Photosynthetic Adaptations of Polar Phytoplankton to Extreme Low Light

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Supervised By Dr. Douglas A. Campbell

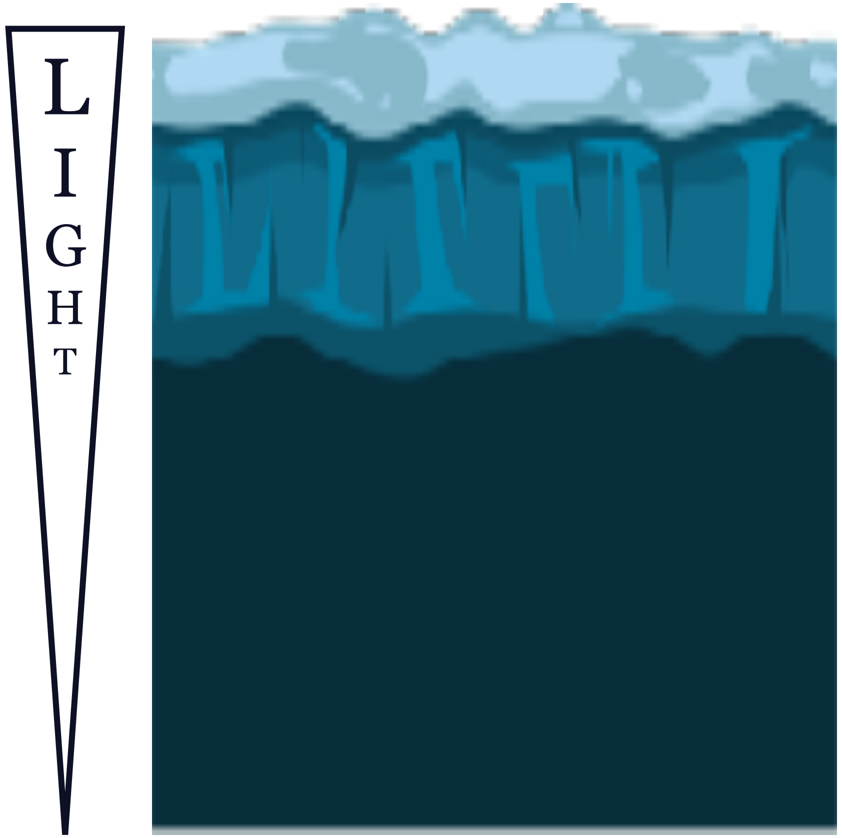
Spring Phytoplankton Blooms

Ardyna & Arrigo, 2020. Nature Climate Change

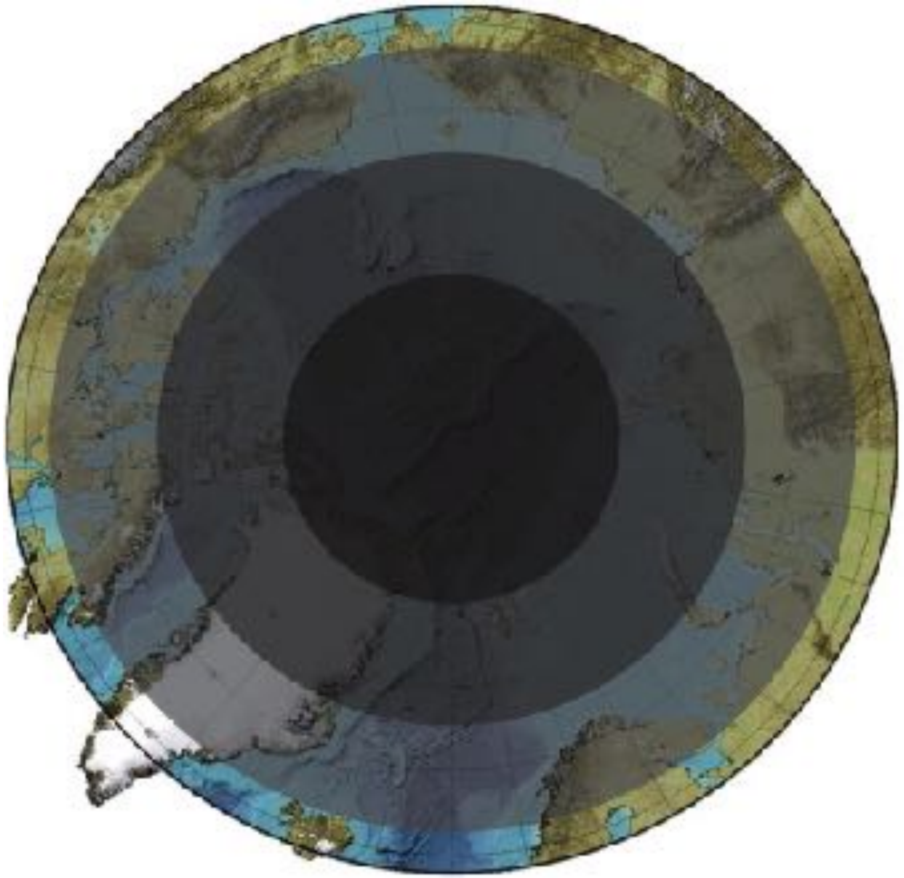
Phytoplankton Bloom in the Barents Sea, Joshua Stevens, NASA

Photic Constraints

Light Attenuation



Polar Night



Have polar phytoplankton adapted to extremely low light by increasing their efficiency of photosynthetic energy conversion?

