Difficulties in sampling for estimation of phytoplankton biomass in estuarine conditions : variabilities and precisions at different temporal scales in the case of the bay Marennes-Oleron

by

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ABSTRACT : Different sampling strategies have been tested for estimation of phytoplanktonic biomasses in a bay submitted to estuarine conditions and high velocity of currents. Daily variations showed that for a precision of 5 % of the daily mean, it is necessary to sample with a 1 hour and a half time scale. Systematic sampling appears to be more precise than the random sampling.

A sampling during 35 days at low tide and at high tide, during the phytoplanktonic bloom, showed the large variability between the days. A precision of 30 % of the mean biomass of the month is obtained with a 8 days time scale.

Comparison between tidal cycle sampling (10 % of precision) with a punctual sample in the middle of the day did not show large differences. As the main variability is between the days and not during one day, the authors suggest to sample 2 days by week during the bloom.

Different sampling strategies have been tested for the estimation of phytoplanktonic biomasses in a macrotidal bay submitted to estuarine conditions and high velocity of currents. The study has been realised in two areas in the center of the bay (station 1, fig. 1) which is well representative of the evolution of the whole bay (Héral et al., 1983) and in the external estuary of the river Charente (station 2, fig. 1).

Material and methods

Differents time scale have been tested :

- the daily variation by measurement of continuous fluorescence with a Turner 112 fluorimeter connected to a flow system and to a computer,

- the interdaily variation is studied by measurement during 35 days at low tide and at high tide the concentration of chlorophylle a and pheopigments retained on Watmann GFC filter, extracted with aceton 90 % and dosed with a fluorimeter following the method of Yentsch and Menzel (1963).

- the seasonal variations have been achieved by bimonthly measurements of the plytoplanktonic biomass with the same technics in half a tidal cycle (6 samples at 2 deepths by day) and are compared with a punctual sample in the middle of the day at the same station, the same day. This study has been realised during 3 years in 1979-1980 and 1985.

The percentage of precision of the mean of the plytoplanktonic biomass in relation with the time of sampling is calculated with a systematic sampling and a random sampling.

The formulas used are described in Cochran (1977) with :

$$\bar{Y}i = \frac{\sum_{i=1}^{n} Yi}{n}$$

$\bar{Y}i$ = mean, Yi = sample, n = number of sample.

The variance of the estimated mean is for the systematic sampling :

$$V\bar{y} = \frac{N - 1}{N} \quad S_2 - \frac{k\,(n - 1)}{N} \quad S^2 wsy$$

$V\bar{y}$ = variance

N = nk with n = number of units and k = random of sampling.

$$S^2 = \frac{\sum_{i=1}^{n} (yi - \bar{y})^2}{n - 1}$$

and $$S2\ wsy = \frac{1}{k\,(n - 1)} \sum_{i=1}^{k} \sum_{j=1}^{n} (yij - \bar{y}i)^2$$

where yij is the j^{th} member of the i^{th} systematic sample.

The variance of the estimated mean of a simple random sample is :

$$V\bar{y} = \frac{N - n}{N} \cdot \frac{S^2}{n}$$

and Cochran (1977) precised that the mean of a systematic sample is more precise than the mean of a simple random sample when

$$S^2_{wsy} > S^2$$

Results

Daily variations (fig. 2A-B, 3A-B)

Two signals are analysed at neap tide and spring tide during 10 hours. It appears large variation during the tidal cycle (fig. 2A-B) with a maximum wich occurs 2 hours before the low tide in relation with the estuarine origin of the water masses and resuspension of the phytobenthos. Daily variations show that for a precision of 5 % of the daily mean of the phytoplanktonic biomass it is necessary to sample with

a 1 hour and a half time scale (fig. 3A-B). Systematic sampling appears to be more precise than the random sampling.

Interdaily variations (fig. 4, 5)

A sampling during 35 days at low tide and at high tide, during the season of the main annual phytoplanktonic bloom showed a large variability between the days. It can be noted that the first peak was in relation with a strong wind wich resuspended the sediment, the phytobenthos and the oyster biodeposits. During the 35 days, the minima of chlorophylla concentrations occured at the neap tides, periods where the turbidities are also minima, demonstrating the relation between the velocity of the currents and the tide amplitude (Héral et al., 1987). With a 10 days time scale a precision of 80 % of the mean biomass is obtained, with a 8 days time scale the precision is 40 %, with a 2 days time scale the precision is 15 % with a systematic sampling.

