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Size Fractionated Phytoplankton Biomass and Primary Productivity in Osaka Bay, Eastern Seto Inland Sea, Japan

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Size fractionated phytoplankton biomass and primary productivity were measured in Osaka Bay during five research cruises made in September, December of 1984 and March, June and September of 1985. Chlorophyll *a* was determined fluorometrically and productivity was measured by an *in situ* ^{13}C method. The chlorophyll biomass (mg m^{-2}) ranged from 5.8 to 587.4 mg m^{-2}, with a mean of 56.2 mg m^{-2} for nanoplankton (less than 10μm) and 15.3 to 1020.9 mg m^{-2} with a mean of 131.5 mg m^{-2} for the total plankton. Phytoplankton biomass was higher in warm seasons than in cold. Nanoplankton accounted for 43 % of the total biomass in the Bay. Mean biomass in terms of carbon was calculated to be3.4 gC m^{-2} and 7.8 gC m^{-2} for nanoplankton and total plankton, respectively. Photosynthetic rates ranged from 0.07 to 14.21 gC m^{-2} d^{-1}, with a mean of 1.77 gC m^{-2} d^{-1} for nanoplankton, and 0.16 to 14.95 gC m^{-2} d^{-1} with a mean of 2.66 gC m^{-2} d^{-1} for total plankton. Photosynthetic rate per unit amount of chlorophyll *a* (assimilation number) at the surface varied from 2.1 to 8.9 mgC mgChl.a^{-1} $h^{-1}$for nanoplankton and from 2.4 to 10.6 mgC mgChl.a^{-1} h^{-1} for total plankton. Relative percentages of nanoplankton to total production varied considerably from 5 to 95% with season and area. Nanoplankton contribution was higher in warm seasons than in cold ones and was lower in northeastern part of the Bay than the southwestern offshore area throughout the survey. Annual primary production was calculated to be 646 gC m^{-2} yr^{-1} for nanoplankton, and 971 gC m^{-2} yr^{-1} for the total phytoplankton. Nanoplankton accounted for 67 % of total production in the Bay. These results indicate that Osaka Bay is one of the most productive waters in Japan and have the characteristics of highly eutrophicated waters where the contribution of nanoplankton is relatively small.

Key words: Osaka Bay, phytoplankton biomass, primary productivity, nanoplankton

Osaka Bay is one of the most eutrophicated bays in Japan, where red tides have occurred perennially (Joh *et al.* 1971). The Bay is, on the other hand, an important fishing ground. In Osaka Bay, about 62 to 135 thousand tons of fish have been exploited annually during 1980s which is equivalent to approximately 20 % of the total catch in the Seto Inland Sea. The catch is characterized by a high proportion (about 90 % of the total) of planktivorous fish such as anchovy, sardine and sand lance (Joh 1991). This fish production is derived ultimately from the primary production in the Bay and adjacent waters through several trophic levels. In addition it is important to evaluate the carrying capacity of the fishing ground for the establishment of a

management scheme for aquaculture. Nevertheless, studies of primary productivity in Osaka Bay have been scarce as well as in other neritic waters in Japan. Endo (1965) measured the primary production by the ^{14}C method at 2 stations in September in 1963 and Joh and Uno (1983) reported the phytoplankton production using the oxygen method. More recently Uye *et al.* (1986) examined the relationship between zooplankton and phytoplankton production using the ^{14}C method.

Importance of studying phytoplankton cell size has recently been emphasized because of the differences in cell size influence the response of phytoplankton to the environment and food chain dynamics (Ryther 1969, Malone 1980). In oceanic waters, nanoplankton play an important role as primary producers (Li *et al.* 1983, Takahashi and Bienfang 1983). Nanoplankton is also important as a prey of the microzooplankters (Verity 1986). However food chains connecting nanoplankton and microzooplankton are poorly detailed due to the lack of basic information on these organisms, especially in highly eutrophicated neritic waters such as Osaka Bay.

In the present paper, phytoplankton biomass and productivity in Osaka Bay were determined using two size categories, i.e., the nanoplankton and the total plankton. Because the use of radioactive carbon in the field has been restricted in Japan, we used the stable isotope of carbon, ^{13}C, for productivity measurements (Slawyk *et al.* 1977, Hama *et al.* 1983, Yamaguchi and Anraku 1984). Seasonal and regional variations in phytoplankton biomass and productivity within the Bay and the relationship between these measurements and oceanographic properties are discussed as well as the relative importance of nanoplankton in the total phytoplankton population.

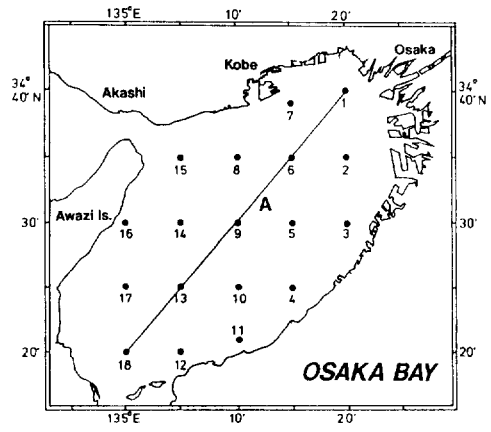

Fig. 1. Sampling stations (1–18) in Osaka Bay and position of transect A.

Materials and Methods

Study site Osaka Bay is located in the eastern part of the Seto Inland Sea (Fig. 1). Measurements of size fractionated phytoplankton biomass and productivity were made at 18 stations and 3 stations (Sts. 1, 9, 18), respectively, during five seasonal surveys carried out in September and December 1984, and March, June and September 1985.