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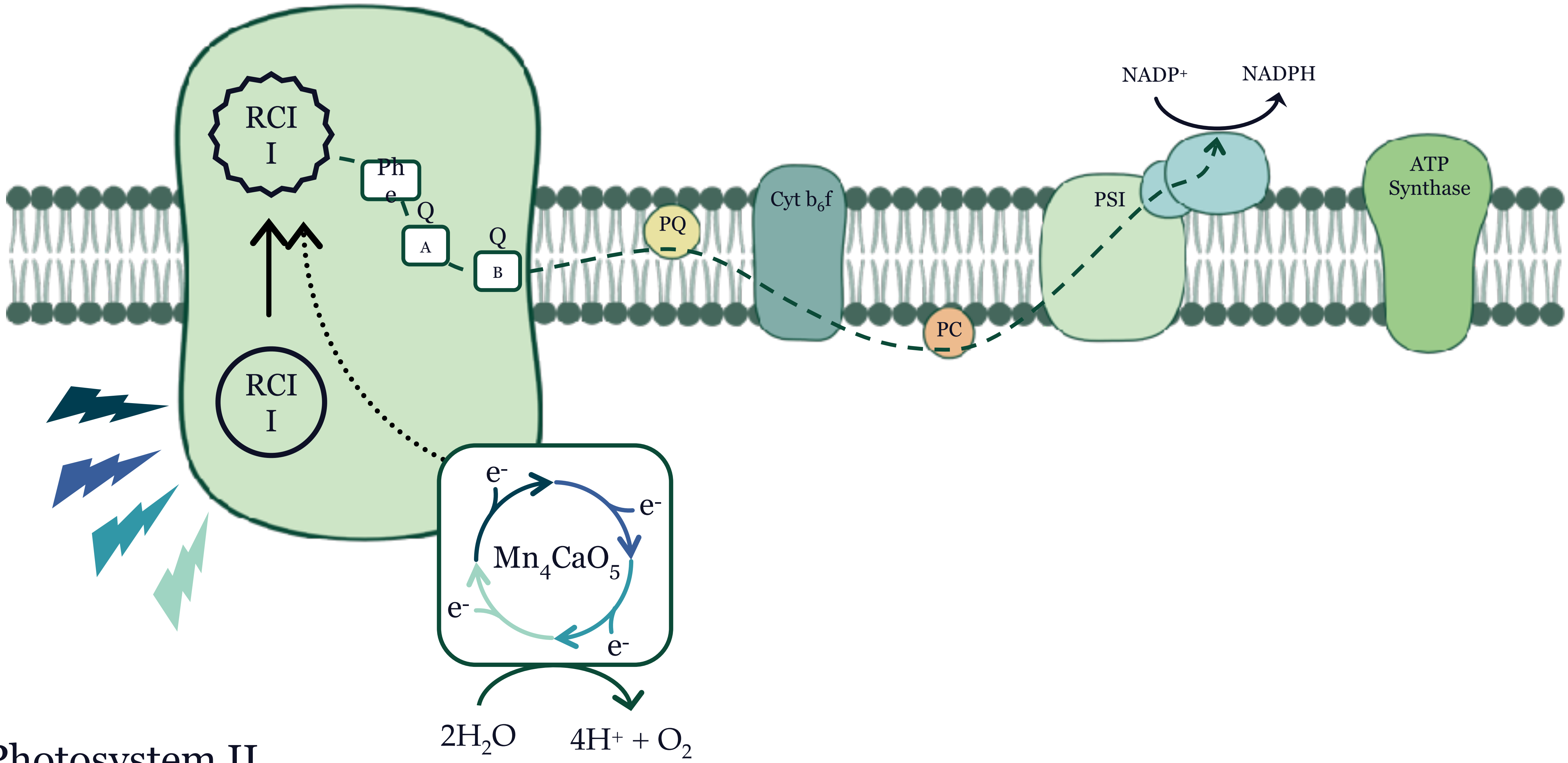
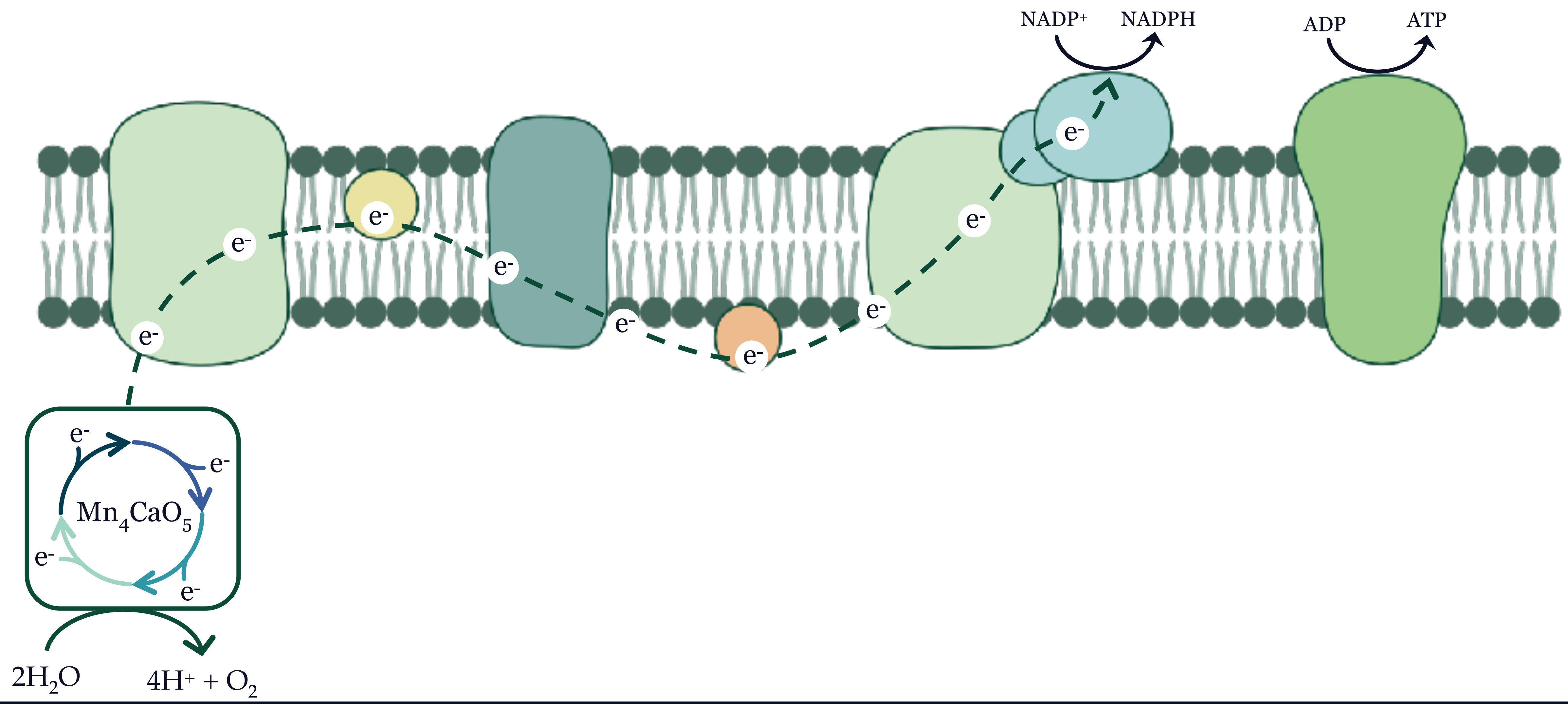
Hypothesized Mechanism: suppressing energetically wasteful charge recombinations in Photosystem II

