D-3.1 Study on the Detection of Temporal Variation of Marine Ecosystem and the Extraction of the Effect from the Continent

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Total Budget for FY1996-1998 49,560,000Yen (FY1998; 19,953,000Yen)

Key Words Ship of Opportunity, (N, P)/Si-ratio, Model, Phytoplankton Species

Abstract

A monitoring scheme was developed using ship of opportunity that plies the route (Japan - East China Sea - Hong Kong - South China Sea - Singapore - Malacca Strait - Port Kelang) to detect the shift of the dominant phytoplankton from diatom to non-diatom species, presumably because of the change in the ratio of the anthropogenic loading of N and P to the natural supply of Si. A three-dimensional numerical simulation of the South China Seas was carried out to interpret the monitoring results . Basically, the results showed that the surface water of the marginal seas is still apparently oligotrophic and N or P-limited except for the coastal seas such as Osaka Bay or the vicinity of Hong Kong, where higher N/Si ratio and seasonal dominance of dinoflagellates were observed. Cyanobacteria was dominant in terms of carbon biomass in the East China Sea. In the South China Sea, contributions of cyanobacteria, dinoflagellates and other smaller flagellates were equivalent . The flow of the dominance of the phytoplankton groups is proposed as follows. The diatom dominates first when and where the nutrients are newly supplied from land (anthropogenic) or from the lower layer (natural) to the seas inherently oligotrophic. When diatom has consumed Si and most of N and P, non-diatom species such as the dinoflagellates appear. Among the world marginal seas, the South China Sea should be watched sustainably because of its closedness and the composition of phytoplankton, although it is still recognized as oligotrophic from the low level of nutrients and low phytoplankton biomass concentration.

Introduction

The change in the ratio of the anthropogenic loading of N and P to the natural supply of Si is hypothesized to lead to the long-term shift in the phytoplankton composition, namely, from dominance of diatom species to that of non-diatom species$^{1)}$. These tendency is presumed to take place in the Asian coastal waters because of the increase of N and P fertilizer and the large scale construction for utilization of the fresh water $^{2)}$. Therefore, it is required to detect and evaluate the changes in the marine biogeochemical conditions (nutirients, phytoplankton biomass and species composition) in terms of the extraction of the anthropogenic factors coexisting with the natural factors.

National Institute for Environmental Studies (NIES) has been conducting a marine biogeochemical monitoring using ships of opportunity in the coastal and adjacent seas of Japan by developing a flow-through measurement and sampling$^{3)}$. To cover the wider Asian Marginal Seas, this method was applied to a container ship Alligator Hope, (OsakaShosen Mitsui Co., Ltd, Japan - Hong Kong - Singapore - Malacca Strait – Port Kelang, see Fig.1).