Phytoplankton biomass Water samples were collected with 10 *l* Van Dorn samplers at the surface, 5 m, and at every 10 m for the stations deeper than 10 m, and at B-1 m (1 m above the bottom). The samples were pre-filtered by gravity through plankton netting (Nytal, mesh opening of 10μm). The filtrates were filtered onto Whatman GF/C glass fiber filters and pigments extracted with 90 % acetone (Nanoplankton fraction). Unfiltered sample were used for the total chlorophyll *a* determinations (Total fraction). Chlorophyll *a* concentrations were measured fluorometrically with a Turner Designs 10-005R fluorometer. Microplankton ($>$ 10 μm) chlorophyll *a*

concentrations were obtained from the difference between the total and the nanoplankton fractions. Phytoplankton chlorophyll *a* concentrations in the water column of one square meter (mg chl.*a* m^{-2}) were calculated by integrating over the depth. Part of the seawater samples were filtered onto precombusted Whatman GF/F filter for particulate organic carbon (POC) determinations. POC was measured with a CHN corder (MT-5, Yanagimoto Co., Japan). Carbon to chlorophyll *a* ratios were obtained from the slope of the linear regression of chlorophyll *a* on POC. Phytoplankton biomass in terms of carbon (gC m^{-2}) was then estimated by multiplying the chlorophyll *a* concentration by the carbon to chlorophyll *a* ratios.

Primary productivity Size fractionated primary productivity was determined by the ^{13}C method. Water samples were collected in Van Dorn samplers at the same depths as for the chlorophyll *a* determinations. The seawater was filtered through plankton netting (mesh size of 300 μm) to remove larger zooplankton and were size fractionated (total and $<10\mu$m fractions) in the same manner as described above. The fractionated water samples were incubated in two 1.2 *l* glass bottles with 1 ml of $NaH^{13}CO_3$ solution (22mg l^{-1}, Prochem, 90 atom %). Incubations were done *in situ* from around 10 a.m. to 3 p.m. (local time) by suspending the bottles at the same depth from which they were taken. At each depth, one sample was incubated in a clear bottle and the other one in a bottle wrapped in a black sheet to correct for dark CO_2 fixation. After incubation, the water samples were filtered as soon as possible through precombusted (450℃, 1h) Whatman GF/F glass fiber filters. The filters were frozen at −20℃ and brought back to the laboratory. The same water samples used for *in situ* incubation experiments were filtered and used for the analysis of POC, atom % of ^{13}C in the natural samples (Ans) and chlorophyll *a*. Concentrations of total inorganic carbon were determined by the pH and alkalinity method (Strickland and Parsons 1968) for the calculation of the atom % of ^{13}C in the total inorganic carbon (Aic).

The filters from the *in situ* incubation experiments were treated with HCl fumes to remove carbonate and were dried in a vacuum desiccator with active silica gel. Isotope ratios of ^{13}C and ^{12}C of the samples were measured by a quadrapole mass-spectrometer (Yanaco MSI-20). Atom % of ^{13}C in the samples were calculated as follows;

$$^{13}C \text{ atom } \% = 100\ (^{13}C)/((^{12}C) + (^{13}C)) = 100/(R+1),$$

where R is the isotope ratio of the sample. The photosynthetic rate (PR:mgC m^{-3} h^{-1}) was calculated according to Slawyk *et al.* (1979);

$$PR = P_0\ (Ais - Ans)/((Aic - Ais)t),$$

where Ans and Aic are the same as specified above, Ais is the atom % of ^{13}C in the incubated sample, P_0 is the POC in the natural sample (mgC m^{-3}) and t is the incubation period (h). The photosynthetic rate was corrected with the discrimination factor of ^{13}C according to Hama *et al.* (1983).

Photosynthetic rate in the water column below the surface area of 1 m^2 was calculated by numerical integration. Daily production rates were obtained by multiplying the hourly production rate by the number

of daylight hours for that day.

Environmental parameters Salinity and temperature profiles were determined with a STD system (Tsurumi Seiki, model 1).

Results

Environmental conditions Figure 2 shows vertical profiles of water temperature, salinity and density of water along transect A shown in Fig. 1. Water temperature was higher in the surface waters of northeast region of the Bay than western waters in September 1984, June and September 1985, while the reverse was the case in December 1984. In March 1985, the temperature was the lowest of all the seasons and was almost uniform throughout the whole water column. Downward intervals of the temperature isotherms indicate that water column was poorly stratified during the entire period of the present investigations. In contrast to temperature, salinity decreased toward the surface waters of the northeast regions. It was also observed that the horizontal salinity gradient was sharper than in the vertical direction, indicating the effect of a freshwater inflow from the northeastern part of the Bay. Water densities exhibited similar trends as was seen in salinity. From these oceanographic observations, Osaka Bay may be divided into two regions, i.e., northeastern part and southwestern part. The former is an area heavily influenced by the freshwater inflow from land throughout all seasons of the year and the latter is affected by the offshore water from Kii Channel.

Phytoplankton Biomass Vertical profiles of the total and nanoplankton chlorophyll *a* and relative abundance of the latter to the former (%) along transect A are shown in Fig. 3. Chlorophyll *a* concentrations were extremely high and variable in the northeastern waters of the Bay and progressively decreased towards the southwestern waters. For the total plankton fraction, chlorophyll *a* concentrations higher than 10 mg m^{-3} were observed from the surface down to the 10 m layers in the western and northeastern waters in September 1984 and were also observed in the whole water column down to the bottom in the northeastern waters in September 1985. In December 1984, the concentrations were lowest (less than 2 mg m^{-3}) compared with the other seasons and the distribution was uniform throughout the water column. Vertical profile of the total chlorophyll *a* in March 1985 was similar to those in June and September 1985 however concentrations were lower. From September 1984 to March 1985 chlorophyll *a* concentrations of the nanoplankton fraction were lower than 5 mg m^{-3} in all water sampled being slightly higher in the upper 20 m. High concentrations of 5 to 50 mg m^{-3} was observed in the northeastern waters of the Bay in June and September 1985. These distribution patterns of high chlorophyll *a* concentration were well consistent with that of low salinity waters (Fig. 2).

