ANALYSIS OF WATER QUALITY RESPONSE TO NUTRIENT LOADING AND SEDIMENT RESUSPENSION AT MIKAWA BAY

G.A.A Kasih and T. Kitada
Department of Ecological Engineering, Toyohashi University of Technology

Abstract
Eutrophication is caused by large influxes of nutrient due to agricultural runoff and urban waste disposal and or re-suspension from the sediment itself. The objective of this study is to examine how effectively various nutrient-reduction measures can improve water quality. Both the hydrodynamic and water quality variables are simulated using a model which includes by a system of hydrodynamic equations and 13 mass conservation equations related to water quality such as chlorophyll-a and dissolved oxygen.

1. INTRODUCTION

Mikawa bay, which is enclosed by two peninsulas of Chita and Atsumi, has 365 km^2 surface water area with the mean water depth varying from about 7.5m at the downstream of Toyokawa river to 24m at mouth of the bay near the open sea and more than 600,000 people are living in the watershed. Thus increased human activities in the watershed have led to deterioration in the water quality and resulted in damage to the ecosystem. Those activities causes algae bloom known as eutrophication phenomena, which deplete dissolved oxygen, block sunlight, and finally force fishes and other aquatic organism to perish. In this study, the response of water quality and eco-system in the bay to nutrient loading from the land area and re-suspension from the sediment is examined. Five scenarios for water quality improvement are examined are follow: 30% reduction of inorganic phosphor, 30% reduction of inorganic nitrogen, 30% reduction of inorganic phosphate and inorganic nitrogen, 30% and 50% reduction re-suspension from sediment. The software from Waterways US Military CE-Qual-W2 is used to simulate the hydrodynamic and water quality of Mikawa bay.

2. METHODOLOGY

CE-Qual-W2 is a laterally averaged 2-dimensional version, where all lateral variation in the model dependent variables are assumed to be less important than longitudinal and vertical variations. Thus the water body of Mikawa bay, as shown in Fig.1, is simplified into 2D water body in which the longitudinal direction is taken as the line connecting points A13, A10, A5, A7 and A14. The water body is discretesized into 30 equally spaced segments and 24 vertical layers as depicted in Fig.2. Each segment has the same length of 855m and each layer has uniform 1.1m thickness with depth varying from 7.5m (6 active layers) to 24m (22 active layers). The initial data were utilized to specify vertical temperature and constituent concentration by applying linear interpolation to the observed data near surface and near bottom. Boundary values consist of data from meteorology, water quality and water surface elevation. The time varying data are input water qualities, water temperature and fresh water loading from river and waste water treatment.

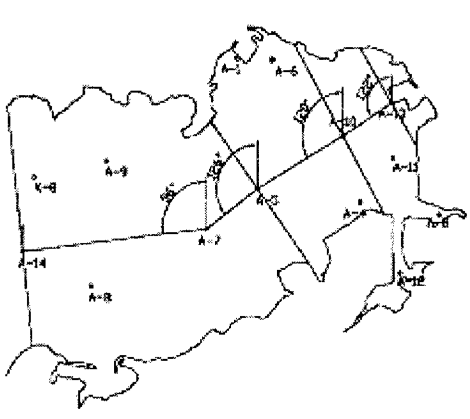

Figure 1 Segmentation model.

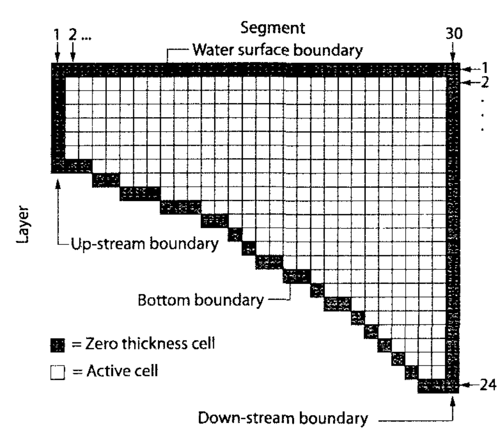

Figure 2 Discretization of water-body.

3. SIMULATION AND EVALUATION OF NUTRIENT REDUCTION MEASURES

The simulation has been performed from 1998 to 2000. The predicted salinity and temperature, as shown in Fig.3, were used for calibration of the model calculation. The results show the model can capture temperature and salinity trend at the bay. The calculated results are compared too with observations on nutrient, chlorophyll-a and dissolved oxygen concentration in Fig.4. Figure 4 shows that the model can capture the seasonal variation found in observation.

