Studies on the Phytoplankton and Nutrients in the Yeosu Haeman

Chang Ho MOON

Department of Oceanography, National Fisheries University of Pusan, Pusan 608-737, Korea

Phytoplankton dominant species and the relationship between nutrient concentrations and salinity in the Yeosu Haeman were investigated in April, June and August, 1989. The dominant species in the Yeosu Haeman were similar with those reported previously in the inner Kwangyang Bay except a diatom, *Navicula* sp. in April. The species seems to be advected to the surface from the bottom during the dredging operation. Nitrate concentrations were negatively correlated with salinity during the study period, while silicate and phosphate concentrations had no relationships with salinity except in April. It seems that biological uptake of nitrate was not significant, but concentrations of silicate and phosphate were affected by the phytoplankton uptake in the Yeosu Haeman.

Introduction

Yeosu Haeman is an important channel which connects open sea southward and Kwangyang Bay northward where a coastal industrial complex is located. Mariculture and fishing have been actively done in the Yeosu Haeman for long time, but the fishery production recently decreased after the constructin of industrial complex such as a steel mill in the Kwangyang Bay, which probably affects the coastal ecosystem by the industrial effluents and waste disposal. Especially, there was a dredging operation in the early part of this study to widen a sea route and the dredged sediments were usued for reclaiming the eastern side of the Yeosu Haeman. Some studies on the phytoplankton ecology have been done in the Kwangyang Bay (Yang, 1977; Shim et al., 1984; Kim et al., 1988), however any reports has not been published in the Yeosu Haeman.

The major sources of nutrients in the Kwangyang Bay are known to be the Somjin River discharge for nitrate and dissolved silicate (Kim et al., 1988) and waste products for ammonia (Shim et al., 1984). It was reported that ammonia concentration was positively related to phytoplankton biomass in the bay.

The objectives of this study were to observe dominant species of phytoplankton in the Yeosu Haeman to compare with those reported previously in the Kwangyang Bay, and to investigate the concentrations of nitrate, phosphate and dissolved silicate in the Yeosu Haeman and to relate them to freshwater drainage. The effects of dredging operation on the nutrient concentrations and dominant species of phytoplankton were also studies.

Materials and Methods

Surface water samples were taken from 17 stations in April, June and August 1989 in the Yeosu Haeman (Fig. 1). Water samples for nutrient analysis were filtered on board through Gelman type A-E glass fiber filters, stored in polyethylene bottles and frozen until the analysis were performed. All nutrient concentrations were determined colorimetrically by the method of Strickland

and Parson (1972). Phytoplankton samples were stored in 500 *ml* bottles and fixed with modified Lugol solution. Identification and counting were done with a Sedgwick-Rafter counting chamber under a microscope. Water temperature and salinity were measured using a bar thermometer and a T. S. meter (El Salinometer SM-2,000), respectively. Transparency was determined by using a Secchi disk.