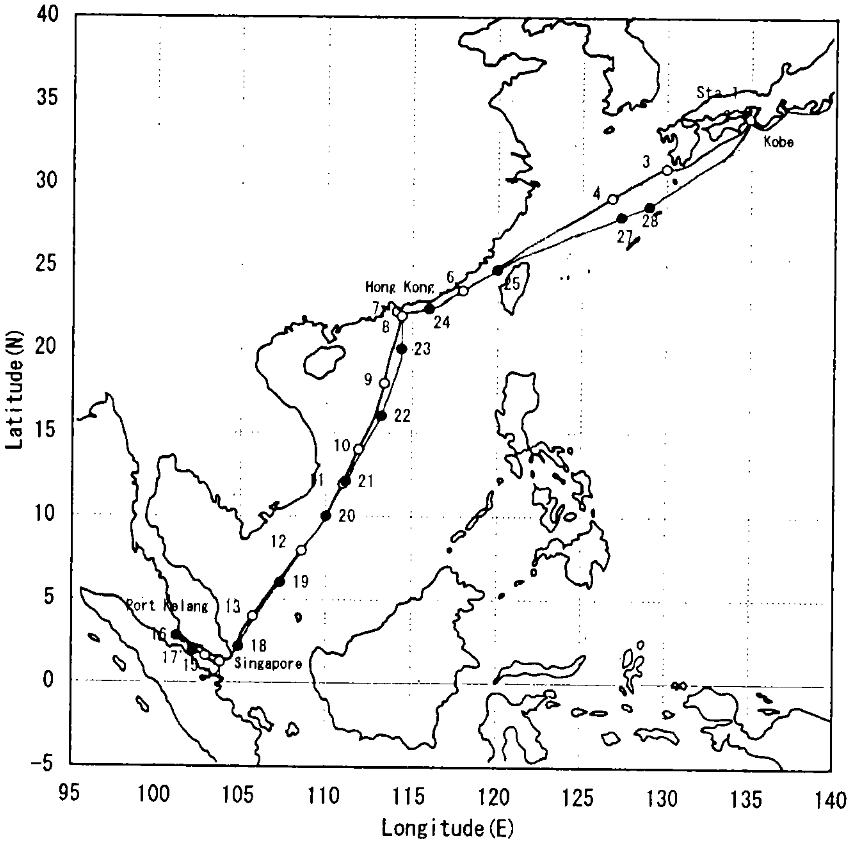

Fig. 1 Track of the container ship used for monitoring and the points in the test monitoring.

Methods

The test cuise was carried out in theOctober 1997. In 1998, route of this ship was shifted to that of Hong Kong-Japan - North America. So the four investigations were carried out on one cruise along the full course in 1997 and on three cruises between Hong Kong and Kobe.

In the container ship, the sea water was continuously pumped up from the bottom and introduced to the Thermosalinograph (SBE21) for measurement of temperature and salinity, to Auatracka for chlorophyll-a. Also, several kinds of bottle sampling were done from the faucet at the sink. Nutrients NO3-N, NO2-N, NH4-N, PO4-P, Si(OH)4-Si were analyzed by the autoanalyzer. The phytoplankton pigments, chlorophyll-a, b, c, phaephotin-a, b, and the other pigments peridinin, fucoxantin, etc., were analyzed by HPLC. Samples for the micro-planktons (>20μ) were fixed by form-aldehide and analyzed by optical microscope. Samples for the nano- and pico-plankton were fixed by grutal-aldehide and dyed by FITC and DAPI for discrimination of the autotrophic cells and heterotrophic cells and sorted by their size using multiple filtration. These two categories of samples were counted by the optical microscope and fluorescence microscope, respectively. In the same time, phytoplankton taxon was identified and cell size and shape were sorted into the classes, [<2μ], [2-5μ], [5-10μ], [10-15μ], . . ., [35-50μ], [50-60μ], [60-75μ], [75-100μ], [100-120μ]. The carbon biomass of each classe was calculated from these data using the empirical formula by Strathmann(1967).

To interpret these data, a numerical simulation of the general circulation in the South China Sea was carried out$^{4)}$. The grid size was 0.25° in latitude and longitude and the number of the level was seven. Monthly climate value of the wind stress and water temperature and salinity were imposed as the boundary condition at the sea surface.

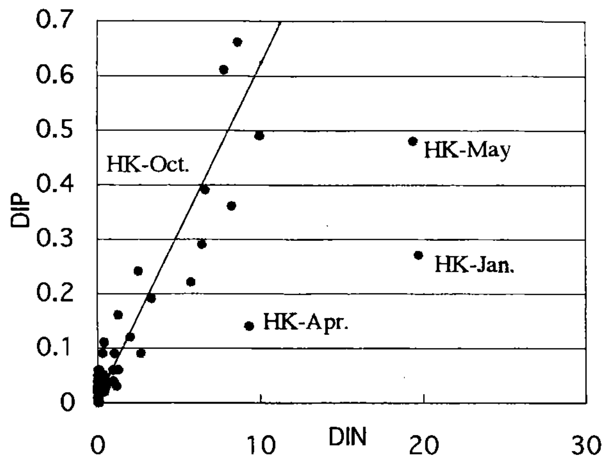

Fig. 2 DIN(=NO3+NO2+NH4) : DIP(=PO4) from the container ship monitoring (μM).

