Response to referee #2

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We thank the reviewer for careful reading of our manuscript and insightful comments. Following is our response to your comments cited in italics.

*General: The authors present results from a coupled physical-biological model for the East China Sea with particular focus on cross-shelf transports. While this topic should be of interest to the readers of Ocean Science, is obviously very appropriate for the Special Issue on Deep Ocean-Shelf Exchanges, and while I endorse their general approach (i.e. analyzing a coupled model for the region), I have serious reservations about important details of this study. Most importantly, validation of the model results is inadequate, and where model-data comparisons are given the model disagrees markedly from the observations. Especially troubling is the disagreement in the DIN concentrations off the shelf break, to which any estimate of cross-shelf transport is extremely sensitive. Given the wrong off-shelf DIN concentrations the estimates of cross-shelf DIN transport cannot be trusted. I have a number of other concerns that are detailed below.*
*Summary: The study has serious flaws that would need to be addressed before publication can be considered.*

Thanks for your critical comments. After reading your comments, we have re-run our model several times to examine its sensitivity to the nutrient concentrations specified at the open boundary, which were artificially adjusted like in our sensitive experiments presented in the manuscript. These new simulations, in which the nutrient concentrations at the open boundary were reduced, indicated the same proportional relation of onshore nutrient flux to the nutrient concentrations specified at the open boundary as those sensitivity experiments in our manuscript, in which the nutrient concentrations at the open boundary were increased. Because of this relation, we can select one case that has the best performance on the nutrient concentrations along 200m isobath to calculate the onshore nutrient flux across the shelf break in the revision. In this response note, we present the results of a case, which decreased the nutrient concentrations at the open boundary by 30%, as the lowest level of nutrient concentrations along the shelf break.

It is necessary to note that the calculation of onshore nutrient flux across the shelf break depends on onshore velocity component and nutrient concentration at the grid points along 200 m isobath. The high values of nutrients off the shelf break, which is likely a bias in our model related to the island chain, have no direct relation to the calculation of onshore nutrient flux.

Our objectives in this study are 1) to examine the oceanic nutrients flux across the shelf break with a three dimensional model; 2) to confirm whether oceanic nutrients can be utilized by the phytoplankton over the shelf; 3) to find where and when the primary production due to oceanic nutrients occurs if the answer to second objective is yes. Our results reported in the manuscript for the second and third objectives were reasonable and were not qualitatively affected by the adjustment of the nutrient concentration at open boundary. For the first objective, with improvement of modeled nutrient concentration along the shelf break, we can also obtain a better estimation on the total nutrient flux across the shelf break and present the spatial distribution of nutrient flux along the shelf break for the first time.

*Specific points:*
*Section 2: Not enough justification is given for the choice of the biological model (I find some aspects non-sensible) and not enough details about the model are given either.*

Following your comments, we will improve the writing of this part in the revision.

*For example, why do the authors think that zooplankton can be neglected in the East China Sea?*

Zooplankton is important in our study area. Since we have two sizes of phytoplankton, we need two sizes of zooplankton (micro-zooplankton and macro-zooplankton) in our model. However, we did not find sufficient field data on the micro-zooplankton and macro-zooplankton in our study area. This is the primary reason why we did not include zooplankton. The secondary reason is because the inclusion of zooplankton will introduces complex biological processes and parameters, which we want to avoid. As we previously mentioned, our objective is to examine onshore nutrient flux and its effects on the primary production over the shelf. For this objective, zooplankton grazing on phytoplankton can be partly taken into account by increasing mortality rate of phytoplankton.

Our biological module is one of NPD type models. Some text books (e.g. Valiela, 1995; Sarmiento and Gruber, 2006) mentioned the application of such NPD type model to a "bottom-up" ecosystem. Some researchers also reported its application in the coastal waters such as North Sea (Skogen et al., 1995) and Mediterranean Sea (Crise et al., 1998). For above reasons, we like to keep our model structure. We will add some sentences in the revised manuscript to address the reasons why we used the NPD type model.

Valiela, I. (1995): Marine Ecological Processes. Springer. 686pp.
Sarmiento, J. L. and Gruber, N. (2006): Ocean biogeochemical dynamics. Princeton University Press. 503pp.
Skogen, M. D., Svendsen, E., Berntsen, J., Aksnes, D., and Ulvestad, K. B. (1995): Modeling

the primary production in the North Sea using a coupled three-dimensional Physical-Chemical-Biological Ocean Model. Estuarine, Coastal and Shelf Science, 41, 545-565.
Crise, A., Crispi, G. and Mauri, E. (1998): A seasonal three-dimensional study of the nitrogen cycle in the Mediterranean Sea Part I. Model implementation and numerical results. Journal of Marine Systems, 18, 287–312.

*Why do they include 3 inorganic nutrient sources (DIN, DIP and silicate) when they appear to have observations for only DIN?*

The reason we included three nutrient elements is because either of them can be a possible limiting nutrient to the primary production. A traditional idea is that the primary production in our study area is limited by DIN or DIP, depending on which area you observe. Recently, silicate was suggested as a potential limiting nutrient to the primary production (Chen et al., 2004; Zhang et al., 2007).

To save space, the observations for DIP and silicate were not presented in our manuscript. In this response note, we presented a full comparison between model results and all the available data (DIN, DIP, silicate) (Figure B1-B9), based on which you can revaluate our study again.

Chen, Y.-L. L., Chen, H.-Y., Gong G.-C., Lin, Y.-H., Jan, S., Takahashi, M. (2004): Phytoplankton production during a summer coastal upwelling in the East China Sea. Continental Shelf Research, 24, 1321-1338.
Zhang, J., Liu, S.M., Ren, J.L., Wu, Y., Zhang, G.L.(2007): Nutrient gradients from the eutrophic Changjiang (Yangtze River) Estuary to the oligotrophic Kuroshio waters and re-evaluation of budgets for the East China Sea Shelf, Progress in Oceanography, 74, 449–478.

*How was the satellite derived extinction coefficient for photosynthetically active radiation (p. 1409, line 24-26) determined?*

The satellite derived SPM data and simulated profile of chlorophyll a were used to determine the light extinction coefficient ($k$).

$$k = k_0 + k_1 C_{SPM} + k_2 \int_0^{\tilde{z}} C_{CHLa}(z)\,\mathrm{dz}$$

Here, $k_0$ is coefficient for clean water, $k_1$ is light attenuation due to SPM absorption, $C_{SPM}$ is satellite derived SPM concentration, $k_2$ is self-shaded by chlorophyll *a*, $C_{CHLa}(z)$ is profile of simulated chlorophyll-a. The values of these parameters are listed in Table 1.

*What are the model equations and the model parameter values chosen? With respect to the model equations the authors refer to a technical report that is not peer-reviewed and not widely available.*

We will add a link (http://www.imr.no/~morten/norwecom/userguide2_0.ps.gz) to the technical report in the revised manuscript. This link is active now and has not limitation to any person. The model equations and its applications can also be found in Aksnes et al. (1995) and Skogen et al. (1995), both of which were well cited peer-reviewed papers. We will add these two references in the revised manuscript.

Aksnes, D.L., Ulvestad, K.B., Balino, B.M., Berntsen, J., Egge, J.K., Svendsen, E. (1995): Ecological modelling in coastal waters: Towards predictive physical-chemical-biological simulation models. Ophelia. 41, 5-36.

Skogen, M. D., Svendsen, E., Berntsen, J., Aksnes, D., and Ulvestad, K. B. (1995): Modeling the primary production in the North Sea using a coupled three-dimensional Physical-Chemical-Biological Ocean Model. Estuarine, Coastal and Shelf Science, 41, 545-565.

The parameters used in our model simulation were listed in Table 1, which will be added to the revised manuscript.

*The authors state that monthly values for surface wind stress were used (p. 1410, line 8-9). This makes no sense (the authors may have used daily wind stress and made a mistake here).*

Exactly, the Scatterometer Climatology of Ocean Winds (Risien and Chelton, 2008) was used in this model. The regression relation with 9 coefficients (annual mean, every two harmonic constants for annual period, for semi-annual period, for 4 months' period and for 3 months' period, respectively) was used to give the wind field at every time step. From this sense, any variation in winds with a period shorter than 3 months was not included in our model. (As we replied to reviewer #1, this causes a northward bias for the position of low salinity water in the East China Sea. However, such bias does not affect our answers to the objectives.)

Daily wind stress is necessary for studying short term variations in ecosystem. Since the most dominant signal in our region is seasonal variation, we like to limit our calculation to it. The short term variations in ecosystem will be one of our future topics.

