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The mesocosm approach for direct comparison of photosynthesis measurements based on active fluorescence (PAM)-, O₂- and ¹⁴C- methods

The Mesocosm-System used for a direct comparison of the different methods for determination of primary production consisted of a polyethylene-container of approximately 1m³ volume (0.9m x 1.1m x 0.98m). The white walls of the container were shaded by black sheets, resulting in a steeper irradiance gradient compared to the field situation, and complicating calculations of obtained light doses for all incubations. The container was filled with a field sample of water from the Darss-Zingst-estuary in the evening hours of the 7.10.1997. Salinity, measured as electrical conductivity of the sample, was 7,2 ‰. Permanent mixing was obtained by means of 2 radial pumps with a throughput of approx. 3l min⁻¹ each.

Irradiance above the surface (incident irradiance) was monitored continuously by means of a cosine-corrected PAR-sensor (LiCor 190, LiCor Inc., USA) mounted alongside the mesocosm. A spherical underwater sensor (LiCor 193, LiCor Inc., USA) installed at 0.68m depth was used as a reference for verification of the calculations of light doses at the individual incubation depths. Data from both detectors were automatically recorded with a datalogger. Figure 1 shows the irradiance data measured on the 8.10.1997 with the two sensors mentioned above. The mesocosm was used for several different types of in-situ incubations on the 8.10.1997. The exact positioning of the various vessels are listed in Table I.

During the incubation period oxygen concentration, temperature and pH of the mesocosm were measured every 30 minutes. The course of these parameters are shown in figure 2.

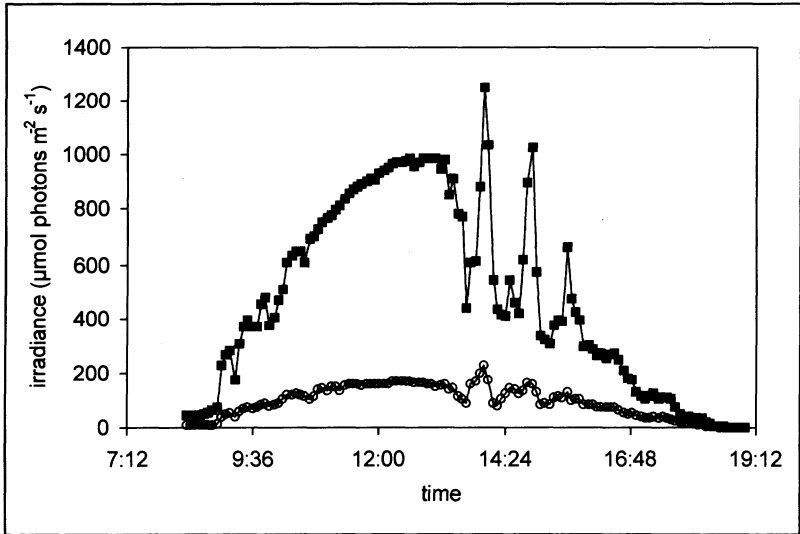


Fig. 1 Surface and underwater irradiance measured in and alongside the mesocosm at Zingst, 8.10.1997. Filled squares: surface irradiance (cosine-readings), open circles: spherical sensor readings at 68cm depth.

Tab. I Location of the in-situ incubation vessels within the mesocosm.

Corners and walls were facing to: corner I East, wall A South-East, corner II South, wall II South-West, corner III West, etc..

Inkubation	position (distance in cm from)					
	corner	first wall	cm	second wall	cm	depth (cm)
Dialysis chamber	II	A	18	B	18	variable
Lift system, small vials	III	B	29	C	30	variable
Lift system, 250ml vials	IV	C	35	D	31	variable
static incubation	I	A	59	D	19	25cm steps, starting at 2cm
LICOR 193UW	III	B	25	C	43	68

