

D-3 Study on the Continuous Monitoring and Evaluation of the Health of Asian Marginal Seas based on the Internal Cooperation (Abstract of the Final Report)

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1. Introduction.

Economic growth of the East Asian countries has been rapid for these decades and it may give adverse effects to the environment in the marginal seas neighboring these countries. Among these there is a possibility implied by the 'silica deficiency hypothesis', *i.e.*, the global increase of stagnant water bodies due to damming of the rivers enhance the sink of dissolved silicate (DSi) and consequently leads to the shift from dominance of diatom blooms (siliceous and mostly benign) to that of the flagellates blooms (non-siliceous and potentially harmful) in the coastal seas receiving such river waters¹⁾. Therefore, we can define an index of the health of the sea by the ratios of DSi (dissolved silicate) and to other nutrients and of the diatom ratio to the other taxonomic growth of phytoplankton. To evaluate above issue, efficient methodology to monitor the temporal/spatial variation of this index of the health of the sea should be developed. Also, these works should be done based on the internal cooperation among these countries.

2. Research Objective

Above requirements are most efficiently fulfilled by constructing systems to monitor the marine biogeochemical variables using ships of opportunity²⁾ and by making it work on the regular tracks in these seas under the international cooperation. We organized this research theme with three sub-themes by each relevant institute: (1) Study on the methodology to evaluate the health of the sea and on establishment of the international cooperation by National Institute for Environmental Studies and Tokai University; (2) Study on the online monitoring of the health of the sea and development of method to recognize phytoplankton by Electro-Technical Laboratory; (3) Study on the formulation of the efficient use of the ship of opportunity by Ship Research Institute.

3. Method and Results

In Sub-theme (1), we constructed a simplified monitoring system using a seawater intake and deployed it a container ship plying between Japan and Malaysia via the East and South China Sea and Malacca Strait. Dissolved inorganic nutrients of nitrogen (DIN), phosphorus (DIP) and silicon (DSi) and carbon biomass of each taxonomic group of phytoplankton were

analyzed by sampling sea water at six monitoring points (off Port Kelan, Malacca Strait, off Singapore, off Vietnam, off Hong Kong, East China Sea) for 12 times (every two months from June 2000 to March 2002).

Results showed that most of the stations are characterized by the oligotrophic sea. However the ratio of DSi to DIN occasionally dropped and the ratios of dinoflagellates and other flagellates increased, which supports the idea of applying silica deficiency hypothesis in the aquatic system in Asian countries. We also surveyed and examined other datasets on nutrients from monitoring using a ferry in the Seto Inland Sea, on red tides for the Seto Inland Sea, on river water quality of Japan. They showed that the ratio of DSi/DIN decreased from before to after the rapid economical growth of 1960s, concentration of DSi is around $200\mu\text{M}$ in the upper river and drops to $30\mu\text{M}$ in Lake Biwa implying that the large stagnant water body with N and P discharge works as a sink of silica due to the uptake and sedimentation of freshwater diatom.

In Sub-theme (2), we developed a remote access station on the ferry in the Seto Inland Sea using satellite marine phone including aiming at operation of image processing system to discriminate diatom and non-diatom phytoplankton species with a microscope which can be operated remotely. A technology were developed to cancel the blurring of images due to the engine vibration and to adjust the phytoplankton location to a field of vision of the microscope. Test of this system showed almost good performance although the establishment of operation-based system requires further technical advance.

In Sub-theme (3), the original depth of seawater sampled at the stern at mid draft of the ship of opportunity for monitoring was estimated by model ship in an experimental pool. We inject dye from the upstream of the model ship and pick the water up from the inlet, then the concentration occupation rate of dye in the water taken from the fixed inlet is analyzed using a spectrophotometer. By iterating the same measurements changing the location of the dye injection, we obtained a contour map of the occupation rate of dye. Furthermore, CFD (computational fluid dynamics) was employed to extend the results on model scale to the actual scale. The experiment in a regular wave is conducted to make above method applicable to real ocean condition. In addition to that, full size numerical computation is performed to validate the new method in its practical use. Results showed that the sampled water comes from near the water surface. In the scale of the ferry being used for monitoring, it was predicted that water at -0.7m is drawn into the inlet at -4 to -5m .

To promote the study on marine environment based on these results and technologies under the international cooperation, the 2nd Workshop towards the Cooperative Marine Environmental Monitoring in the Asian Marginal Seas (2nd CoMEMAMS Workshop) was held in November 2000 inviting the researchers of institute related to the marine environmental research in China, Korea, Malaysia, Singapore, Philippines, and Vietnam.

4. Discussion

The results obtained by the container ship plying in the Asian marginal seas may support the idea of applying silica deficiency hypothesis in the aquatic system in East Asian region. However, the interval of the monitoring (two months) might be not short enough to resolve each bloom event of phytoplankton. The results of the ferry plying in the Seto Inland Sea gave more comprehensive results because the conditions of sampling interval, distance between the sampling stations and duration of monitoring were better. Nutrient values averaged over 7 years (1994-2000) showed that DSi/DIN is lower in the eastern part of the Seto Inland Sea implying the effect of Yodo River system, where the discharge of N and P and sink of Si at Lake Biwa is intense compared to the other rivers. Also total number of

red tides per space is higher in the eastern part³⁾. However, the maximum ratio of the number of red tides of dinoflagellates to that of diatom appeared not in Osaka Bay, where DSi/DIN ratio is lowest, but in Harima Nada. This may be explained by that the inflow of Yodo River continuously supplies DSi in a sense of the absolute value even if DSi/DIN ratio is dropped in Lake Biwa and therefore favors diatom bloom. The shallower, (vertically well-mixed) part is wider in Osaka Bay than in Harima Nada. This may also favor diatom whereas the well-stratified condition favors dinoflagellates, which can migrate vertically across the summer pycnocline. Anyway, our results state that the inclusion of the process of Si is crucial in addition to that of N and P for the evaluation of eutrophication and outbreaks of red tides. These results contributed to the "International Workshop on Nutrient and Silica Cycle" in Sweden (1999) and in Vietnam (2000) organized by SCOPE.

To extend these discussion to the wider marginal or coastal seas of Asian region, technological developments and formulation on the use ships of opportunity, such as the contribution from Sub-theme (2) and (3) is crucial as well as to promotion of international cooperation. Recently EU has initiated the "Ferrybox Program" to operationally monitor the marine environments using ferries in several regions around Europe. Also, PICES (North Pacific Marine Science Organization) is planning to initiate the similar program. The technical points developed in this study also contributed to the basis of these international programs.

Reference

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