< 4 >

A numerical study on Natural and Anthropogenic effects on Primary Production in Gwangyang Bay, Korea

Seung-Hwa Chae[1], Yang-Ki Cho[1], Yong-jin Tak[2] and Myeong-Taek Kwak[3]

cshwac@snu.ac.kr

1) Seoul National University, School of Earth and Environmental Sciences, Seoul, South Korea
2) Gangneung-Wonju National University, Department of Marine Ecology and Environment, Gangneung, South Korea
3) Chonnam National University, Fishery Resource Management Research Institute Based on ICT, Yeosu, South

Introduction

It is well known that phytoplankton blooms in the occurs in spring and autumn. However, the observed concentration of chlorophyll in Gwangyang Bay was higher in winter and summer than in spring and autumn. In this study, we simulated oceanic conditions to estimate natural and anthropogenic effects on seasonal and decadal changes of the primary production using a 3D coupled physical-biogeochemical model.

Study Goal and method

Goal : 1. Causes of unique seasonal variation of primary production

2. Causes of decadal primary production change

Method : 1. Reproduce the winter & summer bloom by numerical model

2. Reproduce decadal primary production change by numerical model

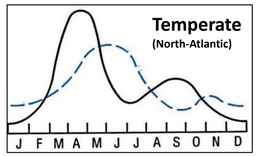

Fig. 0. General seasonal cycles of **phytoplankton** and **zooplankton**. (Cushing 1975, Fuchs 2019)

▪ Study area

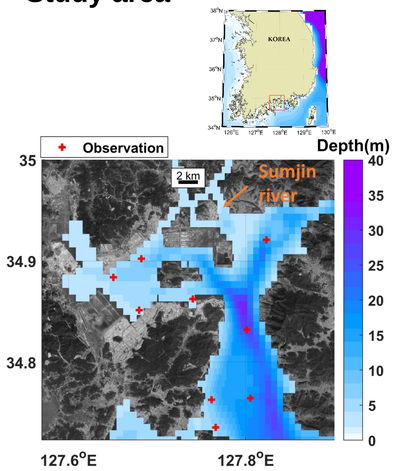

Fig. 1. Model domain

▪ Model setting

- Model: ROMS 3.7 + Bio-geochemical module (Fennel)
- Resolution:
  - vertically 10 sigma levels
  - horizontal resolution: ~ 1km
- Tide: major 8 components at open boundary
- Meteorological force: ECMWF ERA5 (2007~2015, 2016~2020, daily climatological mean)
- River: Observation data (2007~2015, 2016~2019, climatological mean)
- Open boundary(Physical): Reanalysis data (Kim,.2022) (2007~2015, 2016~2020, climatological mean)
- Open boundary(BGC): Observation data (2007~2015, 2016~2020, climatological mean)
- Biogeochemical model
  - Based on Fennel, 2006
  - Altered terms in biological process [Kishi, 2007, Kuhn, 2019]

Results

▪ Cause of unique seasonal variation (2007~2015)

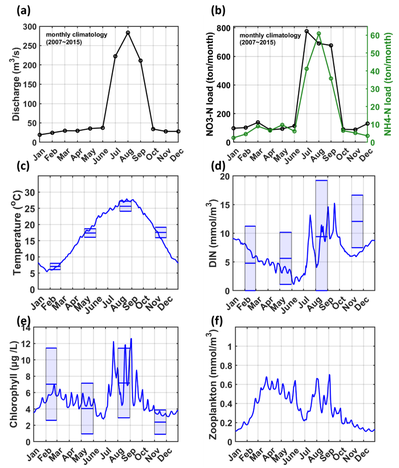

Fig. 2. Surface seasonal variation (a) and (b) from the observation, (c),(d),(e), and (f) lines and bars from model results and observation, respectively. Each data set is a spatial mean of red points in Fig 1.

Spring: warmer temperature, increased amount of zooplankton → phytoplankton decrease

Summer : increased amount of river discharge and nutrients loading → <u>phytoplankton bloom</u>

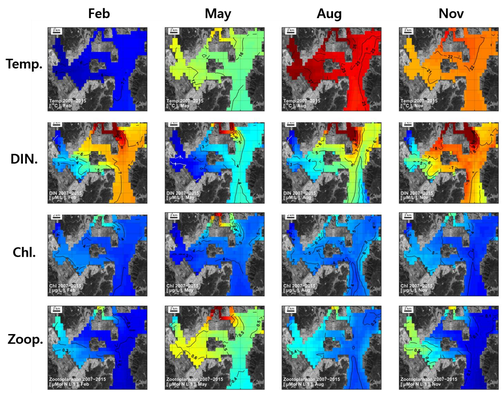

Fig. 3. Surface distribution of temperature, DIN, chlorophyll, and zooplankton from model results.

