SYMPOSIUM OP'24
ADVANCING OCEAN PREDICTION SCIENCE FOR SOCIETAL BENEFITS

Theme # (change mask)

Quantifying the Causes of Winter and Summer Phytoplankton Blooms in Gwangyang Bay, Korea: A Numerical Model Approach

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1. Introduction

- Winter and summer phytoplankton blooms occur in Gwangyang Bay, whereas spring and fall blooms are typical in mid-latitude regions (Cushing 1975).
- Diatoms (large-sized) and cryptophytes (small-sized) are the dominant species in Gwangyang Bay in winter and summer, respectively (Kang 2021).
- Setting up a numerical model for large- and small-sized functional groups (Fig. 2) to simulate the unique winter and summer blooms.
- Analyzing the main causes of phytoplankton blooms among variable forcings (shortwave radiation, wind, temperature, nutrients) based on sensitivity tests assuming no seasonal variation in each forcing.

2. Model configuration

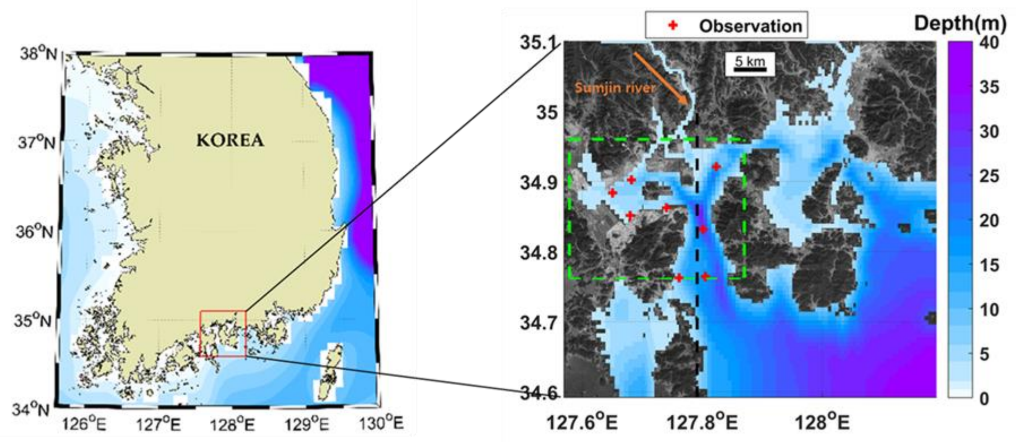

Fig. 1. Model domain

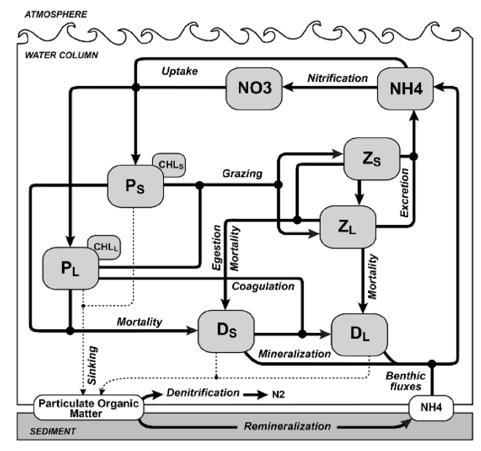

Fig. 2. Schematic of the biogeochemical model (Laurent 2021)

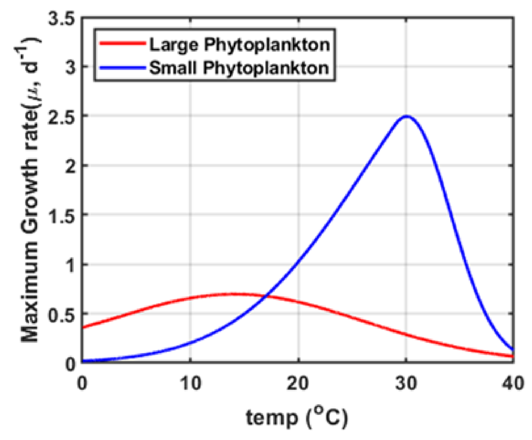

Fig. 3. Growth rate curves of phytoplankton by size as a function of temperature used in the model.

