APPENDIX

Details of model key variables and processes are provided below.

Nitrogen Processes

Nitrogen processes considered are: sinking, regeneration, and uptake by phytoplankton in the top layer and burial and denitrification in the bottom layer. The nitrogen content in the two different layers depends also on diffusive exchange driven by physical processes.

In constructing the N budget, we assumed that only the nitrogen stored in the top layer is available for photosynthesis and that not all of this nitrogen is immediately available for primary production, i.e. some might be of terrigenous origin.

The surface layer receives inputs from the atmospheric deposition, the land runoff, point-source discharges, and from the bottom layer, via entrainment and diffusion processes. The surface layer loses nitrogen through phytoplankton uptake, advective outflow, and sinking through the pycnocline. The bottom layer gains N from regeneration, advection, and it loses N to the upper layer through the same entrainment and diffusion processes and through burial.

Nitrogen processes are formulated as follows:

a. Entrainment, as an upwelled flux of bottom water;
b. Diffusion, as proportional to the vertical N-gradient using the same diffusion coefficient as salinity;
c. Uptake, as the amount available up to the saturation value (associated with each of the three phytoplankton classes);
d. Sinking, calculated as a constant percent of the surface N sinking to the bottom layer. The sinking rate takes into account the opposing upwelling rate of entrainment.
e. Regeneration, calculated through a conversion algorithm between biomass produced by phytoplankton with stoichiometric ratio of N:C while sinking out of the surface layer at constant rates for each phytoplankton class taken from literature. A loss due to zooplankton grazing is also added.
f. Advection, as the flux of inflow or outflow times the N concentration;
g. Sediment burial, as approximately equal to literature values for similar deposition rates in estuaries, e.g. ~10% of new N inputs ;
h. Denitrification, as proportional to the bottom oxygen values and calibrated to satisfy the total N budget.

The total new N reflects the seasonality of the rainfall and, at a shorter time scale, the larger runoff events. The Nitrogen concentration is primarily controlled both by runoff variability and by primary production

Phytoplankton Growth

The phytoplankton growth is driven by the light and nutrient conditions, modified by the circulation and diffusion. Its representation is complicated due to the feedback with nutrient regeneration and predation by zooplankton. Three phytoplankton groups are simulated e.g. diatoms, dinoflagellates, and others in order to simulate seasonal succession. The population balance of growth (nutrients & light), respiration, death, and grazing is expressed in the following equation:

$$dPhB/dt=PhB*(MU\_n+MU\_reg+Light*KI)-(Kr+Km)*(PhB)^2 - Kg*PhB \qquad [1]$$

where:
dPhB is change in phytoplankton biomass;
PhB phytoplankton biomass is calculated for the three different groups- diatoms, dinoflagelates and others;

The coefficients, MU_n, MU_reg, KI, Kr, Km, Kg are explained in Table 1.

Table 1. Coefficients and values of equation 1.

Variable	Coefficient	Explanation	Value
Light	KI	Photosynthesis efficiency parameter	0.01 m^2 W^{-1}
Grazing Zooplankton	Kg	Percent of total biomass	0.1 %
Mortality	Km	Diatoms	0.028÷0.080 day^{-1}
		Dinoflages	0.015÷0.028 day^{-1}
		Others	0.200÷0.480 day^{-1}
Growth rate	MU_n	Growth based on new N:	
		Diatoms	0.7 day^{-1}
		Dinoflages	0.5 day^{-1}
		Others	0.2 day^{-1}
	MU_reg	Growth based on regenerated N	T dependant (conversion table)
Respiration	Kr		0.01 day^{-1}

Light. The observed light is corrected for cloudiness. Its value for the euphotic zone (surface layer) is a vertical integral of the light using a linear attenuation function with an absorption coefficient (KI) through a conversion table.

Nutrients. Nutrients are assimilated considering a specific uptake function (Michaelis-Menten) for each phytoplankton group taking into account the assimilation of new-nitrogen (Nitrate) and regenerated-nitrogen (Ammonium).

Phytoplankton growth rate. We considered the fact that each group has its specific nutrient assimilation ability, which allows diatoms to grow faster in presence of new-nitrogen. By this we obtain two growth rates (MU_n and MU_reg) of each phytoplankton group (Table 1), one based on nitrate and one on ammonium which, when summed, give the total assimilation. The growth rate in presence of regenerated nitrogen is also temperature dependent.

Respiration and Mortality. These are simulated using a quadratic dependency with constant death (Km) and respiration rates (Kr).

Grazing by zooplankton. These are simulated as a linear proportion of the total population through a constant grazing coefficient (Kg).

All calculations are expressed in grams of carbon per cub. m ($gC.m^{-3}$).

Secchi depth

Secchi disc (m) =4.592-0.071*PhB-0.4*TSS [2]

where, PhB is the total phytoplankton biomass ($gC.m^{-3}$), TSS is the total suspended solids in ($g.m^{-3}$), and R=0.78, p=0.005.

The database used to estimate these coefficients considered 26 pairs (phytoplankton biomass and TSS).

Further explanation and details are available from the authors, e-mail: snejanam@abv.bg.