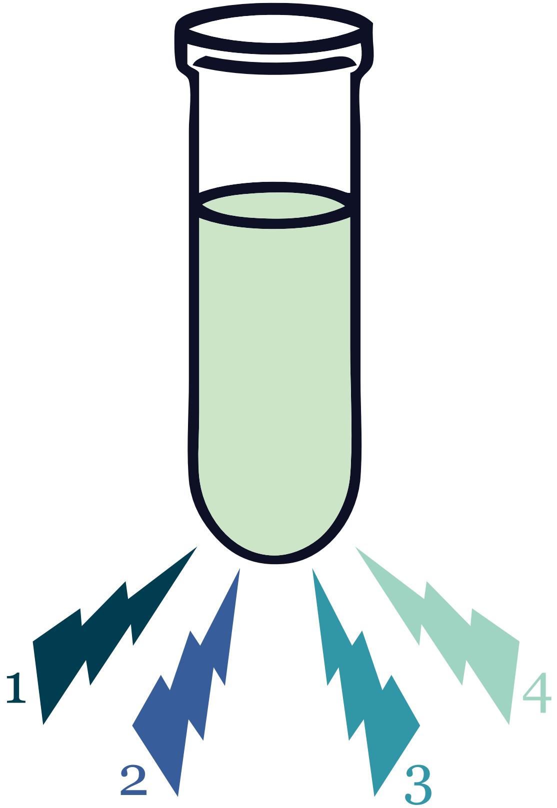


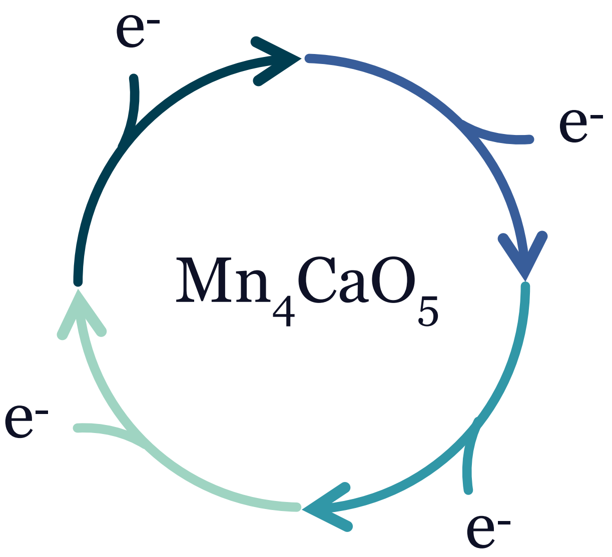
Photosystem II

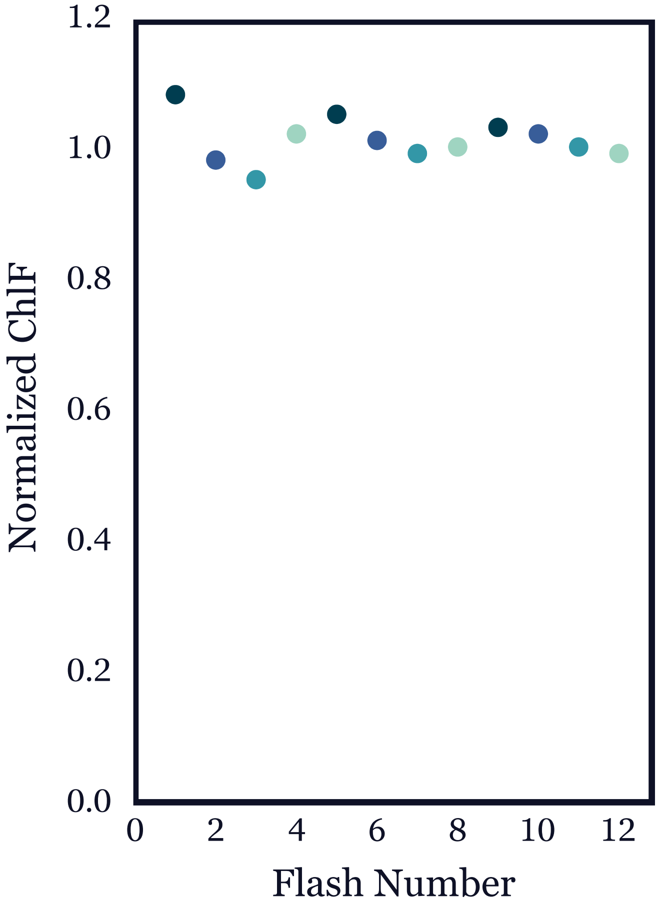
Stable Cycling



St-ChlF Approach

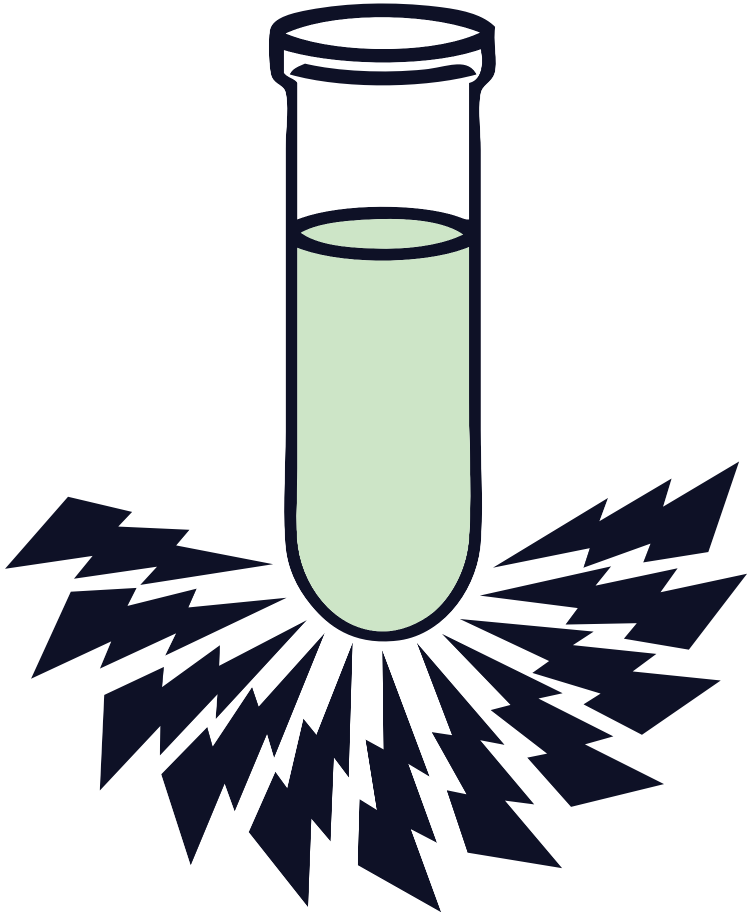






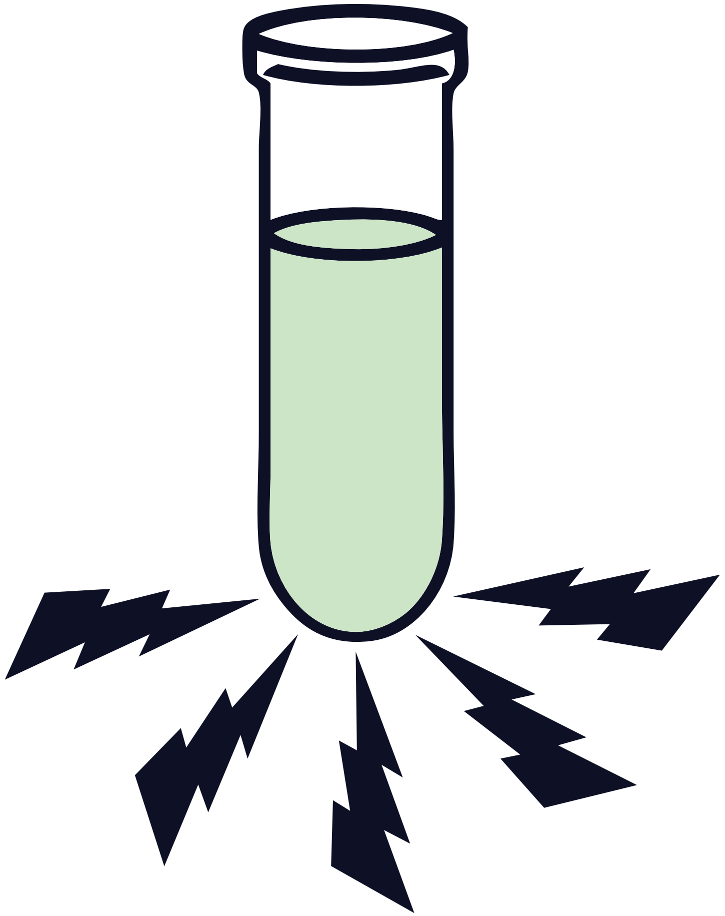
Gates *et al*, 2020. Biochimica et Biophysica Acta
Zaharieva & Dau, 2019. Frontiers in Plant Science
Schuback *et al*, 2021. Frontiers in Marine Science

