Seasonal Changes of Organic Carbon and Nitrogen Production by Phytoplankton in the Estuary of River Tamagawa

YUKUYA YAMAGUCHI*, HIROO SATOH† and YUSHO ARUGA†
*College of Liberal Arts, Saitama University, Shimo-ookubo 255, Urawa, Saitama, 338 Japan
† Tokyo University of Fisheries, Konan 4-5-7, Minato-ku, Tokyo, 108 Japan

Seasonal changes of organic carbon and nitrogen production were investigated at a station in the estuary of River Tamagawa in Tokyo Bay. Standing stock of phytoplankton expressed as a concentration of chlorophyll *a* and their photosynthetic activities fluctuated significantly with sampling periods. Based on the data obtained in 1988 and 1989, the levels of annual production of organic carbon and nitrogen by phytoplankton community in this estuary were estimated to be 1890 gC m^{-2} yr^{-1} and 281 gN m^{-2} yr^{-1}, respectively.

Standing stock of phytoplankton and their photosynthetic activities were monitored to evaluate the role of phytoplankton as a scavenger of the inorganic nutrients flowing into the estuary from the sorrounding land area. Samplings were conducted at about monthly intervals on board the T/S Seiyo-Maru of the Tokyo University of Fisheries. The results of these measurements are presented in this report.

Materials and methods

The location of the sampling station is given in Fig. 1. Serial observations and water samplings were made from the surface down to the bottom at 2.5 m intervals. Water samples were carried back to the land laboratory and the standing stock of phytoplankton was measured as a concentration of chlorophyll *a* by fluorometric method using a Turner Designs 10-005R fluorometer. Photosynthetic activities were measured by 14-C method in a water bath, temperature of which was maintained at about the same as that of surface water where the samples had been taken. Using these data as well as serial observations, daily production of organic carbon in the water column by phytoplankton was estimated according to the following equation of Rodhe (1965) with some modifications:

$$P_{euphotic\ (day)} = Z_{0.5IK} \times A_{max.}$$

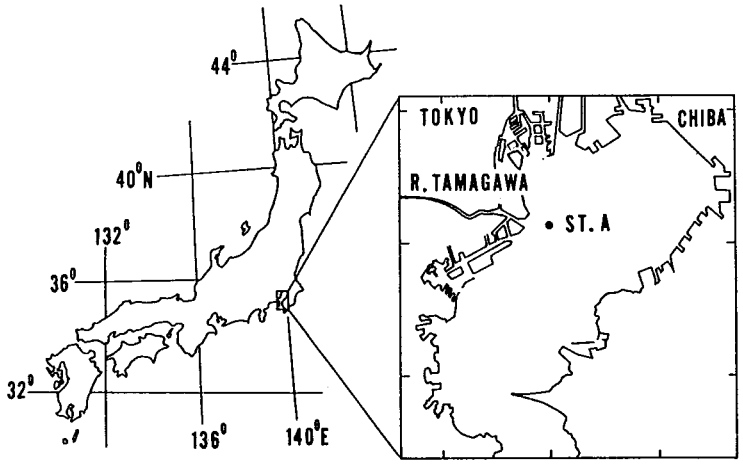

Fig. 1. Location of the sampling station in the estuary of River Tamagawa in Tokyo Bay.

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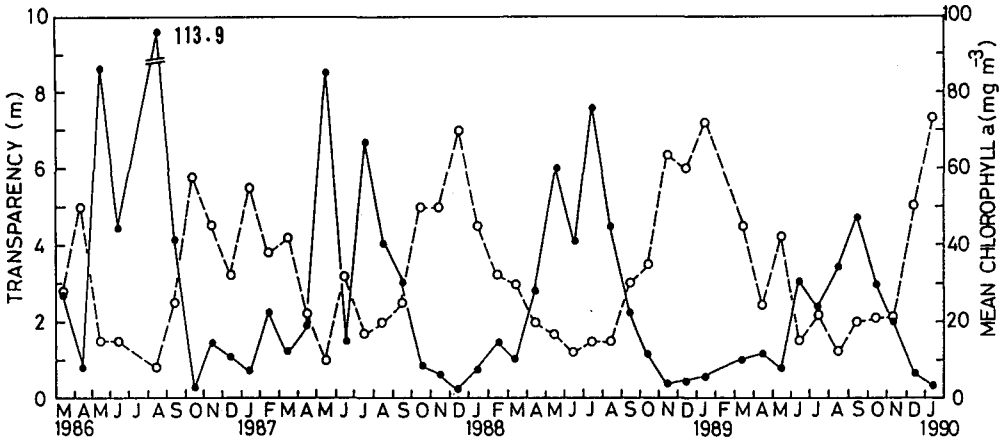