The contribution of nanoplankton fraction to the total was highest in June 1985, when more than 60 % of the chlorophyll *a* was attributed to nanoplankton throughout the water area examined. In September 1984 and 1985, the nanoplankton fraction was less pronounced than in June and the high contribution was restricted to subsurface and southwestern water of the Bay. The percentage of nanoplankton declined considerably in December and was at a minimum in March. Nanoplankton accounted for less than 20 % of the total chlorophyll *a* near the bottom in March (Fig. 3).

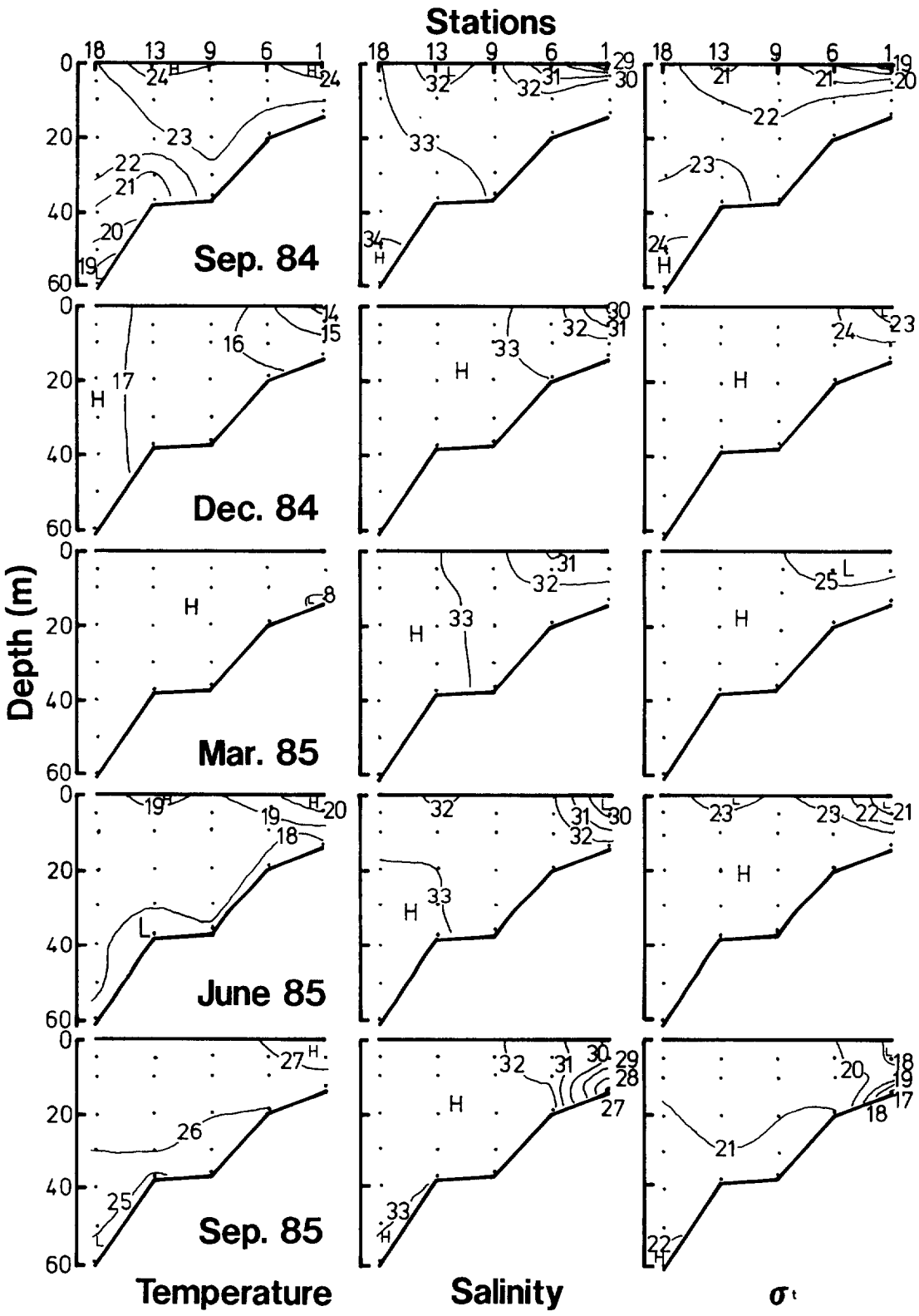

Fig. 2. Vertical profiles of temperature, salinity and density along the transect A shown in Fig.1.

