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MODELE MATHEMATIQUE DE LA POLLUTION EN MER DU NORD

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Four years of primary production measurements . A partial synthesis.

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Since the 1972 and 1973 in situ work, the parameters of the light-photosynthesis relationship have been determined for the phytoplankton in our area of investigation . Hence , the use of an analytical model (Vollenweider,1965) which has been used for the results of all cruises since 1971(Mommaerts ,Tech.Rep.1971-1974/BIOL.01).

1. Review of the steps involved in the calculation of production rates

1.1. The first problem is a problem of conversion of in vitro figures to true gross p_{opt} figures (p_{opt} = production with optimal light).

$$p_{vitro} = p_{opt} \cdot \frac{r}{(\sqrt{1 + (r/2,6)^2})^3} \qquad \text{(hourly rate)}$$

$$= p_{opt} \cdot f$$

hence, $p_{opt} = p_{vitro} \cdot 1/f$

where $r = I/I'_k$ (light in incubator/saturating light)

Corollaryly to the light-photosynthesis function , the f function shows a maximum . Therefrom two very different values of r (hence of I'_k) can give an identical f (see Mommaerts, Tech.Rep.1975/BIOL.01

1.2. The next problem is a problem of double integration on depth and time.

1.2.1. On depth : $p = p_{opt}/\eta \cdot \frac{R}{\sqrt{1 + (R/2,6)^2}}$ (hourly rate)

$$= p_{opt}/\eta \cdot F$$

where $R = I'_o/I'_k$ (surface light/saturating light)

η = extinction coefficient in water column

This F function has an hyperbolical shape and reaches a plateau for $R \geqslant 5$ ($F_{max} = 2,6$).

1.2.2. On time : one takes the sum of the hourly rates

$$P_{day} = p_{opt} / \eta \cdot \Sigma F_t$$

2. Problems associated with the assessment of primary production

2.1. Need for a good determination of I'_k

Our aim is to use the model and in vitro results to replace the long and costly in situ operations . However ,one still needs in situ or at least "simulated situ" work to improve our data on I'_k . The model is indeed very sensitive to this parameter.

2.2. Need for a good evaluation of respiratory rates

Net production rates are difficult to estimate since there is no direct selective method of determination of phytoplankton respiration . According to many authors , respiration has been estimated to amount to 10% of gross optimal production, in light. Darkness (below the euphotic zone or at night) respiration is lower to an unknown extent . Taking this into account , a daily loss of 50% /m^2 seems to be a reasonable figure .

2.3. Need for a correct evaluation of losses (excretory + others) in filtration procedure .

An average excretory loss of 15 % is expected according to several authors . A further loss of labelled organic material has recently been demonstrated . The total loss could amount up to 50 % of fixed $^{14}CO_2$. Our last calculations have been taking the 15% and 50% hypothesises into account.Furthermore methodological adaptations have been introduced. An important topic in the future will be the selective assessment of loss and true excretion, the latter being of importance for bactérial heterotrophic nutrition .

2.4. Need for the assessment of the diel variation of p_{opt}

P_{opt} has been supposed to remain sufficiently constant so that the day rate calculation has the simple form shown in the first paragraph. However,daily growth patterns are real things and imply diel p_{opt} variations. These should be taken into account. A model has been designed for this purpose .

3. Results for the years 1971 to 1974

For the first time , we have enough data for an acceptable estimation of yearly production in the three zones of the Southern Bight (figs 1 , 2, 3) . Fig. 4 provides a graphical help for a quick estimation of daily gross rates , if p_{opt} and η (see also fig.5) are known , using the relation : $P_{day} = p_{opt}/\eta \cdot \sum F_t$

The usual rang of daily gross production for the three zones lies between 100-170 and 2000-3400 mg $C/m^2/day$ (15%-50% loss limits) according to the time of the year . The differences between zones are less pronounced in terms of integrated production than in terms of p_{opt}/m^3 or biomass. Nevertheless , zone 2 (open sea) shows clearly lower spring maxima but higher winter figures than the more coastal areas . The dispersion of results per cruise (95 % confidence limits) is important and it was difficult to draw an average line . Hence the difficulty of demonstrating an automnal peak.

