Corso di Dottorato di Ricerca in Scienze della Vita e dell’Ambiente - Ciclo XXXVIII

Growth and photosynthesis: Exploring algal diversity and adaptations

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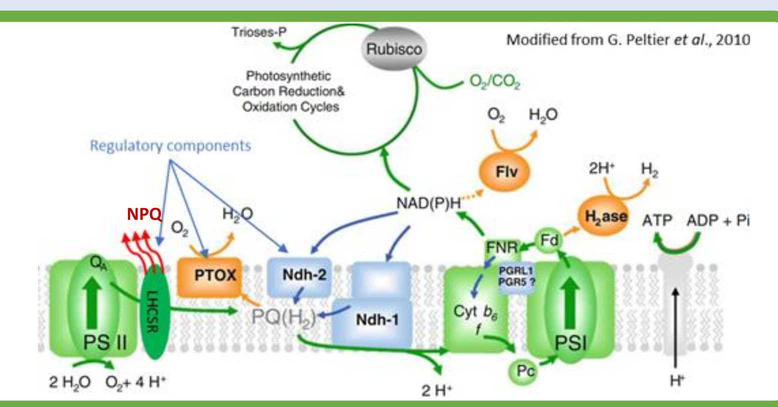
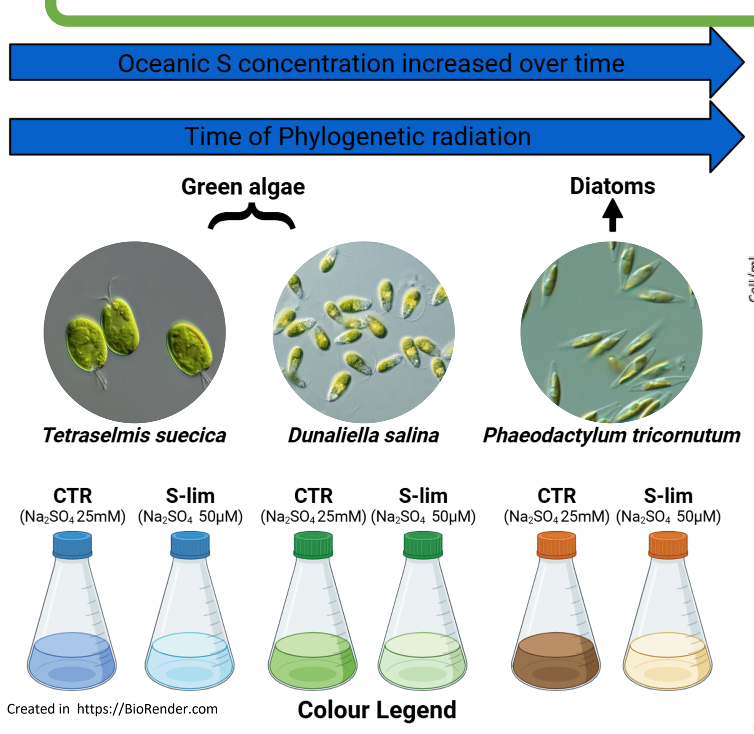
INTRODUCTION

Microalgae are the main **primary producers in our oceans** and **can survive and stive under a great variety of environmental conditions,** from **nutrient poor waters**, to **hypersaline lakes** and **in symbiosis** with other organisms. As such they display a great variability in their phylogeny and physiology.

