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PREDICTION OF THE SHIFT OF DOMINATED PHYTOPLANKTON SPECIES FROM DIATOMS TO FLAGELLATES IN ACCORDANCE WITH DECREASING SILICATE IN THE SURFACE WATERS USING A SYSTEM DYNAMICS MODEL

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Abstract*- *The importance of Silicate behavior at the surface receiving water on the shift of dominant phytoplankton species is well known. While the existing models do not always predict the cause-effect relationship well. Here, a simple system dynamics model was proposed to predict the cause-effect relationship. Using STELLA, the shift of dominant phytoplankton species from diatom to flagellates was well reproduced together with the decreasing silicate. This model could be a tool for runoff control planning from the catchment.

***Keywords* –** Stella, System Dynamics, Diatom, Flagellate, Runoff Control

I. INTRODUCTION

The shift of dominant phytoplankton species from diatom to flagellate was often observed at some experimental ecosystems [1][2] and open seas [3][4][5][6].

The shift mentioned above is quite important in assessing the effect of water quality on the fishery stock because, recently, it is pointed out that diatom initiate the energy flow to fish while flagellate initiate that to jellyfish [5].

It is quite important to predict the changing silicate stock and then to predict the resulting ecosystem changes. However, adequate tool to realize the shift of dominant species together with the changing silicate availability is still in require.

We demonstrate a simple system dynamics model using STELLA which has advantages in simulations. The model described by STELLA icons is shown together with simulation results.

II. THE STELLA MODEL DESCRIBED BY ICONS

The basic unit of material flow in STELLA model can be described as Figure 1. Stock represents changing nutrient availability, species abundances, etc. In and Out flow represent the dynamics affecting the stock, such as biological processes. These could be described as equations. Converter represents parameters in the equations at In and Out Flow.

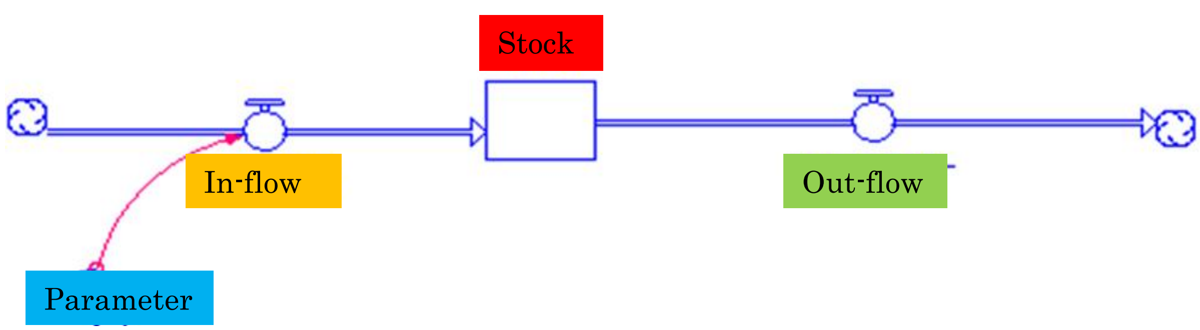

Figure 1 Basic unit of material flow in STELLA

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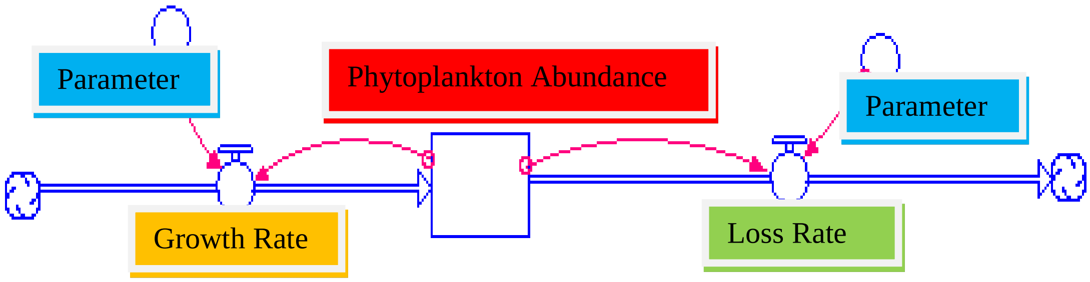

