Towards a simulation model for the Copepods zooplankton spring growth in the Sluice Dock at Ostend.

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As in a previous report on the modelling of the phytoplankton spring bloom, this model attempts to provide a framework based on observational grounds and theoretical assumptions. As such, it remains open to further adjustments. It is designed for interconnection with the phytoplankton model.

Copepods have been shown to take a prominent part in the zooplankton of the Sluice Dock. DARO (1974) has studied the topic extensively. Also VANDENDAELE (1972) and PALMER (1975) have contributed to the knowledge of zooplankton dynamics in the Sluice Dock. According to DARO, overwintering eggs generate a population of nauplii (=first development stage) that develops from the beginning of April. The maximum recorded is 240000 indiv./m$^3$. A copepodites population (next important development stage) follows one week later. The maximum recorded is 20000 to 100000 indiv./m$^3$. And finally, adults have their maximum about one week later (up to 40000 indiv./m$^3$). A second generation of nauplii develops from the end of May (max = 120000 to 100000 indiv./m$^3$) etc.

Our interpretation of these observed data in terms of generation time, growth rate and mortality rate is however
different as we assume that the population(numbers) of a given
development stage is at any time the resultant of :
- input from the previous stage
- minus output to the next stage
- minus mortality

the actual specific growth in the various stages governing the
input and the output rates. Therefrom less signification is to
be attributed to peaks height and apparition time.

All this originates from the fact that eggs are not hatching
on the same day but on a period of about two months (first
generation).

Our simulation model assumes that n classes are generated
on a period of n days (as a matter of simplification),
presumably with an optimal sub-period, hence the sine function
of time:

\[ N_t = x + (x \cdot \sin \left( \frac{2\pi}{n} \left( t - t_0 - \frac{n}{4} \right) \right)) \]

where \( N_t \) = number hatched at time \( t \)
\( x = 1/2 \) of maximum hatched/day in period

Each class \( N_i \) is allowed to grow in biomass until the ratio
\( B_i / N_i \) is such that the class passes into another category,
governed by another growth equation (switch function).

For a given class \( N_i \) :

\[ \frac{d B_i}{dt} = (k - m) B_i \]

and

\[ k = C1 \cdot I_{\text{max}} \left( 1 - e^{-d(P-P')} \right) \]  (Ivlev-Parsons)

\[ m = C2/k + C3 \]  (Mommaerts, cf phytopl. model)

where \( I_{\text{max}} \) = maximal ingestion/unit zooplankton biomass
\( d \) = constant
\( P \) and \( P' \) = actual phytoplankton biomass and threshold
concentration
\( C1 \) = conversion to net production constant
\( k \) = net zooplankton production
mortality. In the absence of demonstrated predation,
we consider a natural mortality inversely proportional
to growth rate (taken as health index) + a statistical
mortality (hence constants C2 and C3).

Where the total biomass of a given development stage is concerned,
one cannot calculate general input, growth and output constants
since the age distribution within the stage is not stable and
since the feeding conditions are changing all the time as a
result of the grazing by all stages. Therefrom numerical
integration and switch functions are needed:

\[
\frac{dB}{dt} = \sum \frac{dB_{input}}{dt} + \sum \frac{dB_i}{dt} - \sum \frac{dB_{output}}{dt}
\]

Figs. 1A and 1B show the simulations of respectively numbers and
biomass variations for the three stages of the first generation
in a much simplified case (growth always maximal and no morta-
ality at all but for the final output from the adult stage).

The further steps would take 1°) zooplankton mortality
into account and 2°) the dual aspect of the zooplankton-
phytoplankton interaction a) grazing mortality

\[m_{phyto} = \sum I B_i \text{ of all stages}\]

b) enhancement of primary production

by excretory products

\[\frac{dN}{dt} = \sum e B_i \quad (e = \text{excreted fraction of Ingestion})\]

so that \[k_{phyto} + \frac{dk_{phyto}}{dt} = \frac{k_{max} + (N + \frac{dN}{dt})}{K_s + (N + \frac{dN}{dt})}\]

3°) Assay of nocturnal or continuous grazing
4°) Simulation of the second generation:

C4. \(N_i\) adult females produce C5 fertile eggs/indiv.
that become nauplii with a time lag C6.
Constants and initial values used in the simplified simulation

\[ X = 5000 \text{ m}^3/\text{day} \]

\[ C_1 = 0.15 \text{ (net production = 15 \% of ingested matter)} \]

\[ I_{\text{max nauplii}} = 0.060 \text{ mg C/mg C animal/hour} \]

\[ I_{\text{max copepodites}} = 0.048 \text{ " " " "} \]

\[ I_{\text{max adults}} = 0.020 \text{ " " " "} \]

Initial biomass of a nauplius = \(8 \times 10^{-5}\) mg C

" " copepodite = \(48 \times 10^{-5}\) mg C

" " adult = \(736 \times 10^{-5}\) mg C

Final biomass of an adult = \(1008 \times 10^{-5}\) mg C