The annual gross production figures would then be :

zone 1-S	:	220 to 374 g $C/m^2/year$
zone 1-N	:	256 to 435 g $C/m^2/year$
zone 2	:	232 to 394 g $C/m^2/year$

Such figures are markedly higher than those usually quoted for the North Sea (Northern area ;Steele : 90 g $C/m^2/year$) . They are well matched by those of the Neth.Inst.for Sea Research (W.Gieskes ,pers. comm.) operating in the Dutch waters.

A general budget evaluation will help to understand the role of phytoplankton in the Southern Bight ecometabolism . Furthermore , the interpretation of production results in terms of growth ,mortality and nutrient and grazing control is going on and should normally lead to a model of plankton dynamics in the area .

Legends of the figures :

Figs 1-2-3 : each dot is the averaged gross production of an actual cruise . the horizontal bar shows the extensio in time of the cruise . The vertical bar shows the theoretical dispersion of results within 95 % confidence limits . If few results were available, the dispersion can be very important . The dots without dispersion indications are relevant to cruises with less than 3 results (possible dispersion $\simeq \infty$).For an average production curve ,the points with little dispersion have received more attention than the others .

The two scales of production are respectively relevant to the 15 % and 50 % loss hypothesises.

Fig. 4 : Relationship between $\sum F_t$ and daily light energy input

Fig. 5 : Average extinction coefficients (base e)in the 400-700 nm range / cruise + 95 % confidence limits.

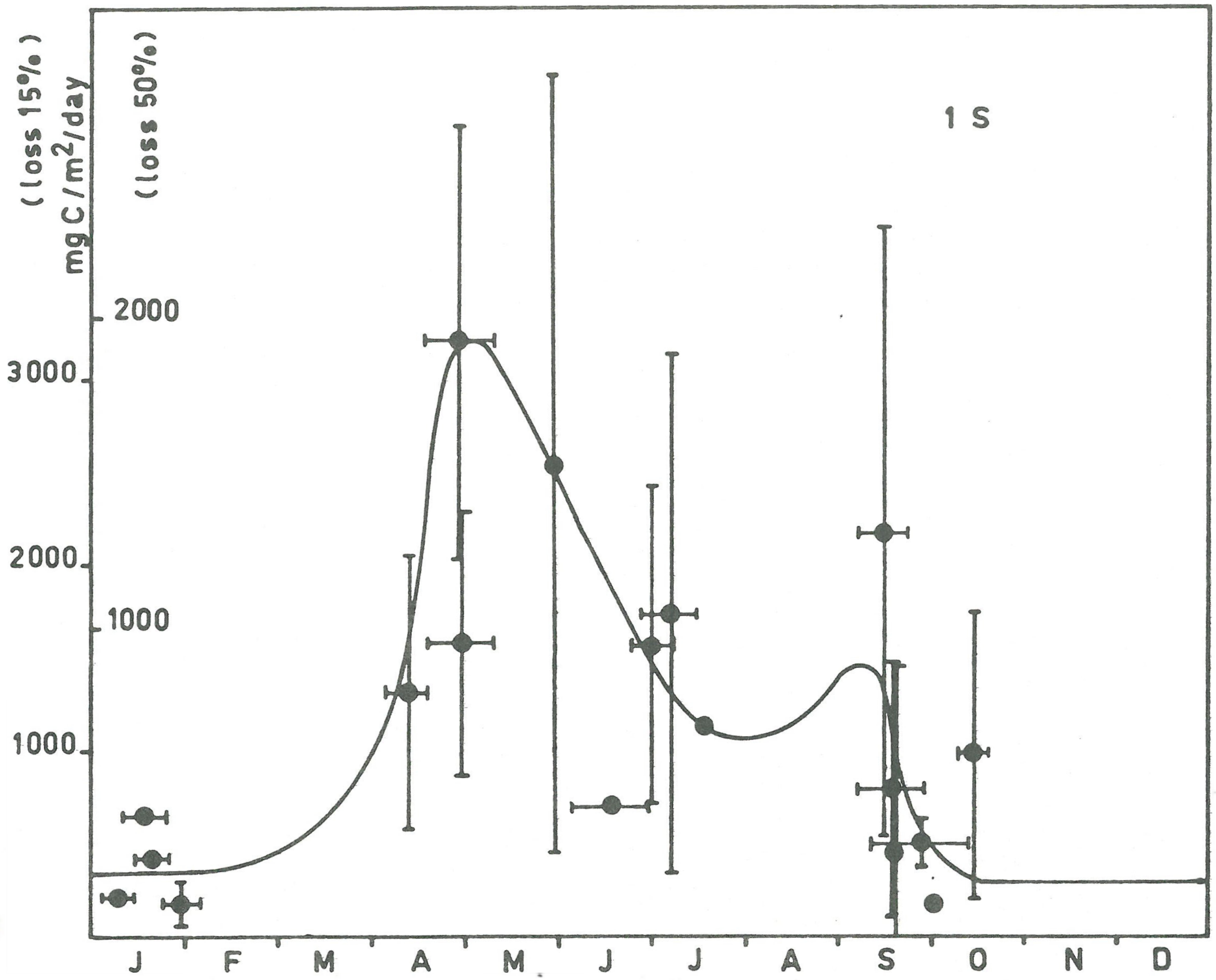
(loss 15‰)
mg C/m²/day
(loss 50‰)
2000
3000
2000
1000
1000
1 S
J
F
M
A
M
J
J
A
S
O
N
D

