POLAR SEAWEEDS IN A CHANGING ENVIRONMENT

A SEASONAL PERSPECTIVE AND IMPLICATIONS FOR THE FUTURE

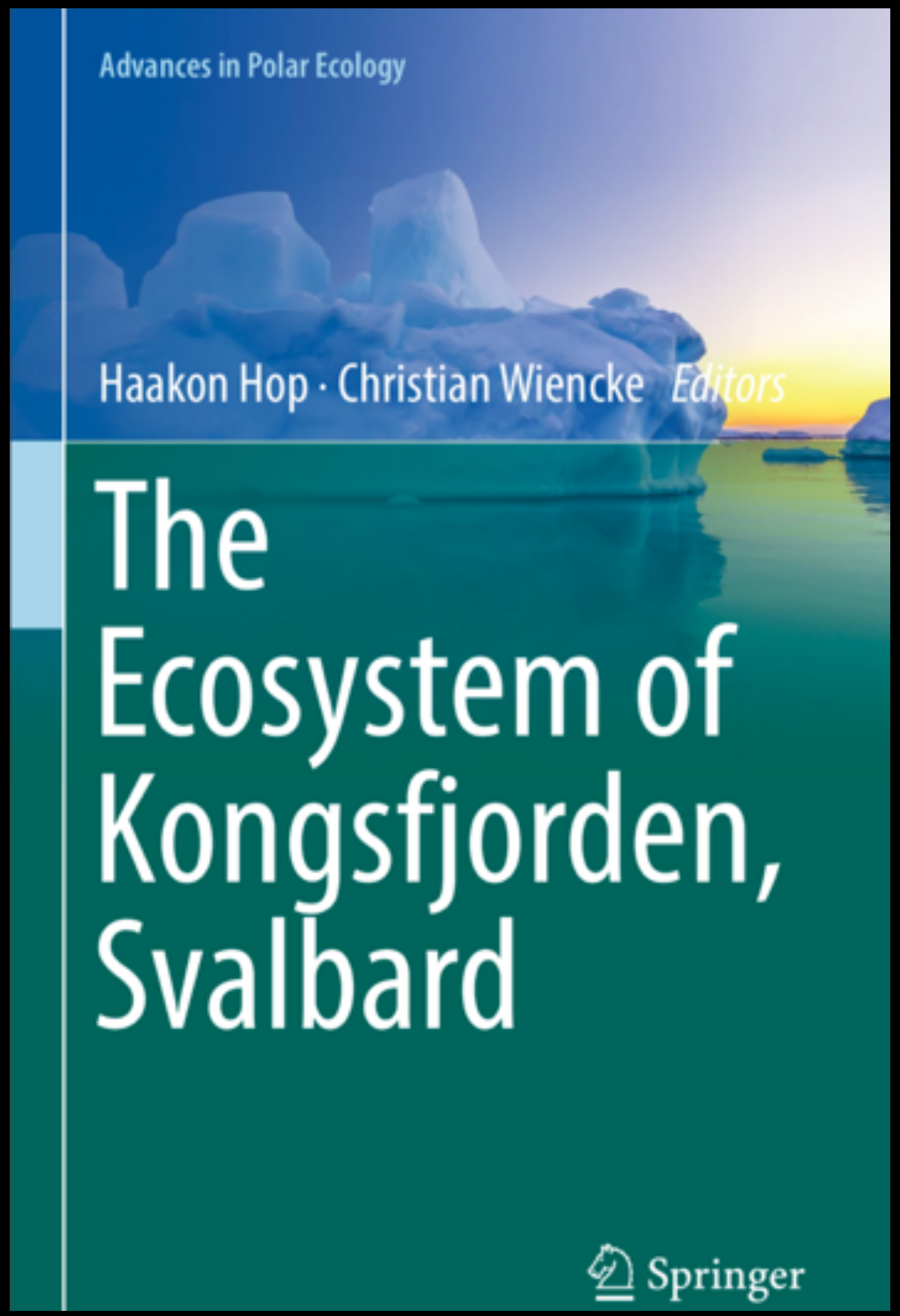
<u>FRAN JL GORDILLO</u>, CONCHI IÑIGUEZ, RAQUEL CARMONA, CARLOS JIMÉNEZ