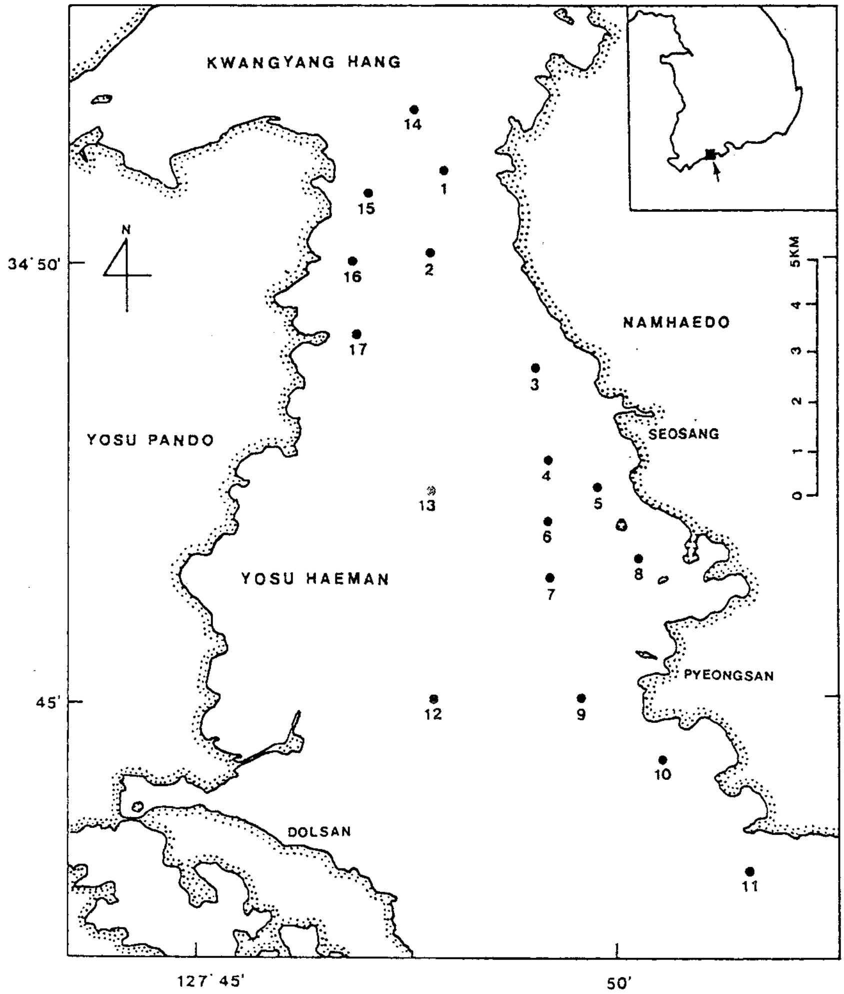

Fig. 1. Sampling stations in the Yeosu Haeman

Result and Discussion

Temperature, Salinity and Transparency

Surface water temperature was in the range of 15.0~16.2℃ in April, 21.0~22.5℃ in June and 24.6~25.0℃ in August. Surface water salinity was high in April (33.51~34.26 ‰) while low in August (28.70~31.05 ‰) after the rainy season (Table 1). In April, relatively low salinity occurred in the middle channel of the Yeosu Haeman because the sampling was done during the ebbing tide while sampling in the coastal area was done during the flooding tide. In June and August, relatively high salinity occurred in the northern side of the Yeosu Haeman and the value decreased in the southern part. In June and August, all sampling were done during the flooding tide. It took about 4 hours to get water samples while the

Table 1. Surface water nutrient concentration during April, June and August, 1989. (units: μg-at/l)

Station	April			June			August		
	NO_3	PO_4	$Si(OH)_4$	NO_3	PO_4	$Si(OH)_4$	NO_3	PO_4	$Si(OH)_4$
1	1.15	1.74	6.00	1.67	2.23	6.03	4.73	1.77	18.02
2	1.12	1.59	5.85	2.58	1.63	7.63	1.27	2.13	20.67
3	0.61	1.14	5.49	0.44	1.53	7.03	1.58	1.20	18.12
4	0.32	0.84	5.54	0.44	2.00	5.79	1.09	0.83	17.61
5	0.71	1.19	6.21	-	-	-	-	-	-
6	0.44	1.09	5.34	0.31	1.58	4.64	1.90	1.51	14.75
7	0.61	1.24	5.59	0.23	2.37	6.03	3.05	1.56	17.15
8	0.20	0.74	5.03	0.57	1.19	6.18	0.60	1.30	13.53
9	0.63	1.09	5.85	0.16	2.47	5.74	1.51	1.87	18.99
10	0.07	0.49	5.23	0.18	0.89	3.94	1.38	1.56	17.82
11	0.07	0.44	5.23	0.07	0.99	2.89	-	-	-
12	1.41	1.74	6.16	0.69	1.43	4.54	3.74	1.77	16.49
13	2.10	2.30	8.92	1.22	2.77	6.08	2.47	1.46	15.82
14	1.46	1.39	6.36	5.60	1.58	6.18	6.13	1.77	20.27
15	-	-	-	2.78	1.63	7.88	6.47	1.72	20.37
16	-	-	-	2.24	2.12	8.18	5.66	1.61	20.93
17	-	-	-	1.38	3.26	8.68	5.77	2.13	21.34

flooding lasted about 6 hours.