Photosynthesis is the main source of sustenance in photosynthetic organisms and is regulated in response to changes in environmental factors such as changes in light and nutrient availability. One of the main **regulatory mechanisms of photosynthesis** is **non-photochemical quenching (NPQ)** through which excess energy is dissipated as heat to prevent damage to the photosystems. Also, through acclimation, algae can **change the stoichiometry of photosystems and their antennae to optimise light utilization.**

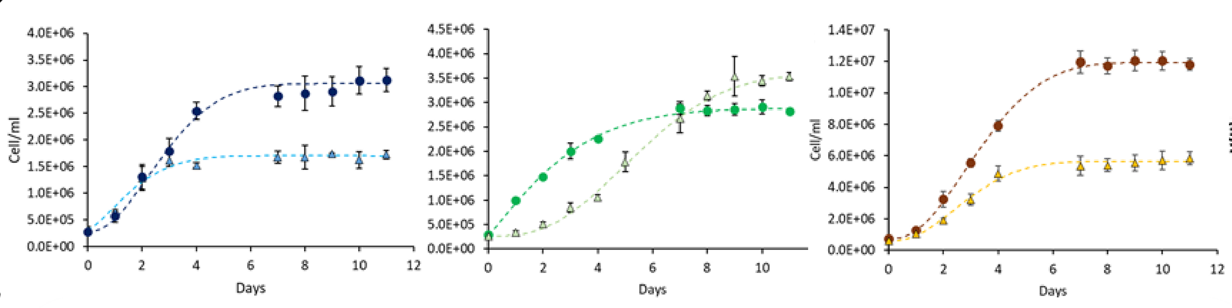


SULPHATE AVAILABILITY

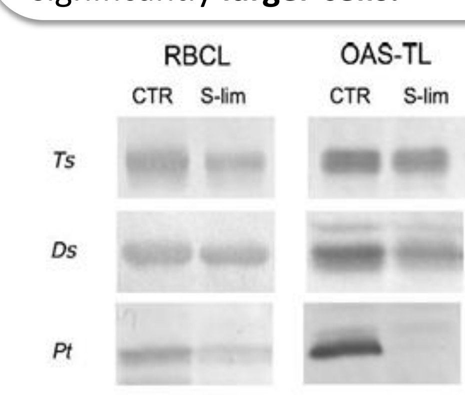


Evolutionary history and environmental conditions at the time of radiation of a group, **influence its physiology. Diatoms have higher S demands** and **radiated** after the green algae, **when S concentrations** were significantly **higher** in the oceans.

Growth and Nutrient assimilation

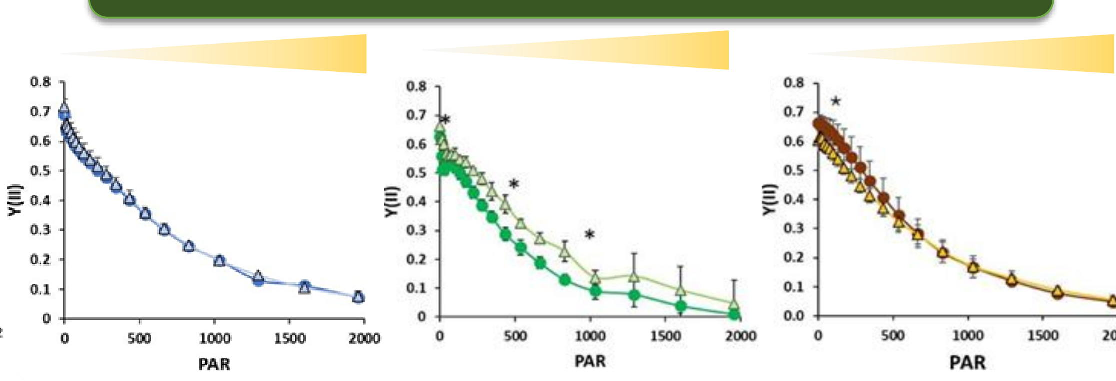


The three species were grown in control (sulphate concentration as in the present oceans) and S limiting conditions (S-lim).
T. suecica maintained it’s growth rate but **reduced max cell** concentration in the culture.
***D. salina* reduced growth rate** with later recovery in cell concentrations.
***P. tricornutum* reduced growth rate and max cell density**, also showed significantly **larger cells.**



The two green algae largely maintain their RuBisCO content and slightly decrease in OASTL, an enzyme involved in **S assimilation into cysteine.** The ***P. tricornutum*** **strongly reduces both RuBisCO and OAS-TL.**

