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# Results of $^{14}C$- and $O_2$ measurements in relation to PAM-fluorescence measurements

In order to compare the results obtained with the $^{14}C/O_2$-based methods and the fluorescence-based methods (PAM) four experiments were carried out during the workshop (Tab.1). The different PAM devices are described by Domin et al. in this volume. For $^{14}C$-based primary production rates (PPR) small aliquots (20ml) of the mesocosm sample at 10:30am were incubated simultaneously in a photosynthetron (Tilzer et al. 1993) at 18° ±1°C at 8 different irradiances for one hour (9; 36; 72; 102; 238; 285; 409; 521 µE $m^{-2}$ $s^{-1}$). A complete description of the $^{14}C$ method is given by Krumbeck et al. in this volume. The $O_2$ measurements were performed with the MK2 Light Pipette (Illuminova) (description in Wolfstein & Hartig 1998 ) in a custom designed plexiglass chamber, which was equipped with a port for the fiberoptic of the PAM 2000. This allowed simultaneous measurements of fluorescence and $O_2$ release.

**Tab.1** Experiments performed and methods used

| Experiment | Sampling time (Mesocosm) | Fluorescence-devices | Classical-method |
|---|---|---|---|
| | | | |
| 1 | 10:30 a | PAM 101 (PM) | $^{14}C$ |
| 2 | 10:30 a | PAM 2000 | $O_2$ |
| 3 | 10:30 b | PAM 2000 | $O_2$ |
| 4 | 16:30 | PAM 2000 | $O_2$ |

Because the values for the electron transport rates of PSII (ETR) are relative, they were scaled to the value range of the carbon assimilation rates ($C_{ass}$) and the oxygen production rates ($O_2$) respectively to provide a better comparison of the values obtained by the different methods according to equation 1:

ETR (after equation 1) = (ETR – y) / m (1)

With: y = offset of the linear regression between ETR and $C_{ass}$ or $O_2$.
m = slope of the linear regression between ETR and $C_{ass}$ or $O_2$.

Photosynthesis vs Irradiance (P-I) - curves for experiment 1 derived with the PAM and the $^{14}C$ method are shown in Fig. 1a .Over the whole investigated incident irradiances both curves (ETR, $C_{ass}$) show nearly a similar shape (Fig.1b). These observations lead to a very linear correlation between C-based ($C_{ass}$) and fluorescence- based (ETR) values (r = 0.99) when both methods are compared directly (Fig. 1c). The small deviations at irradiances between 140 and 380 µE $m^{-2}$ $s^{-1}$ could be caused by quenching mechanisms that diminished the fluorescence values without affecting carbon fixation. A possible explanation for the small deviations at irradiances over 410 µE $m^{-2}$ $s^{-1}$ could be due to electron flow into sinks other than $CO_2$ fixation (see Hartig & Lippemeier in this volume). However the observed differences were very low and in this case the fluorescence values could be used for accurate estimation of $^{14}C$ fixation rates.

The comparison between the oxygen - and the fluorescence-based values for the sample at 10:30 where also $^{14}C$ – incorporation was measured (Tab.1) also showed a very good correlation (r = 0.98) between both methods (Fig. 2a-c). The slightly higher ETR-values at irradiances between 70 and 250 µE $m^{-2}$ $s^{-1}$ could be explained by cyclic electron flow around PSII. For experiment 4 we found a nearly perfect correlation (r = 0.998) (Data not shown). A linear analysis (r = 0.985) for all oxygen vs fluorescence experiments leads to the conclusion that the fluorescence values could also be used for accurate estimation of production rates (Fig. 3).