Transparency was in the range of 0.6~2.7 *m* in April, 2.1~7.0 *m* in June and 3.2~7.0 *m* in August. During the study period, the highest value occurred in August after the rainy season while the lowest in April when the dredging operation was being done. This is in contrast to the observation of Shim et al. (1984) who reported that the transparency was high in spring (2.5~5.0 *m*) and low in summer (0.8~2.5 *m*) in the Kwangyang Bay. Transparency in the study area was generally low in the coastal zone compared with that in the middle channel area. Especially, the transparency in the eastern side of the Yeosu Haeman, the area off Seosang, was extremely low (less than 1.5 *m*) in April since the sediments dredged was used for reclaiming that area.

Dominant spcies and density of phytoplankton

Diatoms were abundant in April, while dinoflagellates became important group in August. In April, the dominant species were *Navicula* sp., *Skeletonema costatum, Nitzchia longissima, N. seriata*, which ocuppied 15.2%, 8.0%, 8.0% and 7.7% of the total abundance, respectively. In June, *Thalassiosira rotula, Chaetoceros curvisetus, Protoperidinium* sp., and *Eucampia zoodiacus* became dominant and their cell numbers were 17.3%, 15.5%, 12.5% and 12.2% of the total, respectively. In August, *Protogonyaulax fratercula* comprised 50.9% of the total abundance, and *Skeletonema costatum* 26.8% and *C. curvisetus* 8.0%.

There was little difference in the dominant species except *Navicula* sp., compared with those reported previously in the Kwangyang Bay (Yang, 1977; Yang and Kim, 1981; Shim et al., 1984). *Navicula* sp., which is a benthic diatom, was most abundant in the dumping site, eastern side of the Yeosu Haeman in April when dredging operation was being done, and the cell number of the species decreased away with distance from the relaiming area. The species are probably advected to the surface water from the bottom during the dreadging and reclaiming work. The species has not been reported previously as an important species in the vicinity of the study area.

Cell density was in the range of 106~328 cells/*ml* in April, 152~824 cells/*ml* in June and 49~336 cells/*ml* in August (Fig. 2). These values are much lower than those reported in the Kwangyang Bay (Shim et al., 1984). When spatial distributions are considered, in April, relatively high abundance occurred in the middle portion of the eastern side where *Navicula* sp. was dominant, with being maximum value at Station 8. In June, the cell number increased in the entire study area, especially in the northern area. The southeastern part of the study area (Station 5~11) showed relatively low abundance. In the Kwangyang Bay, the highest phytoplankton standing crop occurred in spring (Shim et al., 1984), but in the Yeosu Haeman, the abundance was lower in April than in June. This seems be due to much lower transparency in April which limits light penetration into water column and thus phytoplankton growth. The abundance in August decreased in the entire study area except Station 14 and 15.

