Relationship of fluorescence rapid light curves to photoacclimation status and non-photochemical quenching in benthic diatoms

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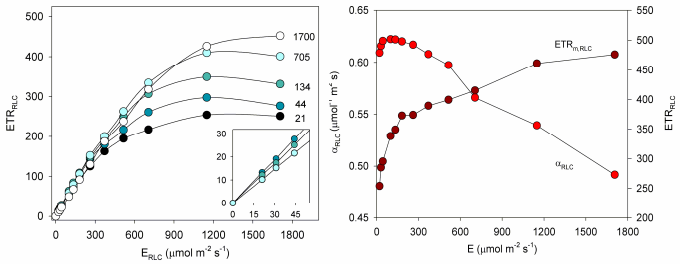
RLCs vs short-term photoacclimation

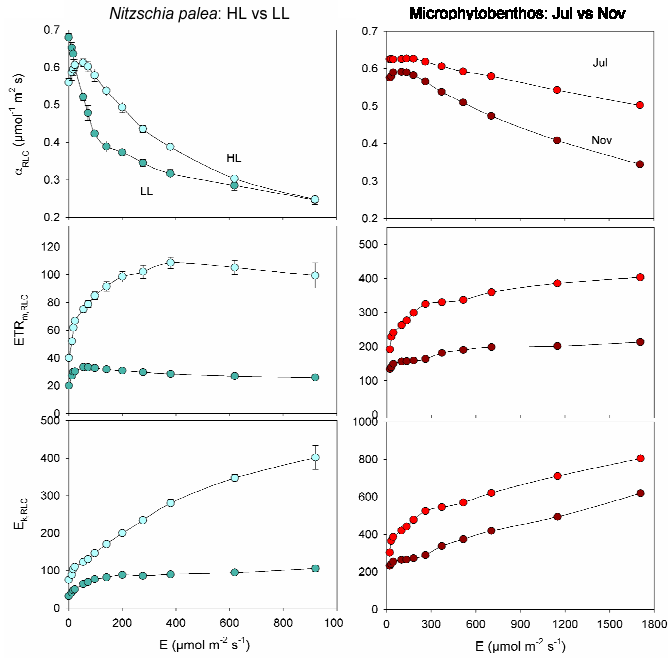


Rapid Light Curves (RLCs) varied with short-term photoacclimation status

- RLC varied with ambient irradiance (*E*), the irradiance level to which the sample is acclimated to immediately before the start of the curve
- The response of RLC parameters to ambient irradiance was often by-phasic, both for light-limited (initial slope, α_{RLC}) and light-saturated (maximum relative ETR, $ETR_{m,RLC}$) parts of the curve
- α_{RLC} and $ETR_{m,RLC}$ increased under low ambient light (E < 20-180 µmol m^{-2} s^{-1}); under higher E levels, α_{RLC} decreased significantly while $ETR_{m,RLC}$ continued to increase but at a lower rate

- RLCs were measured after samples were photoacclimated to different levels of ambient irradiance, using increasing light steps of 10 s
- Measurements were made on a benthic diatom *Nitzschia palea* (Kütz.) W. Smith grown under low light (LL, 20 µmol m^{-2} s^{-1}) and high light (HL, 400 µmol m^{-2} s^{-1}) (12h:12h light:dark, 20 ºC) and on diatom-dominated microphytobenthos suspensions collected in summer (Jul) and winter (Nov)

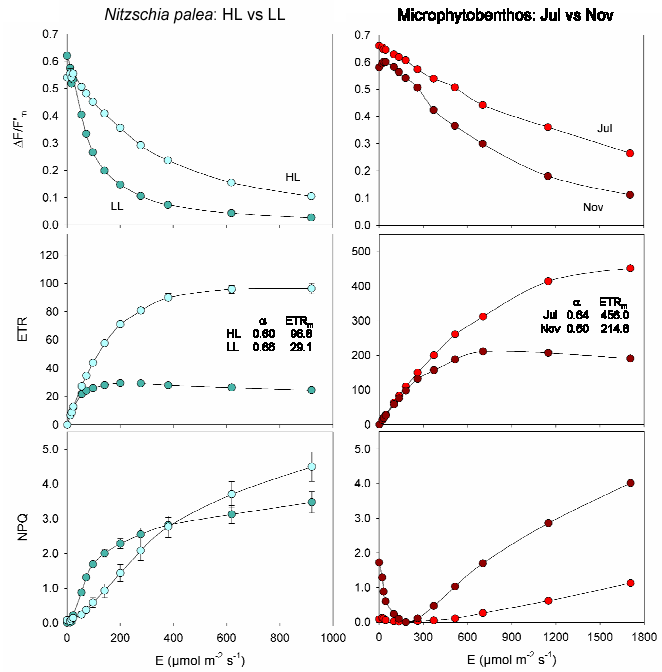
Light response of RLCs and effects of long-term photoacclimation



