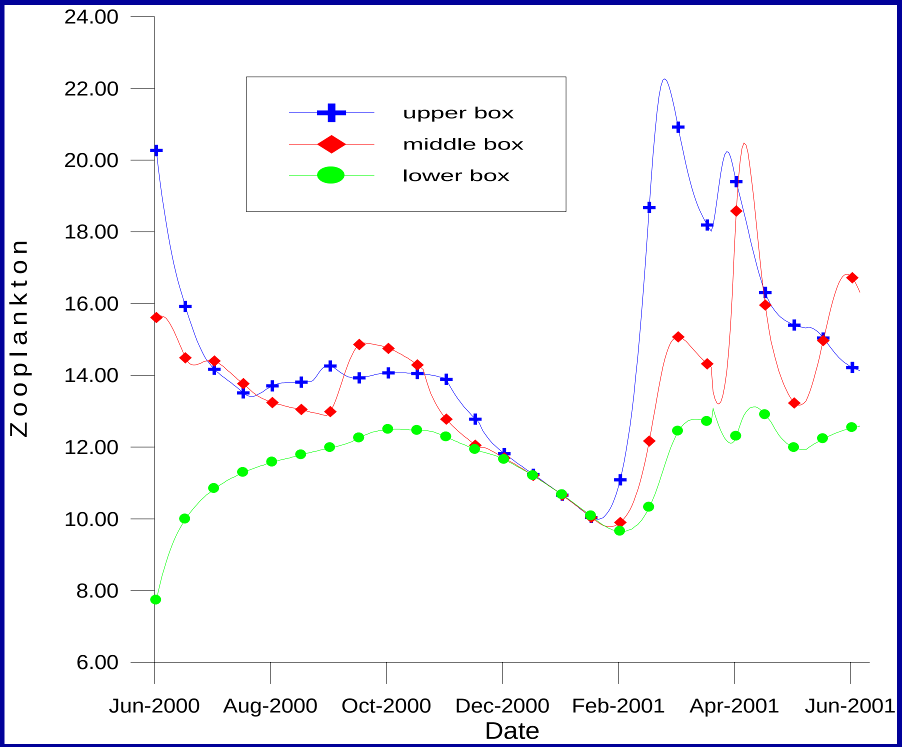
27.4 $gCm^{-2}yr^{-1}$

The contribution of microbial food loop

Zooplankton / Phytoplankton

(Obs.): 0.65 ~ 2.78





Simulated results of phytoplankton and zooplankton biomass cycling （Unit：$mgCm^{-3}$）

Planktonic ecological efficiency

Zooplankton productivity/Phytoplankton productivity

- Simu. 0.47
- Mean 0.2

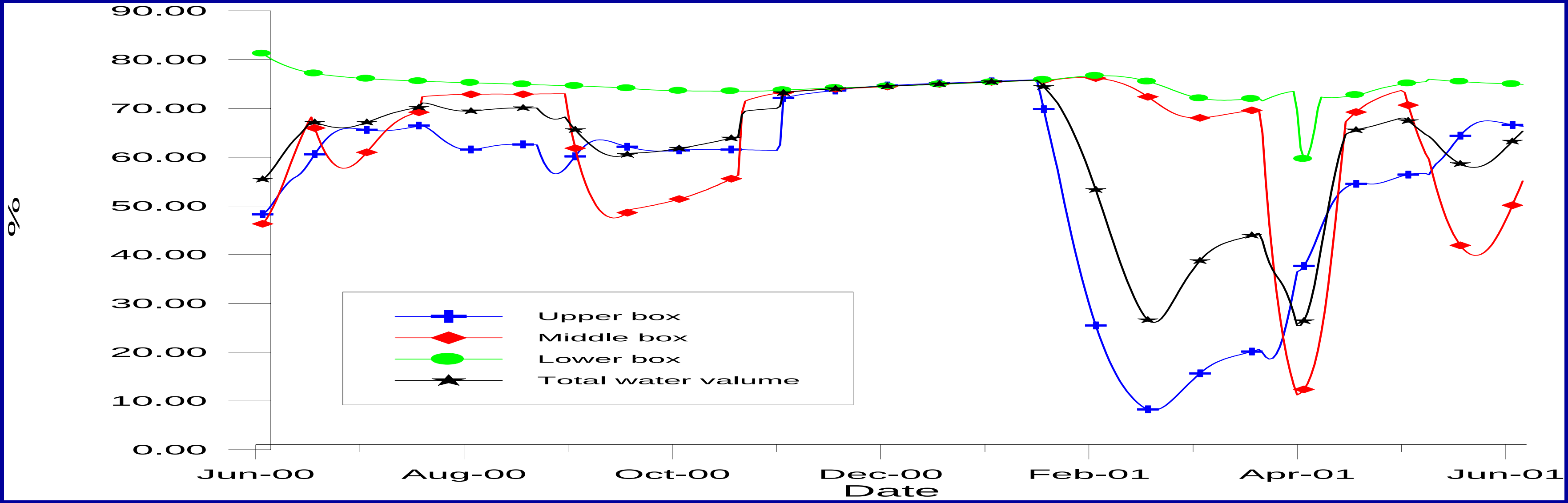
Seasonal variation of microbial loop contribution in the YSCWM （%）