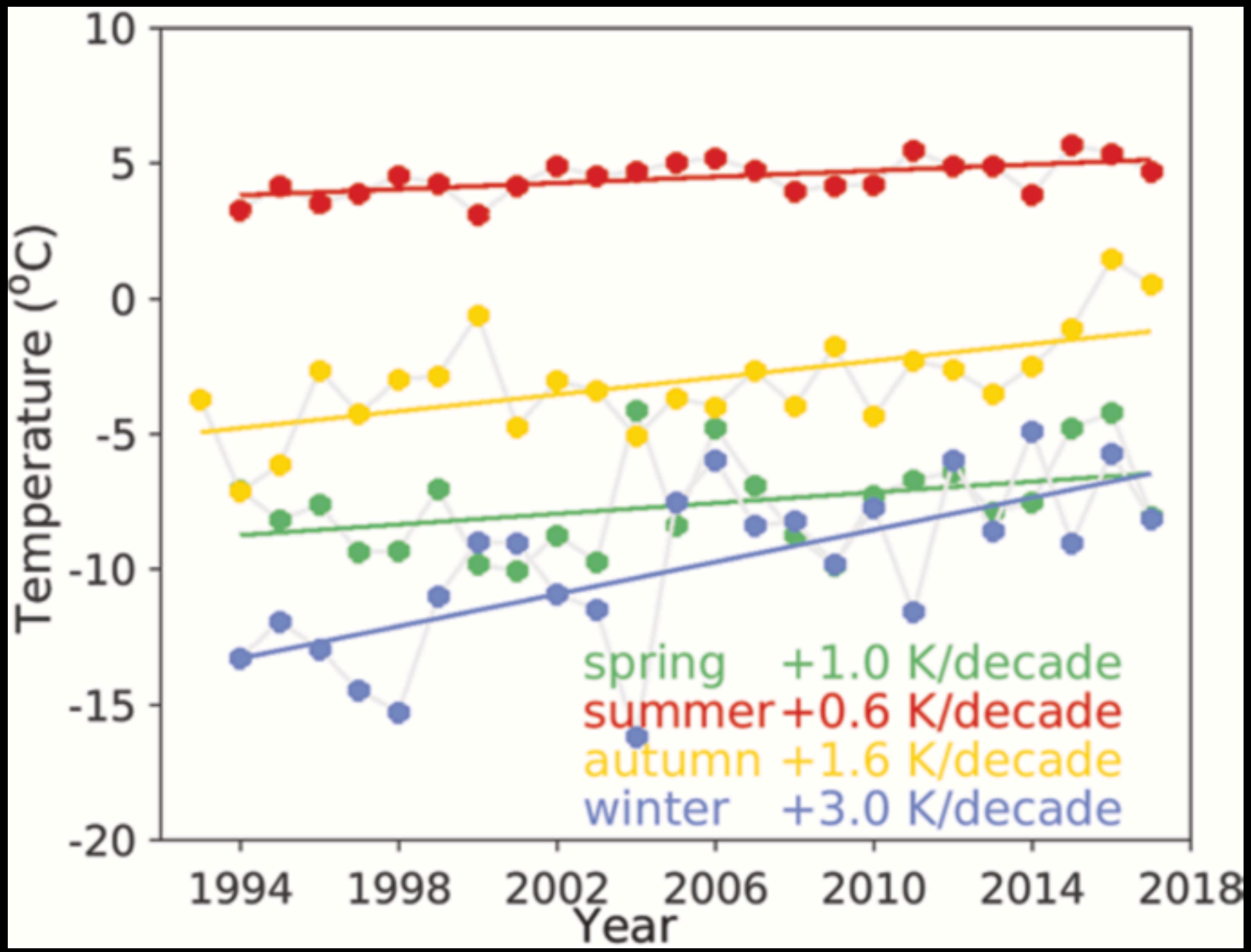
UNIVERSIDAD
DE MÁLAGA

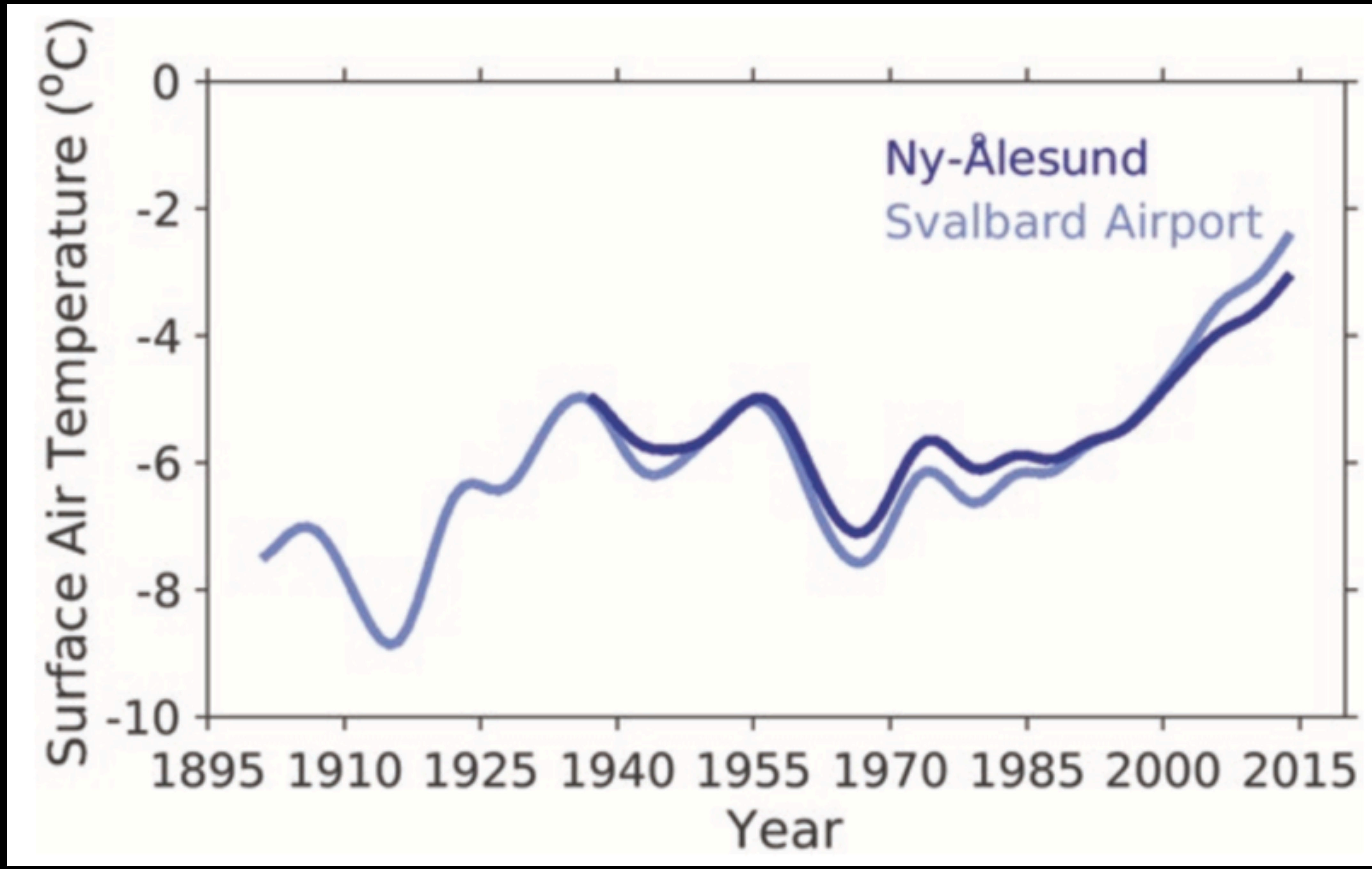
european phycological congress
7th EPC Zagreb 2019