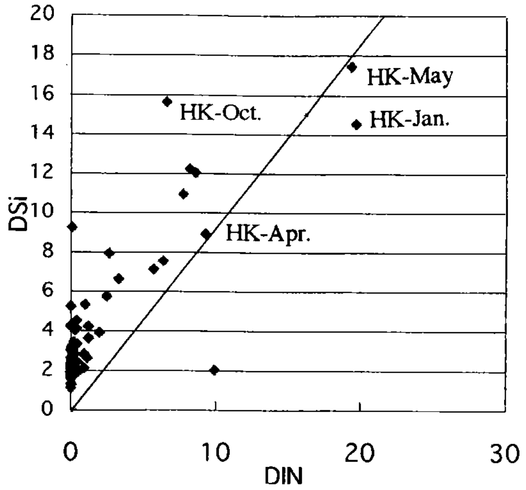

Fig. 3 DIN:DSi (=Si(OH)4)

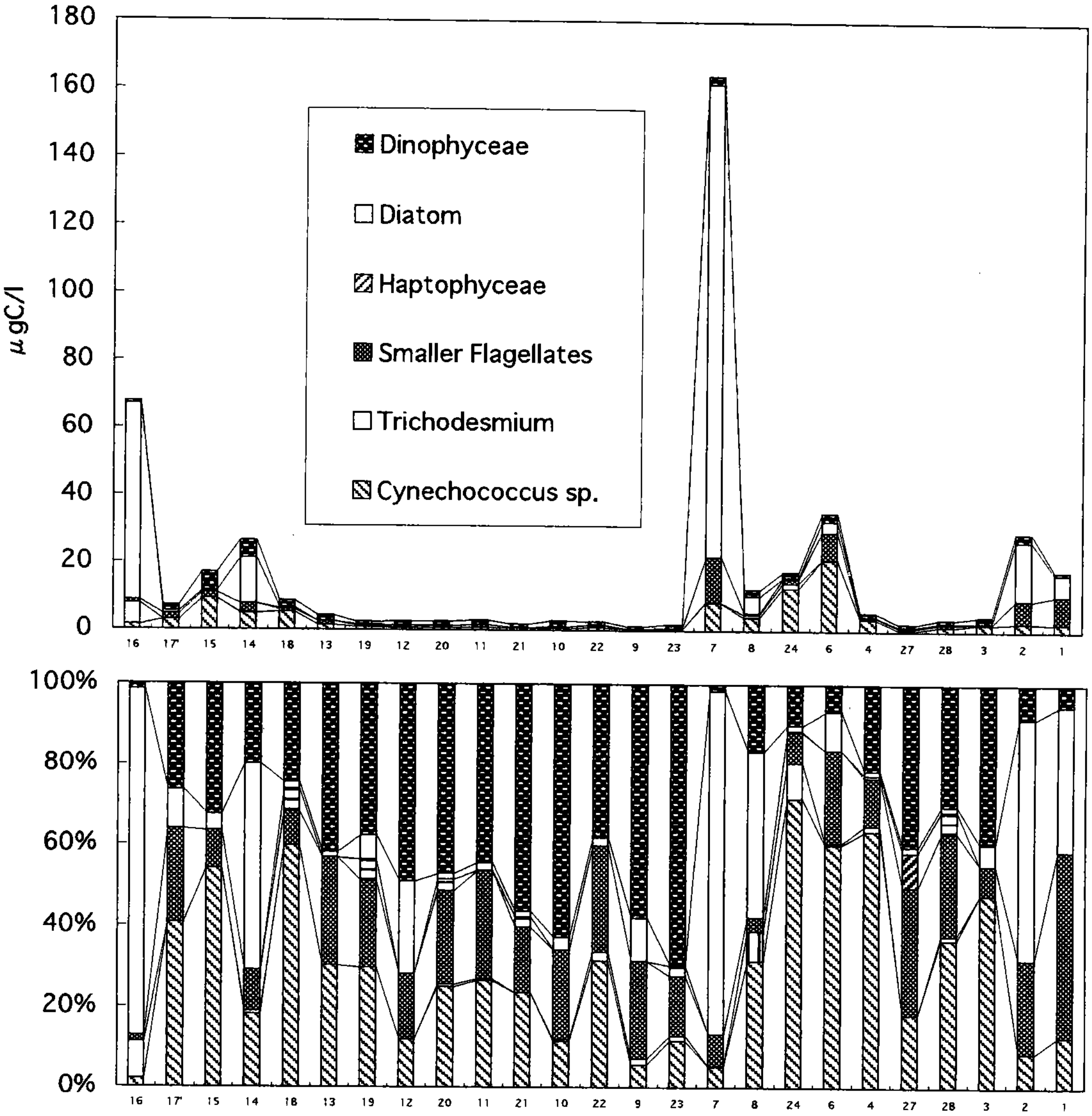

Fig. 4 Distribution of carbon bimass concentration of each phytoplankton group, absolute value(upper, in μg/l) and relative value(lower, in %). Station numbers are shown in Fig. 1.