Fig 1

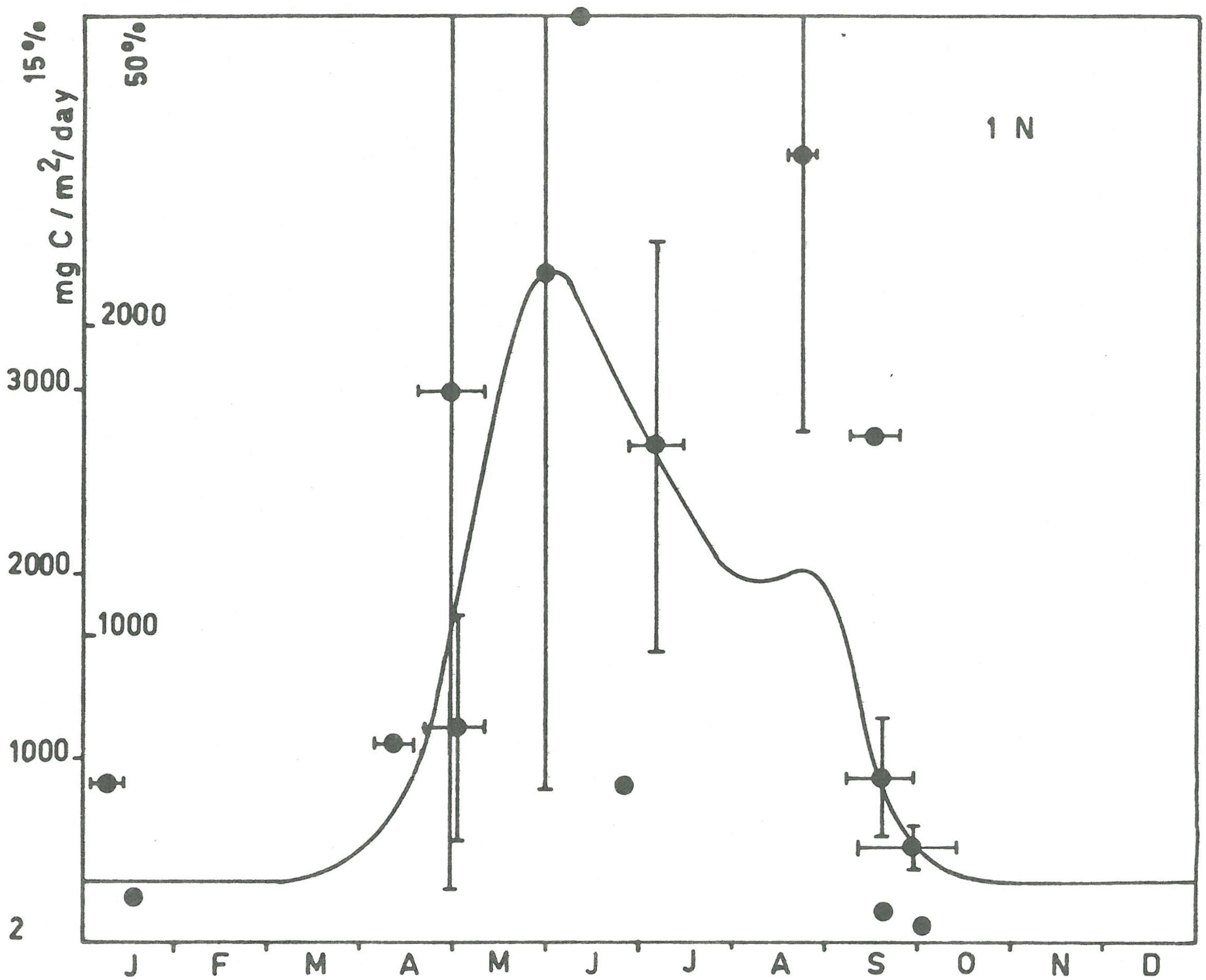

Fig 2

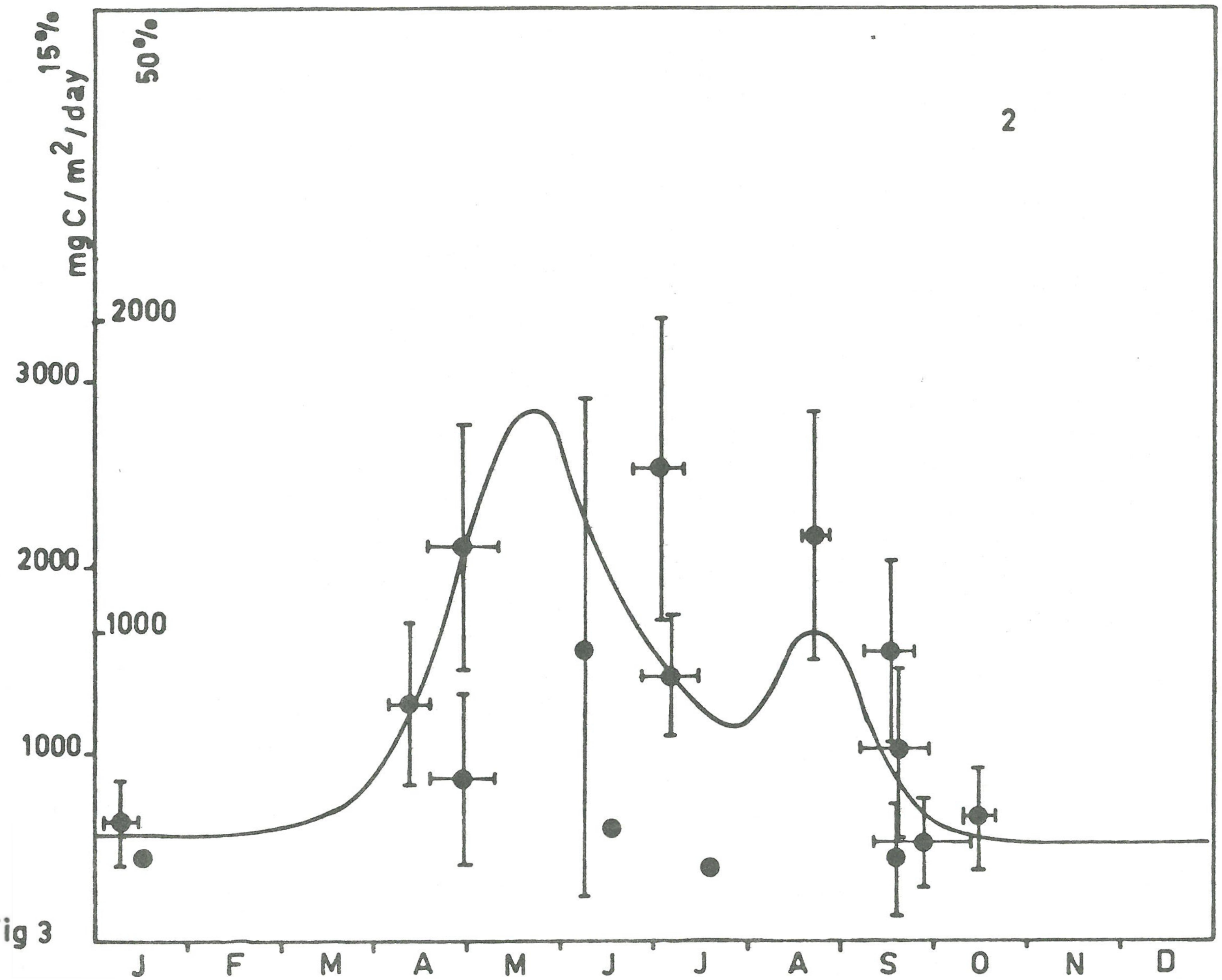