Comparison between tidal cycle sampling and punctual discrete sample (fig. 6)

The comparison between the two technics at the same station have been achieved during 3 years (1979, 1980, 1985). The daily variations have been sampled during half a tidal cycle with one sample each 2 hours which permit to obtain a precision better than 10 %. During the spring time and the begining of the summer it appears no difference between the mean of the day and a punctual sample taken in the middle of the day. In a given day, the phytoplanktonic bloom is so large, that the water masses of the bay present the same evolution. This correspondance is not valuable for the other seasons (Héral et al., 1987).

Discussion - Conclusion

To obtain precise estimation of the phytoplanktonic biomass, it is necessary to develop occurate sampling strategy. In an estuarine macro-tidal area, the main variability is between the days function of the tide amplitude and the condition of the weather. Wind velocity cause significant resuspension in the water column of mineral matter, of particulate organic matter and of phytoplanktonic and phytobenthic spe-

cies. As Demers et al. (1987) precised this resuspension can provide an increased food suply to the benthos filter feeders. To study the trophic relations between water column and filter feeders all these variations must be estimated to avoid large biases (Bacher et al., 1989). For these reasons as the main variability is between the days and not during one day, the authors suggest to sample 2 days by week during the bloom, solution which is unfortunatly lot time consuming.

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Figure 1 : Location of the sampling sites.

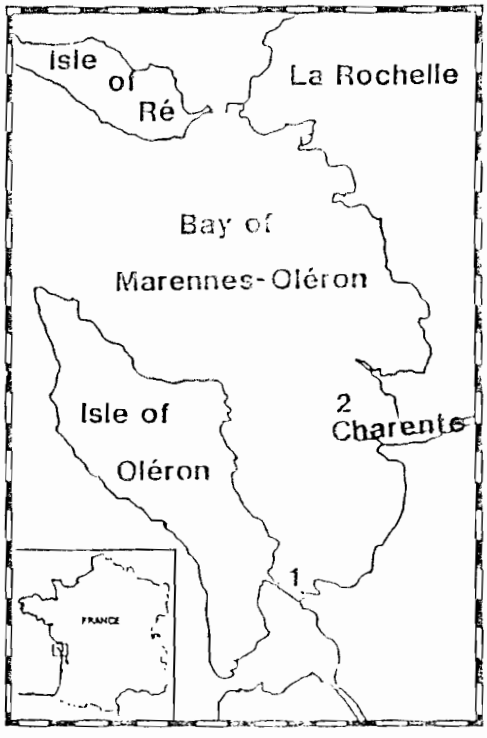
Figure 2 : Signal obtained by continuous measurements of in vivo fluorescence and expressed in ug of chlorophyll a by liter.
A: Signal of neap tide, station 2 : estuary of Charente.
B: Signal of spring tide, station 2 : estuary of Charente.

Figure 3 : Percentage of precision (95 %) of the daily mean concentration of chlorophyll with random ( ) and systematic sampling ( ).
A for the sampling of the signal A of the figure 2.
B for the sampling of the signal B of the figure 2.

Figure 4 : Evolution of biomass of phytoplankton estimated by measurements each day at low tide ( ) and high tide ( ) (st = spring tide, nt = neap tide).

Figure 5 : Percentage of precision (95 %) of the monthly mean concentration of chlorophyll a with random ( ) and systematic sampling ( ).