Photosynthesis and Composition



Despite the reduced growth, all species show **maintained photosynthetic efficiency (YII)** with a slight decrease at low light levels in *P. tricornutum*

	T suecica			D salina			P tricornutum		
	CTR	S-lim	stat	CTR	S-lim	stat	CTR	S-lim	stat
%C on DW	49.7±3.6	49.9±1.1		49.1±1.6	47.1±1.3	*	52.3±0.5	50.0±1.4	
%S on DW	0.53±0.12	0.54±0.11		0.21±0.05	0.09±0.02	*	0.43±0.13	0.21±0.05	*

Regarding C and S content ***T. suecica* remains more homeostatic** while both *D. salina* and *P. tricornutum* reduce their S content.
***D. salina* also reduces its C%** while ***P. tricornutum* maintains its C% in its fewer bigger cells.**

Mantaining photosynthetic efficiency is essential to acclimate to low S. The three species differentially compensate growth and composition to maintain photosynthesis.

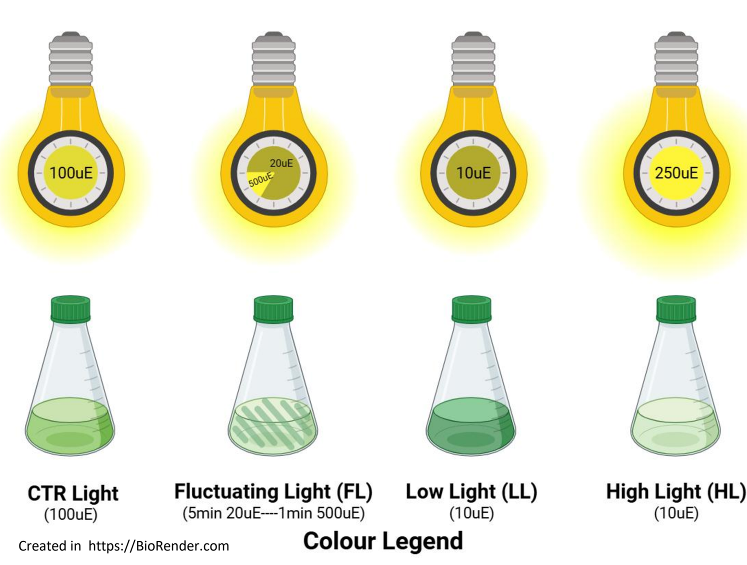
T. suecica remains mostly homeostatic, being the less effected by S-lim.