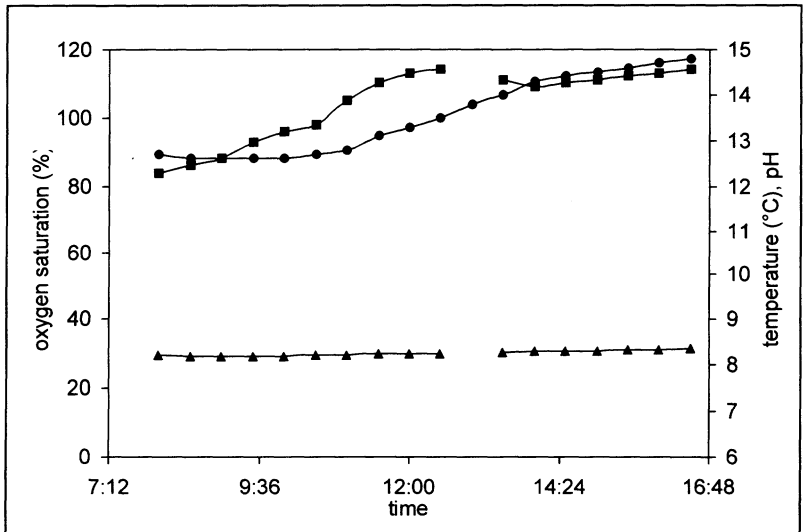


Fig. 2 Course of abiotic parameters of the mesocosm during 8.10.1997

Filled squares: oxygen saturation (%), left y-axis), filled circles: temperature (°C, right y-axis), filled triangles: pH (right y-axis).

For calculating the total light doses received by each of the in-situ incubations, attenuation spectra were measured in the shaded and unshaded part of the mesocosm. There were almost no differences found in slope and absolute values between the two spectra obtained, therefore all calculations were performed on the basis of the spectra obtained in the unshaded part (Figure 3). For calculating irradiances in the shaded part from the surface data, the following algorithm was used:

- 1) calculation of sub-surface irradiance from cosine-corrected just-above-surface readings (adjusted for losses due to reflection) using the equations published by Walsby (1997),
- 2) calculation of underwater irradiance at the depth at which shading starts by means of the attenuation spectrum,
- 3) calculation of the alteration of the irradiance climate within 10 cm of leaving the unshaded part by means of the "conversion spectrum", obtained by averaging 10 measurements across the shadow-line in

- the mesocosm (each reflecting the irradiance difference within 10cm above and below the shadow line) at different depths, and
- 4) calculation of the irradiance at the incubation site, using the attenuation spectrum as in B) for the remaining depth until incubation depth.

Attenuation and conversion spectra are shown in Figure 3, and calculation of the shadow depth at any particular time point was performed by means of a matrix basing on the equations given by Walsby (1997).

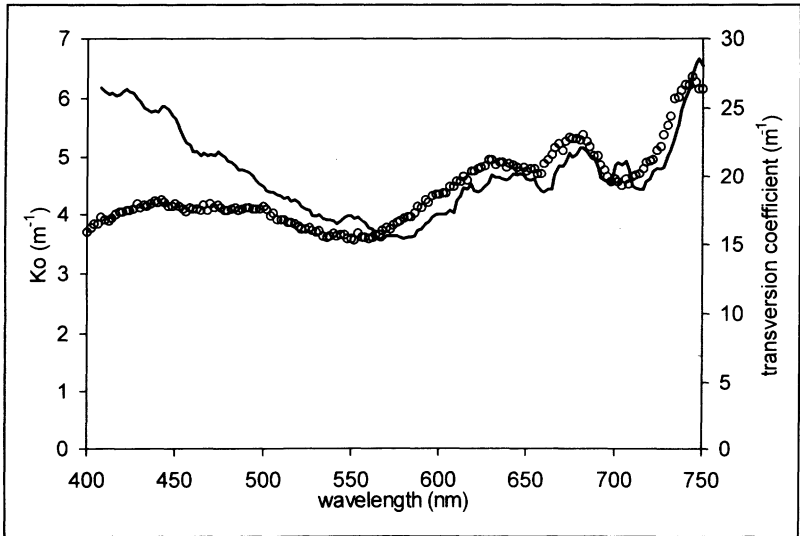


Fig. 3 Attenuation and conversion spectrum

Solid line: attenuation spectrum, measured in the unshaded part of the mesocosm, open circles: "conversion spectrum" obtained from 10 measurements of the alterations of the light climate within 10cm of the shadow line at different depths. The measurements for both spectra were performed with a MACAM SR 9910 spectroradiometer (MACAM Inc., Scotland). The procedure and calculations are described in detail in Schubert et al. (1995).

This matrix was designed to calculate the depth until shading started by comparing 3D-location of the sample with solar position for any time, taking the geometry of the mesocosm into account. It is part of a spreadsheet which is able to calculate the incubation irradiance for dynamic and static incubations and can be obtained free from the authors (german version).

Simultaneously with the in-situ incubations, samples were taken out of the mesocosm and processed for the laboratory investigations, as will be described in the following articles.

References

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- WALSBY, A.E. (1997): Numerical integration of phytoplankton photosynthesis through time and depth in a water column. *New Phytol.* 136, 35-48

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