Readme for the model introduced in

Coupling freshwater mussel ecology and river dynamics using a simplified dynamic interaction model: <https://doi.org/10.1086/684223>

# Introduction

This readme file is intended to assist users interested in running or modifying the model described in the above paper. The model is relatively simple numerically; four independent variables are written as coupled differential equations and integrated forward in time using a basic Eulerian method. There are a number of parameters that vary in time and modify the equations. The model is loosely-hard-coded to run at a daily timestep, with units of driving discharge in L/s. The model is implemented in Matlab.

The file mussels.m contains all the script necessary to model suspended sediment, mussel populations, and chlorophyll-a concentration as described by the above paper. Some basic plotting codes are provided at the end of the script. To run the code, simply change your Matlab path to the path where the “MRB\_mussel\_data.mat” and “MRB\_QS.mat” files reside, then press “Run”. If successful, you will have run the model for 12 sites in the Minnesota River Basin and a plot of the Chippewa River (site 1) site should appear.

Applying this model to a site not considered in the above paper requires significant data and literature to determine appropriate parameters, as well as optimization and calibration. Listed below are these parameters and basic descriptions, but for applying the model elsewhere one should refer to the paper to understand their origins and rationale.

# Inputs

This model requires a number of parameters—some sourced from literature and some based on observations. It also requires initial conditions, which, in the absence of observations as in our case were determined via searching an initial-condition space and choosing the initial condition which minimized the RMSE between observations and model predictions for a validation dataset. Details are in the cited paper. There are two .mat files containing values for setting parameters:

**MRB\_QS**: loads a N x 9 structure, where N is the number of sites. Its fields are:

|  |  |
| --- | --- |
| Field name | Description |
| sitename | the name of the site |
| Q | the daily discharge recorded at the site |
| dates | dates as Matlab datenums corresponding to the Q values |
| alpha\_QS | the alpha coefficient describing the suspended sediment/discharge relationship |
| beta\_QS | the beta exponent describing the suspended sediment/discharge relationship |
| alpha\_Qd | the alpha coefficient describing the depth-discharge relationship |
| beta\_Qd | the beta exponent describing the depth-discharge relationship |
| QS\_Qmin | for some sites, the sediment-discharge relationship exhibited a threshold; this parameter describes the minimum value of Q at which the relationship no longer holds |

**MRB\_mussels**: loads a N x 8 structure with the fields:

|  |  |
| --- | --- |
| Field name | Description |
| SiteNo | site ID number |
| Old\_SiteNo | we modified our site ID numbers halfway through the modeling effort; these were the original site numbers |
| muss\_weight | average mussel weight at each site |
| obs\_cal\_date | Matlab datenum corresponding to date of observed mussel densities used for calibration |
| obs\_cal\_density | mussel density in #/m2 used for calibration |
| model\_end\_date | Matlab datenum describing last date mussel observations were available; the model will terminate at this date |
| obs\_val\_date | Matlab datenum corresponding to date of observed mussel densities used for validation |
| obs\_val\_density | mussel density in #/m2 used for validation |

Parameters hard-coded into the model:

|  |  |
| --- | --- |
| Parameter | Description |
| b\_M | birth rate of mussels |
| eps\_M | death rate of mussels (found via optimizing based on RMSE at calibration sites) |
| M\_in\_cond | mussel density initial condition (found via optimizing based on RMSE at calibration sites) |
| K\_M | mussel carrying capacity (determined based on mussel species present) |
| b\_C | chlorophyll birth rate (from literature) |
| K\_C | chlorophyll carrying capacity in mg/L (from literature) |
| w\_M | average mussel weight at each site in g wet/mussel (from observations) |
| theta\_SM | sediment threshold that modifies birth rate (from literature) |
| theta\_SC | sediment threshold that modifies chlorophyll reproduction through light availability (from literature) |
| SM\_max | parameter describing the effect of suspended sediment on mussel reproduction (from literature) |
| SC\_max | parameter describing the effect of suspended sediment on chlorophyll reproduction (from literature) |
| min\_eta\_SM | parameter describing the effect of suspended sediment on mussel reproduction rate (see paper for formulation) |
| min\_eta\_SC | parameter describing the effect of suspended sediment on chlorophyll carrying capacity (see paper for formulation) |
| min\_eta\_CM | parameter describing the effect of food availability on mussel carrying capacity (see paper for formulation) |
| C\_rebound | value to reset chlorophyll concentration if it drops to zero |
| M\_rebound | value to reset mussel population if it drops to zero |

Outputs  
All outputs are stored in the “res” structure, which contains S x 5 fields, where S is the number of sites that were run.

|  |  |
| --- | --- |
| Field name | Description |
| name | site name |
| Q | discharge in L/s (observed, not modeled) |
| C | chlorophyll-a concentration in mg/L (modeled) |
| S | suspended sediment concentration in mg/L (modeled) |
| M | mussel density in #/m2  (modeled) |