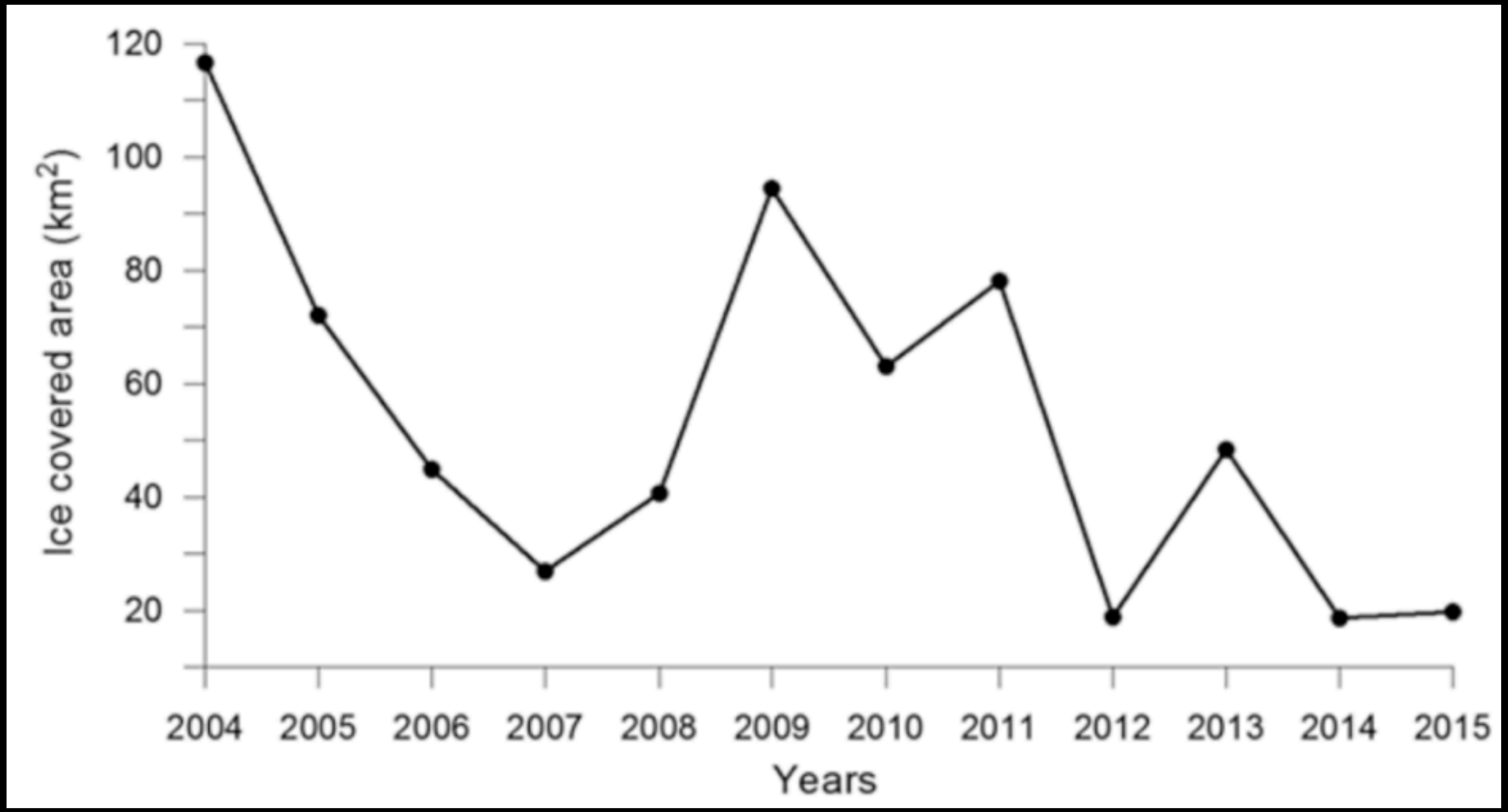
Kongsfjord (Svalbard)
79 °N

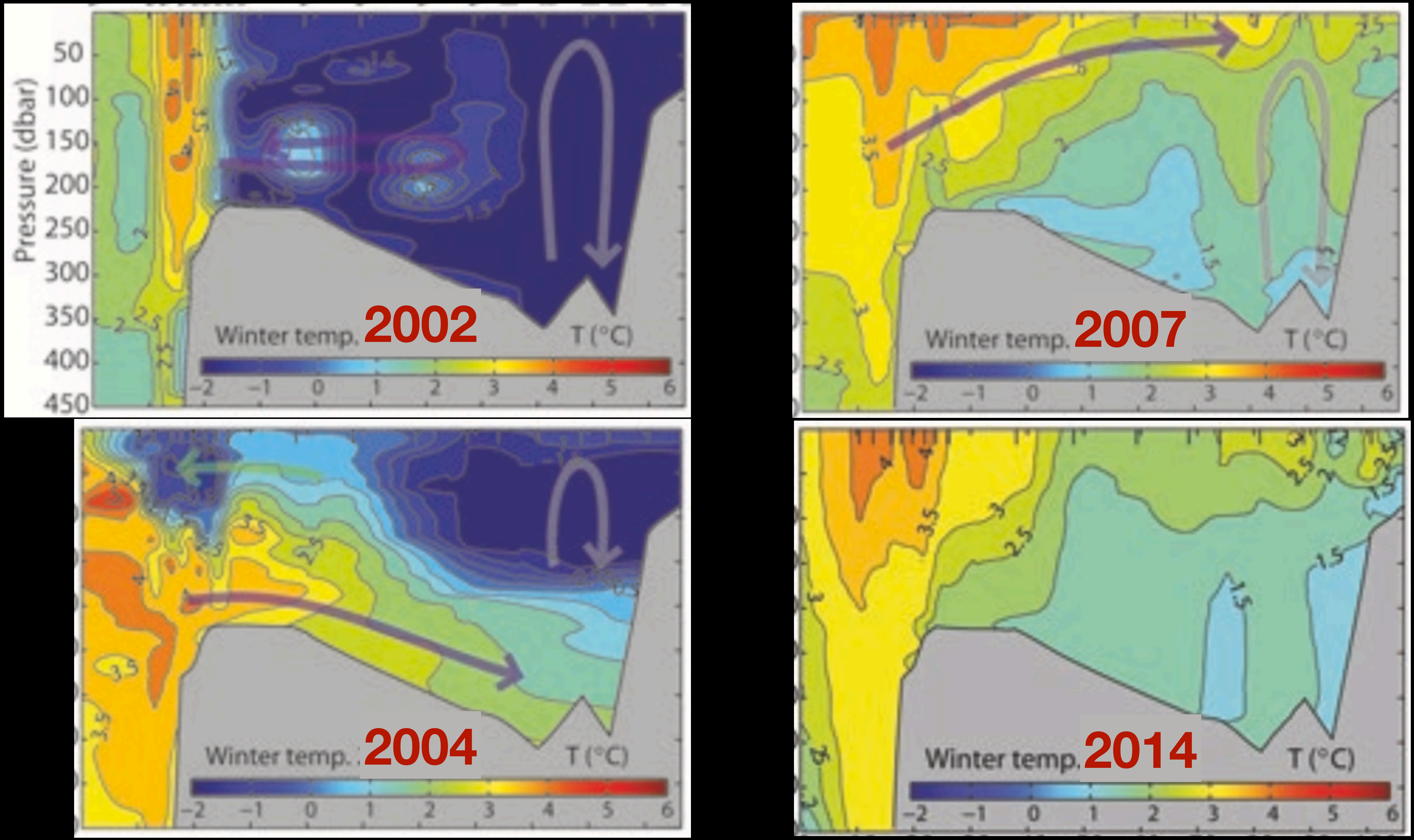
80+ spp of seaweeds


Advances in Polar Ecology
Haakon Hop · Christian Wiencke Editors
The Ecosystem of Kongsfjorden, Svalbard
Springer


Temperature (°C)
Year
10
5
0
-5
-10
-15
-20
1994
1998
2002
2006
2010
2014
2018
spring +1.0 K/decade
summer +0.6 K/decade
autumn +1.6 K/decade
winter +3.0 K/decade


Surface Air Temperature (°C)
Year
Ny-Ålesund
Svalbard Airport
0
-2
-4
-6
-8
-10
1895
1910
1925
1940
1955
1970
1985
2000
2015


Ice covered area (km²)
Years
120
100
80
60
40
20
2004
2005
2006
2007
2008
2009
2010
2011
2012
2013
2014
2015



Pressure (dbar)
50
100
150
200
250
300
350
400
450
Winter temp. 2002
T (°C)
-2 -1 0 1 2 3 4 5 6
Winter temp. 2007
T (°C)
-2 -1 0 1 2 3 4 5 6
Winter temp. 2004
T (°C)
-2 -1 0 1 2 3 4 5 6
Winter temp. 2014
T (°C)
-2 -1 0 1 2 3 4 5 6

THE CHANGING ARCTIC

1. Higher temperature
