

Accurate Quantification of Primary Production of Microphytobenthos Using Tank Method and High Frequency Observation by Mooring Systems to Validate of in-situ Method

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· Introduction

In tidal estuaries where terrestrial materials flow in through rivers, salinity of the shallow water fluctuates greatly with tidal current. In these environments, it is known that abundant microphytobenthos attached to sediments surface to obtain solar energy for photosynthesis. In general, microphytobenthos in tidal estuaries overwhelm phytoplankton in terms of both biomass and primary production, and play an important role as primary producers to support the high biological production in these ecosystems. Therefore, information on the primary production of microphytobenthos is essential for understanding the characteristics of the ecosystem. However, in 17 out of 25 previous studies that measured the primary production of microphytobenthos in estuarine systems, the "in-situ method" that is placed on the tidal flats during a certain period (~1 day) was used. Since the in-situ method cannot reflect the variation of weather and tidal cycle, it is a question as the representative value for longer period (i.e., from month to year). In this study, we constructed field observation and laboratory experiment to estimate the primary production of microphytobenthos in the Midorikawa River tidal flats facing Ariake Bay, Japan, in October 2021. Photosynthesis-irradiance (P-I) curves for the microphytobenthos was calculated by the laboratory experiment, which irradiates sediment samples collected in the field with multiple light levels. We combined the P-I curve with photosynthetically active radiation (PAR) data from mooring systems on the seafloor to quantify the primary production of microphytobenthos. Then, we defined the days when the in-situ method was assumed (Hereinafter, we referred as "days of in-situ measurement") based on the reported tidal height (the Japan Meteorological Agency). Finally, we compared the primary production derived from days of in-situ measurement with the monthly mean based on both P-I curve and the mooring systems and discussed the validity of the estimated primary production by the in-situ method.

· Materials and Methods

We measured salinity and PAR by using a multiple sensor (AAQ, JFE Advantech), and collected surface water and surface sediment (1 cm) samples on October 8, 2021, at two sites (Nakasu and Kamesu) in the estuary of the Midorikawa River facing the Ariake Bay, Japan. Chlorophyll a (Chl-a) concentration and dissolved inorganic carbon were measured in water samples. For sediment samples, grain size composition, water content, and Chl-a content were measured. The incubation for primary production was carried out in an incubator with an in-situ water temperature and an irradiance of $2,493 \mu\text{mol m}^{-2} \text{s}^{-1}$ (five light levels; 100, 50, 10, 1 and 0 %). Sediment samples had been placed in 60 ml glass vials, in-situ seawater was poured into them, and $\text{NaH}^{13}\text{CO}_3$ was added. P-I curves were fit to the physiological equation based on the theoretical model of Eilers and Peeters (1988). PAR, Chl-a concentration, turbidity, water temperature and salinity were measured at 10-minute intervals by mooring systems just above the sea bottom from September 22 to December 6, 2021.

· Results and Discussion

There is a clear difference in P-I curves among the sites (Fig 1). The carbon assimilation efficiency of microphytobenthos at Nakasu increased continuously in the range of 0 to 50 %, and was and photo inhibited at the highest irradiance (Fig 1). P-I curves for Nakasu and Kamesu were $y = 0.267 + 1.96 \times 10^{-6}x - 6.61 \times 10^{-19}x^2$ and $y = 0.172 + 1.04 \times 10^{-6}x - 2.19 \times 10^{-19}x^2$, and the mean values of primary production in October were $352.7 \text{ mgC m}^{-2} \text{ d}^{-1}$ and $399.9 \text{ mgC m}^{-2} \text{ d}^{-1}$, respectively. The daily accumulated PAR ($\mu \text{ mol m}^{-2} \text{ d}^{-1}$) by the mooring system peaked on October 5 and October 20 at 2 sites (Fig 2). These peaks correspond to the period of spring tide. Since the in-situ method is conducted during spring tide, the days of in-situ measurements is defined as when the tidal height at Kumamoto Port was less than 51 cm, and the primary production estimated by both the P-I curves and the mooring system on those days is extracted. The ratios of the primary production on the days of in-situ measurement to the mean of primary production in October ranged from 0.87 to 1.49 on the Nakasu and from 0.93 to 1.18 on the Kamesu (Table 1). The primary production at the days of in-situ measurement tended to be higher than the mean value when the low tide was daytime with fine weather. It was also suggested that the measured values based on the in-situ method were overestimated approximately 50 % at most and were reasonable as representative values for monthly primary production.

• Figures and Tables

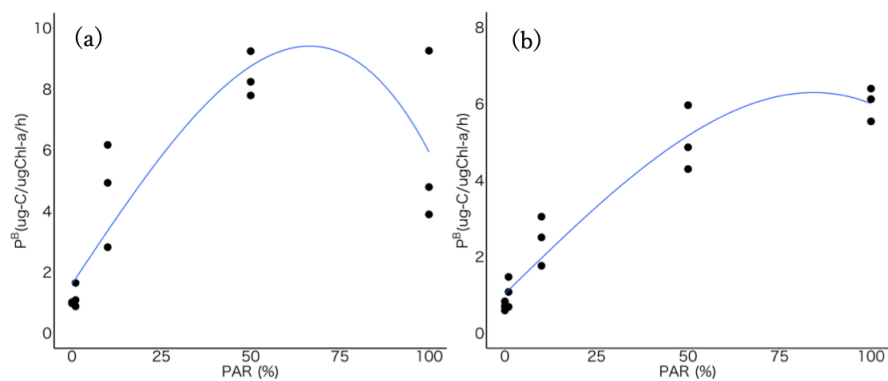


Fig 1. Photosynthesis-irradiance (P-I) curves constructed by the laboratory experiment on October 5, 2021. a : Nakasu, b : Kamesu.

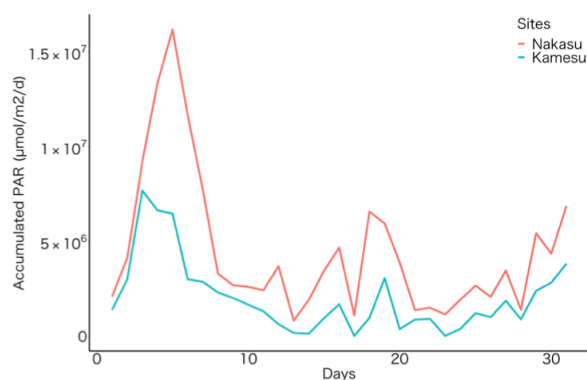


Fig 2. The trend of daily accumulated PAR from the mooring systems on the seafloor for the period October 1 - 31, 2021

Table 1. The ratios of the primary production on the days of in-situ measurement to the mean of primary production at two sites of the Midorikawa river tidal flats in October 2021

Date	Ratio to the mean		Whether	Low tide	Tidal height (cm)
	Nakasu	Kamesu			
10/5	1.49	1.18	Fine	14:13	51
10/6	1.31	1.05	Fine	14:55	42
10/7	1.14	1.04	Fine	15:36	47
10/8	0.96	1.02	Fine then partly cloudy	3:52	34
10/9	0.93	1.01	Fine	4:28	31
10/10	0.93	0.99	Fine	5:02	38
10/22	0.88	0.96	Cloudy and occasional rain	3:33	50
10/23	0.87	0.93	Fine partly rain and occasional cloudy	3:59	51