- Model: ROMS 3.7 + Biogeochemical model
- Resolution: ~ 1km (horizontal), 10 σ levels (vertical)
- Tide: major 8 components at open boundary
- Meteorological force: ECMWF ERA5 (2007~2015, daily climatological mean)
- River: Observation(2007~2015, climatological mean)
- Open boundary(physical condition): Reanalysis data (Kim,.2022) (2007~2015, climatological mean)
- Open boundary(biogeochemical condition): Observation data (2007~2015, climatological mean)
- Biogeochemical model: Based on Laurent, 2021 (Fig. 2)

3. Results

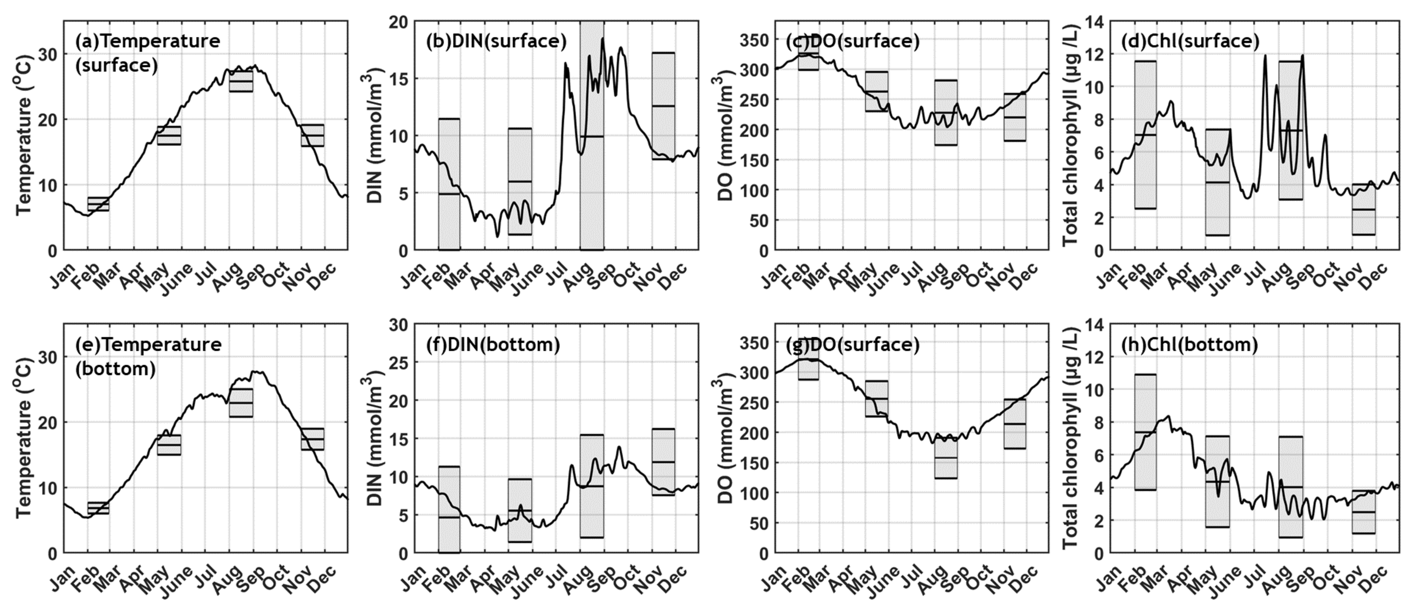

Fig. 4. Comparison of (a, e) temperature, (b, f) DIN, (c, g) Dissolved Oxygen, and (d, h) Chlorophyll at surface between model results (solid lines) and observations (vertical bars). The range of vertical bars represents the standard deviation of observations. Each data point is the spatial mean of observations (red points in Fig. 1). Panels (a-d) and (e-h) represent surface and bottom data, respectively.