2. Higher CO_2
3. Less ice cover (changed hydrodynamics)
4. Changed light field (ice and turbidity)

Still Special: constant light - constant darkness (summer/winter)

Main hypothesis: Specific adaptation to polar conditions may influence the way seaweeds respond to Global Change

THE ARCTIC ECOTYPE

The Arctic population:

- Higher C/N ratio
- Less water content
- Higher rubisco content

At increased CO_2 and Temp:

- More lipids at low Temp
- Less regulated Rubisco and D1 content
- More responsive growth

Olischlager et al. Planta 2014
Olischlager et al. Planta 2017

Comparisons between polar and temperate populations of the same species/genus on RUBISCO

Saccharina latissima: Higher K_{cat}^{c} and K_{cat}^{c}/K_{c} in the Arctic population

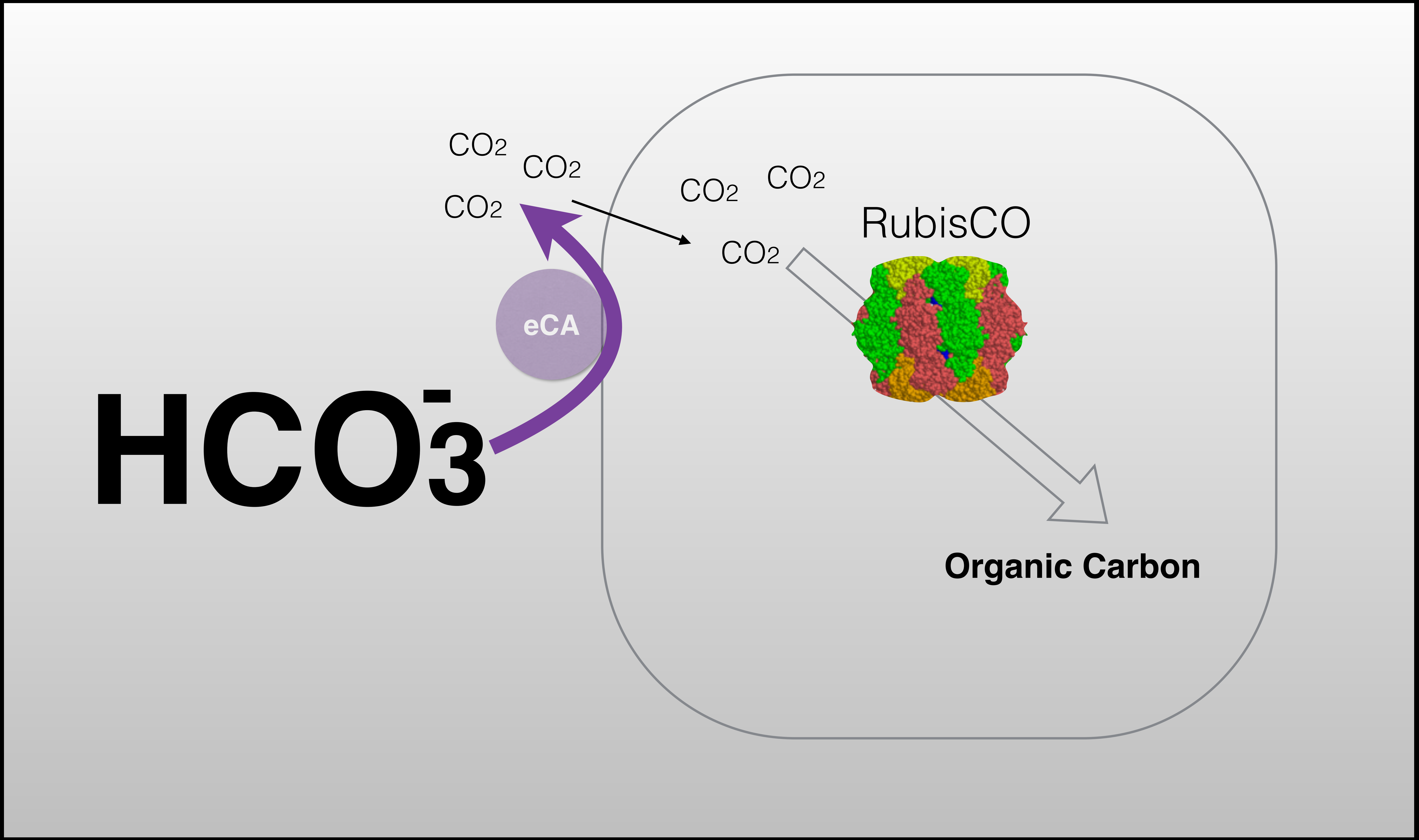
Palmaria sp.: K_{cat}^{c} and K_{cat}^{c}/K_{c} in *P. decipiens* (endemic Antarctic) > Arctic *P. Palmata* > temperate *P. Palmata*