Risien, C.M., and Chelton, D.B. (2008): A global climatology of surface wind and wind stress fields from eight years of QuikSCAT scatterometer data. Journal of Physical Oceanography, 38, 2379-2413.

*Section 3.1: The authors show model output in Fig. 3 and refer to a paper for relevant observations. That is not adequate. The observations that they are comparing their model with need to be included here as well, and ideally some quantitative metrics of the agreement between model and observations should be given. The model-predicted surface chlorophyll should be quantitatively compared with satellite observations.*

In this response note, we added a full comparison between all available figures for observations and our model results from one simulation case, in which the nutrient concentrations at the open boundary were reduced by 30%. The figures for observations include the figures in Chen (2009JMS) for the surface and bottom horizontal distributions of DIN, DIP and silicate in summer and winter (Figures B1-B6), and the concentrations of DIN, DIP, chlorophyll-a along PN section (Figures B7-B9). We do not think it is a good idea to include so many figures in our revised manuscript. If you insist inclusion of them in our manuscript, we will discuss with editor for its possibility.

As a conclusion of above comparisons, the new simulation, in which the concentration of nutrients specified at open boundary was decreased by 30%, decreased the nutrients at shelf break but apparently underestimated the nutrients at the bottom layer over the shelf in summer and autumn. Because the concentration of nutrients along 200 m isobath is important to the estimation of onshore nutrient flux across shelf break and the underestimation of nutrient concentrations at the bottom layer over the shelf will not qualitatively change our conclusions on the role of oceanic nutrients in the primary production over the shelf, we decided to take a priority to the modeled nutrient concentrations along the shelf break. We are now collecting nutrients data along the shelf break of the East China Sea and will make a quantitative comparison between model results and observations in the revised manuscript.

Ocean color data observed by satellites are very useful to know horizontal distribution of chlorophyll-a. Because of high concentration of suspension particle material and colored dissolved organic matter in the East China Sea, Yellow Sea and Bohai Sea, the standard algorithms usually overestimates concentration of chlorophyll-a in our study area. At present, a quantitative comparison is still difficult for the horizontal distribution of chlorophyll-a in the East China Sea, Yellow Sea and Bohai Sea. We know the group of Prof. Ishizaka in Nagoya University, Japan, is hardly working on this topic and expect to be able to compare our model results with their products in the future.

*Fig. 5: The nutrient concentrations off the shelf are wrong in the model. For example, in autumn the observations show DIN concentrations of 1 and 3 mmol m-3 at 100 m and 150 m depth respectively, while the model shows 8 and 10-15 mmol m-3 at those depths (an order of*

*magnitude higher). The other seasons do not look any better.*

The onshore flux of nutrients across 200 m isobath is based on the nutrient concentration along 200 m isobath, more specifically the line given in Figure 1. At the section we presented, this position is at 126.8E. The high nutrients you noted is at the region off the shelf break (>127.5E) and have no direct influence on the values of onshore nutrient flux.

The causes for the overestimation of nutrients off the shelf break (>127.5E) have not been exactly fixed. We tried several cases to find possible explanation on this problem. Our current conclusion is that this problem has a close relation to the presence of island chain, i.e., Ryukyu Islands. The sharp change in bathymetry perhaps caused some numerical troubles in the sigma-coordinate model used in this study.

*Fig. 6: The simulated chlorophyll patterns are very different from the observations, especially in winter, spring and autumn. The authors acknowledge some of the discrepancies (page 1414, lines 20ff). I would argue that these problems have to be corrected before estimates of cross-shelf transport can be made with this model.*

Observations are averaged from 40 years data. What we really want to confirm from comparison between observations and model results is the spatial pattern, not the values themselves, because the values changed dramatically from one cruise to another cruise, especially for chlorophyll-a.

As we previously mentioned in this response note, we want to achieve three aims by this study. The problems mentioned in our manuscript and also by you do not qualitatively change the answers to three aims.

Because of the complication in currents and nutrients dynamic, there is almost no report on ecosystem modeling at the shelf break region and the wide shelf of the East China Sea. Our study becomes one of such pioneering efforts. Sharing our experience and results with community is important to the improvement of ecosystem modeling in this region. As we know, many groups in China, Korea, Taiwan and Japan just started similar works. It is therefore better to report our understanding and our limitation to the community as soon as possible.

*Section 3.3 The authors talk about estimating the onshore flux of water and nutrients. More details about how these fluxes were estimated are needed. The fluxes presented in Fig. 7 show a continuous import of volume. This cannot be correct based on continuity considerations. A sustained on-shore flux of water would imply a sustained rise in sea level in the East China*

*Sea. On page 1416, they refer to this flux as total volume flux. There should be no net volume flux over a 1-year time scale. Flux estimates are given for DIP and silicate although the authors did not present any observations to validate the model predictions.*

We will add a formula in the revised manuscript to show how the onshore flux was calculated. The flux at each grid point along 200m isobath was firstly calculated by vertical integration of the product of onshore velocity component and concentration from sea surface to sea bottom. The total flux across entire 200 m isobath was obtained by horizontal integration of the onshore flux at each grid point along 200m isobath.

The East China Sea is not an enclosed or semi-enclosed sea (Figure 1). It is not strange to have a net onshore flux of volume transport across the shelf break. From a viewpoint of annual mean, the balance of volume transport in the East China Sea is the inflow through the Taiwan Strait (1.2 Sv), the inflow across the shelf break (1.5 Sv), and the outflow through the Tsushima Strait (2.7 Sv) (Guo et al., 2006JPO, Isobe, 2008JO).

Guo, X., Miyazawa, Y., and Yamagata, T.: The Kuroshio onshore intrusion along the shelf break of the East China Sea: the origin of the Tsushima Warm Current, Journal of Physical Oceanography, 36, 2205-2231, 2006.

Isobe, A.: Recent advances in ocean circulation research on the Yellow Sea and East China Sea shelves. Journal of Oceanography, 64, 569-584, 2008.

*Minor points:*
*P. 1407, line 5f: "oceanic nutrients [are] mainly driven by climate change" – What does this mean?*

We want to say that anthropogenic activities have little influence on the variation in oceanic nutrients. It is better to change this sentence to "while oceanic nutrients mainly affected by climate change".

*Fig. 2: The schematic is very confusing. Why are the model state variables drawn multiple times? What do the dashed arrows represent? Maybe sinking? If so, why doesn't SIS sink? What happens to biological and chemical species at the bottom? Why are DIA and FLA drawn inside the sediment?*

We revised this figure by removing some unnecessary lines and processes. Please find a new version of this schematic in Figure B10 and a full description on the processes included by this model in figure caption. The reason why the model state variables drawn multiple times is because we want to emphasize the difference in biogeochemical processes in the euphotic layer, in the layer under euphotic layer, and in the benthic layer, as well as the processes occurring at air-sea and sea-benthic boundaries.

Dashed arrows represent sinking. The sinking of SIS was missed in our previous figure. The biogeochemical processes in the benthic layer are decomposition of DET to NIT and PHO, decomposition of SIS to SIL, denitrification of DET, resuspension and burial of SIS and DET, and the diffusion fluxes of SIL, NIT and PHO from benthic layer to bottom layer. The DIA and FIA inside the sediment in old figure were not correct and were removed in new schematic figure.

*Fig. 3: Labels on color scale bar and isolines are much too small.*

We will improve quality of our figures in the revised manuscript.

*P. 1413, line 13: What does JMA stand for?*

JAM denotes "Japan Meteorological Agency", which was given at the end of section 2 of our manuscript.

