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MODELE MATHEMATIQUE DE LA POLLUTION EN MER DU NORD

TECHNICAL REPORT

1975/BIOL/04

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 :

$$N_t = x + (x . (\sin \frac{2\pi}{n}(t - t_o - \frac{n}{4})))$$

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 $k = C1 \;.\; I_{max} (1 - e^{-d(P-P')})$ (Ivlev-Parsons)

$m = C2/k + C3$ (Mommaerts , cf phytopl. model)

where I_{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

m =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 :

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

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 mortality 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

$$m_{phyto} = \sum I \ B_i \quad \text{of all stages}$$

b) enhancement of primary production by excretory products

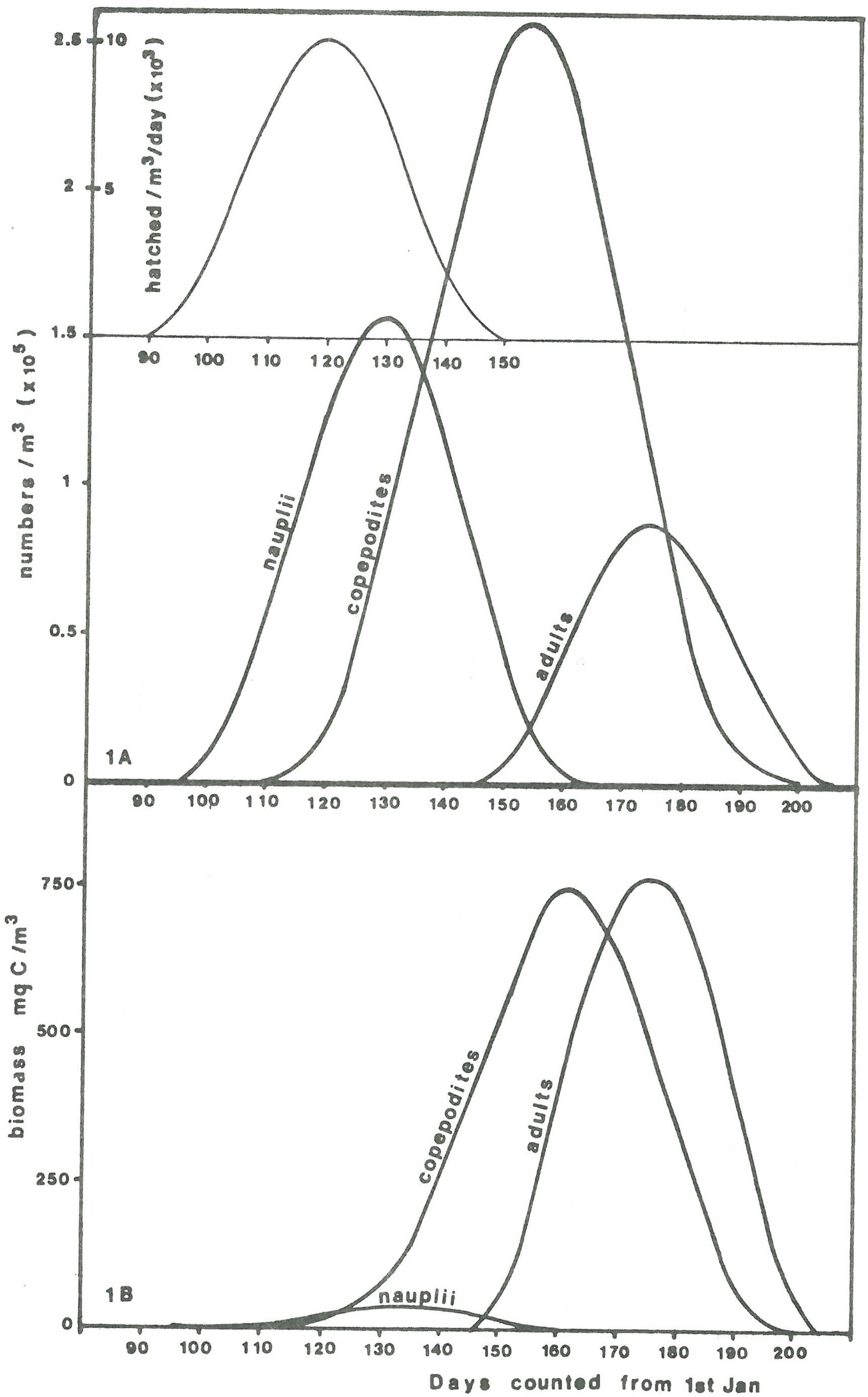
$$+\frac{dN}{dt} = \sum e \ B_i \qquad \text{(e = excreted fraction of Ingestion)}$$

so that $k_{phyto} + \frac{dk_{ph.}}{dt} = \dfrac{k_{max} + \left(N + \frac{dN}{dt} \right)}{K_s \ . \left(N + \frac{dN}{dt} \right)}$

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 .



hatched / m³/day (x10³)
numbers / m³ (x 10⁵)
2.5 10
2 5
1.5
1
0.5
0
90 100 110 120 130 140 150
nauplii
copepodites
adults
1A
90 100 110 120 130 140 150 160 170 180 190 200
biomass mg C /m³
750
500
250
0
copepodites
adults
nauplii
1B
90 100 110 120 130 140 150 160 170 180 190 200
Days counted from 1st Jan

Constants and initial values used in the simplified simulation

X = 5000 $/m^3/day$

C1 = .15 (net production = 15 % of ingested matter)

Imax nauplii = .060	mg C/mg C animal /hour			
Imax copepodites = .048	"	"	"	
Imax adults = .020	"	"	"	

Initial biomass of a	nauplius	=	$8 \cdot 10^{-5}$ mg C
" "	copepodite	=	$48 \cdot 10^{-5}$ mg C
" "	adult	=	$736 \cdot 10^{-5}$ mg C
Final biomass of an adult		=	$1008 \cdot 10^{-5}$ mg C