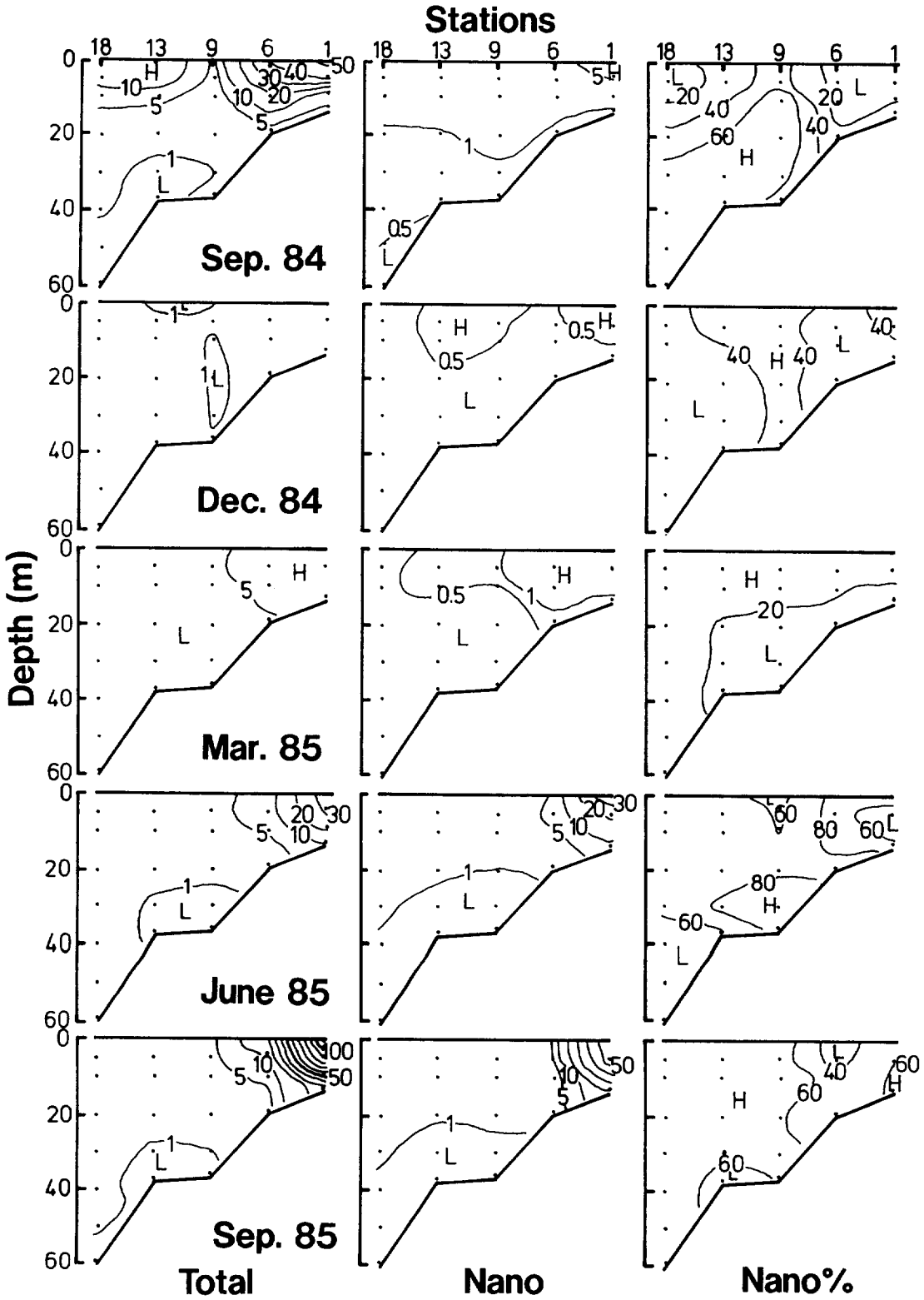

Fig. 3. Vertical profiles of chlorophyll *a* concentrations of the total fraction (Total), nanoplankton fraction (Nano) and relative percentage of nanoplankton chlorophyll *a* to the total (%) along the transect A shown in Fig. 1.

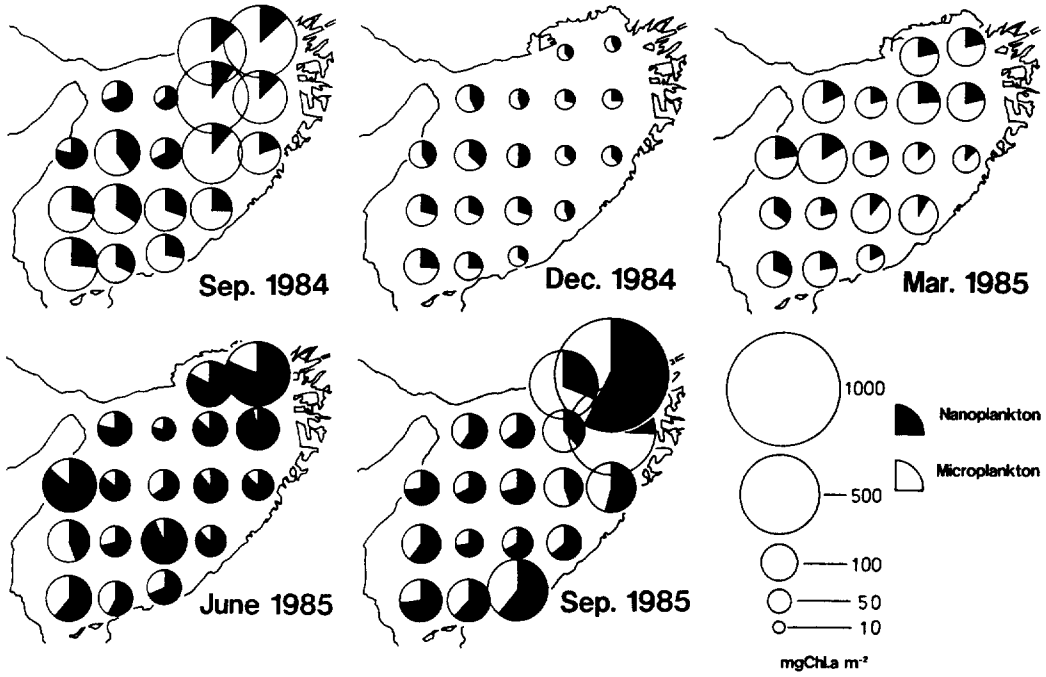

Fig. 4. Seasonal variations in the regional distributions of phytoplankton biomass and relative contribution of nanoplankton to the biomass in Osaka Bay.