Table 1. Parameters used in model simulation for the East China Sea

| Parameters description | Value | Unit |
|---|---|---|
| Diatom production maximum at 0 degree Celsius | 1.33 | 1/day |
| Temperature dependent of maximum production for the diatom | 0.063 | 1/deg |
| Flagellate production maximum at 0 degree Celsius | 1.05 | 1/day |
| Temperature dependent of maximum production for the flagellate | 0.064 | 1/deg |
| Respiration rate at 0 degree Celsius | 0.061 | 1/day |
| Respiration rate temperature dependence | 0.064 | 1/deg |
| Phytoplankton death rate | 0.123 | 1/day |
| Rate of decomposition of detritus | 0.011 | 1/day |
| Photosynthetic active irradiance | 0.4 | / |
| Chlorophyll *a* light extinction coefficient | 0.0138 | $m^2$/mgCHLa |
| Extinction duo to clean water | 0.04 | 1/m |
| Extinction duo to SPM | 0.032 | $m^2$/g |
| Fraction of phosphate and nitrate in a cell | 0.138 | mgP/mgN |
| Fraction of silicate and nitrate in a cell | 1.75 | mgSi/mgN |
| Fraction of nitrate and Chlorophyll *a* in a cell | 8~11 | mgN/mgCHLa |
| Half saturation of nitrogen for flagellate | 1.2 | mmolN/$m^3$ |
| Half saturation of phosphate for flagellate | 0.09 | mmolP/$m^3$ |
| Optimum light intensity for flagellate | 60 | W/$m^2$ |
| Half saturation of nitrogen for diatom | 1.8 | mmolN/$m^3$ |
| Half saturation of phosphate for diatom | 0.115 | mmolP/$m^3$ |
| Half saturation of silicate for diatom | 1.0 | mmolSi/$m^3$ |
| Optimum light intensity for diatom | 90 | W/$m^2$ |
| Reference temperature of nutrients half saturation | 12 | deg |
| Rate of decomposition of silicate shell | 0.0056 | 1/day |
| Sinking rate of detritus | 2.0 | m/day |
| Sinking rate of flagellate | 0.25 | m/day |
| Sinking rate of diatom | 0.3~2.0 | m/day |
| Sinking rate of biogenic silica | 2.0 | m/day |

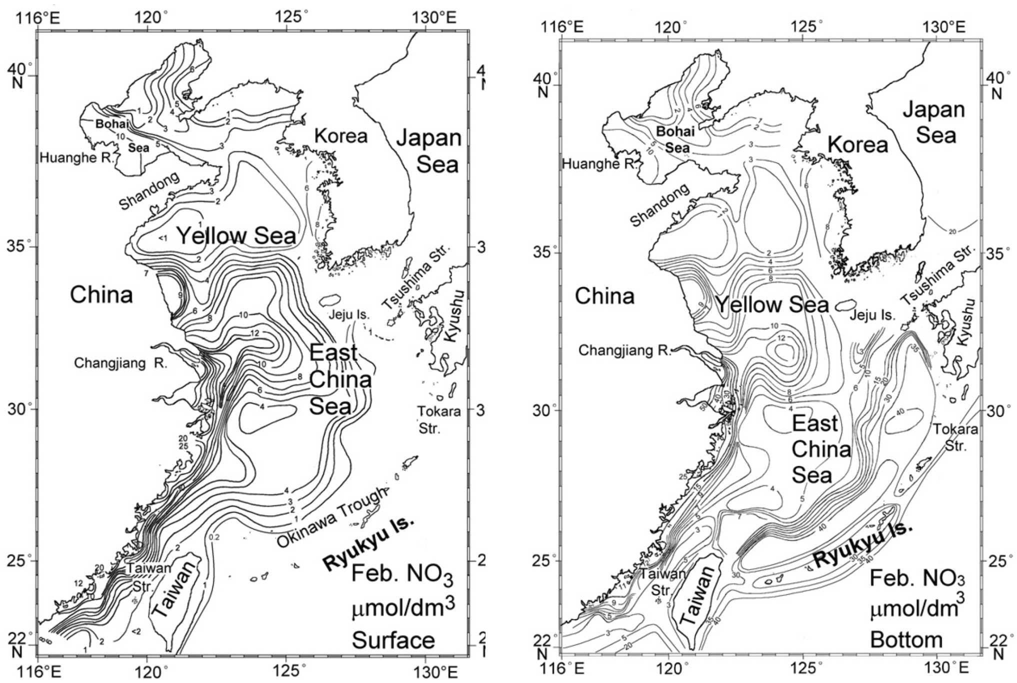


Figure B1 (a). Surface and bottom nitrate concentrations in February presented by Chen(2009JMS).

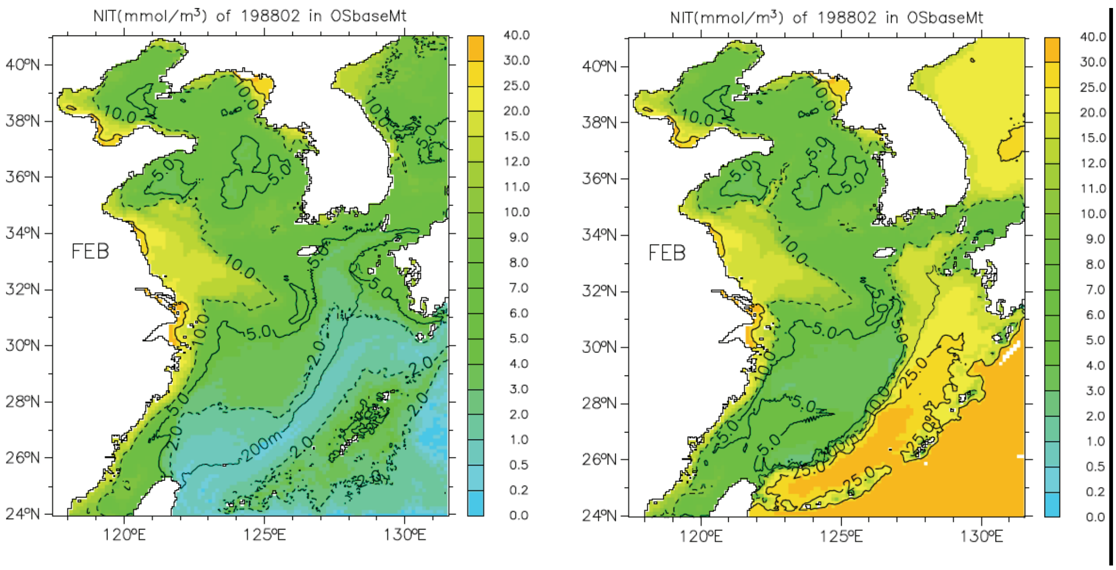


Figure B1 (b). Surface and bottom nitrate concentrations in February calculated by a new simulation with 30% reduction in nutrient concentrations at open boundary east of Taiwan.

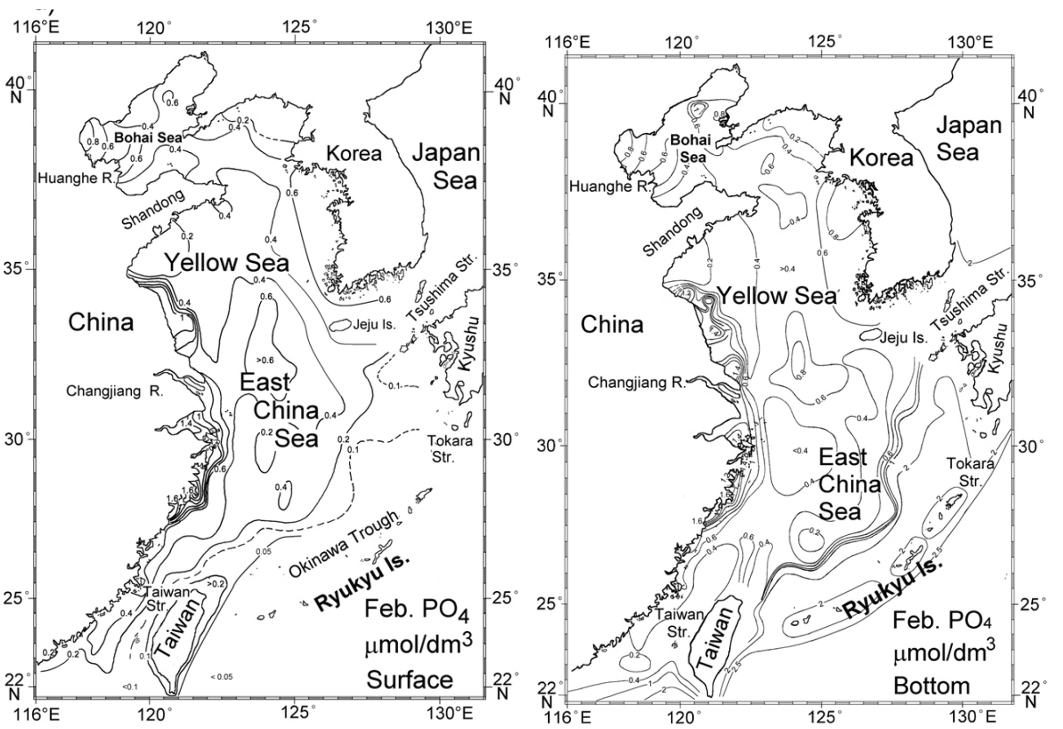


Figure B2 (a). Surface and bottom phosphate concentrations in February presented by Chen(2009JMS).