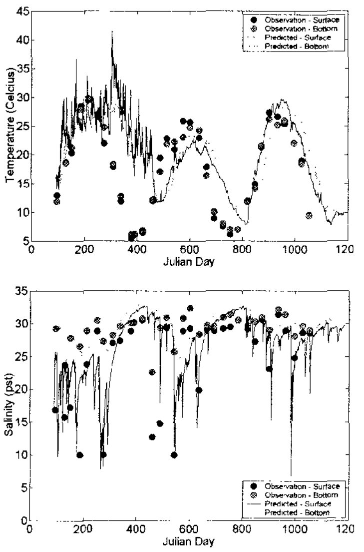

Figure 3 Observation and calculation: temperature and salinity.

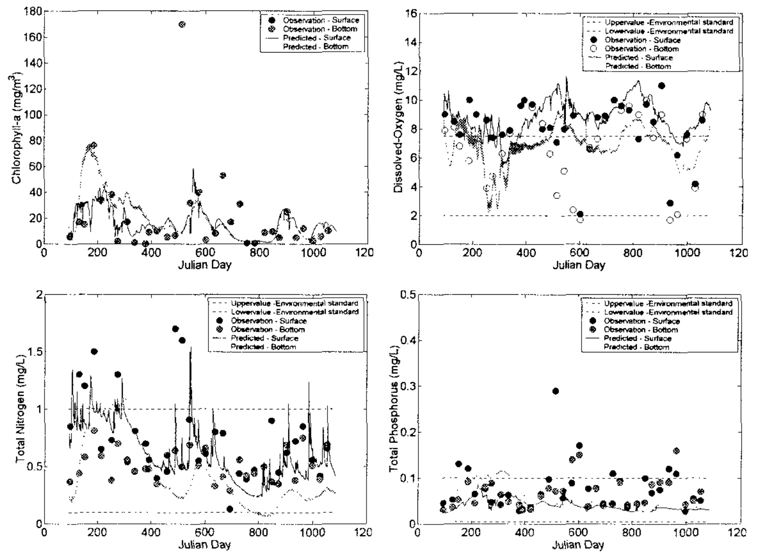

Figure 4 Observation and calculation: chlorophyll-a, DO,TN and TP.

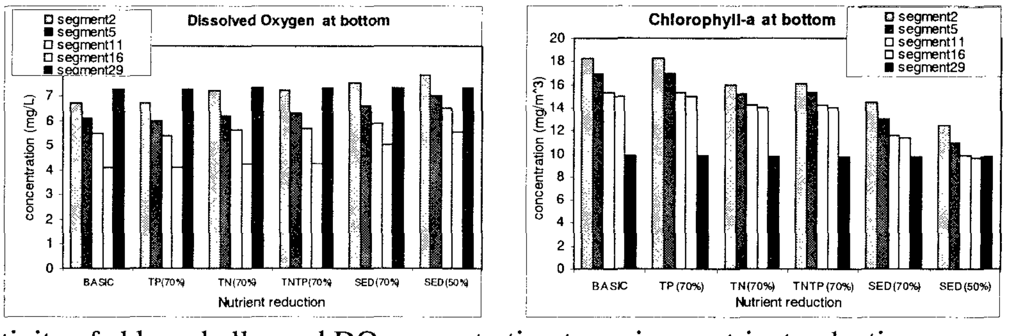

Figure 5 Sensitivity of chlorophyll-a and DO concentration to various nutrient reduction measures showing results at the bottom layer.

The evaluation of nutrient reduction measures were focus on the two important constituent of eutrophication status chlorophyll-a and DO (Fig.5). The result from nutrient reduction measures shows that scenario 1 has no effect on improvement of the water quality. Scenario 2 and 3 the similar result was obtained: DO concentration at bottom increased by average 4% and chlorophyll-a concentration at bottom decreased by average 7%. Scenario 4 and 5 implied that DO concentration at bottom increased by average 8%, 13% and chlorophyll-a concentration at bottom decreased by average 13%, 22% respectively.

4. CONCLUSION

The simulation results of hydrodynamic variables and water quality were in good agreement with the observation data. The result from various nutrient-reduction scenarios showed the controlling factor to reduction of chlorophyll-a concentration is inorganic nitrogen: ammonia is more dominant over nitrate. Reducing re-suspension from sediment improves water quality better than control of nutrient loading from the land area.