Evaluation of the Effects of 2020 Kyushu Floods on the Development of Hypoxia in the Ariake Sea

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1. Aim

According to the AR5 Synthesis Report of IPCC, the world's air temperature is getting higher, with an expected global temperature increase of 1 to 5 °C by the end of this century (IPCC, 2014). Although many studies have shown the impact of climate change on the natural environment and proposed adaptation strategies for climate change, there are still deficiencies in the coastal marine environment and ecosystem. Problems such as sea level rise, sea temperature rise and ocean acidification are accelerating, it is significant to look for climate change adaptation for sustainable development.

The Ariake Sea is one of the most important shallow coastal area for fisheries and seaweed production in Japan. A-class rivers as main inflow of freshwater have obvious impacts on physical oceanographical system in the bay. In 2020 Kyushu floods, the large-scale effluent caused by heavy rainfall occurred from July 5 to July 7 in the Chikugo River basin, which lead to the maximum daily discharge per year exceeded the past 20 years. Heavy rainfall may cause a large amount of freshwater inflow, which will have serious impact on the marine environment and ecosystem in the bay. Therefore, it is necessary to evaluate the effects of 2020 Kyushu floods on the development of hypoxia.

2. Contents

2.1 Methodology

This study uses the hydrodynamic model and lower-trophic ecosystem model, which are the same as Tadokoro and Yano (2019). Besides, since the lack of the 2020 H-Q curve, the inflow freshwater will be calculated according to the 2018 H-Q curve (**Fig. 2**).

As a hydrodynamic model the Delft3D-FLOW module was applied. Calculation domain is a combination of the Ariake Sea and the Yatsushiro Sea (**Fig. 1**). The horizontal grid is a rectangular grid with a Cartesian frame of reference and the vertical grid uses σ coordinate system, where the number of σ-layers is defined as 10 layers with 5% × 3, 10% × 4, 15% × 3 from surface to bottom. Open boundaries are located outside the inlet to the Ariake Sea and on the line connecting *Kabashima* and *Akune*. Heat flux model uses the Murakami model, which prescribes the relative humidity, air temperature and the net solar radiation. SGS-turbulence model and *k-ε* turbulence model are used to describe turbulence processes. Freshwater inflows are considered from eight A-class rivers, nine large B-class rivers and the north and south drainage gates of the Isahaya Bay Sea-Dike. The data including air temperature, humidity, solar

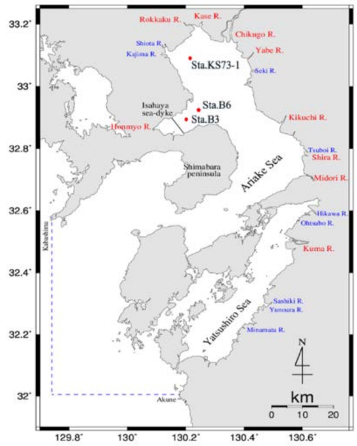

Fig. 1 Calculation domain

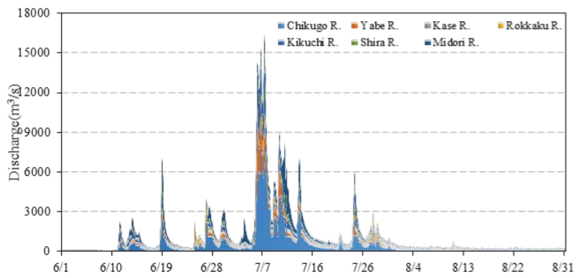

Fig. 2 Hydrograph of A-class rivers in 2020 summer

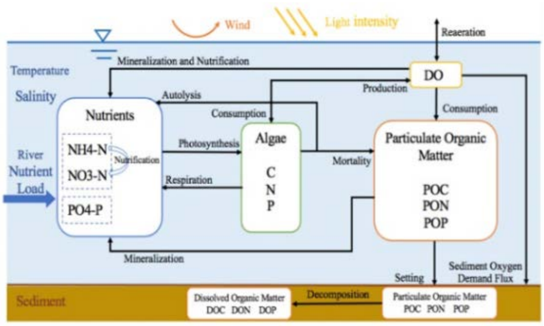

Fig. 3 Conceptual diagram of lower-trophic ecosystem model

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radiation, and wind speed are obtained from Kumamoto observatory of the AMeDAS of the Japan Meteorological Agency (JMA).