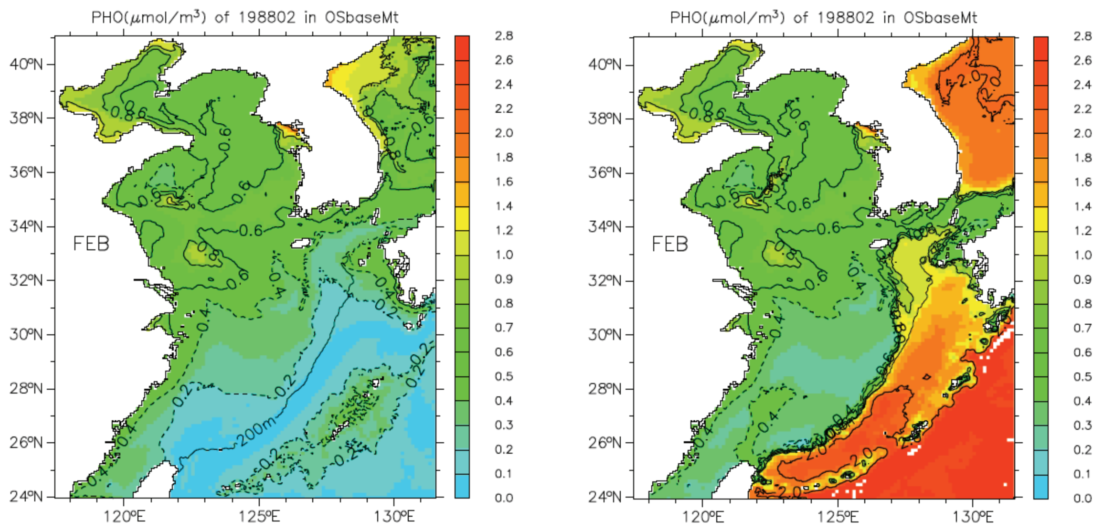


Figure B2 (b). Surface and bottom phosphate concentrations in February calculated by a new simulation with 30% reduction in nutrient concentrations at open boundary east of Taiwan.

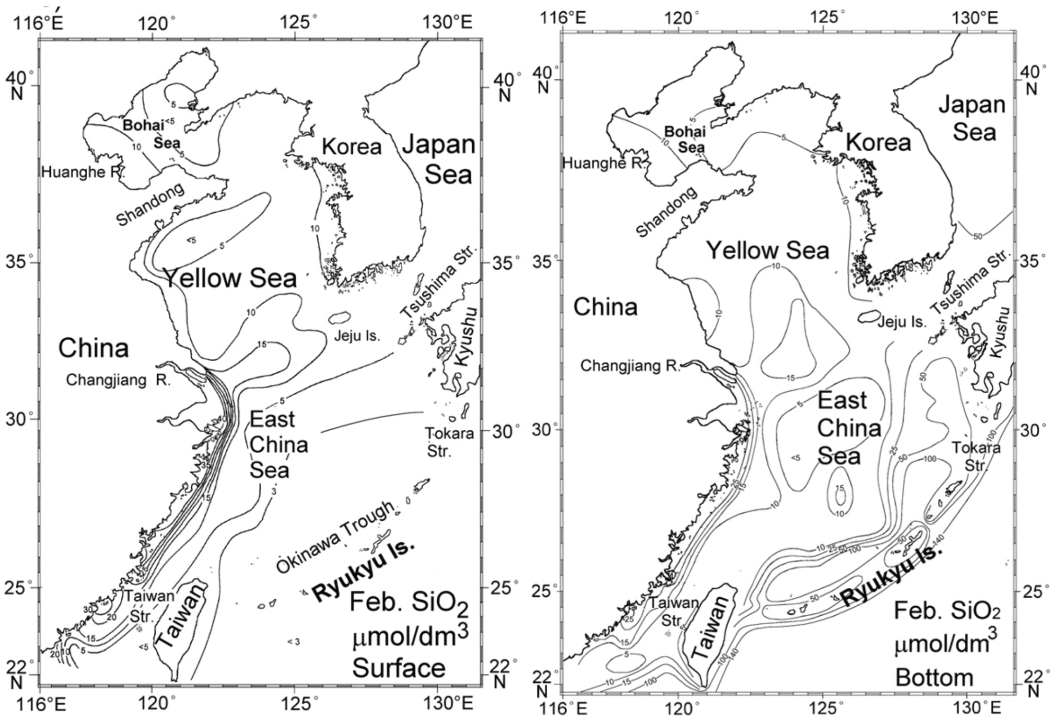


Figure B3 (a). Surface and bottom silicate concentrations in February presented by Chen(2009JMS).

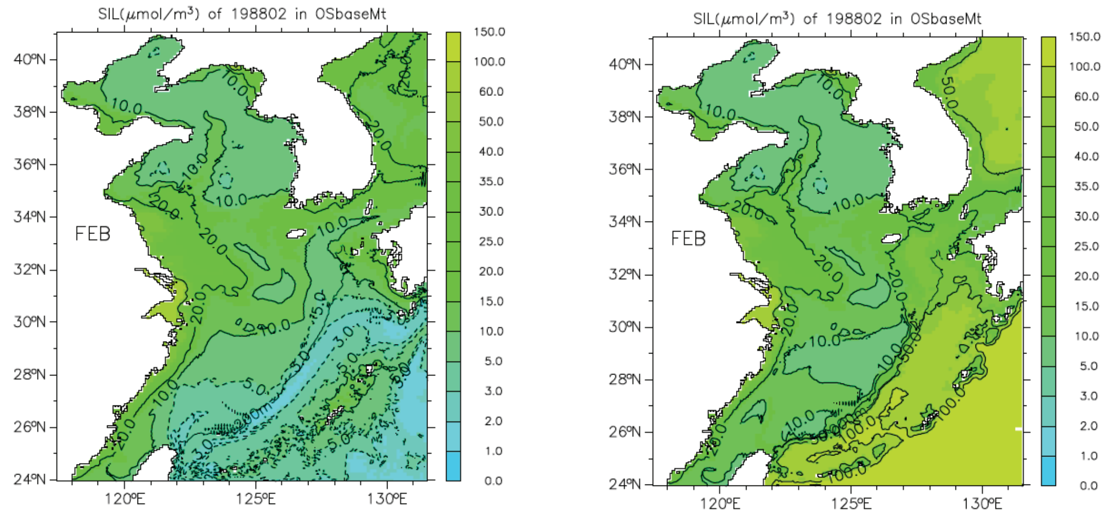


Figure B3 (b). Surface and bottom silicate concentrations in February calculated by a new simulation with 30% reduction in nutrient concentrations at open boundary east of Taiwan.

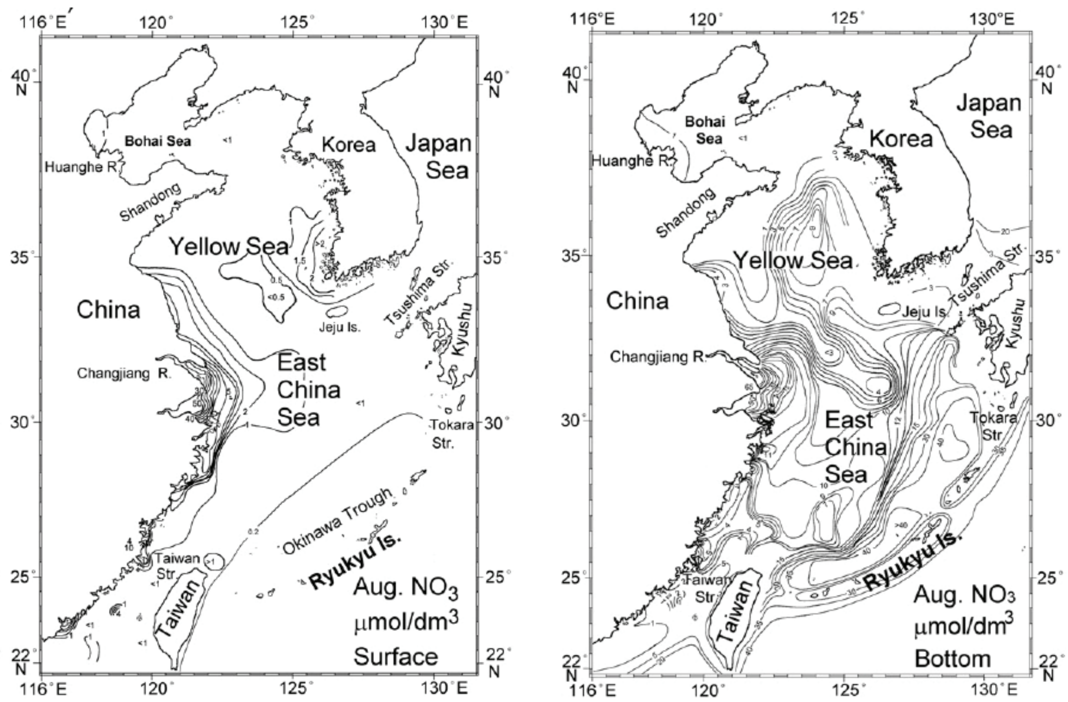


Figure B4 (a). Surface and bottom nitrate concentrations in August presented by Chen(2009JMS).