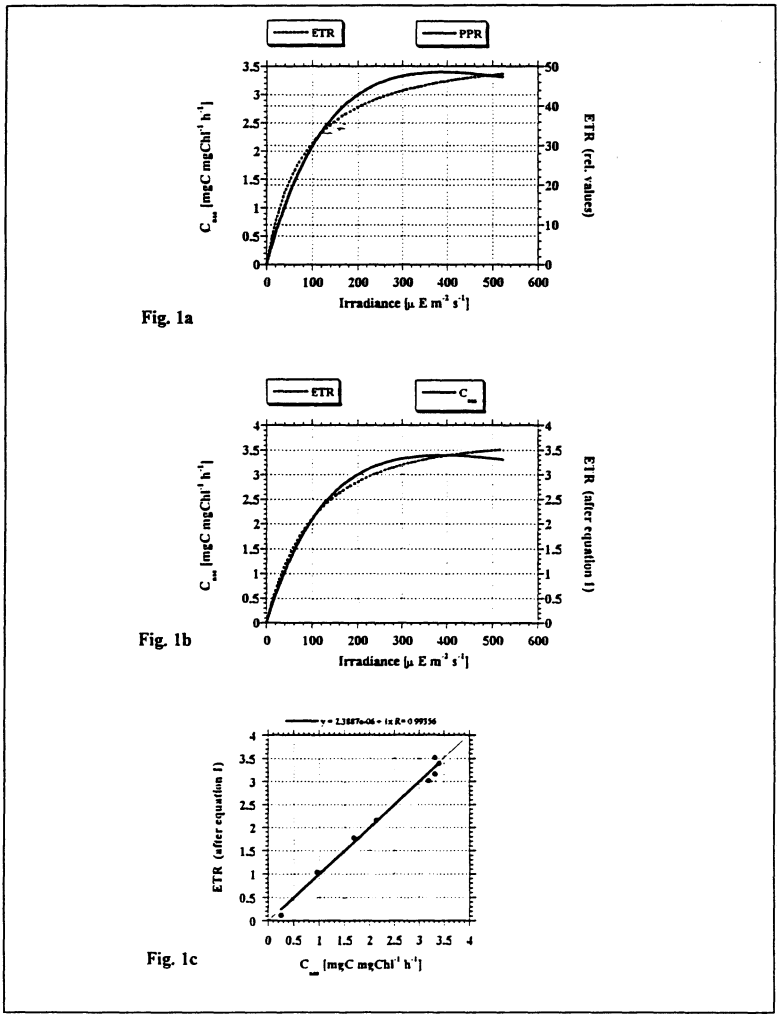


**Fig. 1** Comparison of fluorescence and radiocarbon measurements

1a: P vs I – curves for fluorescence based (ETR) and carbon– based ($C_{ass}$) measurements. ETR was calculated after equation $[(F_m'-F)/F_m' \bullet I]$. For abbreviations see Dau et al. in this volume.

1b: P vs I – curves for ETR (after equation 1) and carbon– based ($C_{ass}$) measurements. ETR (after equation 1) was calculated after equation 1 see text.

