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A Couple Hydrodynamics and Ecosystem Model in an Estuarine System: Application in the Mahakam Estuary, East Kalimantan

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ABSTRACT: Development a coupled physical-biological numerical models are useful tools for understanding the relevant processes and the influence of biota and human activity on the ecological conditions in the estuary, and such a suite of models has been used to assess the impact of zebra mussels on the nutrient cycling in the estuarine system. The models, which are at the third level, should be validated, describing the most relevant parts of the natural system in a credible way in order to be applicable for making projections. The model has application to the hydrodynamics and ecosystem condition of the Mahakam Estuary, East Kalimantan, Indonesia. The work describe in the project with only a part of the component of the system, Its focus is on algal biomass and algal species in relation to the abiotic component: hydrodynamics, suspended sediment and light, nutrient and bottom sediment.

Keywords: Hydrodynamics Model, Ecosystem Model, Estuary System, Suspended Sediment Transport

INTRODUCTION

Man's activities have affected the environmental condition on earth for a long time, but never on such a global scale as witnessed during the last one or two centuries. This is partly because the human population has grown more or less exponentially, but also because industrial and agricultural production per capita grew to unprecedented levels. Direct effects include deforestation, canalization of rivers, farming, construction of artificial lakes and reservoirs etc. Often ecological consequences are significant i.e. loss of biodiversity, accelerated extinction of certain species and in contrast a massive explosion of others, development of new habitats etc. Somewhat more indirect effects occur due to the release of various substances into the environment. These include toxic substances, green house gases, which affect the global climate, but also nutrient, which are not toxic but in contrast, promote growth of plants and algae.

In many areas nutrient loading to aquatic ecosystem have increased considerably as a result of population growth, industrial development and urbanization. This has resulted in enhanced growth of phytoplankton, shifts in composition of the plankton community, and changes in the structure of ecosystem, which are often considered to be objectionable. To help understanding these processes and to predict future condition, a numerical model will developed and apply in an estuarine system: case study in the Mahakam Estuary, East Kalimantan (Fig. 1). It simulates the biomass and composition of phytoplankton and macro algae in relation to the amount of nutrient, the underwater light climate and grazing. It can be applied as relatively simple screening tool, but also as part of advanced integrated modelling systems including additional hydrodynamics, suspended matter and habitat components.

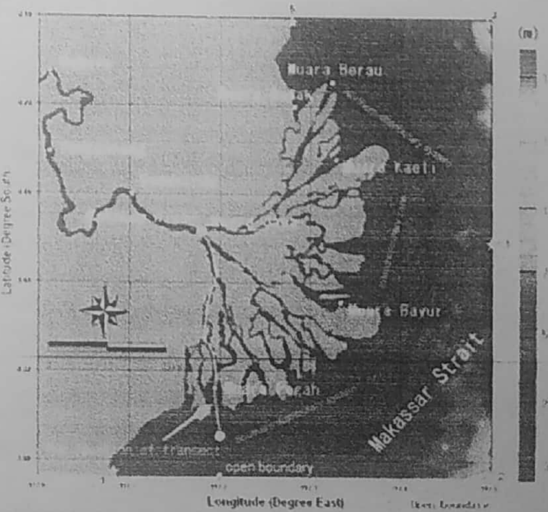

Fig. 1 . Bathymetric map of the Mahakam Estuary from DISHIDROS of Indonesian Navyand the locations of the transect (solid line). Numbers show the depth in meters

THE OBJECTIVE STUDY

1. To development and application of mathematical models for primary production by phytoplankton and macro algae that are credible and fit for purpose.
2. To describe a detailed primary production model hindcasting the seasonal phytoplankton cycle in the Mahakam estuary as well as a thorough sensitivity analysis.