Fig 3

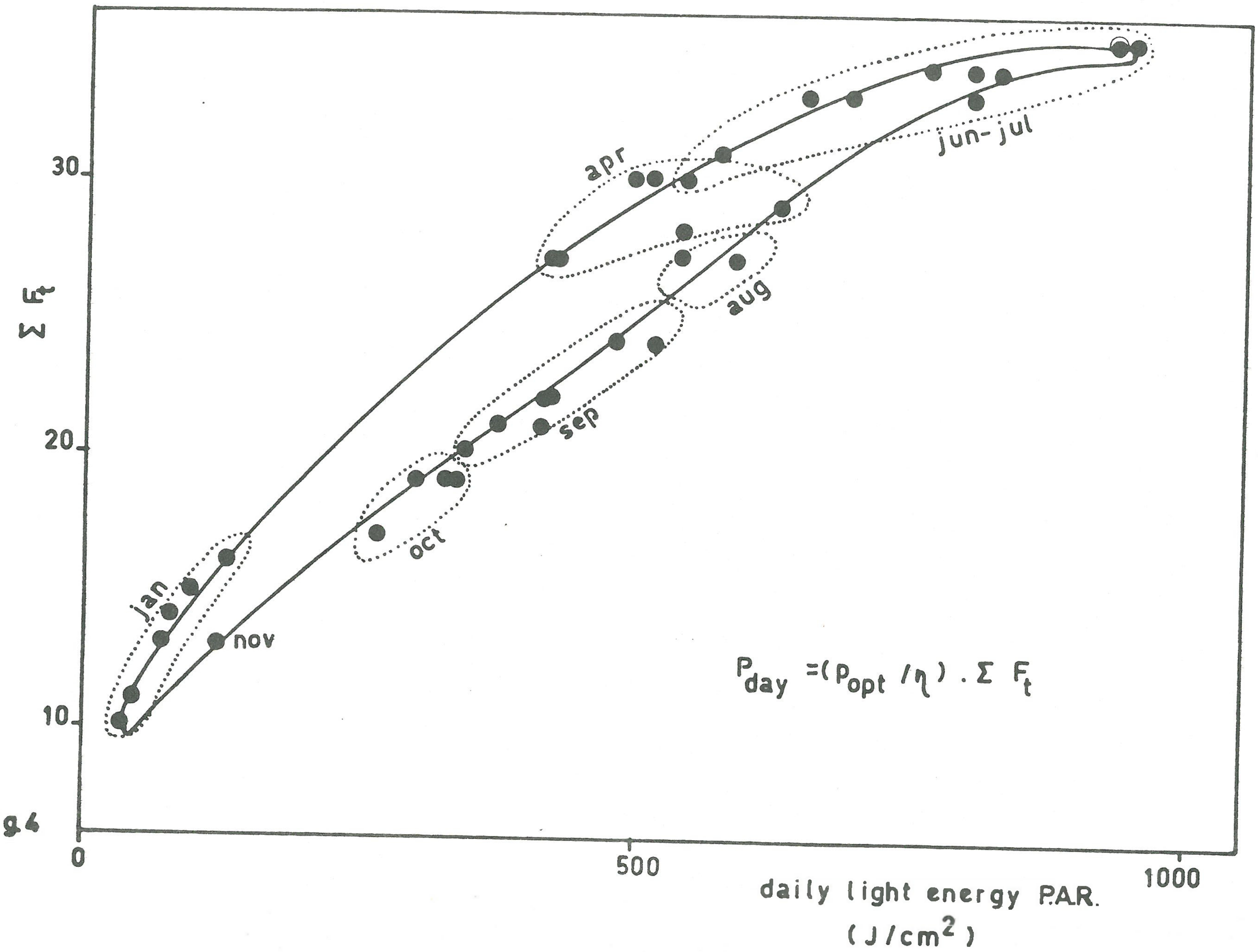
Σ Ft
30
20
10
0
500
1000
daily light energy P.A.R.
(J/cm2)
jan
nov
oct
sep
aug
apr
jun-jul
P_day =(P_opt /η) . Σ F_t