Fall: decreased river discharge and nutrients loading, increased amount of zooplankton → phytoplankton decrease

Winter: cold temperature, decreased amount of zooplankton → <u>phytoplankton bloom</u>

▪ Causes of decadal primary production change

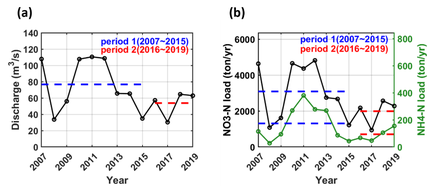

Fig. 4. Observed time series of (a)river discharge and (b)nutrient loading(Sumjin, Fig. 1)

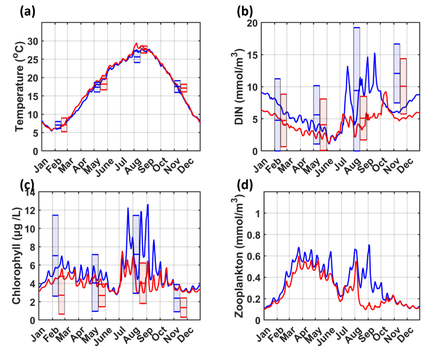

Fig. 5. Comparison of (a)temperature. (b)DIN, (c)chlorophyll,(f)zooplankton. The **blue** and **red** represent two periods same as Fig. 4. lines and bars are model results and observation, respectively. Each data set is a spatial mean of red points in Fig 1.

Decreased river discharge and nutrients loading → <u>Phytoplankton summer and winter blooms were weaken</u>

Reference

Cushing, D.H. (1975). Production cycles in space and time. In: Marine Ecology and Fisheries. Cambridge Univ. Press., pp. 11-24

Heidi Fuchs (2019). Presentation material

Kim, Y.-Y., Kang, Y.-K., Lee, S.-T., Jung, H. K., Lee, C. I., Kim, S., Jeong, K. Y., Byun, D.-S. & Cho, Y.-K. (**2022**). Potential Impact of Late 1980s Regime Shift on the Collapse of Walleye Pollock Catch in the Western East/Japan Sea. Frontiers in Marine Science, 9, 802748. https://doi.org/10.3389/fmars.2022.802748

Fennel, K., Wilkin, J., Levin, J., Moisan, J., O'Reilly, J. & Haidvogel, D. (**2006**). Nitrogen cycling in the Middle Atlantic Bight: Results from a three-dimensional model and implications for the North Atlantic nitrogen budget. *Global Biogeochemical Cycles*, *20*(3), n/a-n/a. https://doi.org/10.1029/2005gb002456

Kishi, M. J., Kashiwai, M., Ware, D. M., Megrey, B. A., Eslinger, D. L., Werner, F. E., Noguchi-Aita, M., Azumaya, T., Fujii, M., Hashimoto, S., Huang, D., Iizumi, H., Ishida, Y., Kang, S., Kantakov, G. A., Kim, H., Komatsu, K., Navrotsky, V. V., Smith, S. L., … **Zvalinsky, V. I.** (**2007**). NEMURO—a lower trophic level model for the North Pacific marine ecosystem. *Ecological Modelling*, *202*(1–2), 12–25. https://doi.org/10.1016/j.ecolmodel.2006.08.021

Kuhn, A. M. & Fennel, K. (**2019**). Evaluating ecosystem model complexity for the northwest North Atlantic through surrogate-based optimization. *Ocean Modelling*, *142*, 101437. https://doi.org/10.1016/j.ocemod.2019.101437

Kang, Y. and Oh, Y.: Different Roles of Top-Down and Bottom-Up Processes in the Distribution of Size-Fractionated Phytoplankton in Gwangyang Bay, Water-sui, 13, 1682. https://doi.org/10.3390/w13121682. 2021.

Discussion and summary

The seasonal and decadal changes of primary production were successfully reproduced using numerical modeling. The large seasonal variation and decadal decrease of river discharge due to natural causes and large decrease of nutrients due to anthropogenic cause result in unique seasonal and decadal change of primary production in Gwangyang Bay. Large river discharge and nutrient loading result in high primary production in summer. On the other hand, higher primary production in winter might result from the low grazing rate. This result is consistent with the previous study that winter bloom can be triggered by low grazing pressure in Gwangyang Bay [Kang, 2021]. Decadal decrease of primary production results from the decrease in river discharge and nutrient loading. Further experiments are necessary to understand fully seasonal and long-term variation of phytoplankton biomass.