D. salina modulates its composition and decreases in growth rate but maintains a sustained growth.

P. tricornutum decreases its S and carbon assimilation, possibly altering its cell cycle to retain bigger cells.

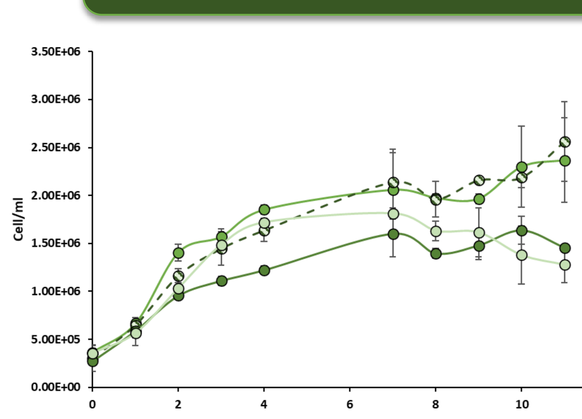
Minio *et al.* submitted

ACCLIMATION TO DIFFERENT LIGHT AVAILABILITY IN *D. SALINA*

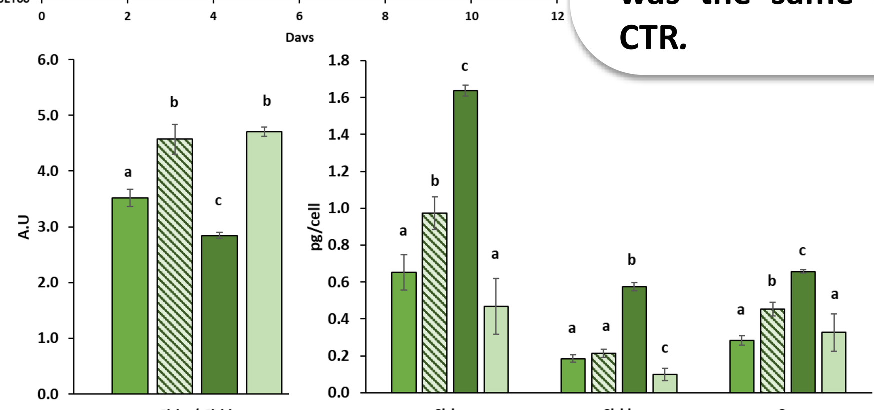


Light is essential for photosynthetic organisms who possess complex regulatory mechanisms to acclimate to a variety of light conditions.
Growth in **Fluctuating light** is **closer to natural conditions** where light levels constantly shift.

Growth and Pigment content



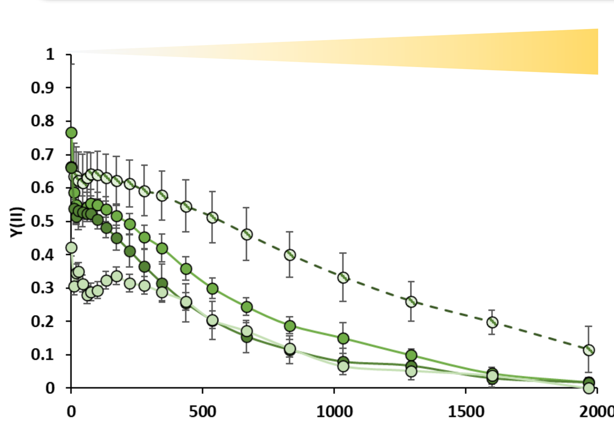
D. salina was grown at three constant light intensities (CTR, LL and HL) and fluctuating light (FL).
In **FL light** the total amount of **Light/time was the same as the CTR.**



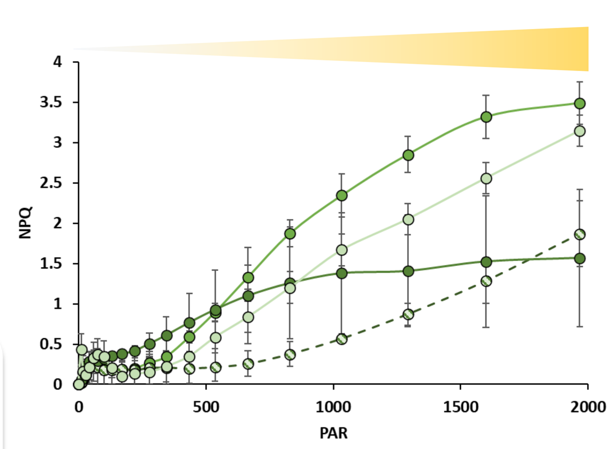
Changes in Chla/b suggest D. salina modulated its antennae size to capture more or less light according to the growth conditions.

FL and HL have the **same Chl a/b ratio** but **opposite trends in pigment accumulation.**

Photosynthesis



Significant **decrease in Photosynthetic efficiency in HL** samples due to excessive light exposure.
FL samples show **higher efficiency** especially at higher light intensities.



In **LL photoprotection** mechanisms **(NPQ)** are **reduced** as they are less needed.
FL retains more NPQ capacity than LL as it doesn’t plateau, **but this mechanism is activated at higher light intensity** to better exploit the few minutes of light it has.