1c: Correlation between ETR (after equation 1) and $C_{ass}$

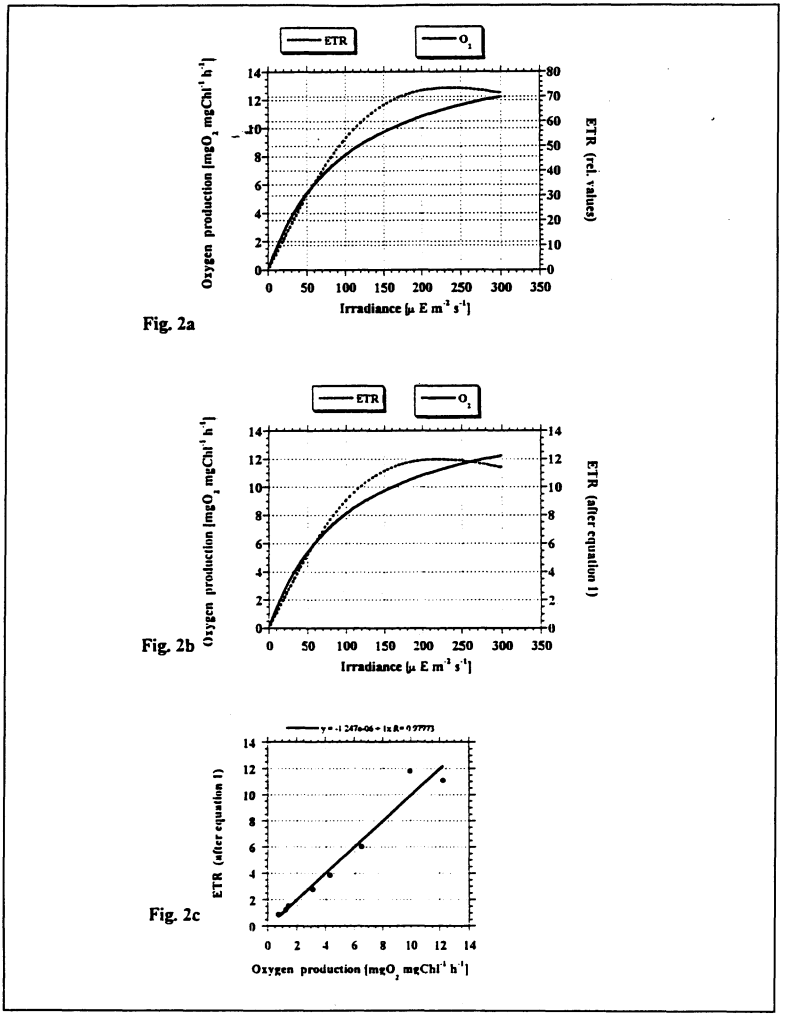


**Fig. 2** Comparison of fluorescence and oxygen exchange measurements

2a: P vs I – curves for fluorescence based (ETR) and oxygen– based ($O_2$) measurements. ETR was calculated after equation [$(F_m'-F)/F_m' \bullet I$]. For abbreviations see Dau et al. in this volume.

2b: P vs I – curves for ETR (after equation 1) and oxygen– based ($O_2$) measurements. ETR (after equation 1) was calculated after equation 1 see text.

2c: Correlation between ETR (after equation 1) and $O_2$

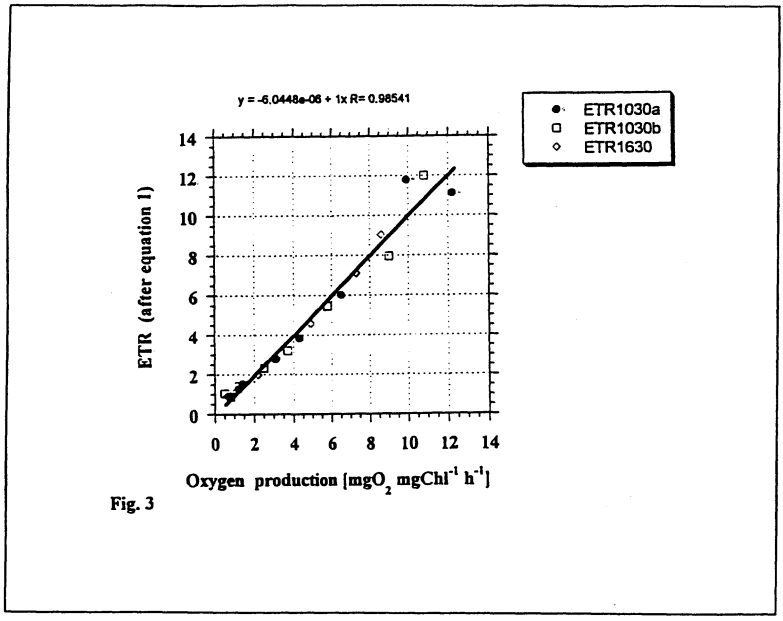


Fig. 3

**Fig. 3** Correlation between ETR (after equation 1) and $O_2$ for all oxygen measurements (experiments 2,3,4).

The good correlation between C- based and fluorescence based values could be due to the fact that we measured rather gross production than net production, because of the short incubation time (1h). It has to be mentioned that some of the observed deviations between the different methods could be due to difficulties of the irradiance measurements in concentrated algal samples (see Forster, this volume). For calculation of absolute values an estimation of the PSII concentration and of the functional absorption cross section of PSII by fluorescence techniques is needed (Kieber & Falkowski 1993, Hartig et al.1998). Development of this technique is already in preparation and calculation of these parameters will hopefully be possible during the next workshop.

**References**

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