Horizontal distributions of the integrated chlorophyll *a* value from the surface to the bottom (mg m^{-2}) and the relative abundance of nanoplankton and microplankton are shown in Fig. 4. Integrated chlorophyll *a* concentrations were generally higher in the northeastern waters of the Bay in all seasonal surveys except for December 1984, when it was higher in the western waters. Relative percentages of nanoplankton to the total chlorophyll *a* were always less than 50 % from September 1984 to March 1985, but they increased to between 29 and 73 % in September 1985. In June 1985, the percentage of nanoplankton was considerably higher varying from 45 to 97 %. An interannual difference in the percentage of nanoplankton were evident in the results of September of 1984 and 1985, the percentage being higher in 1985 than in 1984.

Nanoplankton and total chlorophyll *a* data obtained at each station were pooled for each sampling date (Table 1). The concentrations ranged from 0.25 to 59.62 mg m^{-3} (mean: 2.25 mg m^{-3}) for nanoplankton, and 0.36 to 115.67 mg m^{-3} (mean: 5.50 mg m^{-3}) for total plankton. Over the entire period of this study, the mean concentration was the highest in September 1985 and the lowest in December 1984 for both size fractions. The standard deviation (SD) of the mean of the chlorophyll *a* concentration was larger in September 1984, June and September 1985 than in December 1984 and March 1985. Thus chlorophyll *a* concentrations varied more considerably in the warm season than in the cold season of the year.

Table 2 shows the results of the regression analysis between of chlorophyll *a* and POC. The linear relationships between chlorophyll *a* and POC were significant.

Table 1. Chlorophyll *a* concentrations (mg m^{-3}) of the size-fractionated phytoplankton in Osaka Bay. n=number of samples.

Date	n	Nanoplankton (<10 μm)		Total	
		Range	Mean±SD	Range	Mean±SD
Sep. 1984	96	0.32– 7.75	1.68±1.38	0.44– 53.36	8.34±11.91
Dec. 1984	95	0.31– 1.04	0.50±0.15	0.57– 3.36	1.41± 0.52
Mar. 1985	94	0.26– 2.54	0.67±0.49	1.10– 10.58	3.55± 2.43
June 1985	95	0.37–35.77	3.82±4.89	0.57– 39.75	4.88± 5.72
Sep. 1985	94	0.25–59.62	4.58±9.20	0.36–115.67	9.32±19.29

Table 2. Carbon to chlorophyll *a* ratios estimated from linear regressions of POC on chlorophyll *a* of the total phytoplankton. All correlation coefficients (r) were statistically significant ($p<0.01$). n=number of samples.

Date	n	C/Chl.*a*	Intercept	r
Sep. 1984	54	56.8	240.3	0.94
Dec. 1984	52	90.6	84.8	0.66
Mar. 1985	52	79.6	149.9	0.91
June 1985	53	83.6	254.3	0.89
Sep. 1985	52	31.7	400.4	0.82
Pooled	263	39.9	318.8	0.82

Table 3. Integrated chlorophyll *a* and phytoplankton biomass in terms of carbon, the latter estimated from chlorophyll *a* concentrations and carbon to chlorophyll *a* ratios of the size-fractionated phytoplankton in Osaka Bay.

Date	Nanoplankton (<10 μm)			Total		
	Chlorophyll *a* (mg m^{-2})		Carbon	Chlorophyll *a* (mg m^{-2})		Carbon
	Range	Mean±SD	(g m^{-2})	Range	Mean±SD	(g m^{-2})
Sep. 1984	25.1– 62.8	43.0± 12.0	2.4	46.7– 408.6	180.6±109.6	10.2
Dec. 1984	5.8– 25.7	15.1± 6.2	1.4	15.3– 90.3	44.2± 20.1	4.0
Mar. 1985	7.6– 33.0	19.5± 8.1	1.6	53.1– 182.1	101.4± 33.0	8.1
June 1985	35.9–269.5	96.1± 60.6	8.0	45.6– 332.8	122.4± 69.9	10.2
Sep. 1985	43.8–587.4	107.4±125.2	3.4	61.0–1020.9	209.0±241.1	6.6

Thus phytoplankton biomass in terms of carbon (gC m^{-2}) was estimated by multiplying the chlorophyll *a* concentration by the slopes of the regression (carbon to chlorophyll *a* ratios). Thus estimated phytoplankton biomass in terms of chlorophyll *a* and carbon were summarized in Table 3. The chlorophyll biomasses (mg m^{-2}) for nanoplankton ranged from 5.8 to 587.4 mg m^{-2} (mean: 56.2 mg m^{-2}) and for the total plankton 15.3 to 1020.9 mg m^{-2} (mean: 131.5 mg m^{-2}). Thus nanoplankton accounted for 43 % on average of total biomass in Osaka Bay. The carbon biomass varied from 1.4 to 8.0 gC m^{-2} (mean: 3.4 gC m^{-2}) for nanoplankton, and from 4.0 to 10.2 gC m^{-2} (mean: 7.8 gC m^{-2}) for the total. Combining these data with the area of Osaka Bay (1529 km^2), phytoplankton carbon biomass in the entire Bay is calculated to be 5.2×10^3 ton C for nanoplankton and 11.9×10^3 ton C for the total phytoplankton.