High Light



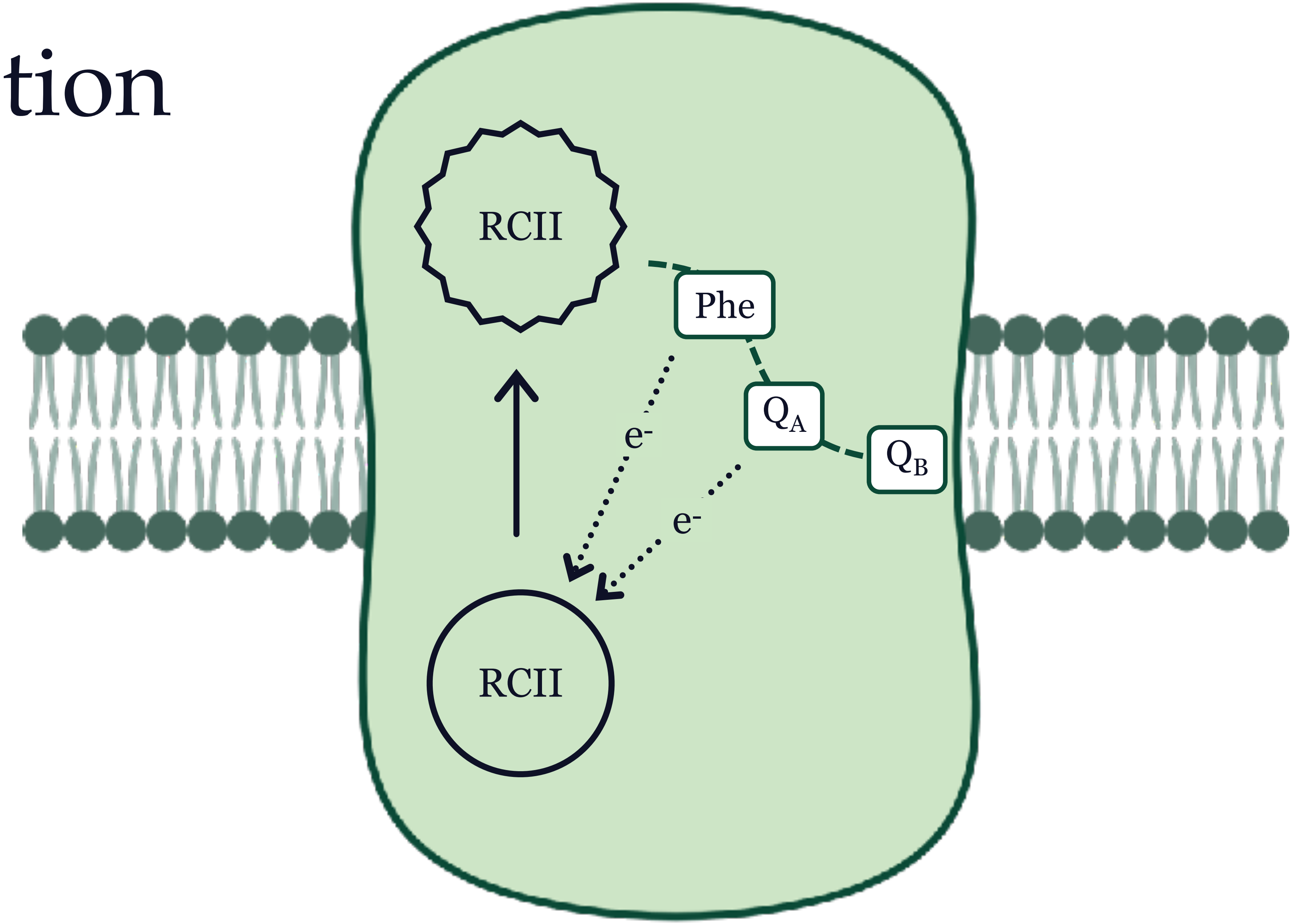
Shorter spacing between flashes

Low Light

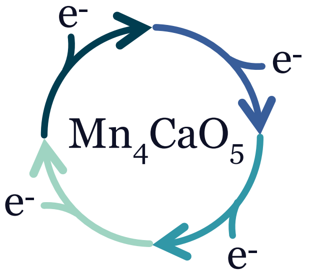


Longer spacing between flashes

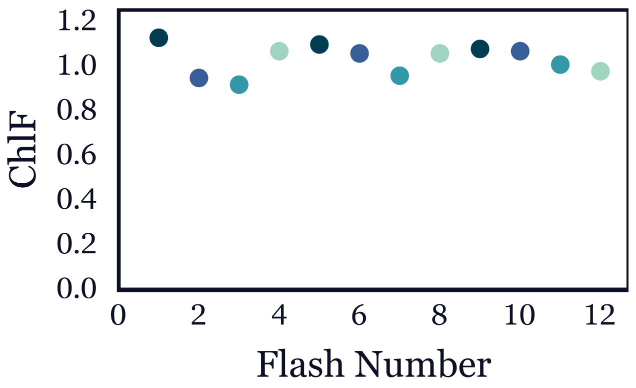
Recombination



Idealized PSII Population

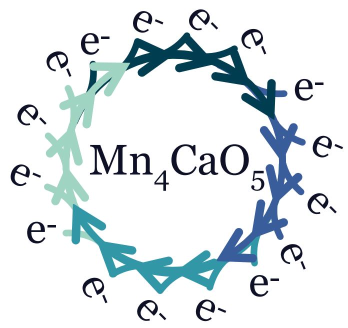


Synchronized Cycling

