Conference or Workshop Item

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Abstract for PROTECH

PROTECH (Phytoplankton Responses to Environmental Change) is a 1-D process-based phytoplankton lake community computer model. It has been developed over the last two decades (Reynolds *et al.*, 2001). It simulates the simultaneous phytoplankton population dynamics in lakes and reservoirs of up to eight phytoplankton species, from a library of over 100.

The model works on the simple premise that a phytoplankton will grow to its maximum daily potential, corrected for certain rates of loss (i.e. sinking, wash out and grazing), provided that no essential resources are limiting. Thus, the maximum growth rate is calculated from functions (derived from culture experiments) with respect to the phytoplankter's morphology and temperature. This growth rate is reduced by further functions if light intensity or nutrient thresholds fall below certain thresholds. Thus, the daily change in the chlorophyll a concentration (X, g L-1) of each phytoplankton species:

[1] $\Delta X/\Delta t = (r' - S - G - D).X$ $\mu g\ l^{-1}\ d^{-1}$

where *r*' is the growth rate defined as a proportional increase over 24 hours, *S* is the losses due to settling out of the water column, *G* is the loss due to grazing (species > 50 μm are not grazed) and *D* is the loss due to dilution. The growth rate (*r*') is further defined by:

[2] $r' = \min\{r'_{(\theta,I)}, r'_{P}, r'_{N}, r'_{Si}\}$ d^{-1}

where $r'_{(\theta,I)}$ is the growth rate due to temperature and daily photoperiod and r'_{P}, r'_{N}, r'_{Si} are the growth rates determined by phosphorous, nitrogen and silicon concentrations.

These replication-rate performances were related to the sizes and the habits of the algae (Reynolds, 1989). The best predictor of the maximum specific replication rate, r'_{20} , was found to be the ratio of the surface area (s, in μm 2) of the algal "unit" (be it a unicell or coenobium, including mucilage if present) to its volume (v, in μm^3), in accord with the power function,

[3] $r'_{20} =$ 1.142 (s / v) 0.325 d^{-1}

This is the first equation in the model and is employed in the form (Fig. 1):

[4] $\log\ r'_{20} = a + b \log\ (s / v)$

and where the standard value of the regression intercept $a = \log(1.142)$ and the standard value of the slope, $b = 0.325$ ($r = 0.72$; $r^2 = 0.52$; $p < 0.05$).

The base growth rate is further modified to allow for temperature and light availability, using two other equations that are also related to the phytoplankter's morphology (see Reynolds *et al.*, 2001). Loss rates are then applied to account for zooplankton grazing, movement of the algae and dilution.

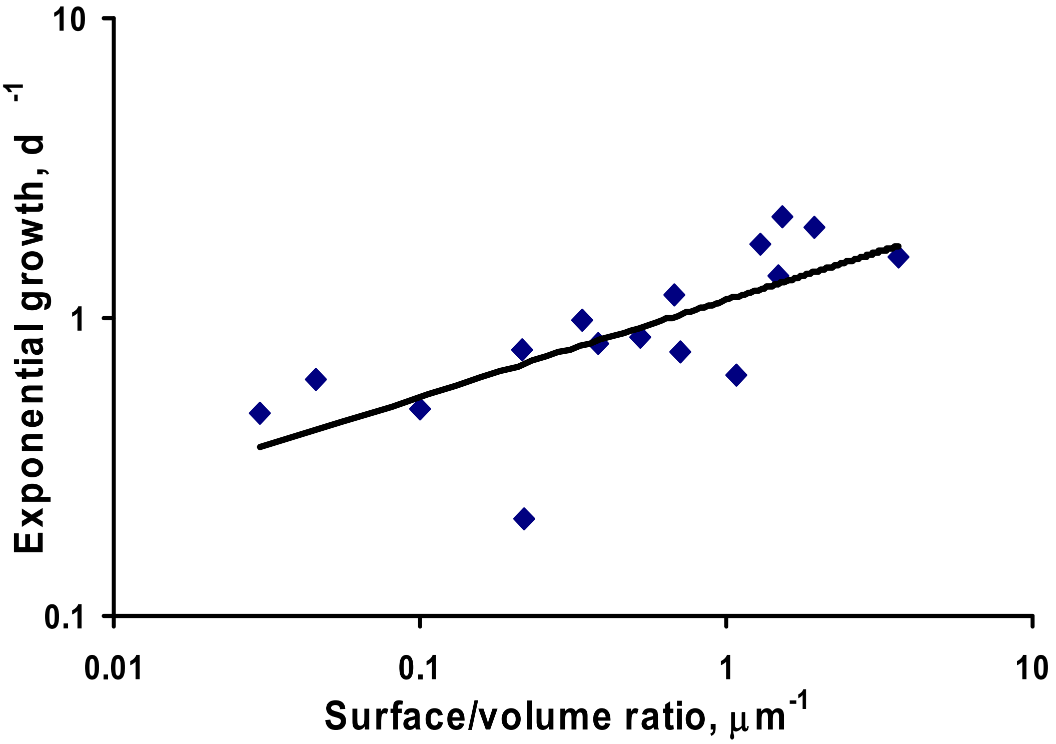

Fig. 1. The r'_{20} growth relationship derived from the work in Reynolds (1989).

The physical side of the model divides the simulated water body into 10 cm layers, which are adjusted in volume and surface area to reflect the morphology of the basin. An initial profile for the water column (containing temperature, nutrient concentrations and inoculum sizes for algal species) is defined for day 1 (normally equivalent to 1 January). Daily wind speed, cloud cover, river inflow (including nutrient concentrations) and outflow data are input to the model and daily insolation is adjusted depending upon the time of the year and latitude. For each 24 hour time-step, the Monin-Obukhov equation is used to calculate the mixed layer thickness as a function of heat flux and wind stirring on a given day. The starting water column profiles of temperature, nutrients and phytoplankton are changed at the start of each time-step as a result of mixed layer changes. Biological functions are then used to calculate the new biomass and dissolved nutrient concentrations at the end of the time-step, assuming no further vertical movements.

References

Reynolds C.S., Irish A.E. & Elliott J.A. (2001) The ecological basis for simulating phytoplankton responses to environmental change (PROTECH). *Ecological Modelling*, **140**, 271-291.