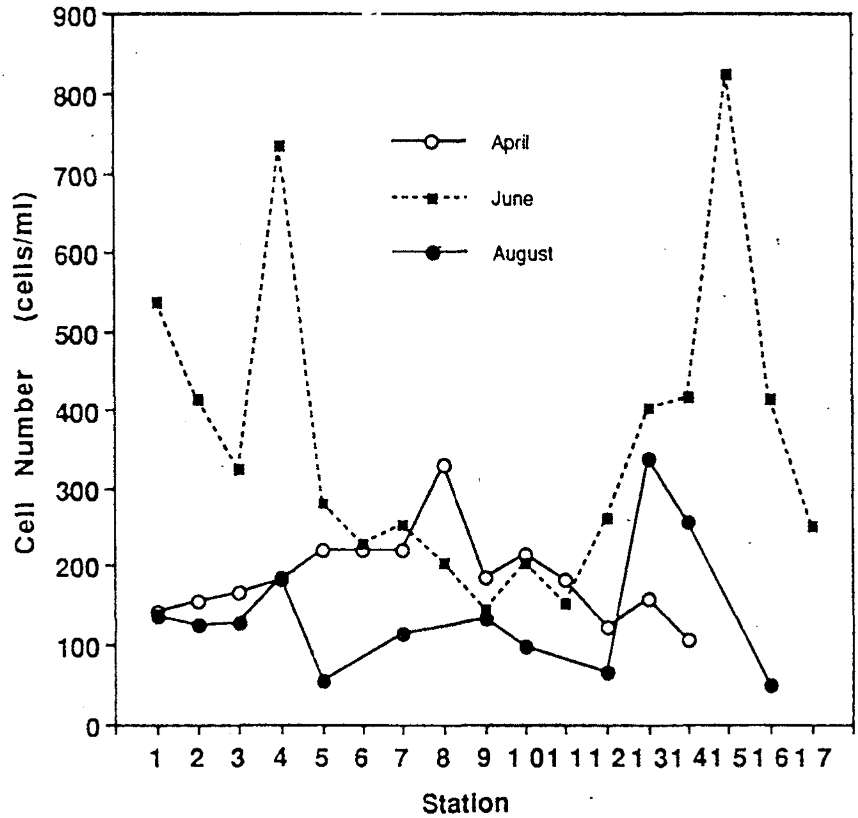

Fig. 2. Phytoplankton standing crop in the Yeosu Haeman

Nutrients

Nutrient concentration at each station is shown in Table 1. Nitrate concentration was in the range of 0.02~2.10 *μg-at/l* (average 0.73) in April, 0.07~5.60 *μg-at/l* (average 1.30) in June and 0.60~6.47 *μg-at/l* (average 3.05) in August. Dissolved silicate concentration was in the range of 5.03~8.92 *μg-at/l* (average 5.88) in April, 2.89~8.68 *μg-at/l* (average 6.12) in June and 13.53~21.34 *μg-at/l* (average 18.18) in August. The highest concentrations of both nitrate and silicate occurred in August, the rainy season, and when spatial distribution is considered, relatively high concentration occurred in the middle channel area (in April) or the northern part of the study area (in June and August) where salinity was relatively low. The concentrations of nitrate and silicate was lower than those reported in the inner Kwangyang Bay by Shim et al. (1984). Phosphate concentration was in the range of 0.44~2.30 *μg-at/l* (average 1.16) in April, 0.89~3.26 *μg-at/l* (average 1.88) in June, and 0.83~2.13 *μg-at/l* (average 1.56) in August. Unlike the nitrate and silicate distribution, the highest concentration of phosphate occurred in June.

Nutrient concentrations were plotted against salinity to investigate the nutrient behavior in the Yeosu Haeman. In April, all nutrient concentrations were negatively related to the salinity (Fig. 3). Correlation coefficients (r^2) were 0.582 (n=14) for nitrate, 0.446 (n=14) for phosphate, and 0.448 (n =14) for silicate. There was relatively much depature of the concentrations of Station 1, 8, and 13 from the straight line. Relatively high concentrations at Station 1 and 13 seem to be results of waste disposal from the Kwangyang Bay and vertical mixing by dredging operation. Relatively low concentration at Station 8 seems to be related with the highest phytoplankton cell density at that time. When the concentrations at Station 1, 8 and 13 were not considered, the correlation coefficient became 0.949 for nitrate, 0.813 for phosphate and 0.699 for silicate.

In June, nitrate concentrations were negatively related with the salinity (r^2=0.709, n=16). There were no clear relationships of concentrations of silicate and phosphate with salinity (Fig. 4). Relatively high concentrations of nutrients at Station 13