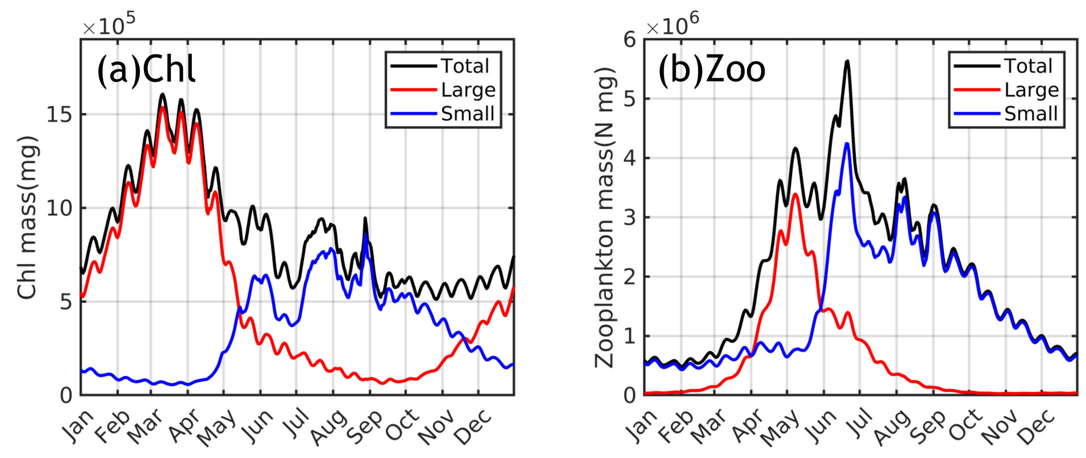

Fig. 5. Monthly time series of phyto and zooplankton masses from the model results. (a) and (b) represent vertically integrated chlorophyll and zooplankton mass, respectively. The Red, blue, and black lines indicate large, small, and total plankton mass. Each value was calculated horizontally integrating the green box area in Fig 1.

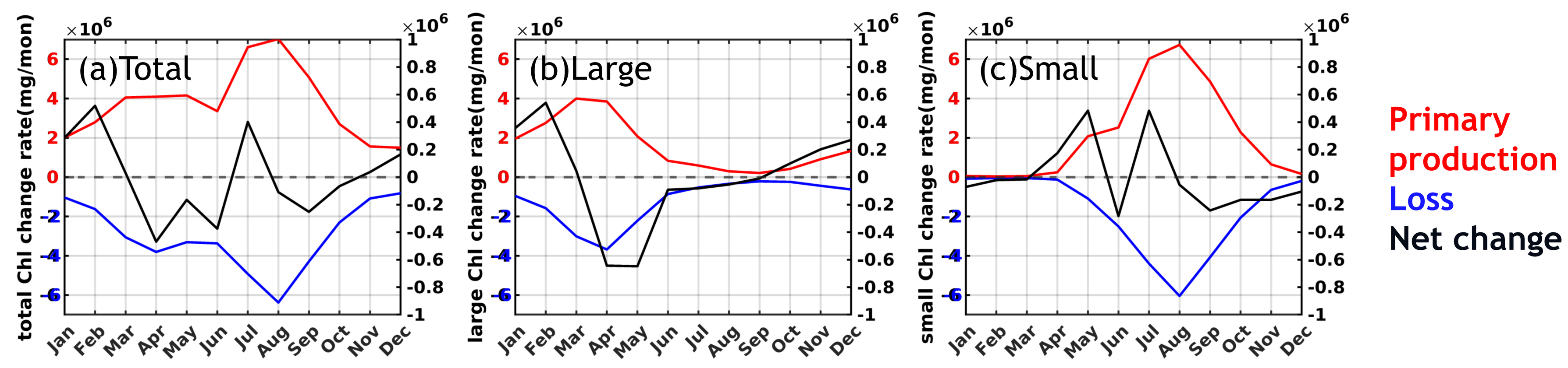

Fig. 6. Monthly time series of phytoplankton biomass change rate from the model results. (a), (b), and (c) represent vertically integrated total, small, and large sized Chlorophyll respectively. The Black, blue, and red lines indicate the biomass change rate due to primary production, loss (include grazing, mortality, and coagulation), and net change. Each data point was calculated by horizontally integrating the green box area in Fig. 1.