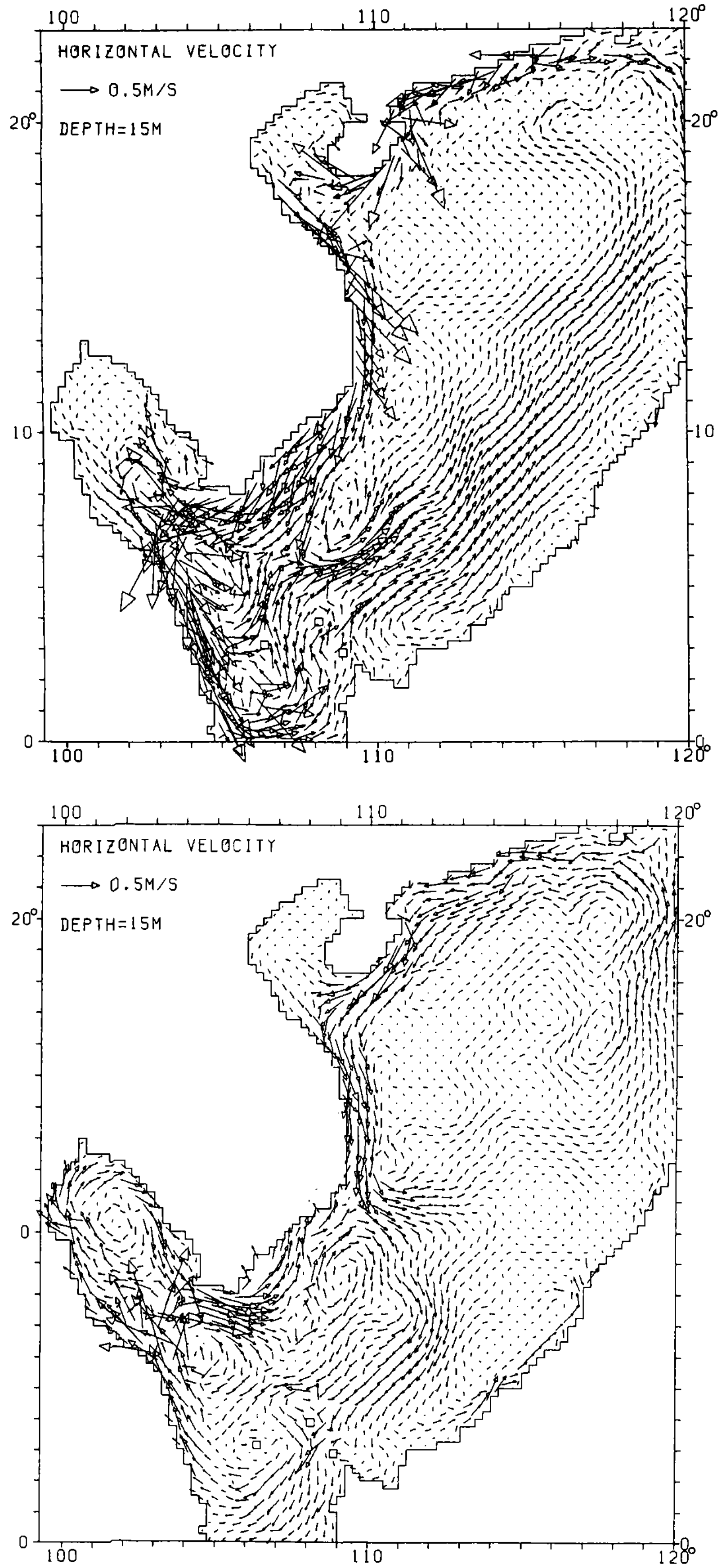

Fig. 5 Distribution of velocity vectors of −15m level of the South China Sea simulated by a numerical model, January (upper) and July(lower).

Results

Correlation of DIN(=NO3+NO2+NH4) and DIP(=PO4) measured in the four cruises are shown in Fig.2. The slanting line shows the Redfield ratio (N:P:Si = 16:1:15). The points measured in the vicinity of Hong Kong are tagged with the symbols of H.K. and the. Fig.3 shows the correlation of DIN:DSi (=Si(OH)4) in the same way. The data points distributed in low ranges of DIN, DIP and Dsi except for those from Osaka Bay and from the vicinity of Hong Kong, where the ratio DIN/DSi is higher compared to the other stations. This is presumably due to the anthropogenic effect via the land-based effluent.

The compositions of phytoplankton biomass of each taxonomic group are shown in Fig.4(a) for sampling points in Fig.1 (unit is μgC/l). Relative contributions of each taxon are shown in Fig.4(b). The total biomass concentration was high and in the same time diatom was dominant in three regions, the Japanese coastal sea, the vicinity of Hong Kong, and the Malacca Strait. However, in the former two regions, dinoflagellates took over the diatom depending on the season. In the other regions biomass concentration was low and the non-diatom speceis shared the composition. In the East China Sea, cyanobacteria (*Synechococcus* and *Trichodesmium*) were dominant. In the South China Sea, dinoflagellates and the other smaller flagellates were dominant although the total biomass concentration was low. Only at the point off vietnam, diatom showed a larger.

Fig.5 shows the simulated flow pattern of the South China. It was found that the over-all nature of the flow pattern is wind-driven. In winter monsoon season, counter-closkwise circulation was generated in the whole basin. In summer monsoon season, clockwise circulation appeared in the southern half of the South China Sea accompanying the coastal upwelling of the coast of Vietnam. Above-mentioned dominance of diatom off Vietnam is consistent with the upwelling predicted by this model.

A summary of the appearance of dominant phytoplankton group is proposed in a flow diagram shown in Fig.6. The diatom dominates when and where the nutrients are newly supplied from land (anthropogenic) or from the lower layer (natural). When diatom has consumed Si and a least amount of of N and P remain, dinoflagellates or other smaller flagellates appear . Along the present container ship route, the Osaka Bay and the vicinity of Hong Kong fall into this category. Basically, most of the off coast part of the marginal seas is nutrient-limited. In the South China Sea, cyanobacteria, dinoflagellates, other smaller flagellates and haptophyceae equally contributed to the carbon biomass. There remains an uncertainty