Figure 2 Description of phytoplankton abundances

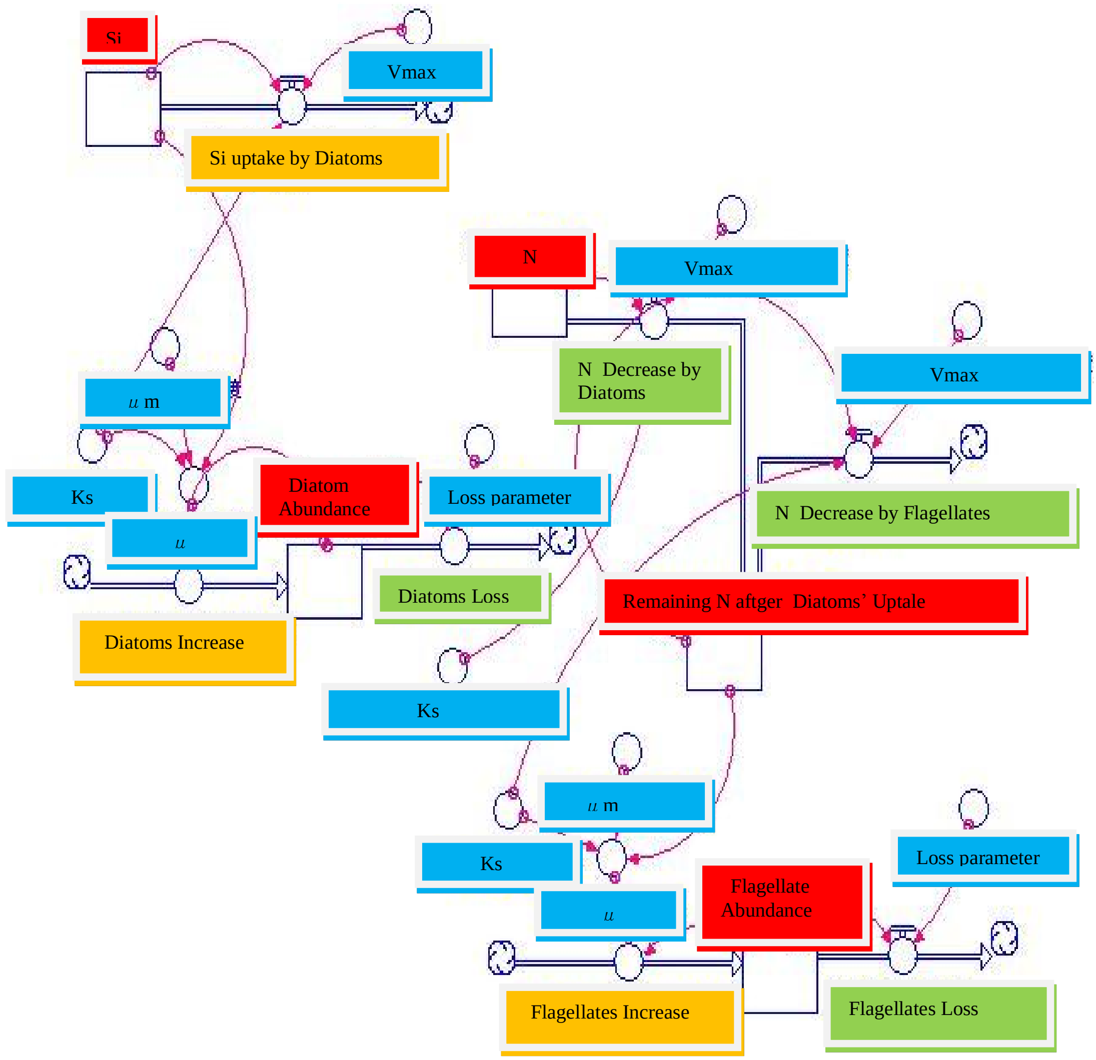

Figure 3 Simple model considering dominant species change accompanied by Si decrease

In the case, phytoplankton abundance is the target, Figure 1 can be written as Figure 2. In the figure, Stock, In and Out flow and Converters can be defined by operating the icons. Moreover, the systems shown in Figure 2 can be developed as a model to represent the dominant species change accompanied by Si decrease. In Figure 3, Diatoms and Flagellates increase is described by the following equation.

$$\frac{dX}{dt} = \mu X \qquad (1)$$

where μ is growth rate, and X is phytoplankton abundance.

μ can be described by the following equation.

$$\mu = \mu m \frac{S}{Ks + S} \qquad (2)$$

where μm is maximum growth rate, and Ks is half saturated constant and S is Si or N availability.

III. SIMULATION RESULTS USING THE MODEL IN FIGURE 3

With adequate parameters, the model shown in Figure 3 simulates the variations in abundances of diatoms and flagellates (Figure 4) and those of Si and N availability (Figure 5).

