VERIFICATION OF THE PREDICTED SHIFT FROM DIATOMS TO FLAGELLATES IN COASTAL SEAS USING LARGE SCALE MESOCOSM DATA

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Abstract - The shift of dominant species from diatoms to flagellates together with nutrient abundances was predicted and verified using data obtained from large scale mesocosm experiments. The prediction was done using a system dynamics model shown in authors’ previous study. With common parameters, most of the variables were predicted well. Some important factors such as wind mixing, migration by flagellates, etc. were pointed out.

Keywords – Stella, System Dynamics Modeling, Diatom, Flagellates, Shift of Dominant Species, NIES Mesocosm

I. INTRODUCTION

Species transition with change of silica abundance keeps scientific attention [1]-[7]. According to Harashima [5][6], the reduction of silica decides whether a fish or jellyfish to where an energy flow finally excel. The increase in jellyfish is really pointed out [8]. As for the cause of the increase in jellyfish, there is the indication that a change of the water temperature or the change of the shore environments, also, are related [8]. However, the importance to assess the effects of silica abundance on species changes still be remaining. Silica supplied conventionally from the forest and varied with the urbanization of the catchment and the construction of the dam. Thus, fundamentally, we have to be more careful to know the effect of silica decrease from catchments to coastal seas. In our previous study [9] we showed potential effects of silica decrease on species changes based on system dynamics (STELLA) modelling. In this study, we compared the modelling results (silica, dissolved inorganic nitrogen, diatom abundances and flagellate abundances) with actual data obtained through NIES (National Institute for Environmental Studies) mesocosm experiments [1][2][10]-[13]. In these experiments, the effects of the variations in silica abundances were observed. And we can find discussion on the sift of ecosystems and resulting changes in the food chains. The mesocosm is 5m in diameter and 18 in depth, the huge test tube put up in the sea, suitable site to discuss the relationship between silica decrease and species changes.

II. MATERIALS AND THE METHODS

Data obtained in the experiments conducted in 1989 [1][10][11] and 1991[1][2][12][13] were used in this study. The structure of the mesocosms and variations in average concentrations of silica, dissolved inorganic nitrogen, diatom abundances and flagellate abundances in 0-5m layer are shown in Harada et al. (1996) [1].

The reason why we used average concentration of silica, dissolved inorganic nitrogen, diatom abundances and flagellate abundances among 0-5m layer is the layer was well mixed [10].

The system dynamics model used in this study is mostly same as that shown in Harada & Aoki [9], the slight modifications are done on dissolved inorganic nitrogen flow. Parameters in the model were calibrated using the data obtained in the 1991 experiment and applied to the data obtained in the 1989 experiment.

Dissolved inorganic phosphorus was not considered in the model, because, phosphorus abundances mostly exceeded general half saturated constant of diatoms and flagellates.

III. RESULTS

Calibrated parameters are shown in Tab.1. The values are mostly common such as the ones shown in Amano et al. [11]. Predicted variations in silica and dissolved inorganic nitrogen agreed with the observed ones, generally (Figs.1-4). But increases in silica and dissolved inorganic nitrogen were shown at the latter period in both 1989 and 1991 experiments (Figs.1-4). The variations in diatom abundances matched well (Figs. 5 & 6). However, the variations in flagellate abundances did not match though the average abundances were in the same orders in both years (Figs. 7 & 8: see DISCUSSION).
Fig. 1 Predicted and Observed silicate in 1991

Fig. 2 Predicted and Observed dissolved inorganic nitrogen in 1991
Fig. 3 Predicted and Observed silicate in 1989

Fig. 4 Predicted and Observed dissolved inorganic nitrogen in 1989
Fig. 5 Predicted and Observed diatom abundances in 1991

Fig. 6 Predicted and Observed diatom abundances in 1989
Fig. 7 Predicted and Observed flagellates abundances in 1991

Fig. 8 Predicted and Observed flagellates abundances in 1989
IV. DISCUSSION

Factors affecting the increase in silica and dissolved inorganic nitrogen at the later period may be: 1) supply of them from deeper layer by wind mixing and 2) supply of them via rapid regeneration within the 0-5m. The changes of vertical profiles of silica and dissolved inorganic nitrogen in 1991 experiment suggest the importance of the former factor (Figs. 9 & 10). Also Watanabe et al. (1995) indicated that strong wind mixing occurred at the later period in 1989 [10]. The latter factor should be analysed more in the next step.

Factors affecting the differences in the discrepancy between predicted and observed flagellate abundances may be migration of flagellates. The changes of vertical profiles of flagellates abundances (Figs. 11) indicates that flagellates concentrated at the surface. The meaning of our prediction (Figs. 7 & 8) is that we could predict the potential transition from diatoms to flagellates as shown in Harada & Aoki (2013) [9] using the common parameters (Tab.1). The real distribution of flagellates should be predicted considering the ability to migrate as shown in Amano et al. (1998) [11].

![Observed vertical profiles of silica in 1991](image_url)

**TABLE I CALIBRATED PARAMETERS**

<table>
<thead>
<tr>
<th>Parameters</th>
<th>diatoms</th>
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<th>flagellates</th>
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<tr>
<td></td>
<td>silica</td>
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<td>nitrogen</td>
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![Graph of observed vertical profiles of silica in 1991](image_url)
Fig. 10 Observed vertical profiles of dissolved inorganic nitrogen in 1991

Fig. 11 Observed vertical profiles of flagellates abundances in 1991
V. CONCLUSION AND THE FUTURE WORKS

The potential shift of diatoms to flagellates accompanied with the decrease of silica abundance was reproduced with common parameters and verified by the NIES mesocosm data. The prediction should be expanded into the whole layer of the mesocosm and then some other factors such as regeneration of silica and inorganic nitrogen, migration of flagellates will make sense. Furthermore, more precise prediction on the performance of different species such as centric and pennate diatoms should be considered. Also the effects of the changes in zooplankton should be considered by taking into account the changes of loss parameters.

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REFERENCES


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