Long term variation in dissolved oxygen and COD budgets in the inner area of Ariake Sea in summer

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[Introduction]
In the inner area of Ariake Sea, the hypoxia occurs every summer now. Since it induced massive kills of bivalves, it became a big problem. The increase in oxygen consumption by organic matter decomposition is one the potential mechanisms for the long term increase in hypoxia. In the inner area of Ariake Sea, the monitoring of the Chemical Oxygen Demand (COD) in water has been carried out for the index of the concentration of the organic matter. Therefore, in order to clarify the long term variation in the bottom DO in summer and to understand the mechanism of the variation, we made data analysis.
[Data and methods]
The data we used are the monthly monitoring data taken by the Saga Prefectural Ariake Fisheries Research and Development Center and the Fukuoka Fisheries and Marine Technology Research Center Ariake-Sea Laboratory from 1972 to 2014. And also, the river discharge and riverine input of COD through the 4 class A rivers (Chikugo, Yabe, Kase and Rokkaku River) flow into the inner area of Ariake Sea were used. As the river discharge and COD loads, the dataset by Tezuka et al (2013) and supplement until 2014 were used. The bottom DO in the inner area of Ariake Sea in summer fluctuates largely affected by the variation in stratification caused by the river discharge. Therefore, In order to remove the effect of the variation in stratification, we calculated the potential of hypoxia DO_s using the method by Hayami et al (2006). In order to understand the mechanism of the long time variation in COD, we made a box model analysis of COD for the inner part of the Saga and Fukuoka waters (Fig.1). We calculated the average salinity in the box 1 and 2 during 11 consecutive years. Using these salinities and river discharge, the salinity budget for the box 1 was calculated to get the water exchange flux between the box 1 and 2 (q). Using q, river discharge, riverine input of COD and the average COD in the box 1 and 2 during 11 consecutive years, we calculated the COD budget for the box 1. From this calculation, we got the internal production of COD in the box 1. It is the balance between the organic matter production by algae and the consumption of organic matter by grazers.
[Results and discussions]
The DO_s in the Saga water in July decreased from 1970s to early 90s then recovered slightly (Fig.2). The COD in the bottom water in July increased from 70s to early 90s then decreased slightly (Fig.2). There was a strong negative correlation between DO_s and 11 year running mean of the bottom COD (R=-0.94).
The COD in the box 1 in July and August increased from 80s to early 90s (Fig.3). There are 4 potential reasons for this increase, 1) the increase in the initial value (COD in June), 2) the increase in internal production, 3) the decrease in the fluxes by advection and water exchange and 4) the increase in riverine input. The flux by water exchange decreased and the advective flux and riverine input remained almost in the same level (Fig.4). The initial value increased from 1986 to 1988 but then decreased. On the other hand, the internal production increased. It means that the organic matter production in the sea increased or the consumers of the organic matter (grazers) decreased. In the same period, the catch of bivalves in Saga and Fukuoka prefectures decreased. Moreover, there were oyster reefs of the area of 546 ha, but it decreased to 161 ha now (Fisheries Agency, 2011). These facts indicate that the decrease in grazers actually occurred. The increase in

COD without the increase in terrestrial input suggests that such increase in COD was due to the organic matter production in the sea. Moreover, these results suggest the negative feedback control that the decrease in bivalve lead the increase of phytoplankton and it lead the increase of organic matter in the bottom water to decline the bottom DO with the decrease of the benthos.

Keywords: long term variation, dissolved oxygen, chemical oxygen demand, box model, Ariake Sea