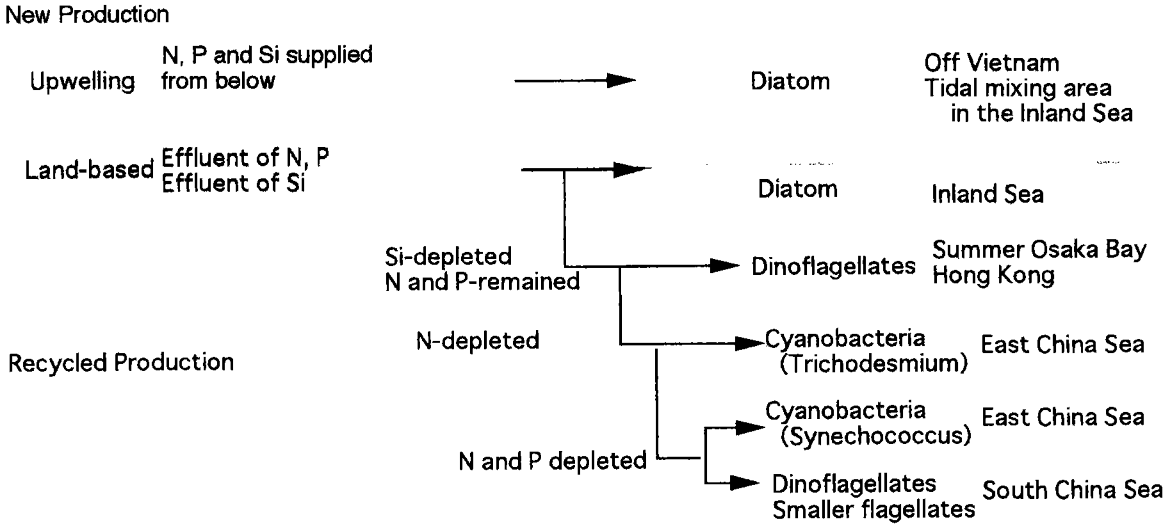

Fig.6 A proposed flow diagram of the selection of dominant phytoplankton groups.

concerning the reason in spite that the cyanobacteria is dominant in the East China Sea. It will be possible to presume that the potentially harmfull phytoplankton would tends to appear if dinoflagellates could appear if N and P are anthropogenically added.

Concluding Remarks

The biogeochemnical monitoring is effective to detect and evaluate the environmental change in the Asian coastal and marginal seas. Among the world marginal seas, the South China Sea should be particularly important from its biodiversity, closedness from the Pacific ocean and the present results on phytoplankton composition, although it is apparently recognized as oligotrophic in terms of the concentration of nutrients and phytoplankton biomass . Therefore it should be weighted to construct a scheme for sustainable monitoring and evaluationof this area by the international collaboration. To initiate such a scheme, a meeting5) was held inviting the specialists from the related coastal countries. Based on the discussion there, the Panel for CoMEMAMS (Cooperative Marine Environmental Monitoring in the Asian Marginal Seas) is proposed as well as the development of monitoring based on the ships of opportunity.

References

1)Justic, D. *et al.*, Stoichiometric Nutrient Balance and Origin of Coastal Eutrophication, Marine Pollution Bulletin, 41-46 (1995).

2)Vörösmarty, C. J. et al. (ed.) Drainage basins, river systems, and anthropogenic change: the Chinese example, in Galloway, J. N. *et al.* (eds.), Asian Change in the Context of Global Climate Change (1998).

3)Harashima, A., Tsuda, R., Tanaka, Y., Kimoto, T., Tatsuta, H. and Furusawa, K: in Mati Kahru et al.(eds.) Monitoring Algal Blooms -New Technique for Detecting Large Environmental Change, Springer, 85-11 (1997) "Monitoring algal blooms and biogeochemical changes in the adjacent seas of Japan with a flow-through system deployed on ferries in the adjacent seas of Japan"

4)Takano, K., Harashima, A. and Namba, T.:"A numerical simulation of the circulation in the South China Sea - Preliminary results -", Acta Oceanographica Taiwanica (1998)

5)Harashima A. (ed.) (1998) Abstracts of CoMEMAMS Meeting, Tokyo, Japan.