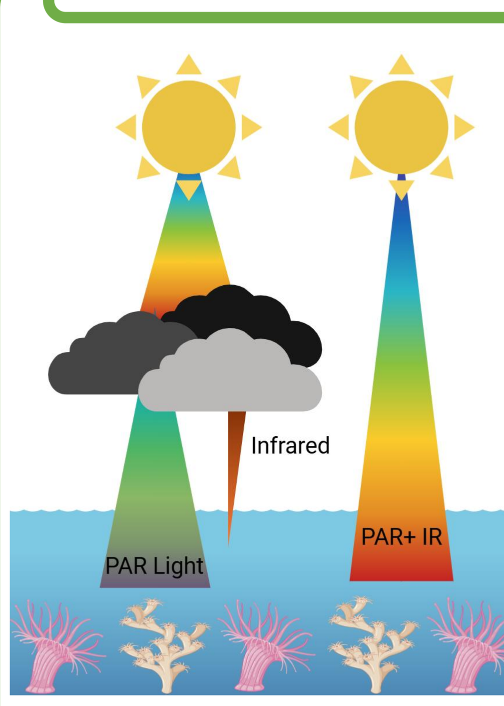
D. salina reorganises its photosynthetic apparatus to acclimate to various illumination conditions.

In **HL** the **photosynthetic apparatus is reduced** to avoid photodamage. Yet, the tested HL conditions are likely stressful for D. salina, as cell/ml decreased in the last days of growth curve, and photosynthetic efficiency dropped with respect to CTR.

In **LL** the photosynthetic apparatus is expanded to capture all available light.

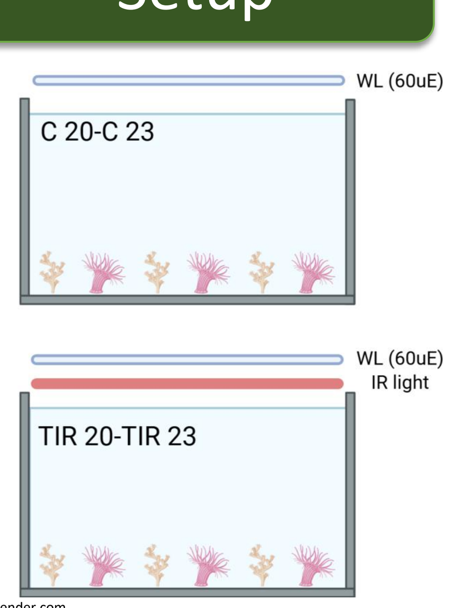
In **FL the use of the few minutes of high light is optimised** by increasing photosynthetic pigments but reducing antennae size reducing damage to PSII during the high light phases.

SYMBIOSIS

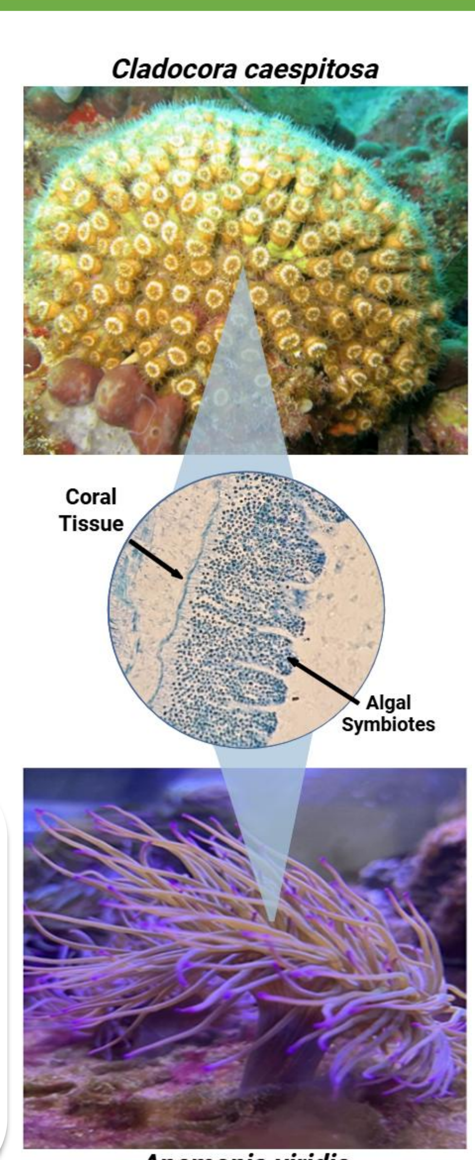


Decreased cloudiness and increased water temperature has been registered in the last decades.
These changes in light and temperature **may impact coral photosynthesis.**