Fig. 2. Seasonal changes of the transparency (open circle) and the mean concentration of chlorophyll *a* in the euphotic layer (solid circle).

In this equation, the depth $Z_{0.5IK}$ was estimated as equivalent to the depth of 8.8 % relative light intensity ($D_{8.8\%}$). The depth $D_{8.8\%}$ was obtained on graphs of light attenuation in which the depth of euphotic layer ($D_{1\%}$) was calculated from the transparency (Secchi disc depth. D_S) as

$$D_{1\%} = 2.67 \times D_S \quad \text{(Aruga, 1973).}$$

A_{max} was calculated from the data of mean chlorophyll *a* concentration (CHL) and maximum photosynthetic activity ($\overline{P}_{max}$) within the euphotic layer as

$$A_{max} = \overline{P}_{max} \times CHL \times 2/3H.$$

The duration of available production time was considered to be 2/3 of the local daylength. The production of organic nitrogen was calculated from the rate of carbon production using the conversion factor of C/N = 6.6.

Results and discussion

Seasonal changes of the transparency and the mean concentration of chlorophyll *a* in the euphotic layer during the past four years are shown in Fig.2. The transparency fluctuated significantly with months, ranging from 0.8 to 7.3 m with a clear tendency of shallower in the summer and deeper in the winter seasons. The chlorophyll *a* standing stock also fluctuated and ranged from1.81 to 113.91 mg m^{-3}. An inverse relationship between the transparency and the mean concentration of chlorophyll *a* was clearly observed in every year, indicationg the importance of phytoplankton in this estuary. Red tides were observed during the summer seasons.

Table 1. The estimations of organic carbon and nitrogen production in the estuary of River Tamagawa in 1988.

Date	WT (1)	D_S (2)	$D_{1\%}$ (3)	CHL (4)	$\overline{P}_{max}$ (5)	C-Prod. (6)	N-Prod. (7)
Jan. 19	12.2	4.5	12.2	10.78	2.65	1.38	0.21
Mar. 17	10.0	3.0	8.0	14.19	2.11	1.08	0.16
Apr. 20	14.3	1.9	5.1	38.94	8.38	7.76	1.18
May 16	18.8	1.8	4.8	75.32	3.16	6.00	0.94
June 14	19.5	1.8	4.8	48.40	5.75	7.31	1.11
July 13	24.2	1.4	3.8	98.27	7.15	14.61	2.21
Aug. 10	25.7	1.8	4.8	46.72	4.97	5.63	0.85
Sept.11	23.5	1.5	4.0	39.19	7.07	5.24	0.79
Oct. 26	18.9	2.3	6.1	18.82	7.18	3.70	0.56
Nov. 9	16.3	5.5	14.7	9.21	4.28	2.25	0.34
Dec. 13	12.6	6.1	16.3	6.68	3.03	1.13	0.17

units; (1) °C, (2) m, (3) m, (4) mg m^{-3}, (5) mgC chl.a $mg^{-2}hr^{-1}$, (6) gC $m^{-2}day^{-1}$, (7) gN $m^{-2}day^{-1}$