The light response of RLCs varied with the long-term photoacclimation status

- The bi-phasic light-response pattern of α_{RLC} was not displayed for LL cultures, and was attenuated in microphytobenthos collected in the summer
- $ETR_{m,RLC}$ and $E_{k,RLC}$ increased bi-phasically with ambient irradiance in all cases
- In all cases, after the initial phase of rapid increase, $ETR_{m,RLC}$ displayed a saturation-like pattern, while $E_{k,RLC}$ continued to increase almost linearly
- The maximum values of $ETR_{m,RLC}$ varied significantly with growth irradiance (cultures) and season (microphytobenthos), but always attaining much higher levels in the case of microphytobenthos
- The rate of $E_{k,RLC}$ increase varied with growth irradiance (cultures), but not with season (microphytobenthos)
- The light-response pattern of α_{RLC} and NPQ were virtually symmetrical

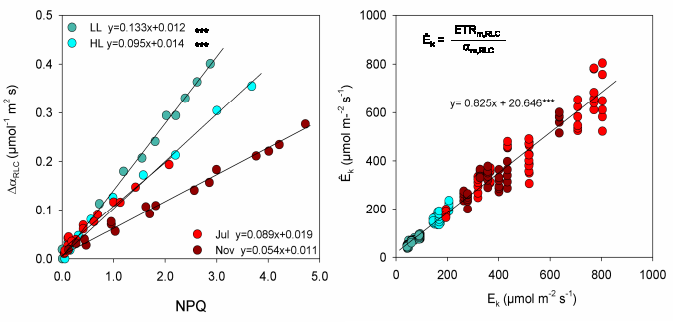
Long-term photoacclimation: steady-state light curves and NPQ



Growth irradiance (cultures) and season (microphytobenthos) determined the long-term photoacclimation status

- The light-response curves of PSII effective quantum yield ($\Delta F/F_m'$), electon transport rate (*ETR*) and non-photochemical quenching (NPQ) measured under steady-state conditions varied markedly with growth irradiance (cultures) and season (microphytobenthos)
- $\Delta F/F_m'$ was consistently higher for HL cultures and for microphytobenthos in summer; the exception were the higher values observed for LL cultures under low irradiances
- ETR vs *E* curves of HL cultures displayed higher maximum relative ETR values (ETR_m) but lower initial slope (α) than LL cultures; for microphytobenthos, both α and ETR_m were higher in summer
- Under low ambient irradiance, LL cultures displayed higher NPQ values; under high irradiance, the highest NPQ levels were obtained for HL cultures
- For microphytobenthos, NPQ levels were in all cases higher in winter
- Very high NPQ levels under low light or darkness were observed for microphytobenthos in winter

RLC vs NPQ, RLC vs E_k



RLCs can be used to estimate NPQ and the parameter E_k of steady-state light curves

- The high light-induced decrease of $\alpha_{m,RLC}$ ($\Delta\alpha_{RLC}$) was found to vary linearly with the NPQ level established immediately before the start of the RLC
- The slope of the $\Delta\alpha_{RLC}$ vs NPQ relationship varied significantly with growth irradiance and with time of collection (hourly to seasonal time scales)
- $\hat{E}_k$, an index based on the ratio of $ETR_{m,RLC}$ (measured for E > 250 µmol m^{-2} s^{-1}) to the maximum value of the α_{RLC} vs *E* curve ($\alpha_{m,RLC}$, measured under low light) was found to correlate significantly with the light-saturation parameter of steady-state LCs, E_k
- A single regression equation described the $\hat{E}_k$ vs E_k relationship of all the data, including LL and HL cultures, and microphytobenthos collected on different seasons

Notation: α - initial slope of a ETR vs *E* curve; $\alpha_{m,RLC}$ – maximum value of a α_{RLC} vs *E* curve; $\Delta\alpha_{RLC}$ – decrease of α_{RLC} under high light (=$\alpha_{m,RLC}$–α_{RLC}); $\Delta F/F_m'$ – effective quantum yield of PSII; *E* – ambient PAR irradiance (light step of a LC); E_{RLC} – light step of a RLC; E_k – light-saturation parameter of a LC; $\hat{E}_k$ – proxy for E_k; ETR – relative electron transport rate; ETR_m – maximum value of a ETR vs *E* curve; F_m' – maximum F_m' value of a LC; LC – steady-state light curve; NPQ – non-photochemical quenching; RLC – rapid light curve; subscript denoting a RLC parameter

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