Phycodrys rubens: No change in Rubisco carboxylation kinetics and Rubisco content.
Photosynthetis relies on diffusive CO_2 entry

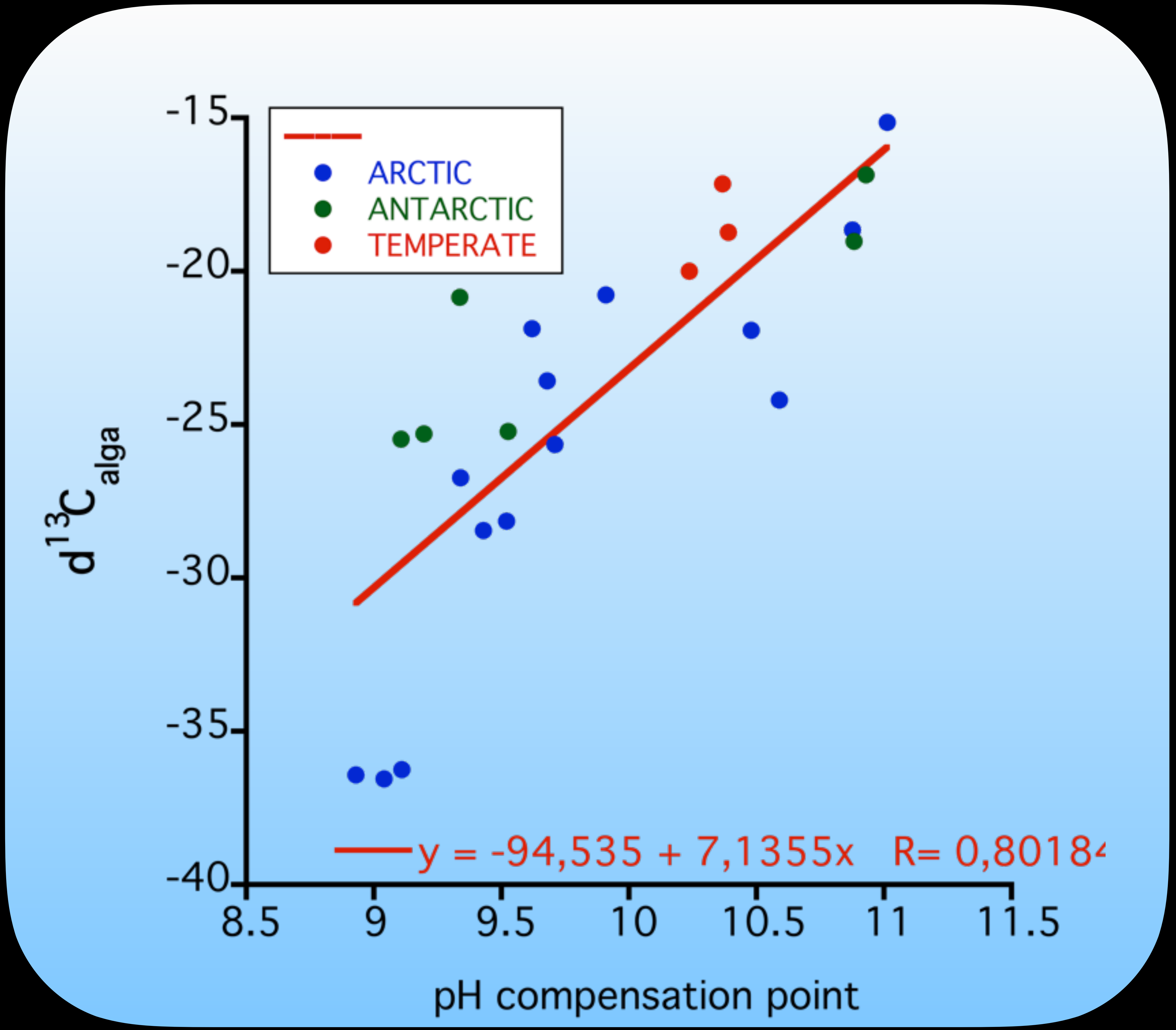
Acrosiphonia arcta: No significant change in Rubisco carboxylation kinetics at 4°C.
Higher Rubisco content (% TSP) in the Arctic and Antarctic vs. temperate population