HYDRODYNAMICS AND ECOSYSTEM MODEL

The development of three-dimensional (3D) hydrodynamic models started in the late70's. Three-dimensional hydrodynamic models are numerical code solving generally the Boussinesq equations. The availability of equations based on physical laws of classic mechanics, know from 18th century, is one of the main differences between hydrodynamic and biogeochemistry models, because equations for biogeochemical phenomena are generally not universally accepted and in most cases empirical or semi-empirical.

The main differences between available three-dimensional hydrodynamic models rely mostly on: (i)There presentation of the vertical dimension; (ii) the numerical treatment given to turbulence; (iii) the numerical methods used to solve partial differential equations, such as finite difference or finite element methods.

The biological model cycles concentrations of organic carbon and nitrogen through microplankton and detrital compartments with associated changes in dissolved concentrations of nitrate, ammonium and oxygen. The concentrations are updated in time by solving a transport equation for each state variable where by the biological interactions are included as source and sink terms and which takes account of vertical sinking and the physical transport by advection and diffusion. As an exception, chlorophyll is derived algebraically from microplankton carbon and nitrogen concentrations. The sediment model determines the time evolution and transport of inorganic particulate material. Exchanges between the water column and the seabed are modelled through a "fluff" layer in the microplankton and detritus compartments and in the sediment model.

PRELIMINARY RESULTS

As a first step in this research has been done previous research on the development of two-dimensional hydrodynamic model (2-D), cohesive sediment transport in the 3-D hydrodynamic baroclinic models , and ecosystem dynamics (NPZD simple model) which is applied in the Mahakam Delta Estuary and has been published in journals International and under submit in International Journal.

Based on our preliminary results, we have confident to development and application of mathematical models for primary production by phytoplankton and macro algae that are credible and fit for purpose, to describe a detailed primary production model hindcasting the seasonal phytoplankton cycle in the Mahakam estuary as well as a thorough sensitivity analysis, and to simulates the biomass and composition of phytoplankton and macro algae in relation to the amount of nutrient, the underwater light climate and grazing.

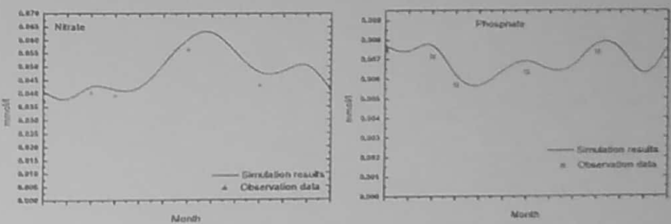

Fig. 2. Verification model between simulation and observation data for nitrate and phosphate

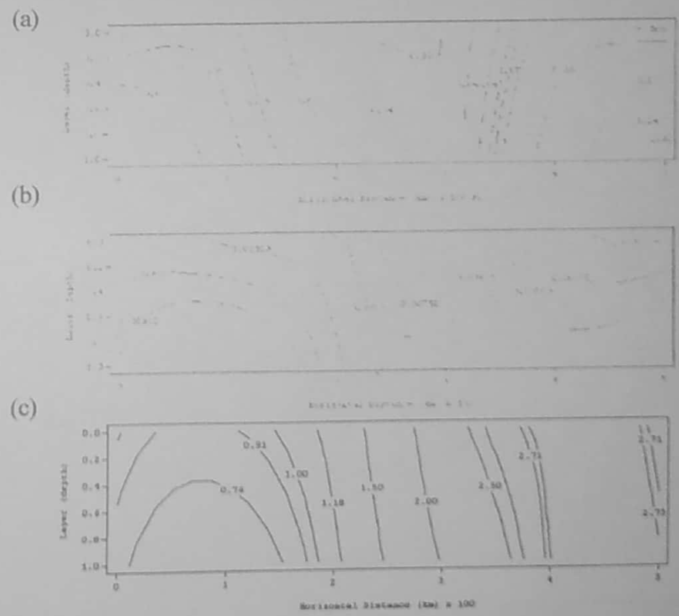

Fig. 3. Distribution pattern (a) DIP, (b) DIN, and (c) Chl-a in the Mahakam Estuary.

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