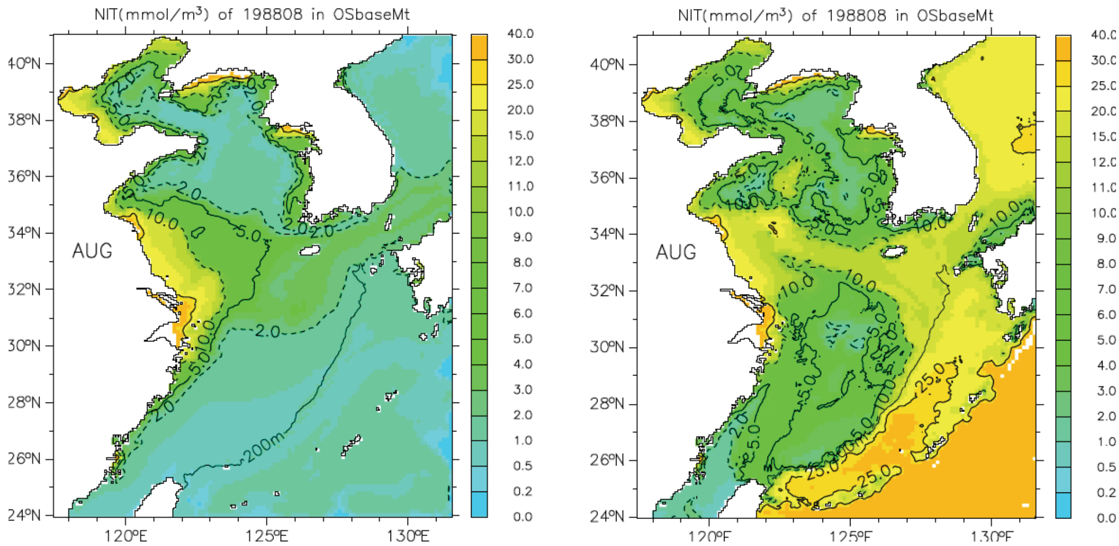


Figure B4 (b). Surface and bottom silicate concentrations in August calculated by a new simulation with 30% reduction in nutrient concentrations at open boundary east of Taiwan.

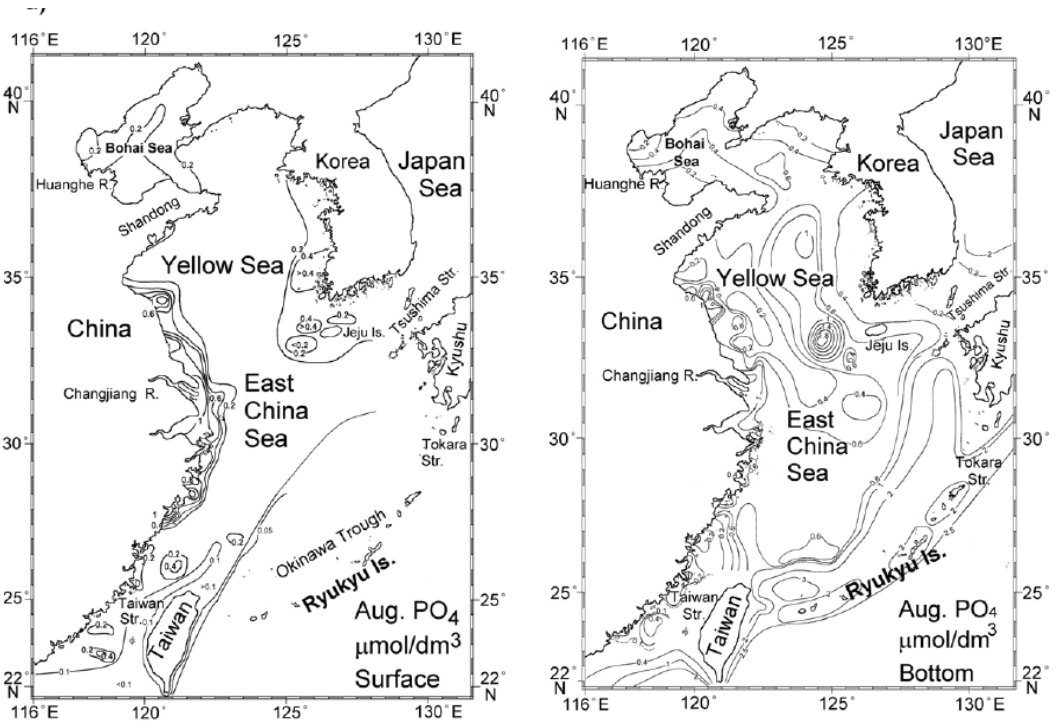


Figure B5 (a). Surface and bottom phosphate concentrations in August presented by Chen(2009JMS).

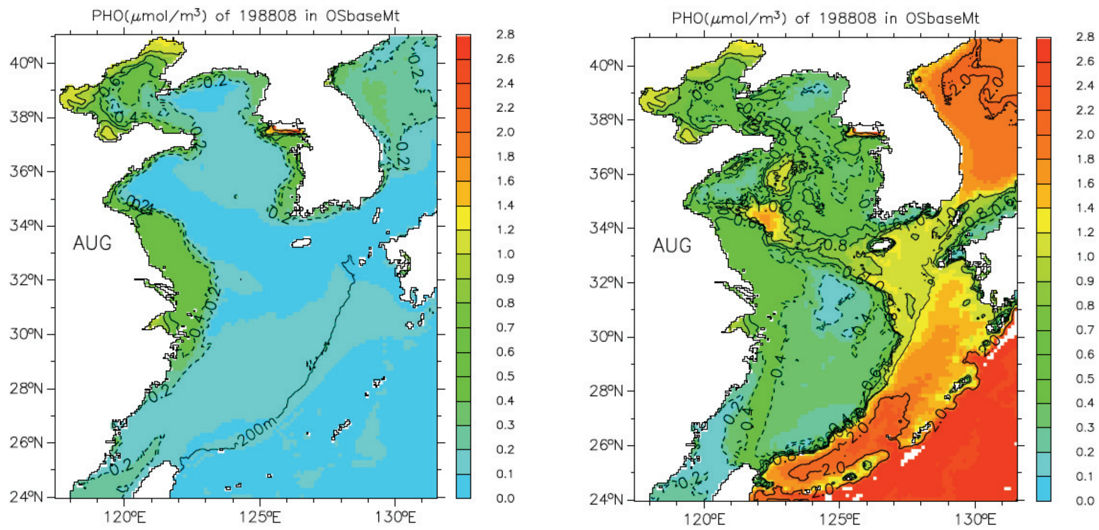


Figure B5 (b). Surface and bottom phosphate concentrations in August calculated by a new simulation with 30% reduction in nutrient concentrations at open boundary east of Taiwan.