Primary Productivity Vertical profiles of the photosynthetic rate obtained by *in situ* productivity experiments at Sts. 1, 9 and

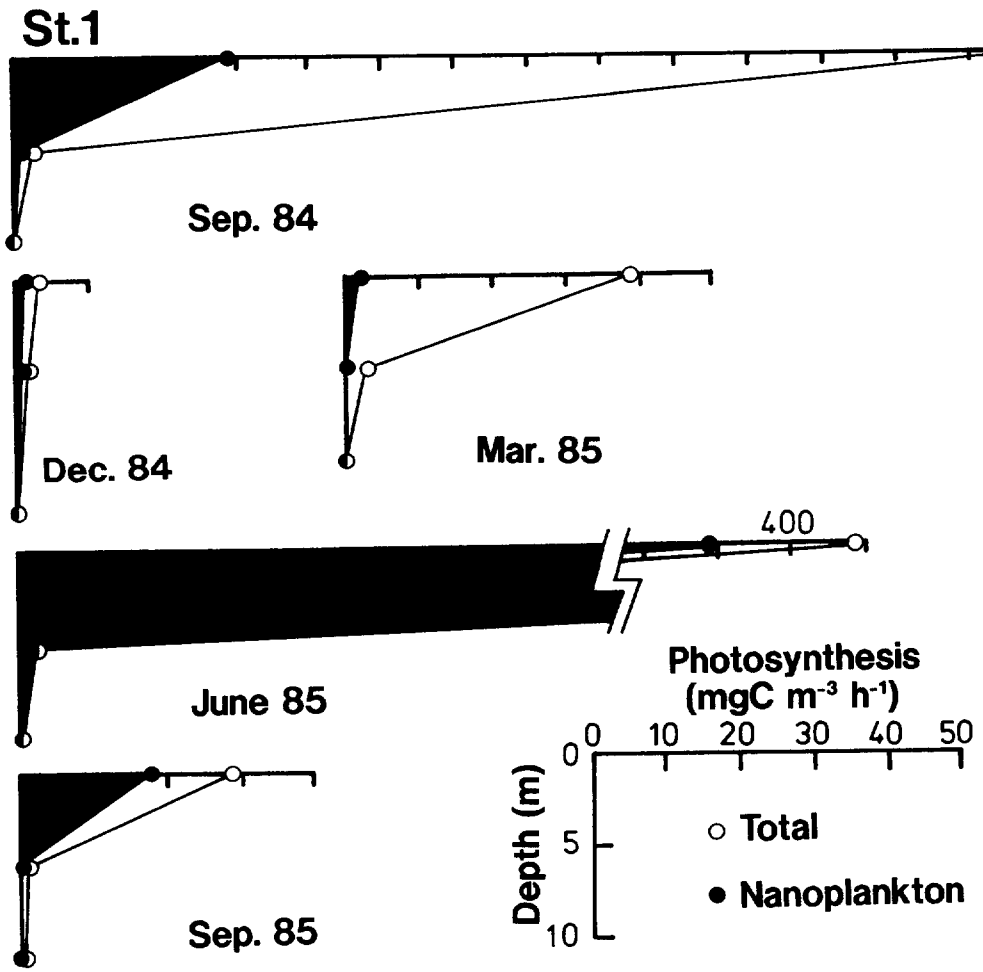

Fig. 5. Vertical profiles of the size fractionated photosynthetic rate at Sts. 1, 9 and 18.