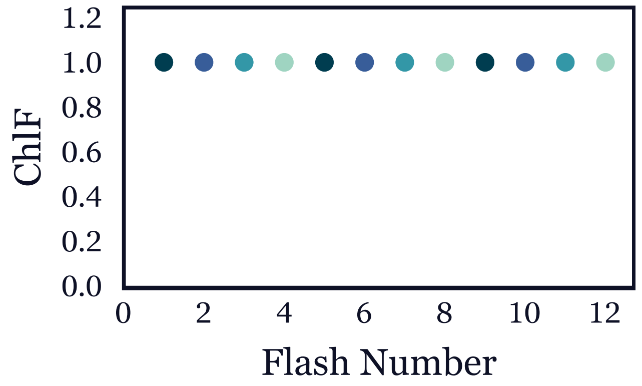


Periodic ChlF Oscillations

PSII Population with Recombination



Desynchronized Cycling

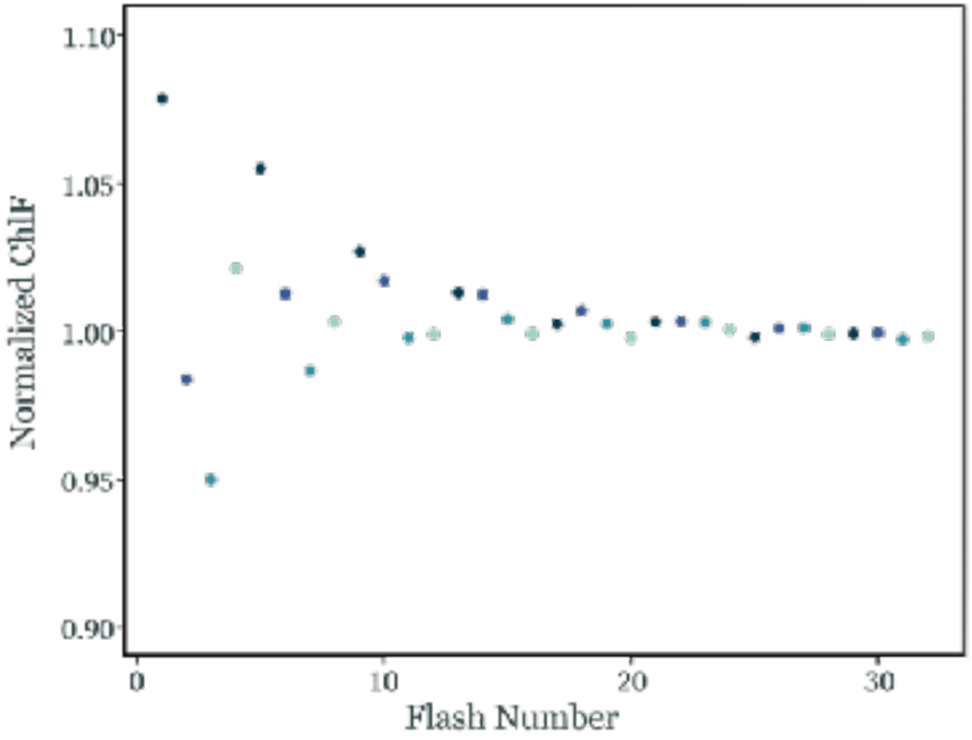


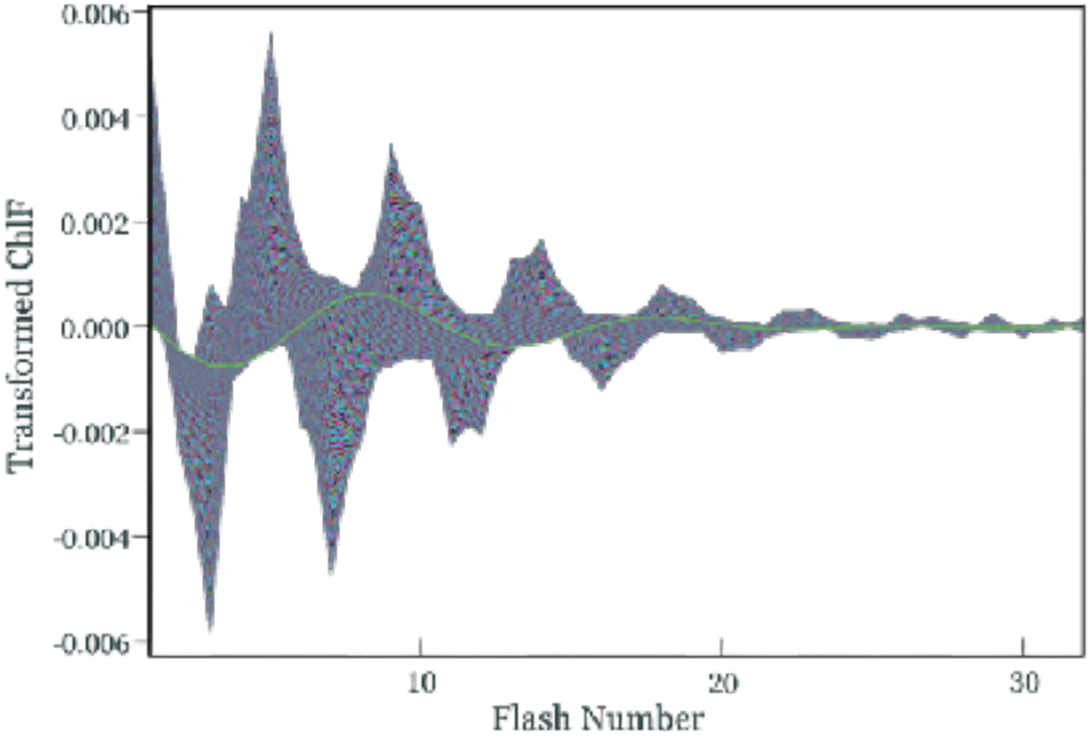
Damped ChlF Oscillations

Wavelet Transformation

Sample Plots: *Fragilariopsis cylindrus* at 0°C and 0.6 µmol photons $m^{-2}s^{-1}$