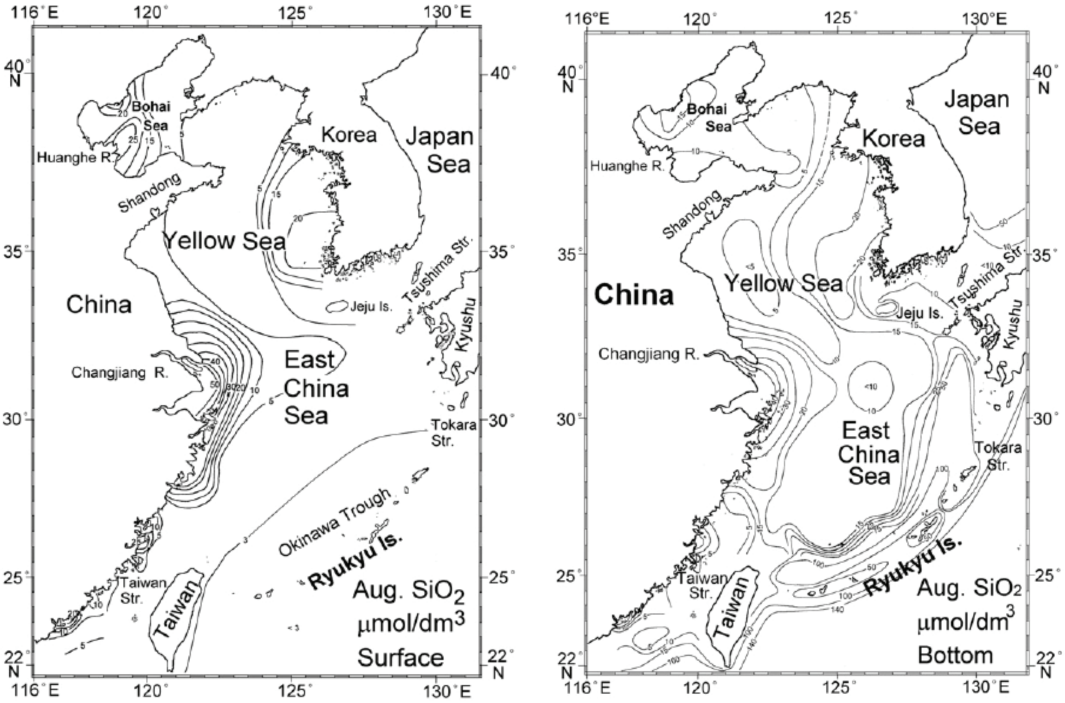


Figure B6 (a). Surface and bottom silicate concentrations in August presented by Chen(2009JMS).

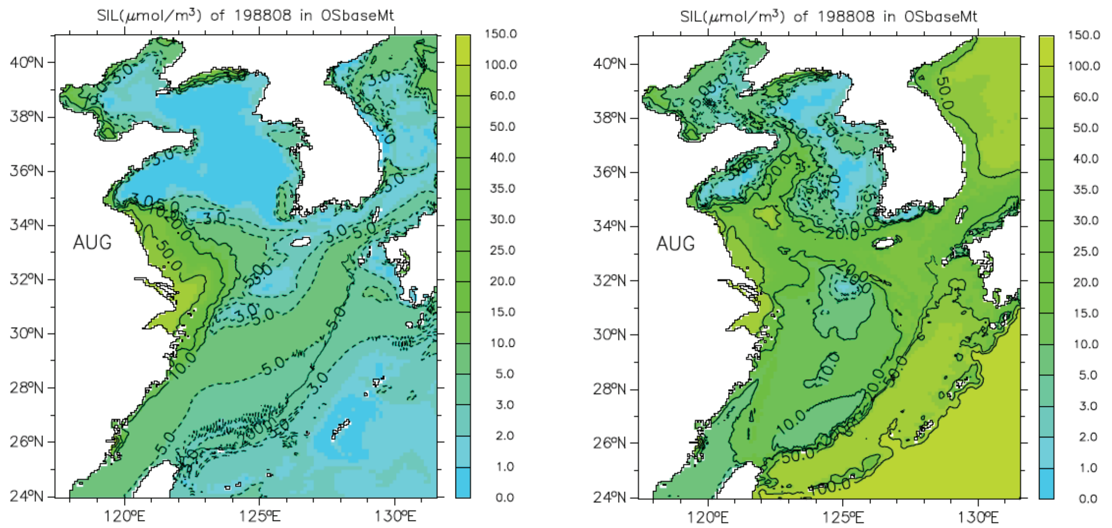


Figure B6 (b). Surface and bottom silicate concentrations in August calculated by a new simulation with 30% reduction in nutrient concentrations at open boundary east of Taiwan.

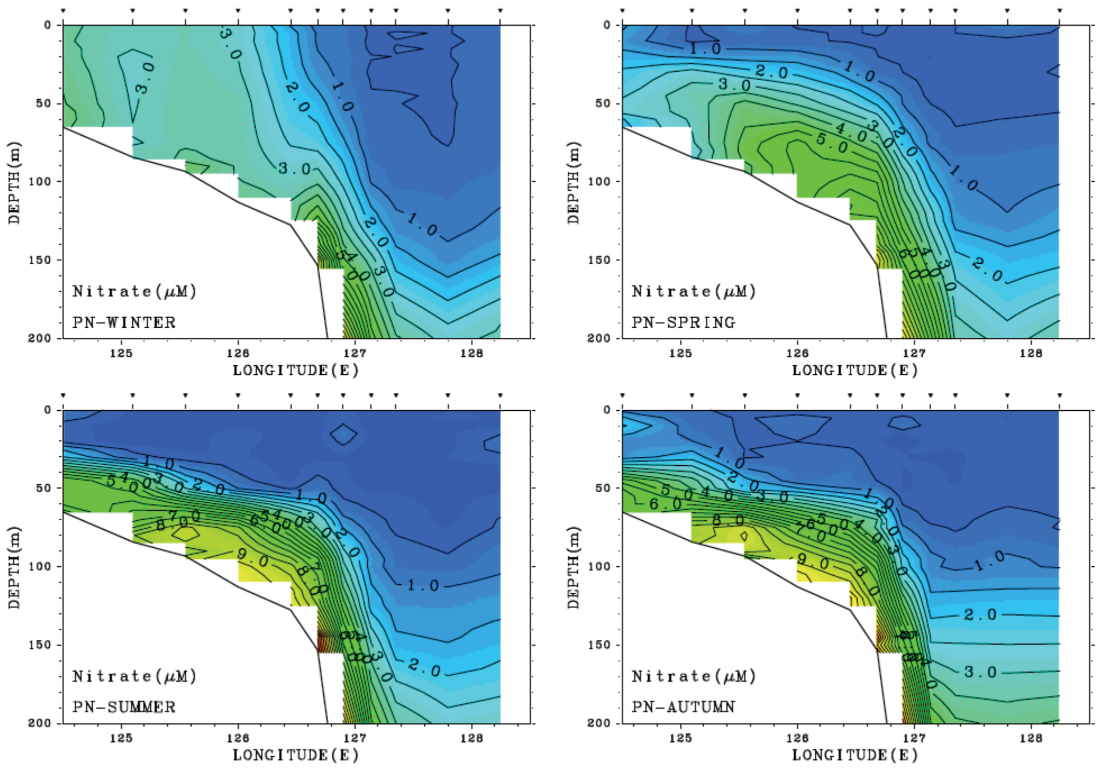


Figure B7 (a). Nitrate concentration observed along PN section in four seasons.

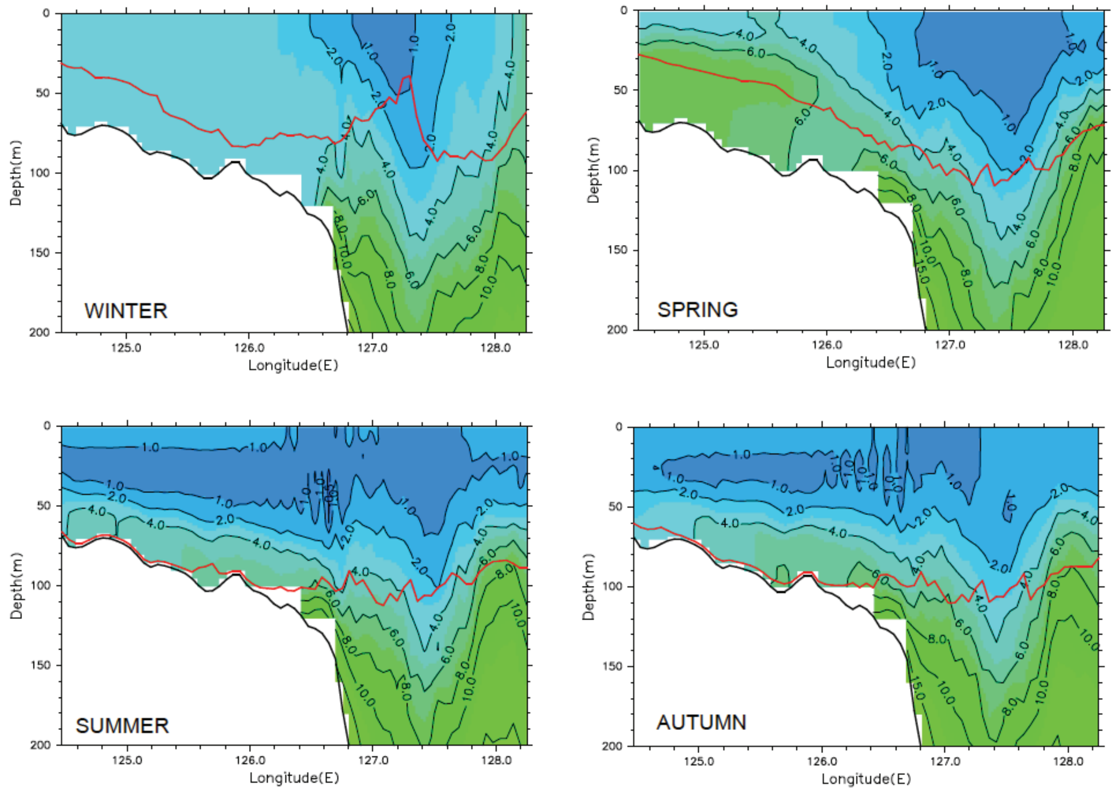


Figure B7 (b). Nitrate concentration along PN section in four seasons calculated by a new simulation with 30% reduction in nutrient concentrations at open boundary east of Taiwan.