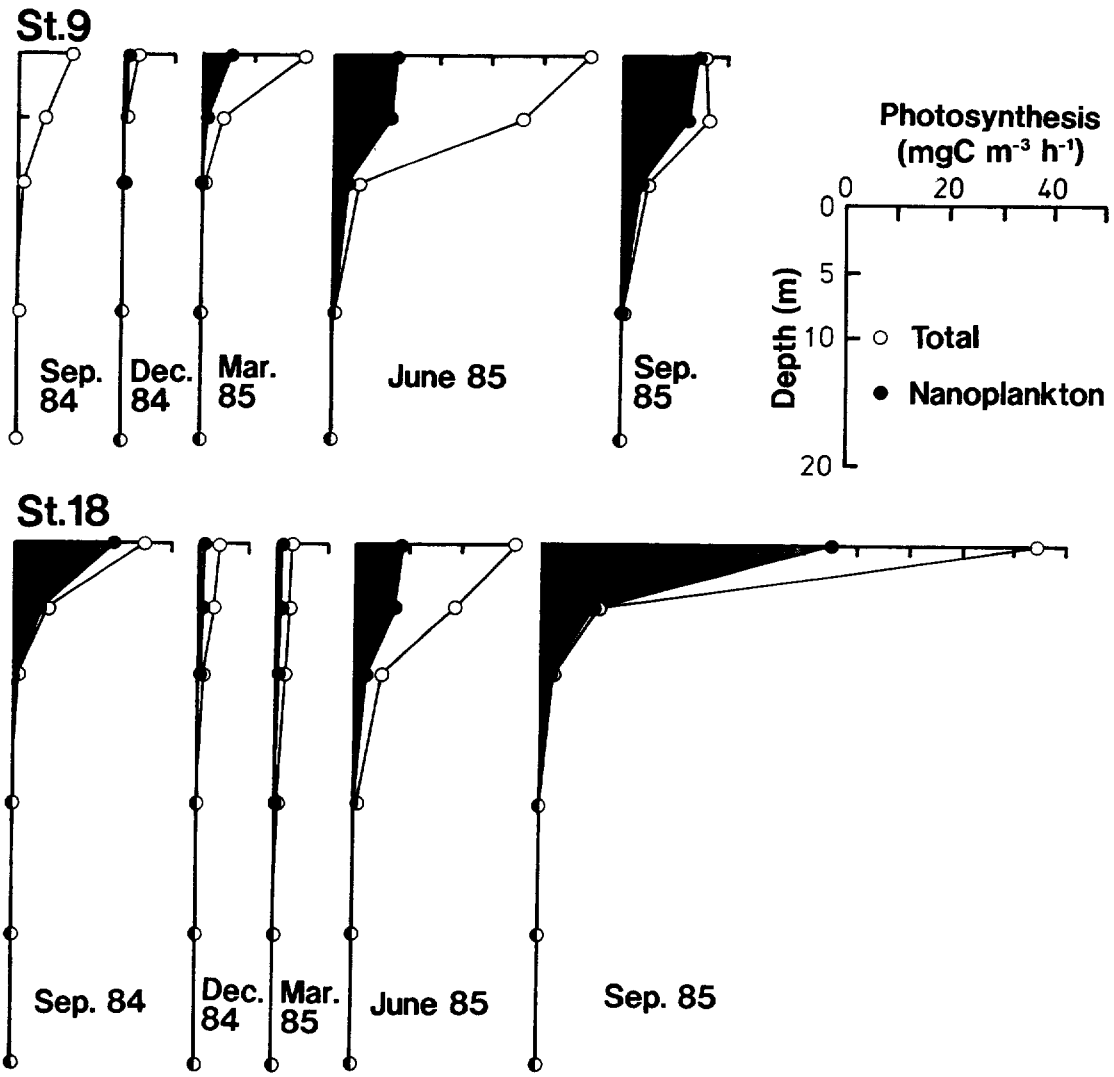

Fig. 5. Continued.

18 are shown in Fig. 5. During the experiments, size fractionation was not performed at St. 9 in September 1984. Seasonal and vertical variations of photosynthetic rate were most evident at St. 1. Except for December 1984, photosynthetic rate showed a considerable decrease with depth and the proportions of nanoplankton to the total also varied with depth and seasons. At Sts. 9 and 18, vertical profiles of the photosynthetic rate were almost uniform compared with that obtained at St.1, but seasonal changes in the proportions of nanoplankton to the total were also evident. Maximum photosynthetic rate was observed at the surface at almost all the stations.

Daily photosynthetic rates and assimilation numbers (photosynthetic rate per unit amount of chlorophyll *a*) are summarized in Table 4. Photosynthetic rates ranged from 0.07 to 14.21 gC m^{-2} d^{-1}(mean: 1.77 gC m^{-2} d^{-1}) for nanoplankton, and 0.16 to 14.95 gC m^{-2} d^{-1} (mean: 2.66 gC m^{-2} d^{-1}) for total plankton. The rates were higher in September 1984, June and September 1985 than in December 1984

Table 4. Daily photosynthetic rates and assimilation numbers at the surface of size-fractionated phytoplankton in Osaka Bay.

Date	Sts.	Nanoplankton (<10 μm)		Total		Nanoplankton %
		Daily photosynthesis ($gC\ m^{-3}d^{-1}$)	Assimilation number ($mgC\ mgChl.a^{-1}h^{-1}$)	Daily photosynthesis ($gC\ m^{-3}d^{-1}$)	Assimilation number ($mgC\ mgChl.a^{-1}h^{-1}$)	
Sep. 1984	1	1.02	2.56	4.47	4.73	22.8
	9	ND	ND	0.78	6.51	ND
	18	1.01	6.49	1.29	7.22	78.3
Dec. 1984	1	0.10	5.79	0.22	4.84	45.8
	9	0.09	2.24	0.16	3.62	56.3
	18	0.14	2.98	0.31	5.57	45.2
Mar. 1985	1	0.07	1.22	1.36	2.11	5.1
	9	0.24	3.38	0.92	2.91	26.1
	18	0.21	1.75	0.48	2.02	43.8
June 1985	1	14.21	12.23	14.95	11.60	95.1
	9	1.62	7.66	5.00	10.58	32.4
	18	1.15	6.89	3.07	9.70	37.5
Sep. 1985	1	0.59	0.51	1.00	0.45	59.0
	9	1.64	10.56	1.90	8.57	86.3
	18	2.61	9.48	3.96	11.35	65.9
Mean		1.76		2.66		

and March 1985. Mean assimilation number of the total plankton obtained at the surface over the three stations were 6.2, 4.7, 2.4, 10.6 and 6.6 mgC $mgChl.a^{-1}$ h^{-1} in September and December 1984 and March, June and September 1985, respectively. The respective values obtained for nanoplankton were 4.5, 3.7, 2.1, 8.9 and 7.1 mgC $mgChl.a^{-1}$ h^{-1} and were slightly lower than those of the total plankton (Table 4).

Relative contributions of nanoplankton production to the total production varied with season and area from 5 to 95% (Table 4). Nanoplankton contribution was lower in cold seasons and was higher in warm season. Areal differences of the nanoplankton contribution were evident in each season, but were variable from season to season. While the contributions were lower in northeastern part of the Bay (St.1) than in offshore area (Sts. 9 and 18) in September 1984, March and September 1985, a reverse pattern was observed in June 1985. No appreciable areal difference was seen in December 1984.

Based on the daily photosynthetic rate, annual primary production was calculated to be 646 gC m^{-2} yr^{-1} for nanoplankton, and 971 gC m^{-2} yr^{-1} for the total phytoplankton. Thus nanoplankton production accounted for 67 % on average of the total

primary production in the Bay. Annual production in the whole Osaka Bay was estimated to be 9.8×10^5 ton C for nanoplankton and 14.8×10^5 ton C for the total phytoplankton.

Discussion

Chlorophyll *a* concentrations in Osaka Bay ranged from 0.38 to 115.67, with a mean of 5.50 mg m^{-3}. The chlorophyll *a* concentration in Osaka Bay is 10 to 40 times higher than in the Kuroshio and Oyashio regions (Saijo and Ichimura 1960), and about 4 times higher than that obtained in Suo Nada, western Seto Inland Sea (Yamaguchi and Anraku 1984), but similar to that in Ise Bay (Iwasaki *et al.* 1982). The range of chlorophyll *a* concentrations in Osaka Bay is nearly identical to that reported in Tokyo Bay (Brandini and Aruga 1983). In terms of annual mean of integrated chlorophyll *a*, the present results from Osaka Bay (132 mg m^{-2}) is about twice as high as that found in Ise Bay and Mikawa Bay (Saijo *et al.* 1978).