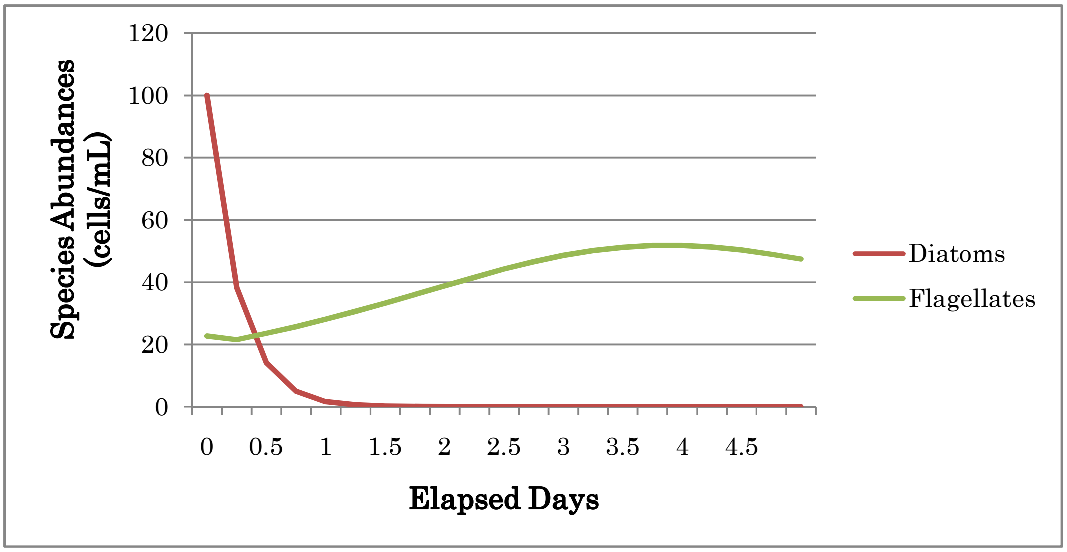

Figure 4 Shift of dominant species from diatoms to flagellates

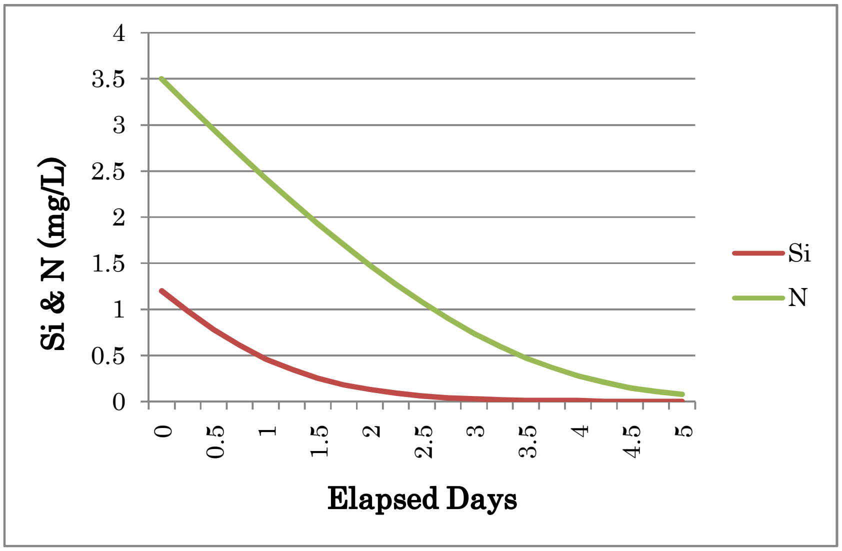

Figure 5 Nutrient availability

In Figure 4, diatoms quickly decreased as observed in enclosed ecosystems at the Seto Inland Sea (mesocosm) [1][2]. The decrease of diatoms was consistent with the decrease in Si (Figure 5). Thus, the simple model shown in Figure 3 can describe the superiority of diatoms when Si is available. Also the model can describe the activity of flagellates after diatoms vanished. This simple model is useful in so many cases such as 1) Si and N are given to the receiving water constantly and ii) Si and N are given to the site inconstantly, though currently the stocks are given instantaneously as an initial conditions.

IV. CONCLUSION AND THE FUTURE WORKS

The model shown in the Figure 3 is simple but useful enough for the sensitivity test for nutrients runoff control from the catchment to the receiving waters. Currently grazing by zooplankton and micro-zooplankton are not considered in the model. Also the vertical transport of plankton and nutrients should be considered in the near future.

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