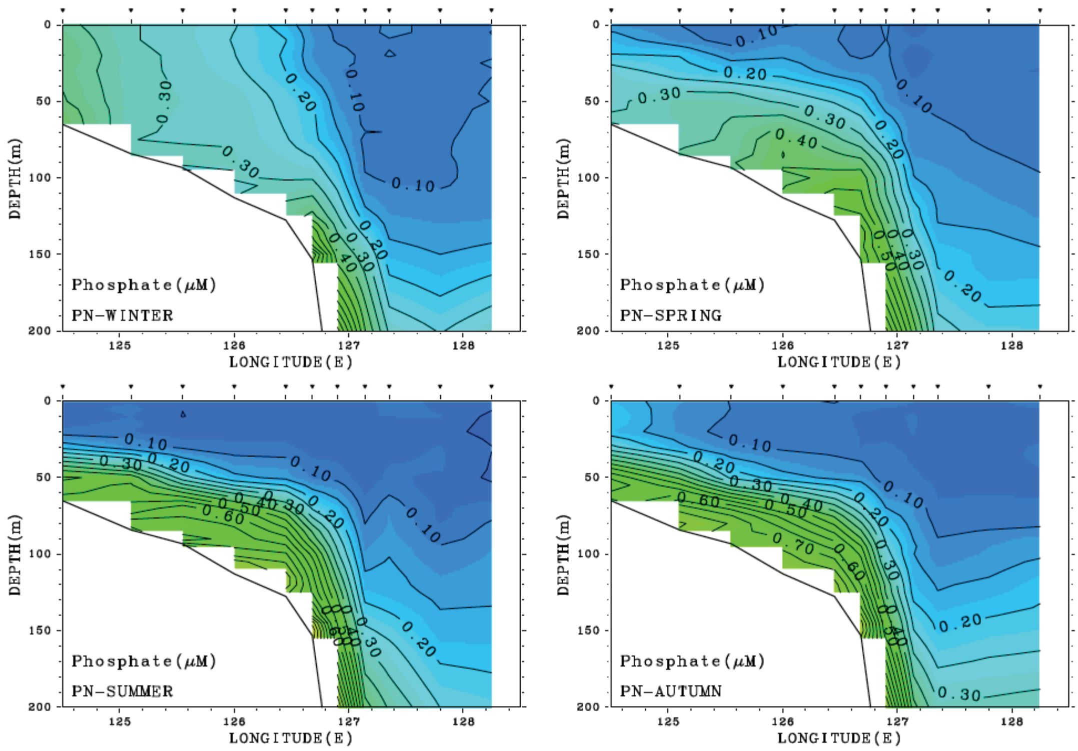


Figure B8 (a). Phosphate concentration observed along PN section in four seasons.

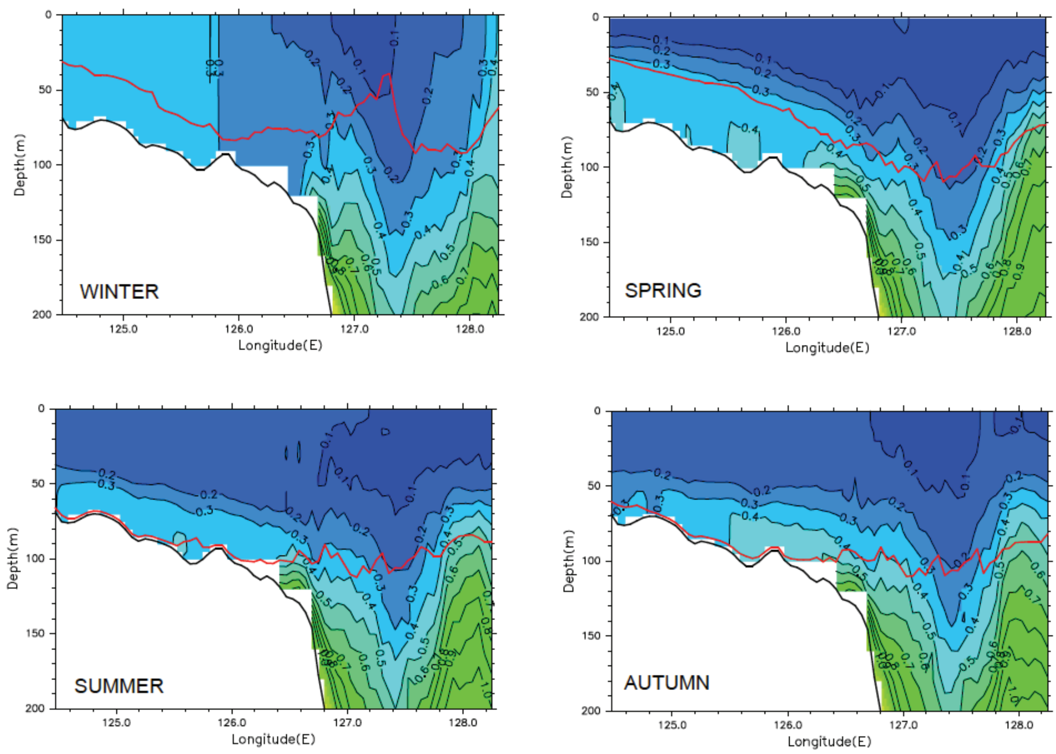


Figure B8 (b). Phosphate concentration along PN section in four seasons calculated by a new simulation with 30% reduction in nutrient concentrations at open boundary east of Taiwan.

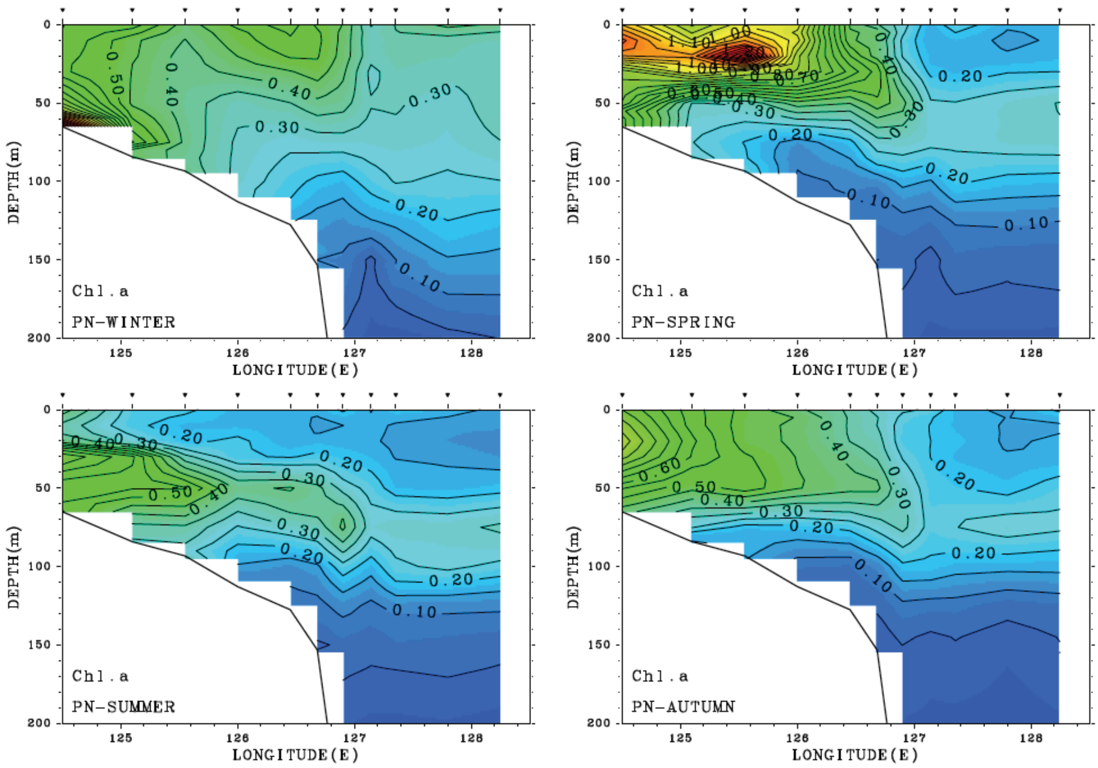


Figure B9 (a). Chlorophyll-a concentration observed along PN section in four seasons.

