

Eutrophication has become a significant environmental problem in the Baltic Sea during recent decades. Indications of this problem include larger and more frequent phytoplankton blooms of cyanobacteria, increased hypoxic areas, fish kills, etc. A complete assessment and long-term monitoring of eutrophication based on measurements of all system parameters with a proper resolution in time and space would be by far too costly and time- and labor-consuming. The best approach is to use both, data from observations and mathematical models that integrate such data. Marine environment can be described with mathematical models in a similar way as we know from everyday weather predictions. The **main objective** of this project is to develop improved phytoplankton ecosystem model. Model will account for links between optical properties of seawater in the Baltic Sea and its composition, including phytoplankton, detritus and colored dissolved matter (CDOM). The model will be used to show how changes to these optically important constituents (their concentrations and optical properties) feed back to the system, impacting phytoplankton life, competitive advantages of some phytoplankton types, and interactions with physical oceanographic processes.

We want to a) assess how the competitive capabilities of different phytoplankton functional types are used in different conditions; b) to derive improved understanding how physical conditions (solar insolation, winds, input of water from rivers and North Sea etc.) and human activities (for example increased or decreased supply of nutrients) affect the ecological status of the Baltic Sea and what are the most important biological influences on physical processes and hydrography; c) to assess what changes of the ecosystem can or cannot be observed using ocean color satellite data merged with an ecosystem model. These goals will be reached through carefully planned numerical experiments where we will study the cause/effect relationships. Note that only numerical models let us carry out such experiments. Without models it is impossible to quantitatively predict the responses of a complex, nonlinear marine system to changing conditions;

**The methods** will be based on numerical modeling verified through extensive comparisons with observational data. To simulate the physical processes we plan to use the Princeton Ocean Model (POM, [www.aos.princeton.edu/WWWPUBLIC/htdocs.pom/](http://www.aos.princeton.edu/WWWPUBLIC/htdocs.pom/)). To model phytoplankton we will use updated version of the model developed for Baltic Sea by Neumann (2000). Our efforts will include work on the modifications to improve the treatment of light propagation and phytoplankton photophysiology. Coupling optics to ecosystem model will provide following advantages. (1) Subsurface light-field will be more accurate, which is important for simulating light sensitive biogeochemical processes such as photosynthesis and photo-oxidation, and for estimates of thermal heating of the water. (2) Added constraints on model parameters will reduce uncertainties in ecosystem simulations. (3) Including optical relationships will make it possible to directly compare model output to the remotely sensed ocean color. We will also put more emphasis on including more functional groups of phytoplankton. We will use an approach, which allows the diverse phytoplankton types to compete according to relative fitness. This approach has not been used in the modeling studies in the Baltic Sea so far, but it can result in new insights about competitive capabilities of different phytoplankton functional types.

**The significance of this project** is related to the fact that phytoplankton blooms are one of the most critical issues with environmental, economic and health hazard impacts in the Baltic Sea. Our project will provide basic information that can be used to improve the management of this marine environment. A complete assessment of the functioning of the Baltic ecosystem based solely on in situ experiments is impossible, due to the complex nature of marine system. The best approach is to use numerical models that integrate observational data, as we propose here. Our novel approaches to ecosystem modeling will bring an answer to a question why sometimes certain phytoplankton types (i.e. cyanobacteria) undergo intensive blooming.