Iñiguez et al. J Exp Bot 2018

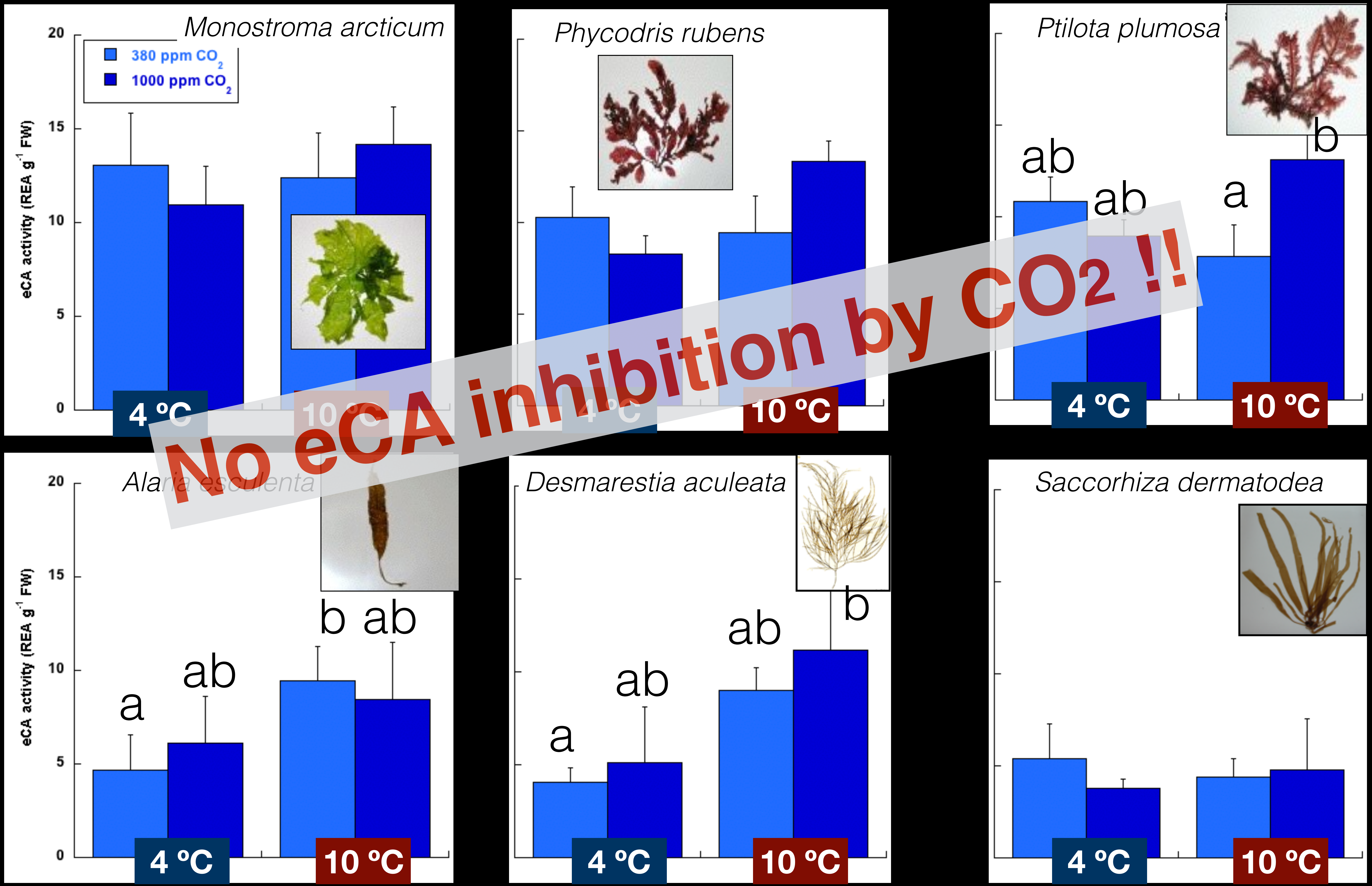
Carbon Acquisition: External Carbonic Anhydrase (eCA)



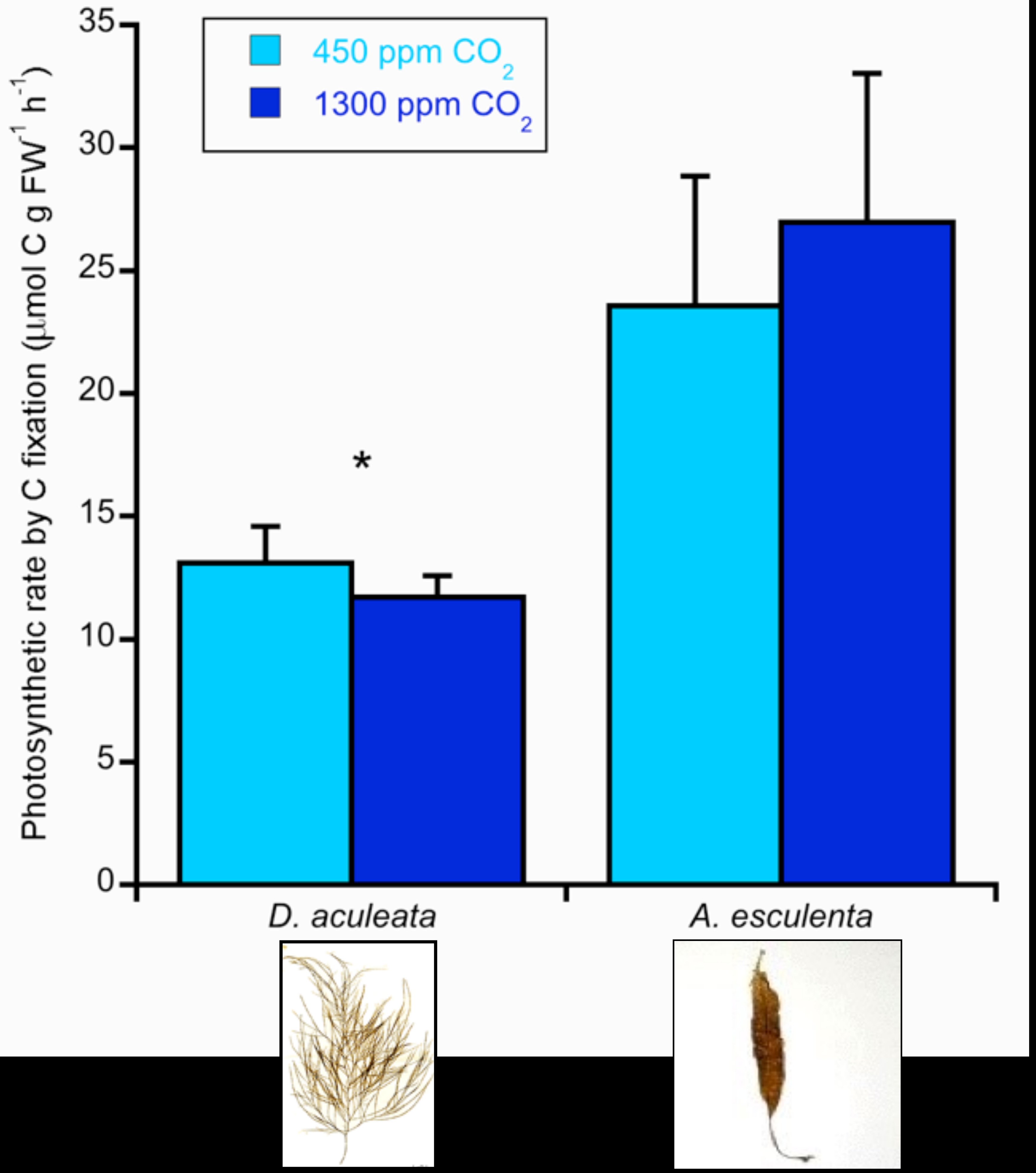
Carbon Acquisition: Are they HCO_3^- users?