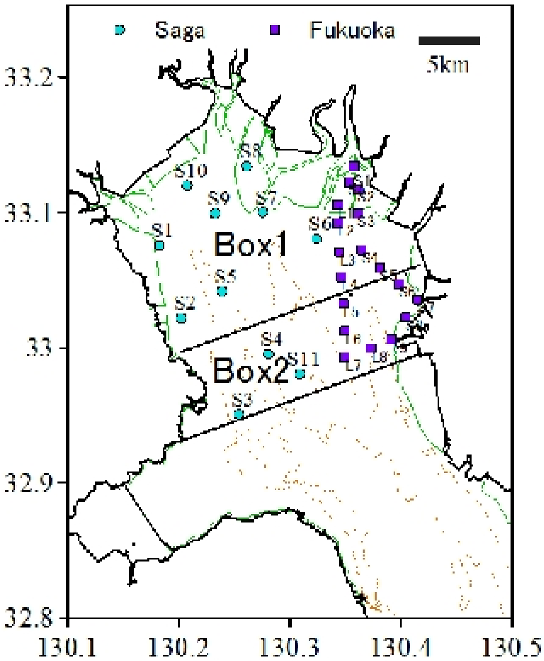

Fig.1 Map of the inner area of the Ariake Sea and location of the observation stations.

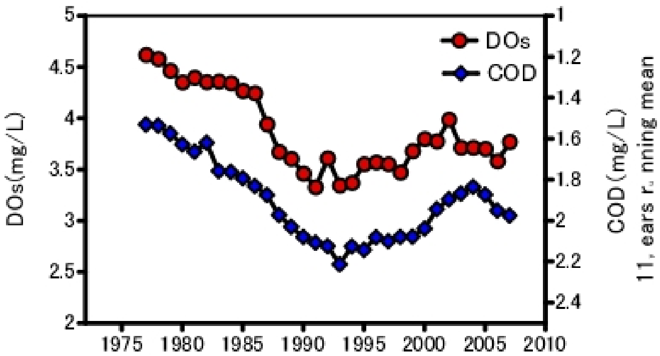

Fig.2 Variations in DO_s and COD (11 years running mean) in the bottom layer in Saga water in July.

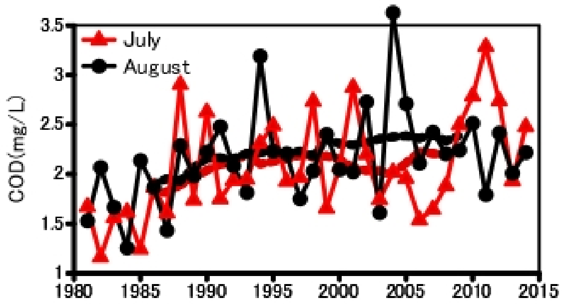

Fig.3 Variation in COD in Box1 in summer. Brocken lines are 11 years running mean.

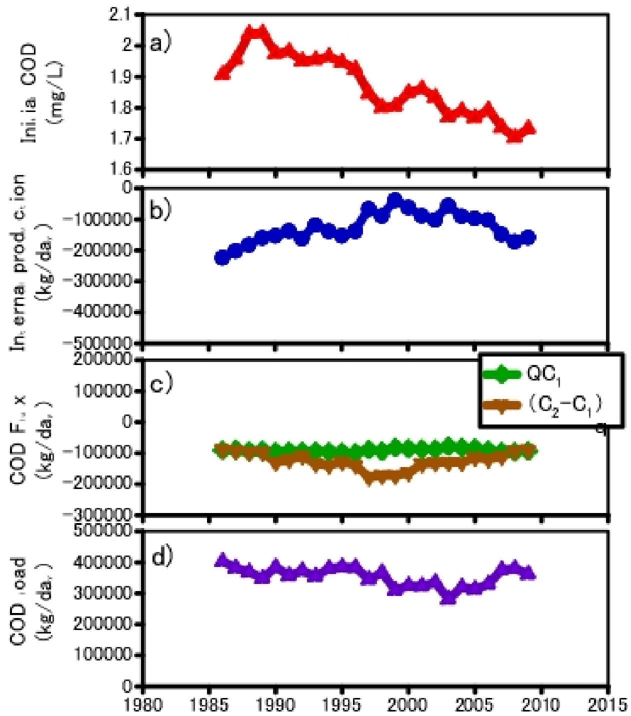

Fig.4 Variations in a) initial COD, b) internal production of COD, c) COD flux by advection and water exchange between box1 and box2 and COD load from rivers.