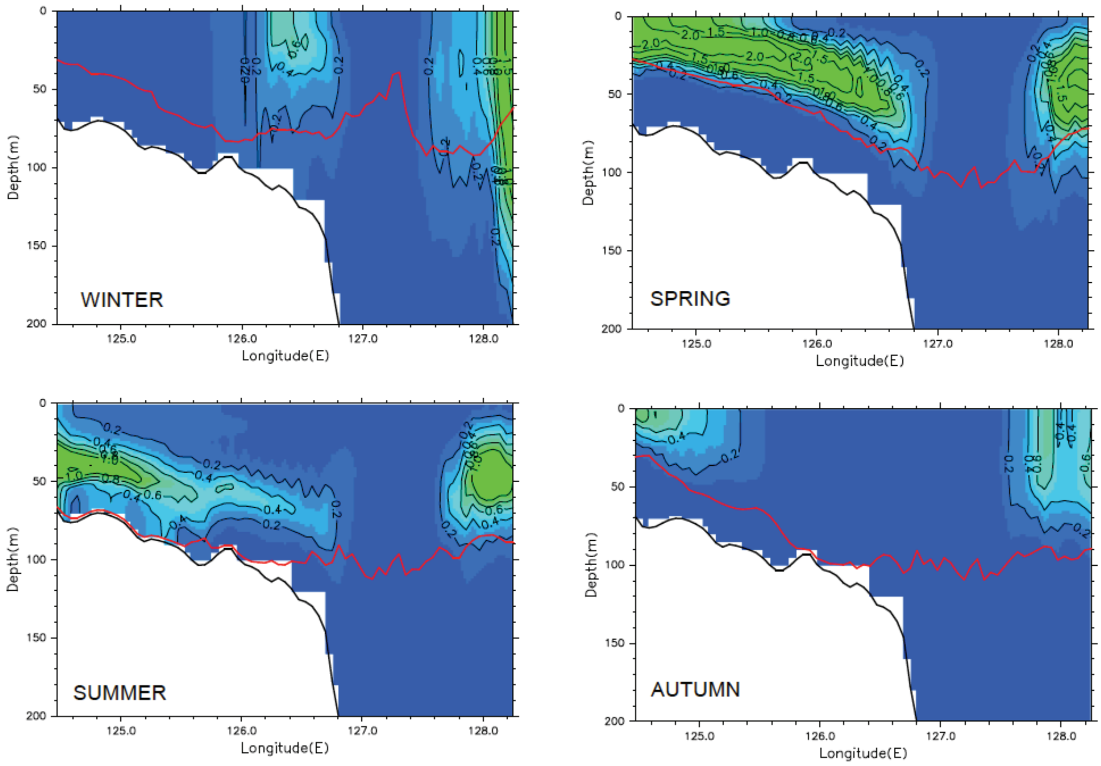


Figure B9 (b). Chlorophyll-a concentration along PN section in four seasons by a new simulation with 30% reduction in nutrient concentrations at open boundary east of Taiwan.

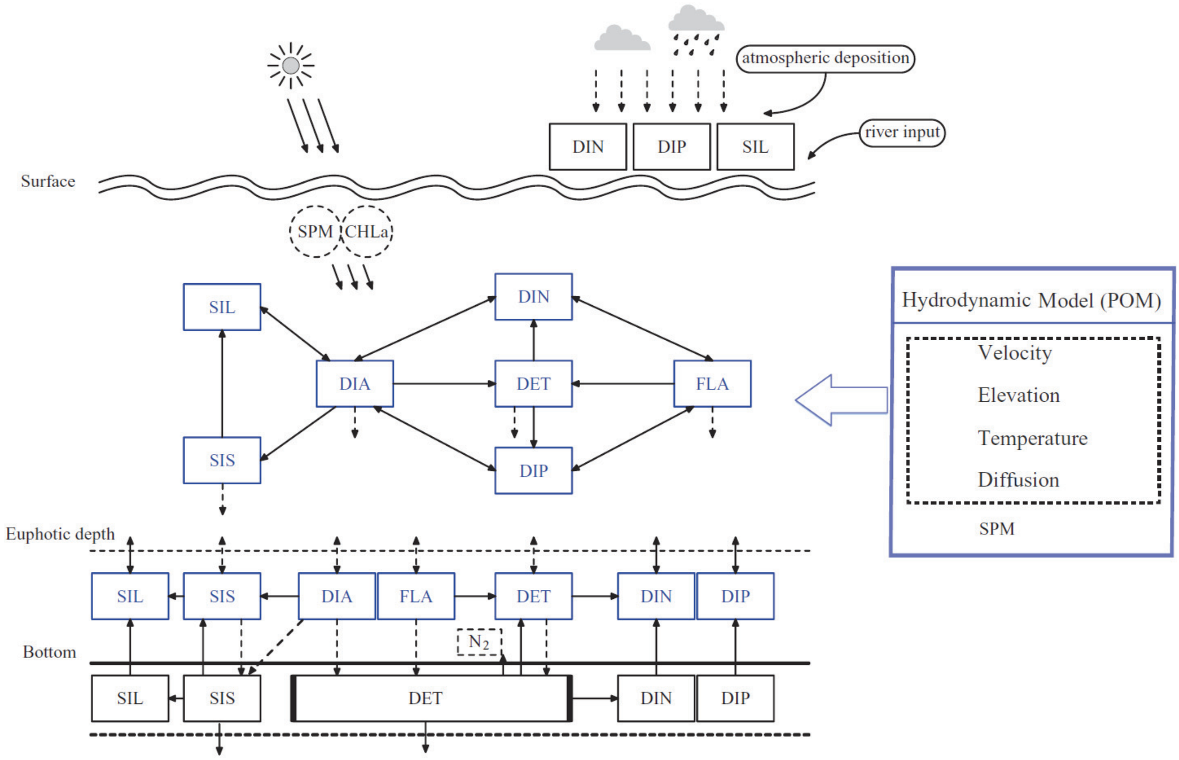


Figure 10. Schematic illustration of the biophysical model that has a hydrodynamic module and a biological module. The biological module includes three elements of nutrients (dissolved inorganic nitrogen (DIN), dissolved inorganic phosphorus (DIP), and silicate (SIL)), two types of phytoplankton (diatoms (DIA) and flagellates (FLA)), and two types of biogenic organic materials (dead organic matter containing nitrogen and phosphorus (DET) and biogenic silica (SIS)). The processes included in this module are 1) input of nutrients (DIN, DIP and SIL) and light from atmosphere from sea surface; 2) input of nutrients (DIN, DIP and SIL) from river mouths; 3) shading of light by SPM and chlorophyll-a in euphotic layer; 4) biological processes in the euphotic zone (photosynthesis and respiration of DIA inducing two way relations with SIL, with NIT, and with PHO; photosynthesis and respiration of FLA inducing two way relation with NIT and with PHO; mortality of DIA inducing one way relation to SIS and to DET; mortality of FLA inducing one way relation to DET; decomposition of DET to NIT and PHO; decomposition of SIS to SIL); 5) biological processes under the euphotic zone (mortality of DIA to SIS and to DET; mortality of FLA to DET; decomposition of DET to NIT and PHO; decomposition of SIS to SIL); 6) biogeochemical processes in the benthic layer (decomposition of DET to NIT and PHO; decomposition of SIS to SIL; denitrification of DET; resuspension of SIS and DET; burial of SIS and DET); 7) sinking of DIA, FLA, DET and SIS from sea surface to sea bottom (broken lines). In addition, the diffusion fluxes of SIL, NIT and PHO from benthic layer to bottom layer were also included.