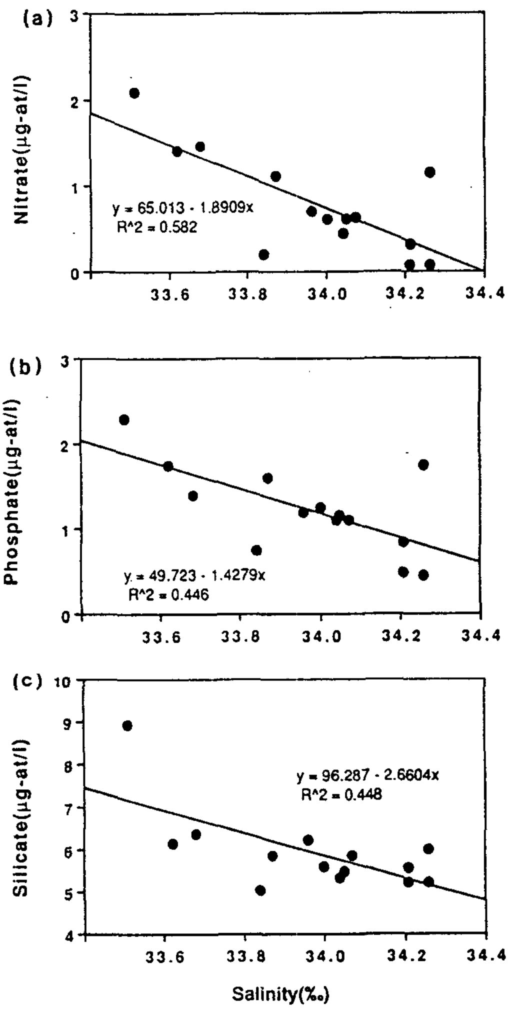

Fig. 3. Relationships of nitrate, phosphate, and silicate with salinity in April (A: Station 1, B: Station 13, C: Station 8)

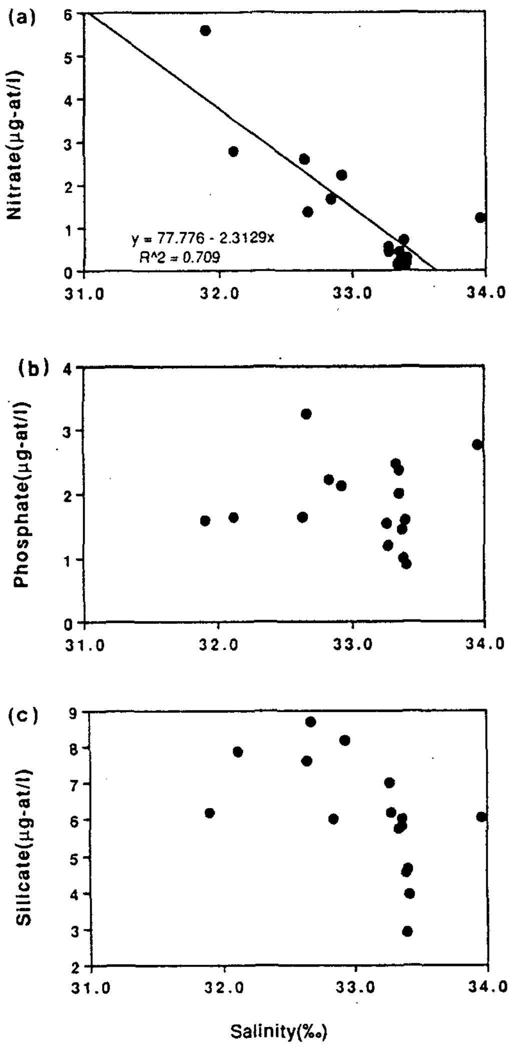

Fig. 4. Relationships of nitrate, phosphate, and silicate with salinity in June (A: Station 13)

seem to be a result of vertical mixing due to blasting bed rocks in the bottom. The lowest salinity occurred at Station 14 and 15, but silicate and phosphate concentrations were relatively low there.

In August, the relationship between nutrients and salinity was similar with that in June. Nitrate concentrations were well correlated with salinity (r^2=0.874, n=15), but silicate and phosphate concentration were not (Fig. 5). At Station 14 and 15 where the lowest salinity occurred, silicate and phosphate concentrations were relatively low. Relatively high cencentrations of nutrients occurred at Station 13 in April and June, but the concentrations in August were not high.