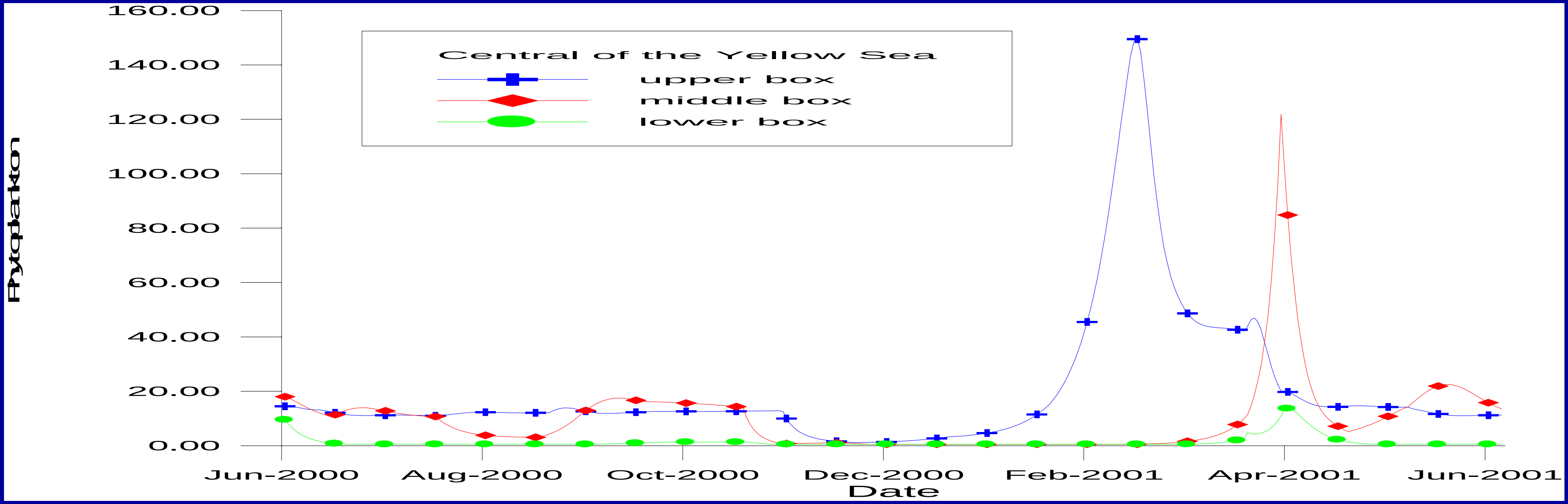
season	Upper box	Middle box	Lower box	Whole volume
spring	20.2	43.3	73.2	39.8
summer	59.5	54.1	76.3	62.8
autumn	60.2	59.4	74.8	64.8
winter	71.0	74.1	74.9	73.7
whole year	47.9	56.8	74.9	59.7

Taiwan Strait, 60％. Huang *et al.* 2002

The NE subarctic Pacific, 58％. Rivkin *et al.* 1999

Annual cycling of microbial loop contribution (%)





Biomass of phytoplankton ($mgCm^{-3}$)

Summary

- The model is well simulated the YSCWM ecosystem. The results are reasonable.
- The simulated analysis reveals that both the primary productivity and new production are lower in the YSCWM.
- Microbial loop plays a crucial role in the zooplankton growth, the contribution of microbial loop to zooplankton growth is about 60% in the YSCWM ecosystem.

Further work

Although the effect of microbial loop on the growth of zooplankton is very important, but it’s hardly to explain the abnormal high ratio of the zooplankton biomass to phytoplankton biomass. This problem would be studied in future work.

Thanks