Fig.4

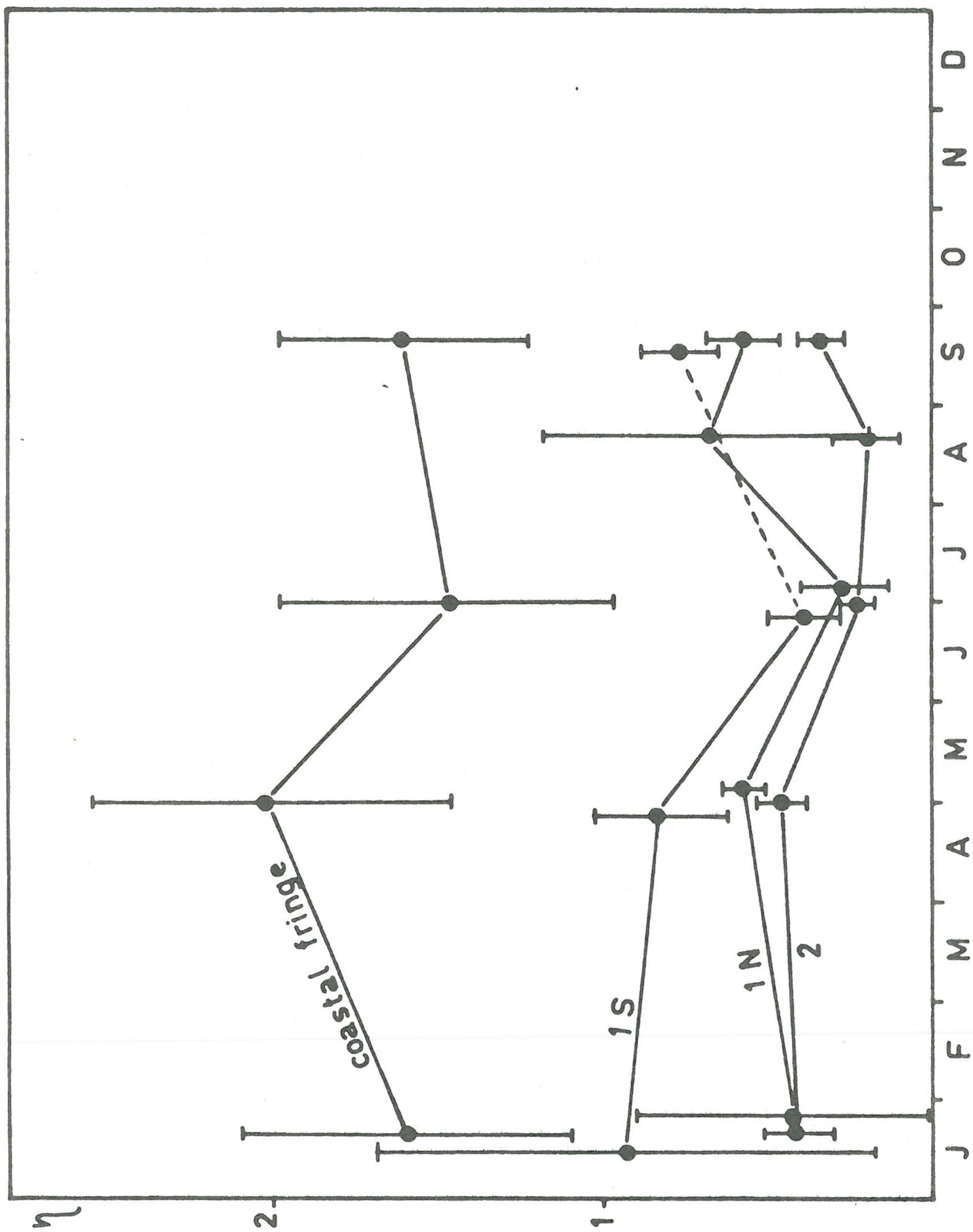

Fig5

Fig. 10