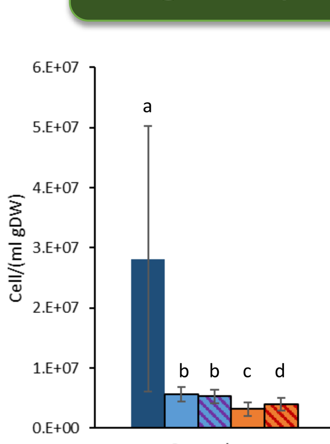
Setup



Corals were acclimated to **increased light** and **temperatures** compared to rearing conditions.
Tanks were illuminated with **white light (CTR) or white light + IR (TIR) at two temperatures: 20 and 23 °C.**

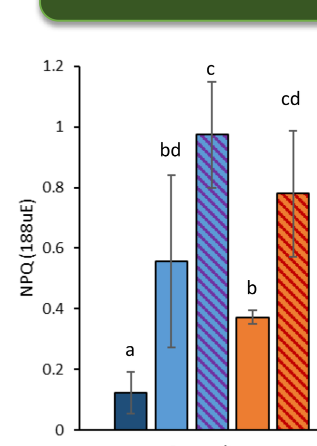


Algal symbiote content



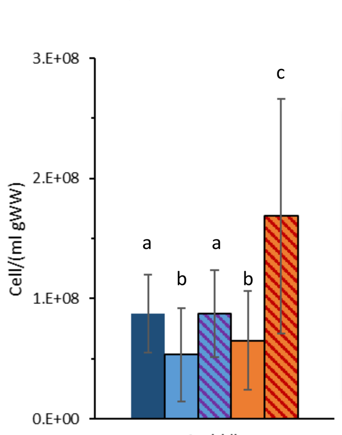
***C. caespitosa*:**
Significant decrease in algal symbiotes after 60 days of acclimation.
Increased light-stress compared to rearing conditions.

Photoprotection

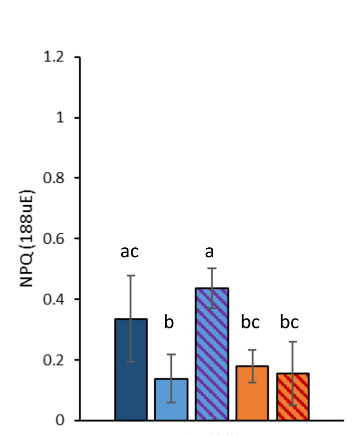


***C. caespitosa*:**
Exposure to **IR** light stimulates **higher NPQ activation** increasing photoprotection.

Day-0 | CTR 20 Day-60 | TIR 20 Day-60 | CTR 23 Day-60 | TIR 23 Day-60



***A. viridis*:**
IR grown samples **retained more algal symbiotes** after 60 days of acclimation.
A. viridis was less stressed by the tested conditions.



***A. viridis*:**
IR increased NPQ at lower temperatures.
NPQ generally **lowered after acclimation.**

C. caespitosa was more **stressed by the increased light and temperature,** and IR stimulated NPQ.

A. viridis maintained its **Symbiont content** being less impacted by the tested conditions. **IR** affected had a **positive effect on Symbiont content.**

An **increase in the IR** portion of available light **signals** increased **closeness to the water surface and light exposure** to the corals (as IR is absorbed in the first cm of water). **Stimulating an increase in NPQ.**

Differences between the two corals could be due to different species of symbiotes. Or their relationship with the host.

This project is in collaboration with Cristina Gioia di Camillo