Figure 6 : Evolution of the concentration of chlorophyll a sampled in tidal cycle ( ) and in punctual discrete sample (☆).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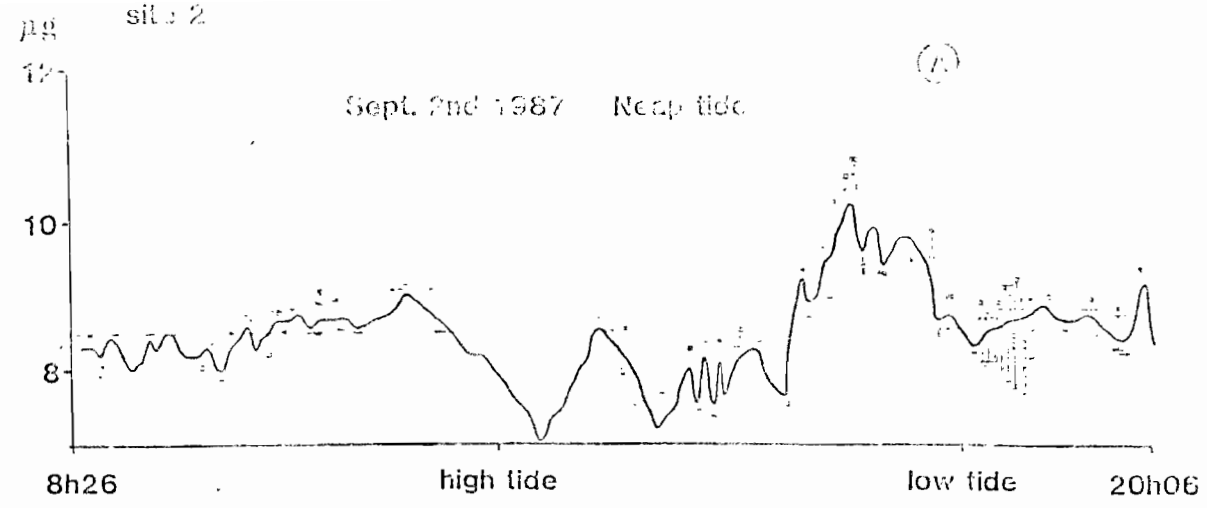
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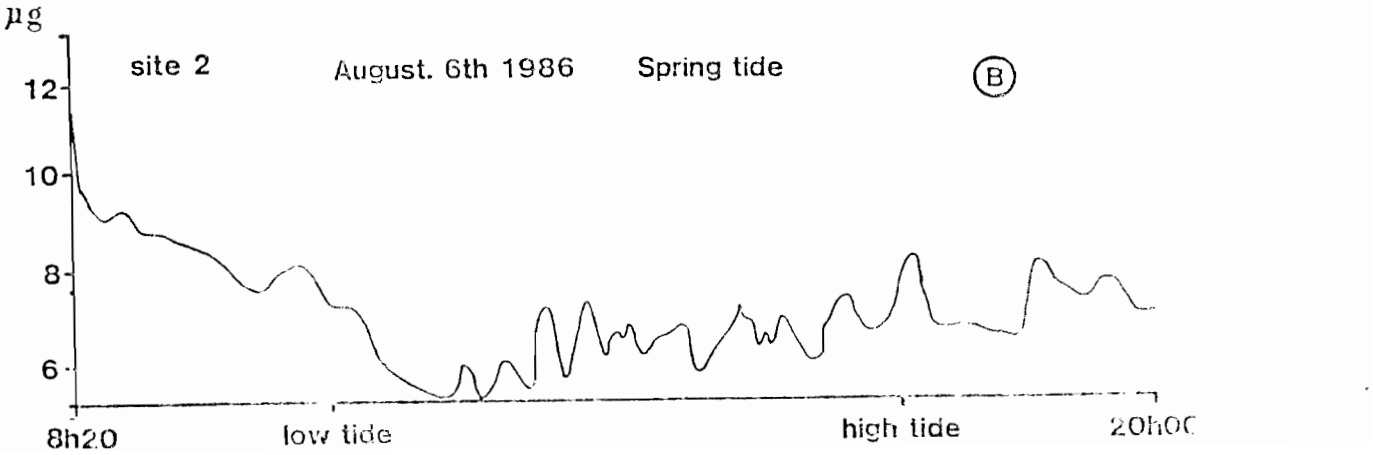