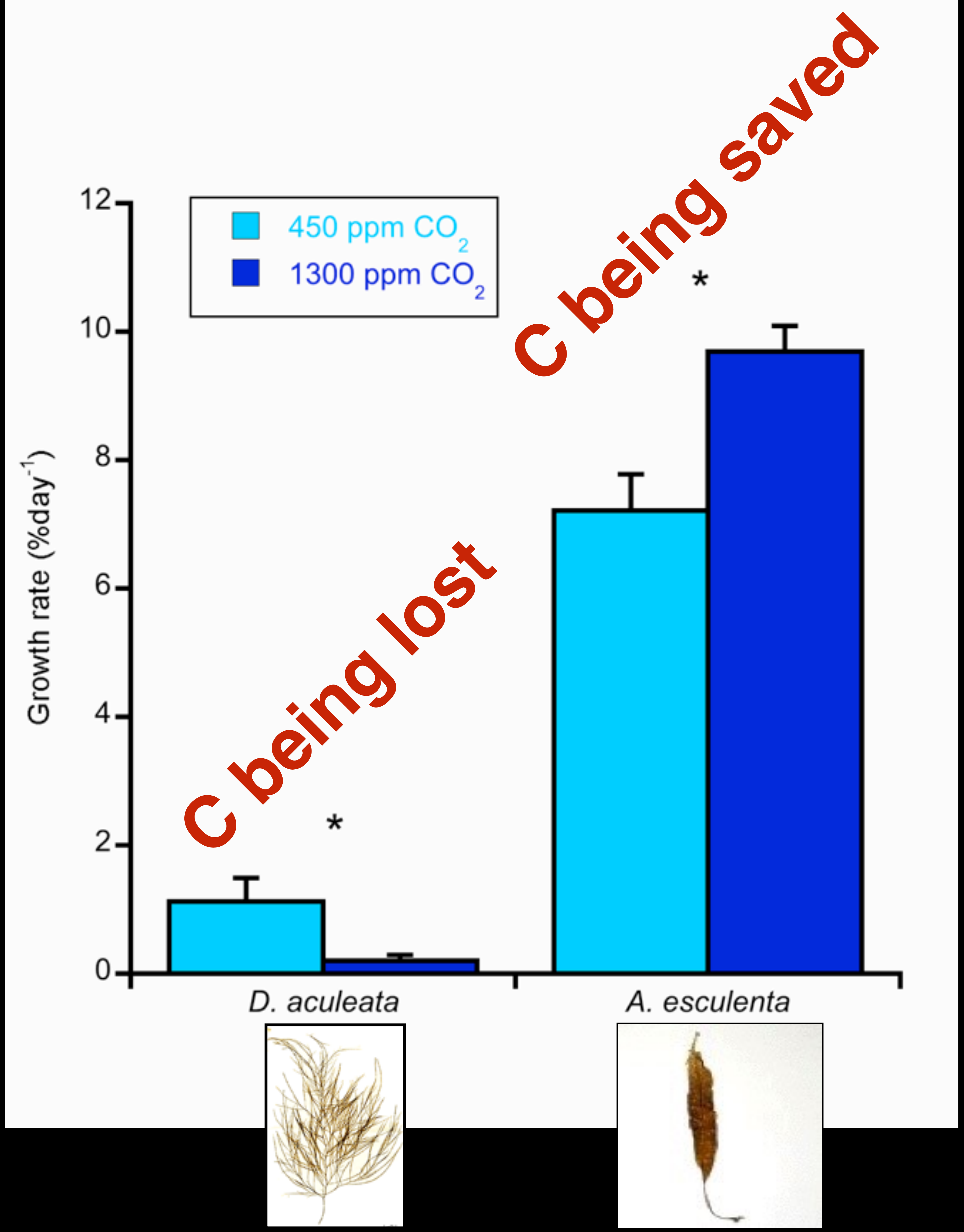


Carbon Acquisition: External Carbonic Anhydrase (eCA)