Raw Fluorescence Data → Fourier Wavelets



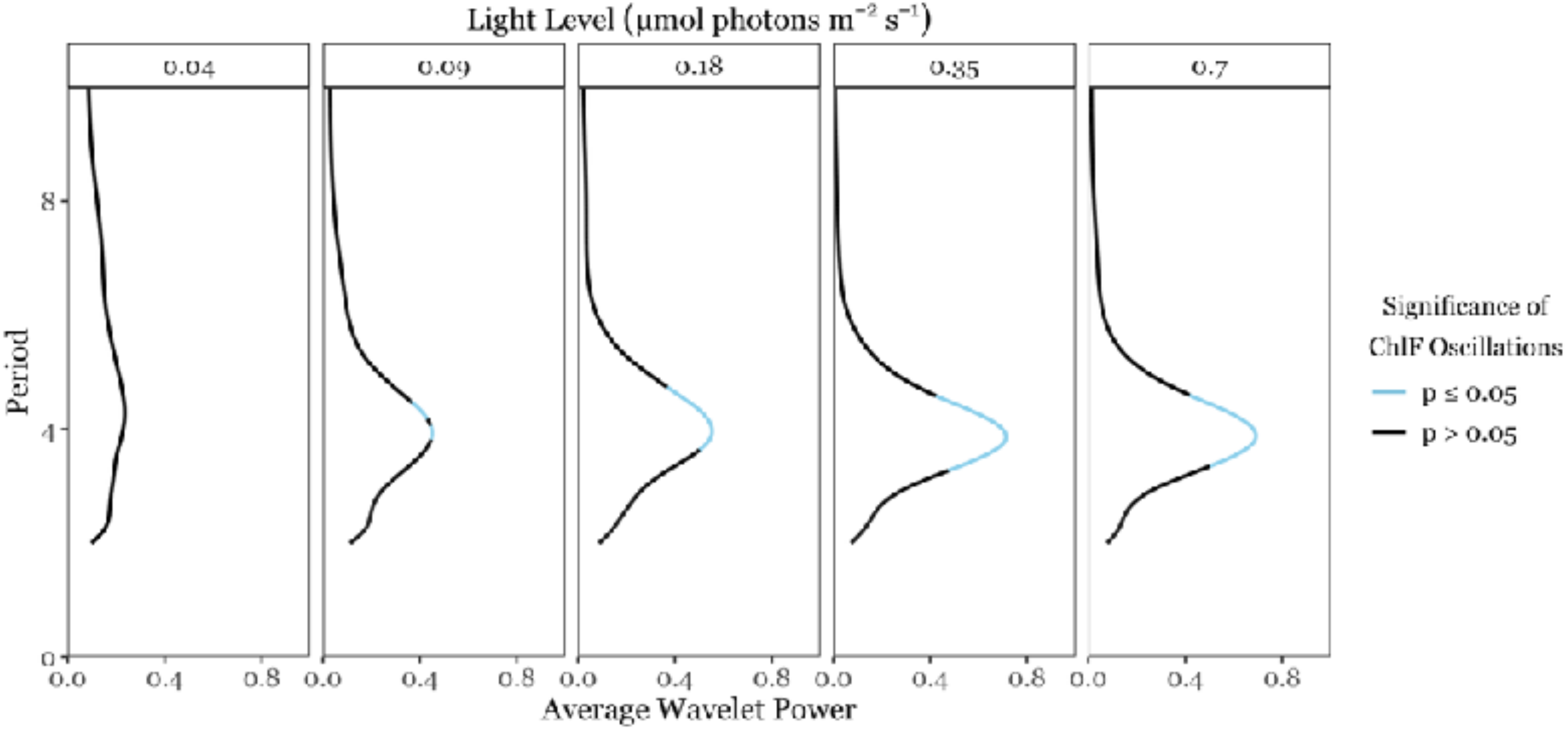


Roesch & Schmidbauer, 2018. WaveletComp

Theis & Meyer-Bäse, 2010. Biomedical Signal Analysis

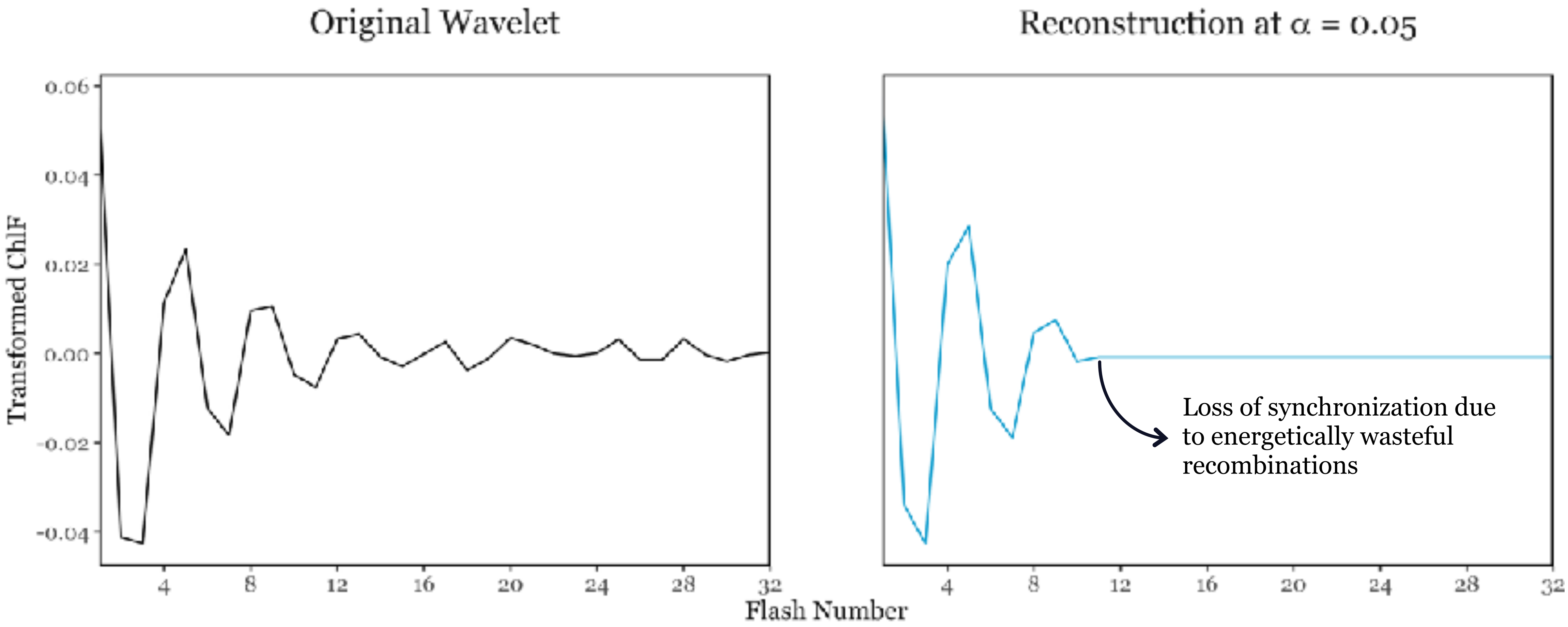
ChlF Periodicity