The lower-trophic ecosystem model by Delft3D-WAQ module can solve the transport of substance, which is based on the results of hydrodynamic model by Delft3D-FLOW module. For simplifying the model, only a single type of phytoplankton is considered. **Fig. 3** shows the conceptual diagram of the ecosystem model. The main processes are photosynthesis, production and consumption of oxygen, decomposition of organic matter, settlement of particulate organic matter, nutrification, mineralization and reaeration on the sea surface. Dissolved oxygen (DO) is also included as one of components in the model. Model parameters are same as the setting in Tadokoro *et al*. (2018).

2.2 Results and Discussion

For reproducibility of the development of hypoxia, Tadokoro and Yano (2019) has proven that calculation results of DO are basically in line with the observation, particularly at low values. In addition, comparing the calculation results with the intermittent observational data obtained from Fisheries Research Institute of the Ministry of Basic Fisheries also showed good performance (**Fig. 4**).

Fig. 5 shows the isopleth of DO in 2020 summer at Sta. B3 (**Fig. 1**) for more than 2 months. Red line is the counter line, indicating the hypoxia standard is DO=3 mg/L. It indicates that after the large-scale effluent of Chikugo River ended, the continuous development of hypoxia began and dissipated completely on September 3. The same calculation method was used to investigate the hypoxia in 2006 (figure omitted), showing that extreme flooding in 2020 caused the longer duration of hypoxia than that in 2006, which may cause great harm to benthic ecosystem of the Ariake Sea.

3. Conclusions

It is clarified that the large-scale effluent of Chikugo river due to 2020 Kyushu floods caused long duration of hypoxia at the bottom layer for more than 2 months. Furthermore, compared with the largest hypoxia in 2006 summer after 2000 (Hamada *et al*., 2008), historical extreme flood event in 2020 generated the longer duration of continuous hypoxia than that in 2006. The numerical models were used to evaluate

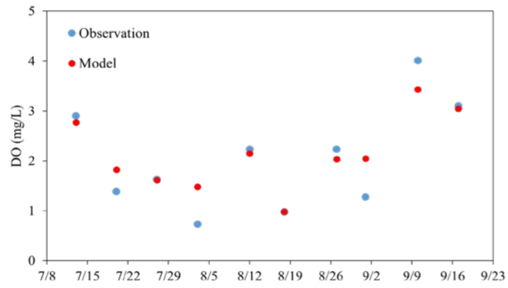

Fig. 4 Observation and calculation results of DO at Sta.B3 in 2020

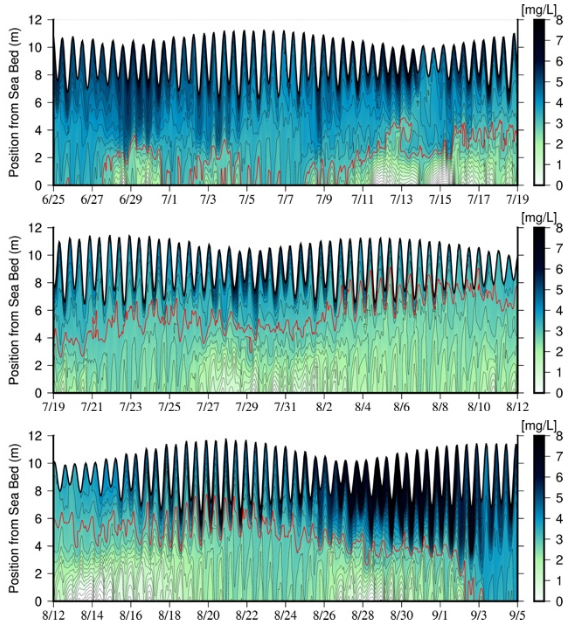

Fig. 5 Isopleth of DO in 2020 at Sta. B3

the effects of 2020 Kyushu floods on the development of hypoxia, which is of great significance for supporting climate change adaptation and providing measurements for fisheries management. In future studies, we will continue to investigate the benthic ecosystem and make more detailed discussions.

Acknowledgements:

Some data of river discharge and HQ relations in A-class rivers was provided from Ministry of Infrastructure, Land, Transport and Tourism. We express our gratitude.

Reference:

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Hamada *et al.* (2007): *Proc. Coastal Engrg., JSCE* , 54, 1121-1125.