4. Discussion

Case	Remarks
Control	All forcings vary seasonally
Temp	Constant Temperature (yearly mean)
Turbidity	Constant Turbidity (yearly mean)
Riv_{load}	Constant river DIN loading(yearly mean)
Swrad	Constant Short wave radiation (yearly mean)
Wind	Constant Wind (yearly mean)

Table 2. Model sensitivity test.

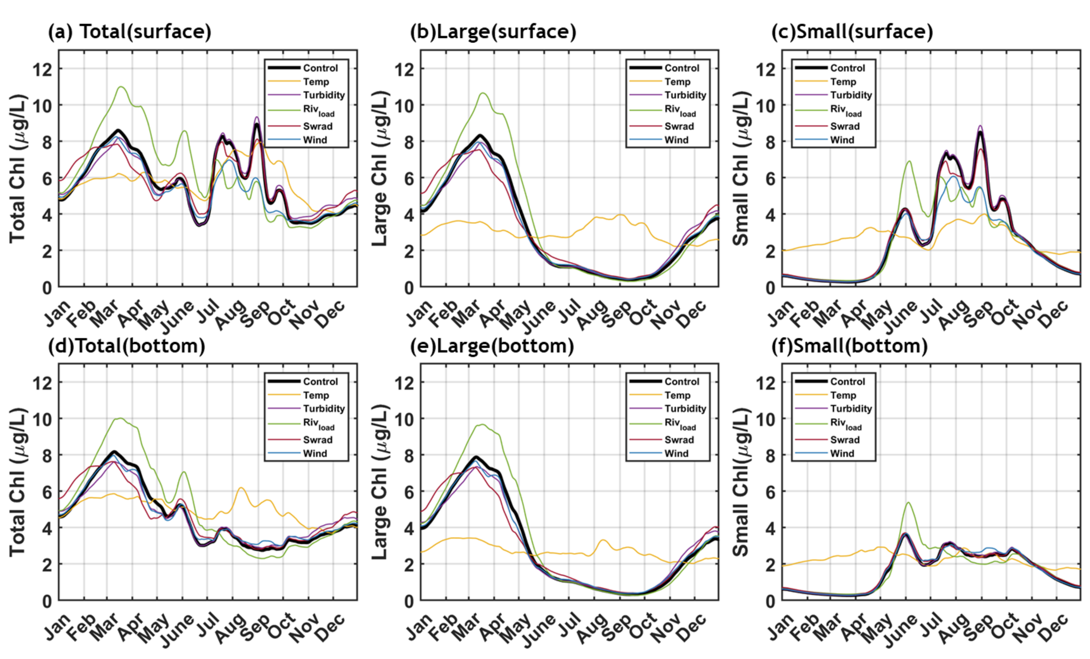

Fig. 7. Sensitivity test outputs of phytoplankton from the model results. (a-c) and (d-f) represent surface and bottom results, respectively. All results are filtered using a 15-day moving average. (a, d), (b, e), and (c, f) represent total chlorophyll (including small and large sizes), large-sized chlorophyll, and small-sized chlorophyll, respectively. Each data point is the spatial mean value of the red points in Fig. 1.

5. Conclusions

- The winter bloom of large-sized phytoplankton is caused by high production but low loss at low temperatures under moderate nutrient concentrations.
- The summer bloom of small-sized phyto-plankton is caused by higher primary production than loss at high temperatures under high nutrient concentrations.
- Sensitivity test with no seasonal variation in temperature suggests no winter bloom but does suggest a summer bloom.
- Sensitivity test with no seasonal variation in DIN loading suggests no summer bloom but does suggest a winter bloom.