Sample Plot: *Chlamydomonas priscuii* at 8°C

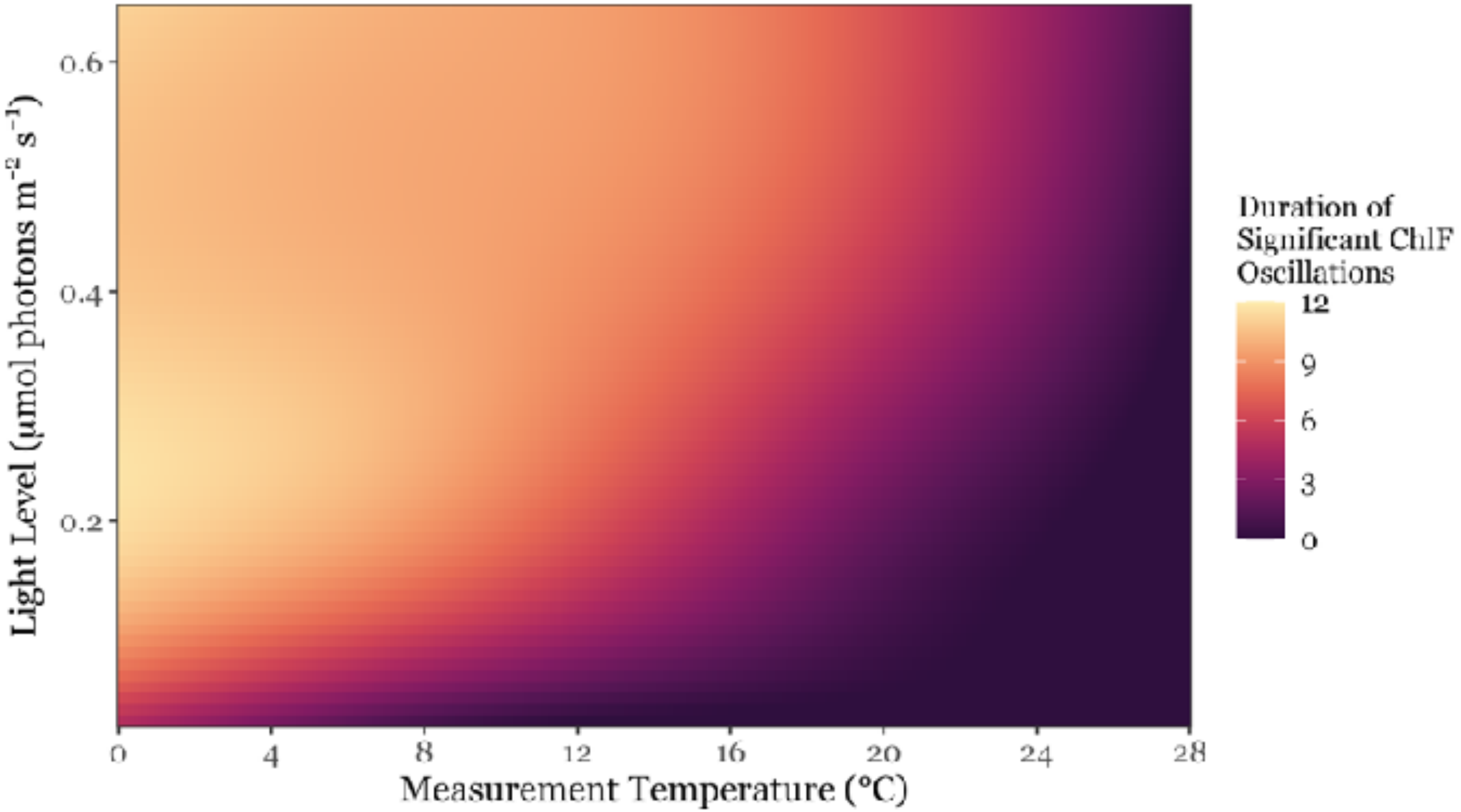


Duration of Cycling

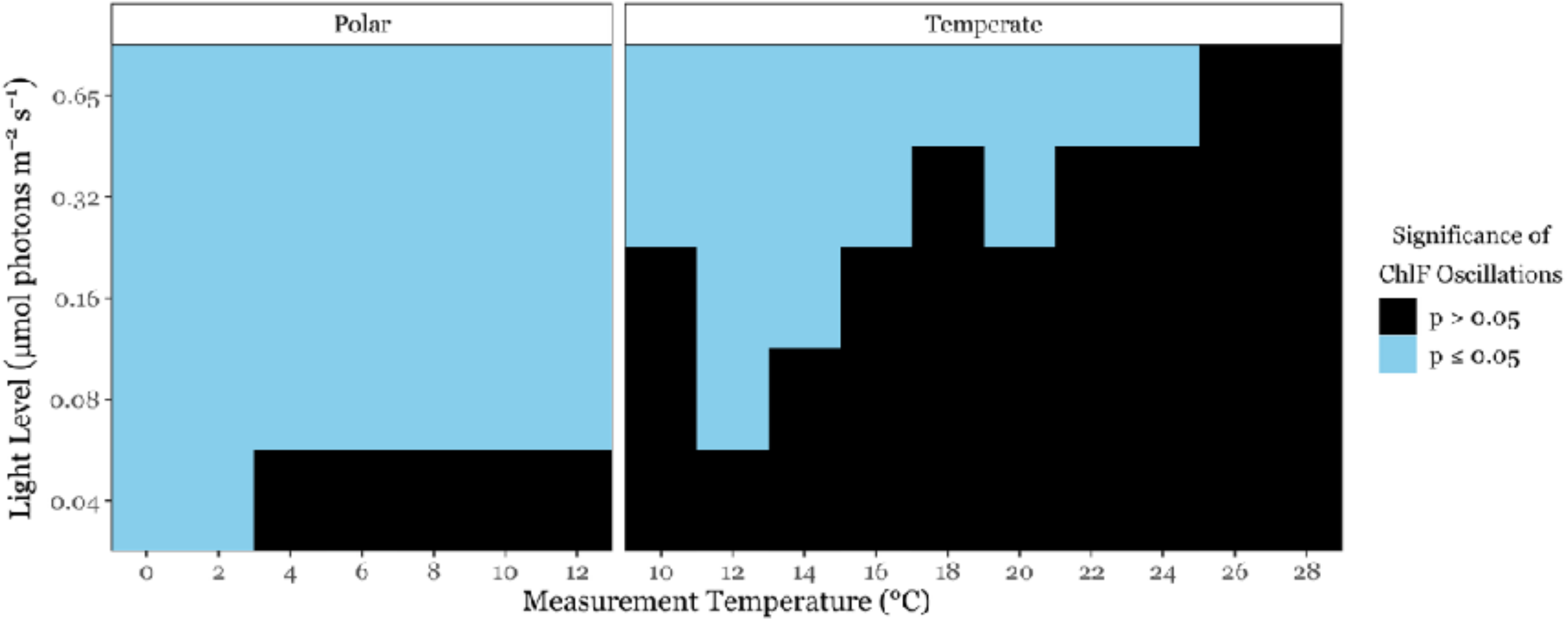
Sample Plot: *Chlamydomonas priscuii* at 8°C & 0.7 µmol photons $m^{-2}s^{-1}$