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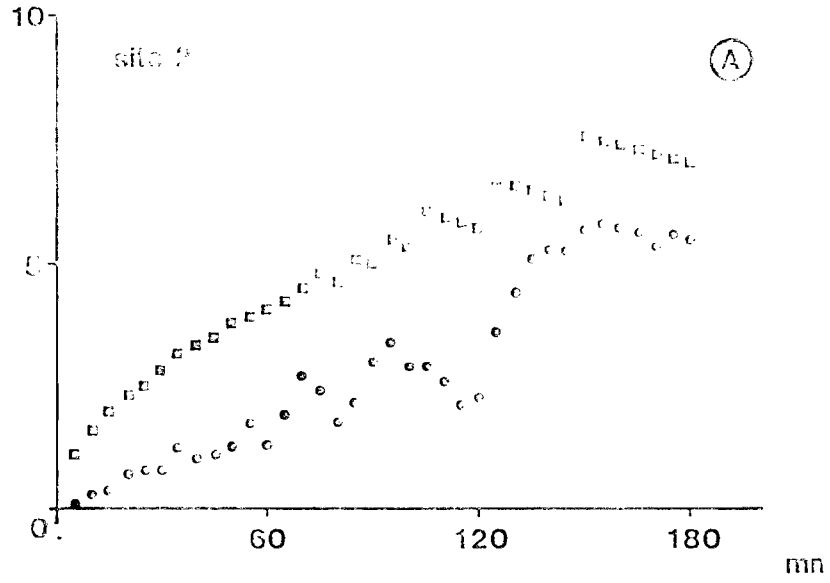
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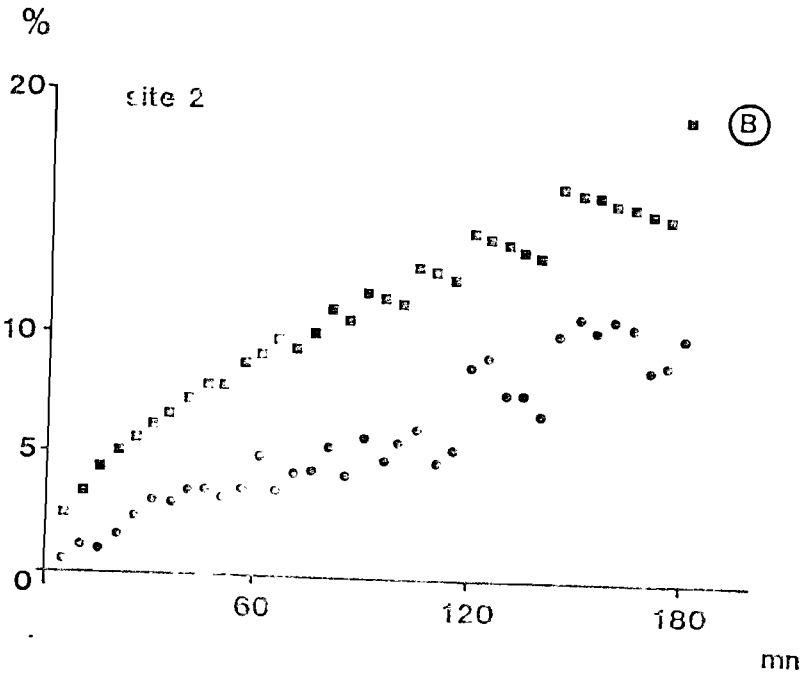
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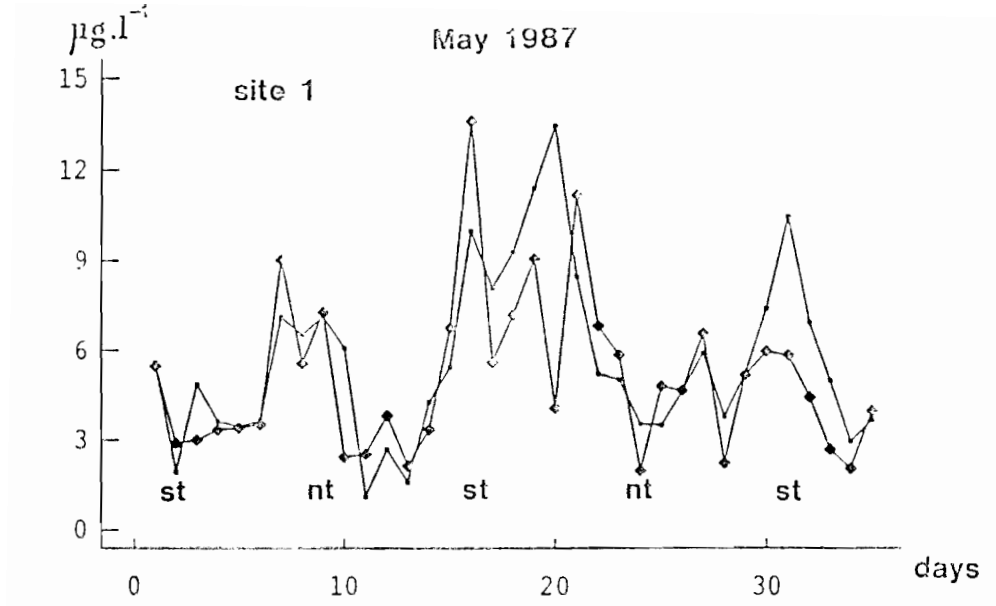