In conclusion, nitrate concentrations were well correlated with salinity during the study period. This is in agreement with observation of Kim et al. (1988) who reported that the major source of nitrate was the freshwater discharge from Somjin River. Biological uptake of nitrate seems not to be significant in the Yeosu Haeman, because phytoplankton take up ammonia preferencially and ammonia concentration considered to be high in the study area (Shim et al., 1984) due to the waste disposal or industrial water in the Kwangyang Bay. The major source of dissolved silicate in an estuary is known to be riverine input of silicate produced both from weathering and dissolution of crustal mineral crystals and from the decay of biological material such as terrestrial plants that contain silica (Silverman, 1979). Municipal wastewater contains low amunts of silicate (Officer and Ryther, 1980), and thus contribute little to the estuary. In this study of the Yeosu Haeman, no clear relationship of silicate concentrations with sailinity in June and August suggests that biological uptake of silicate plays an important role in determining the distribution pattern of silicate. There was also no relationship of phosphate concentrations with salinity in June and August. In the Kawangyang Bay, it was reported that the Somjin River is not major source for phosphate because phosphate concentrations are positively correlated with salinity (Kim et al., 1988). It seems that major source of phosphate is the waste products from the Kwangyang Bay and biological uptake is important in determining the distribution pattern of phosphate in the Yeosu Haeman.

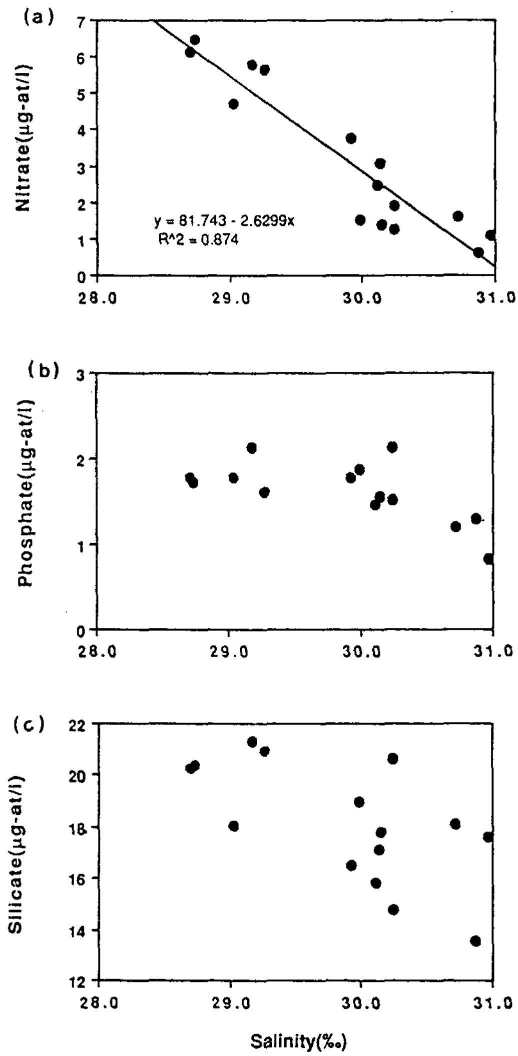

Fig. 5. Relationships of nitrate, phosphate, and silicate with salinity in August

References

Kim, S. H., C. B. Song, S. H. Kang, D. B. Yang and J. S. Hong, 1988. The distribution pattern of nutrients at the cultivation ground of laver in Kwangyang Bay, 1986. Ocean Research, Korea, 10 : 1−8.

Officer, C. B. and J. H. Ryther, 1980. The possible importance of silicon in marine eutrophication. Mar. Eco. Prog. Ser., 3 : 83–91.

Shim, J. H., Y. K. Shin and W. H. Lee, 1984. On *the phytoplankton distribution in the* Kwangyang Bay. Jour. Oceanol. Soc. Korea, 19 : 172–186.

Silverman, M. P., 1979. Biological and organic decomposition of silicates. In Biogeochemical Cycling of Mineral-forming Elements. Studies in Environmental Science, Vol. 3, pp. 445~465.

Strickland, J. D. H. and T. R. Parson, 1972. A Practical Handbook of Seawater Analysis, 2nd ed. Fish. Res. Bd. Canada, Bull. 167.

Yang, H. C., 1977. Diatom of Yeosu coasts of Korea in spring. Thesis Collect. Yeosu Fish. Tech. Coll., 11 : 71–81.

Yang, H. C. and Y. H. Kim, 1981. Seasonal change in abundance and composition of plankton in the Kwangyang Bay, Korea. Thesis Collect. Yeosu Nat. Fish. Coll., 15 : 35–45.

Received December 20, 1989
Accepted January 20, 1990