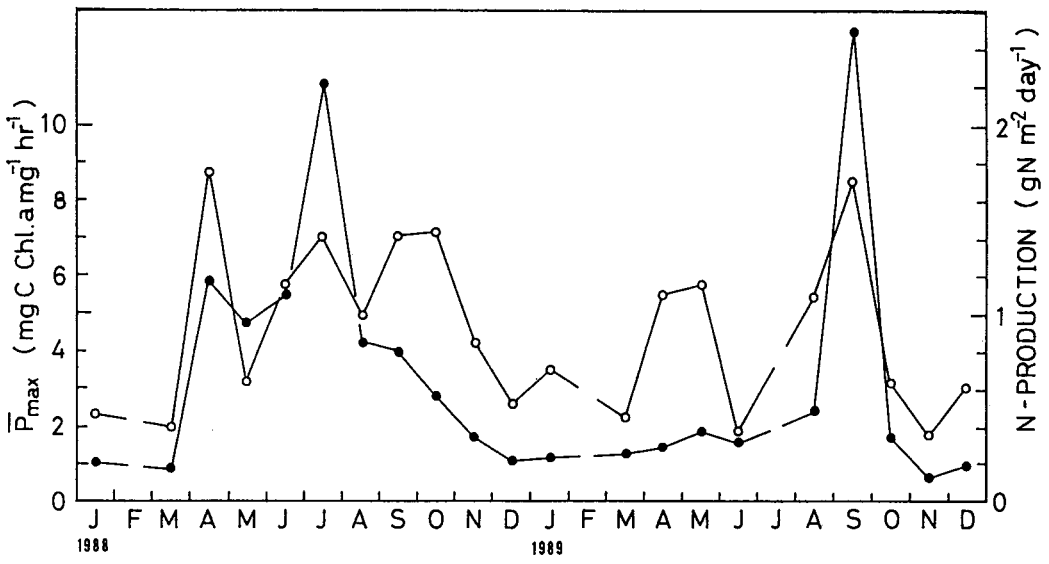

Fig. 3. Seasonal changes of the mean maximum photosynthetic activity ($\overline{P}_{max}$) in the euphotic layer (open circle) and the rate of organic nitrogen production (solid circle) in the estuary of River Tamagawa.

The photosynthetic activity of phytoplankton was determined from 1988 to 1989, and the rate of organic carbon production was estimated. A part of these estimations is summarized in Table 1. In 1988, the depth of euphotic layer changed from 3.8 m in July to 16.3 m in December. The mean standing stock of phytoplankton chlorophyll *a* in the euphotic layer ranged from 6.68 to 98.27 mg m^{-3}. $\overline{P}_{max}$ showed higher values during the summer season but decreased during the winter season. The daily production of organic carbon within the water column was lowest in March (1.08 gC $m^{-2}day^{-1}$) and showed its maximum in July (14.61 gC $m^{-2}day^{-1}$) with the mean value of 5.5 gC m^{-2} day^{-1}. The organic carbon production in 1989 calculated with the same procedure ranged from 0.90 to 16.42 gC $m^{-2}day^{-1}$ (mean value 3.34 gC $m^{-2}day^{-1}$). Thus, the rate of organic nitrogen production in 1988 and 1989 was calculated to be from 0.16 to 2.21 gN $m^{-2}day^{-1}$ (mean value 0.833 gN $m^{-2}day^{-1}$) and from 0.14 to 2.49 gN $m^{-2}day^{-1}$ (mean value 0.508 gN $m^{-2}day^{-1}$), respectively. The seasonal changes of organic nitrogen production in the estuary of River Tamagawa as well as $\overline{P}_{max}$ within the euphotic layer are indicated in Fig. 3. Based on these data obtained in 1988 and 1989, the levels of annual incorporation of carbon and nitrogen by phytoplankton community in the estuary of River Tamagawa, could be 1860 gC $m^{-2}yr^{-1}$ and 281 gN $m^{-2}yr^{-1}$, respectively. According to the report of the Department of Environmental Preservation of Tokyo (1988), the annual input of inorganic nitrogen (DIN) through River Tamagawa into Tokyo Bay is estimated to be about 2300 tN $ha^{-1}yr^{-1}$. In order for phytoplankton to take up the DIN completely along with photosynthesis, about 8.2 ha of sea surface will needed in this estuary.

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