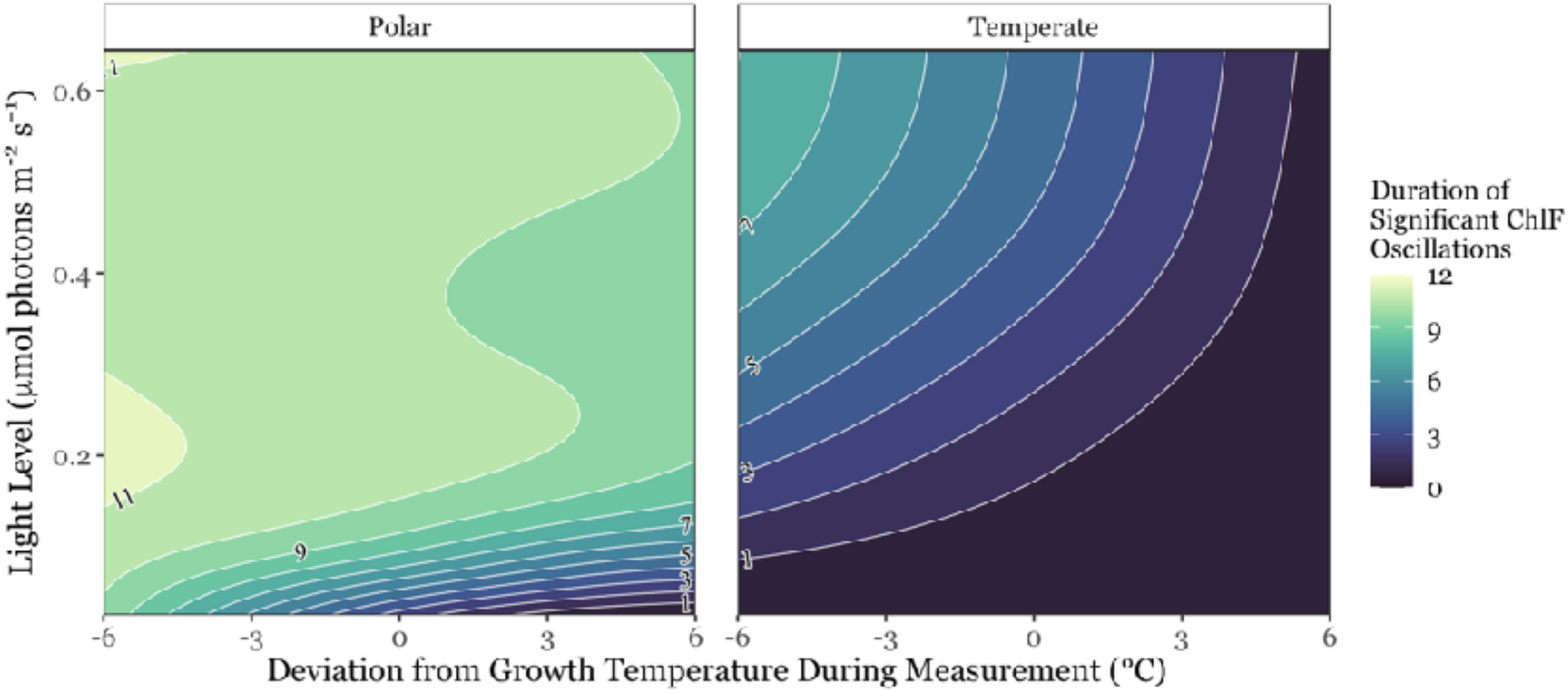
Individual strains sustain ChlF oscillations longer under measurement at **higher** light levels & **lower** temperatures

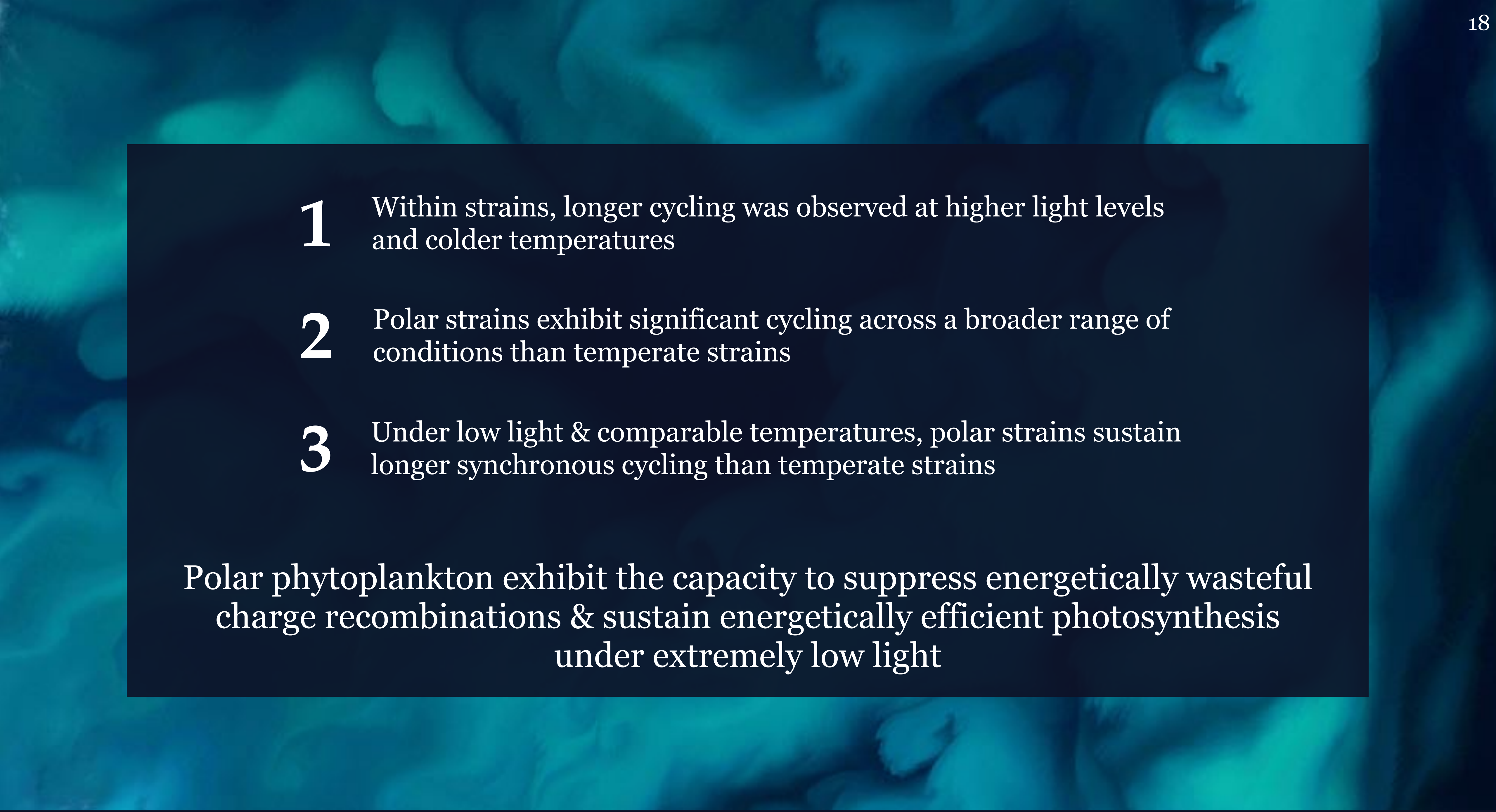


Polar strains exhibited synchronous cycling under a **broader** range of conditions



Polar strains sustained **longer** cycling under low light & comparable temperatures





1 Within strains, longer cycling was observed at higher light levels and colder temperatures

2 Polar strains exhibit significant cycling across a broader range of conditions than temperate strains

3 Under low light & comparable temperatures, polar strains sustain longer synchronous cycling than temperate strains

Polar phytoplankton exhibit the capacity to suppress energetically wasteful charge recombinations & sustain energetically efficient photosynthesis under extremely low light

Phytoplankton Bloom extending over 500 000 km^2 in the Barents Sea, 2022. Copernicus

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