Mean primary productivity in Osaka Bay was calculated as 2.66 gC $m^{-2}d^{-1}$. This value is 6 to 9 times higher than the estimate for the whole area of the Seto Inland Sea (Endo 1970) and that in Suo Nada (Yamaguchi and Anraku 1984). The value is also one order of magnitude higher than that reported from the Kuroshio and Oyashio regions (Saijo and Ichimura 1960, Aruga and Monsi 1962). But this value is comparable to the value reported in Tokyo Bay (Yamaguchi and Shibata 1979). From these comparisons with other areas around Japan, it can be said that the phytoplankton biomass and its productivity in Osaka Bay is one of the most productive regions in Japan.

Assimilation number obtained in this study is almost identical to that obtained in Suo Nada (Yamaguchi and Anraku 1984), but is higher than that in Kuroshio and Oyashio regions (Saijo and Ichimura 1960). Endo (1965) investigated the phytoplankton production and chlorophyll *a* in Osaka Bay. From the data of Endo (1965), the assimilation number was calculated to be 3.8 mgC mgChl.a^{-1} h^{-1} for the year of 1965, which is less than the 6.1 mgC mgChl.a^{-1} h^{-1} of the present study. Therefore, the assimilation number in Osaka Bay has increased nearly two times during the last twenty years. This may reflect the changes in phytoplankton species composition (Joh 1980) and/or enhanced eutrophication during this period which may affect to the physiological state of phytoplankton populations in the Bay.

Nanoplankton were responsible for on average 43 % of the phytoplankton carbon biomass, and 67 % of phytoplankton productivity over the study period. Our results contrast to those reported from oceanic waters, where nanoplankton typically accounted for more than 75 % of the biomass and 80 % of the productivity of phytoplankton (Malone 1980). Our results are, however, comparable to the observations made in Narragansett Bay and Hiroshima Bay, where nanoplankton contributed 47 % of the biomass and 51 % of the phytoplankton production (Durbin *et al.* 1975, Yamaguchi *et al.* 1995). From these comparisons, it is considered that the low contribution of nanoplankton to the total phytoplankton is one of the characteristics of eutrophicated coastal waters (Kalff 1972).

Seasonal variations of the relative contribution of nanoplankton biomass to the total were marked in Osaka Bay. Nano-

plankton fraction dominated in the phytoplankton population during the early summer and microplankton dominated during the winter to early spring. These seasonal patterns of dominance of each size category have also been reported in other waters (Durbin *et al.* 1975, Larsson and Hagström 1982, Maita and Odate 1988). Several factors such as differences in the growth rates between nano and microplankton (Malone 1980), nutrient conditions (Maita and Odate 1988), seasonal changes in grazing pressure by copepods (Chervin 1978) and by microzooplankton (Verity 1986) have been considered to attribute to seasonal variations in size compositions of phytoplankton. More information is necessary to elucidate the major sources of variation of the relative importance of different sizes of phytoplankton in Osaka Bay.

In conclusion, the present results clearly indicate that Osaka Bay is one of the most productive waters in Japan, where nearly 1 kg C m^{-2} is produced annually by phytoplankton. However, these high production level may not be efficiently transferred to higher trophic levels, because 67 % of the production is attributed to small sized nanoplankters. Possible low transfer efficiencies in the Bay could result in accelerating eutrophication through the processes of bacterial decomposition and remineralization. As a next step, a study on the food web structure in Osaka Bay is necessary toward to the effective utilization of this high production and a solution for preventing further eutrophication in the Bay.

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大阪湾におけるサイズ画分ごとの植物プランクトン現存量と基礎生産量

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1984年9月～1985年9月の期間，計5回の航海によって，大阪湾の定点でサイズ画分（ナノプランクトン及び全植物プランクトン）ごとの植物プランクトン現存量と生産量の測定を行った。現存量はクロロフィル*a*を蛍光法で求め，それに炭素／クロロフィル*a*比を乗じて炭素量に換算した。また，生産量は^{13}Cをトレーサーとした現場吊り下げ法によった。クロロフィル*a*現存量はナノプランクトン画分(10μm以下)で5.8～587.4 mg m^{-2}（平均56.2 mg m^{-2}）の範囲に，全植物プランクトン画分で15.3～1020.9 mg m^{-2}（平均131.5 mg m^{-2}）の範囲にあった。現存量は高水温期に高く，低水温期に低かった。ナノプランクトン画分は全植物プランクトン現存量の43%を占めた。炭素量に換算した現存量は，ナノプランクトン画分，全植物プランクトン画分でそれぞれ3.4 gC m^{-2}，7.8 gC m^{-2}であった．光合成速度はナノプランクトン画分，全植物プランクトン画分でそれぞれ0.07～14.21 gC m^{-2} d^{-1}(平均1.77 gC m^{-2} d^{-1})，0.16～14.95 gC m^{-2} d^{-1}（平均2.66 gC m^{-2} d^{-1}）であった。単位クロロフィル*a*当たりの光合成速度はナノプランクトン画分，全植物プランクトン画分でそれぞれ2.1～8.9 mgC mgChl. a^{-1} h^{-1}，2.4～10.6 mgC mgChl. a^{-1} h^{-1}であった。全生産量に対するナノプランクトンの寄与率は季節及び海域によって5～95%と大きく変動した。ナノプランクトンの寄与率は高水温期に大きく，低水温期に小さく，また海域的には，湾東北部で小さく，湾南西部で大きかった。年間基礎生産量はナノプランクトン画分，全画分でそれぞれ646 gC m^{-2} yr^{-1}，971 gC m^{-2} yr^{-1}であった。ナノプランクトンは全生産量の67%を占めた。以上のように，大阪湾は我国で最も基礎生産の高い海域であること，さらにそこではナノプランクトンの現存量及び生産量に占める寄与率が比較的小さいことが判明した。

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