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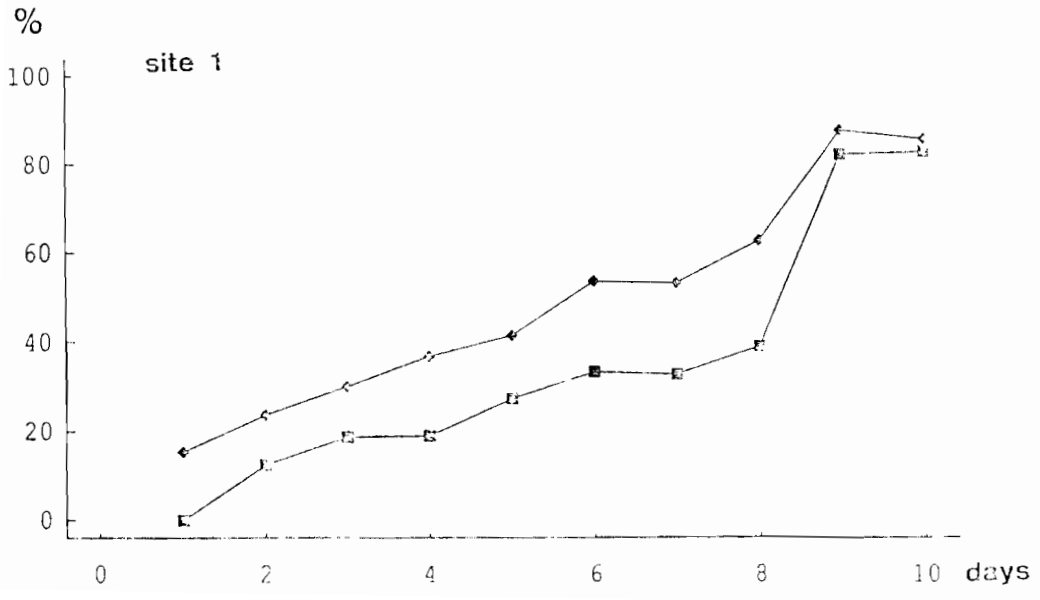
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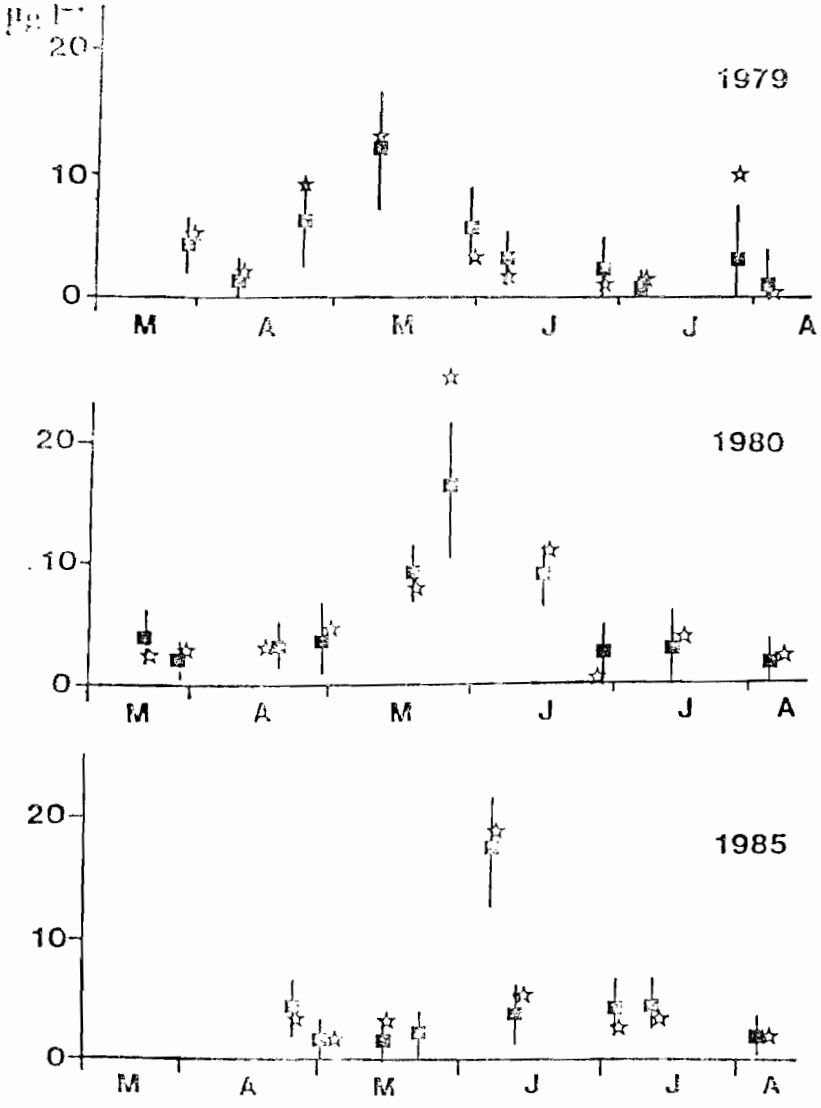
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