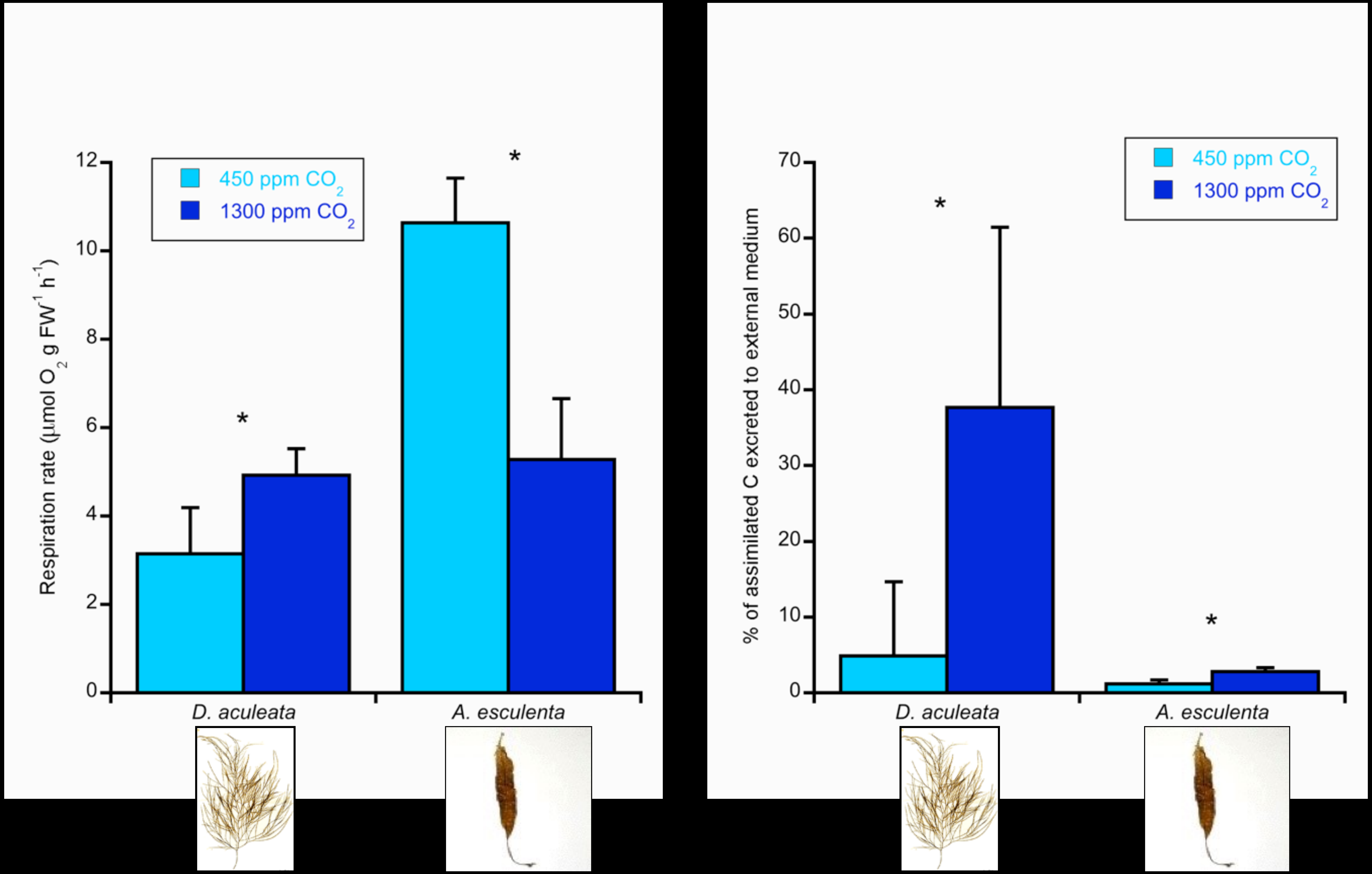


Carbon Balance: Gains





Carbon Balance: Losses



SURVIVING THE LONG WINTER

16 weeks in Darkness

3.5 and 8° C

(Collected end of September)

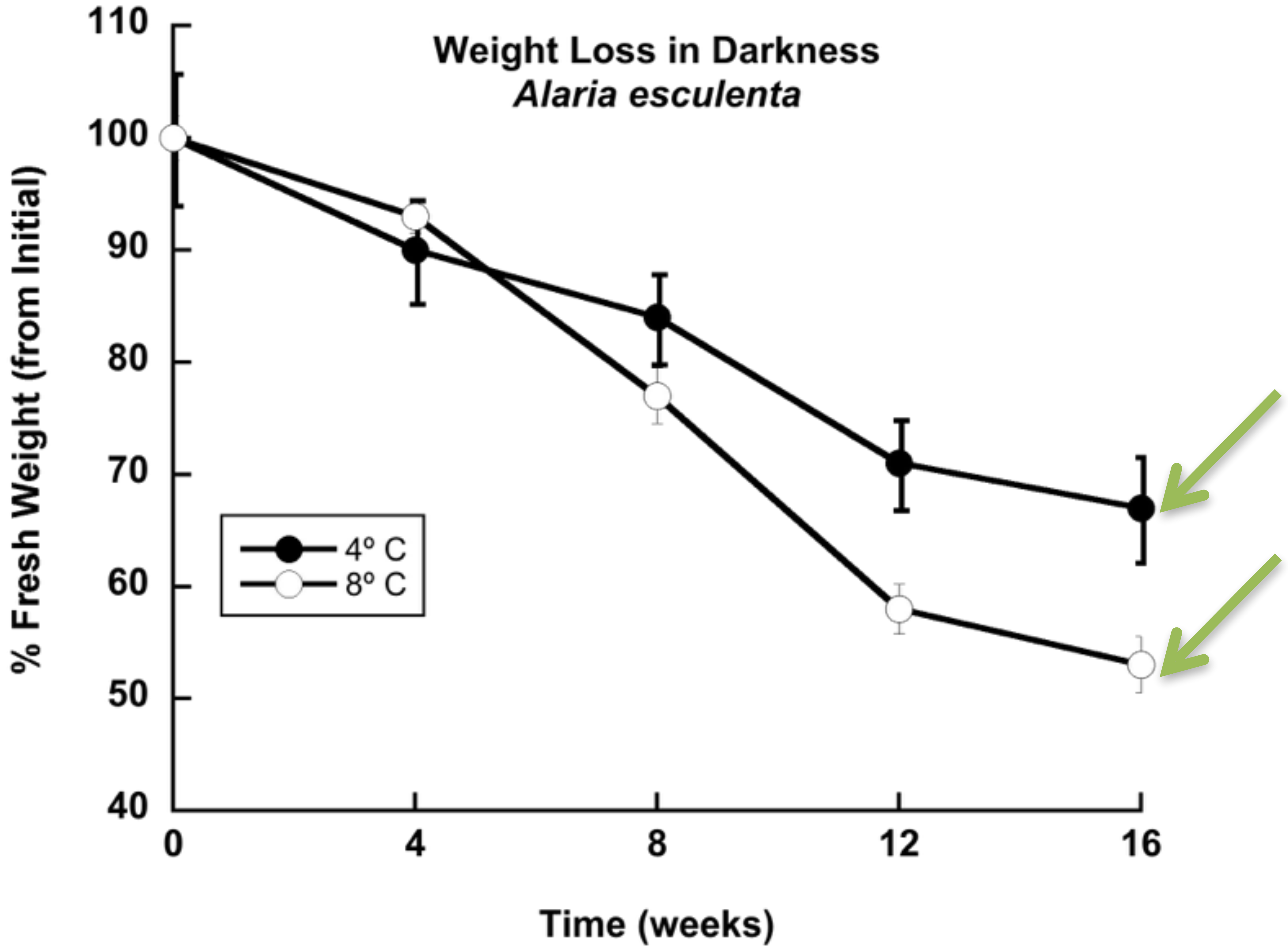
Alaria esculenta

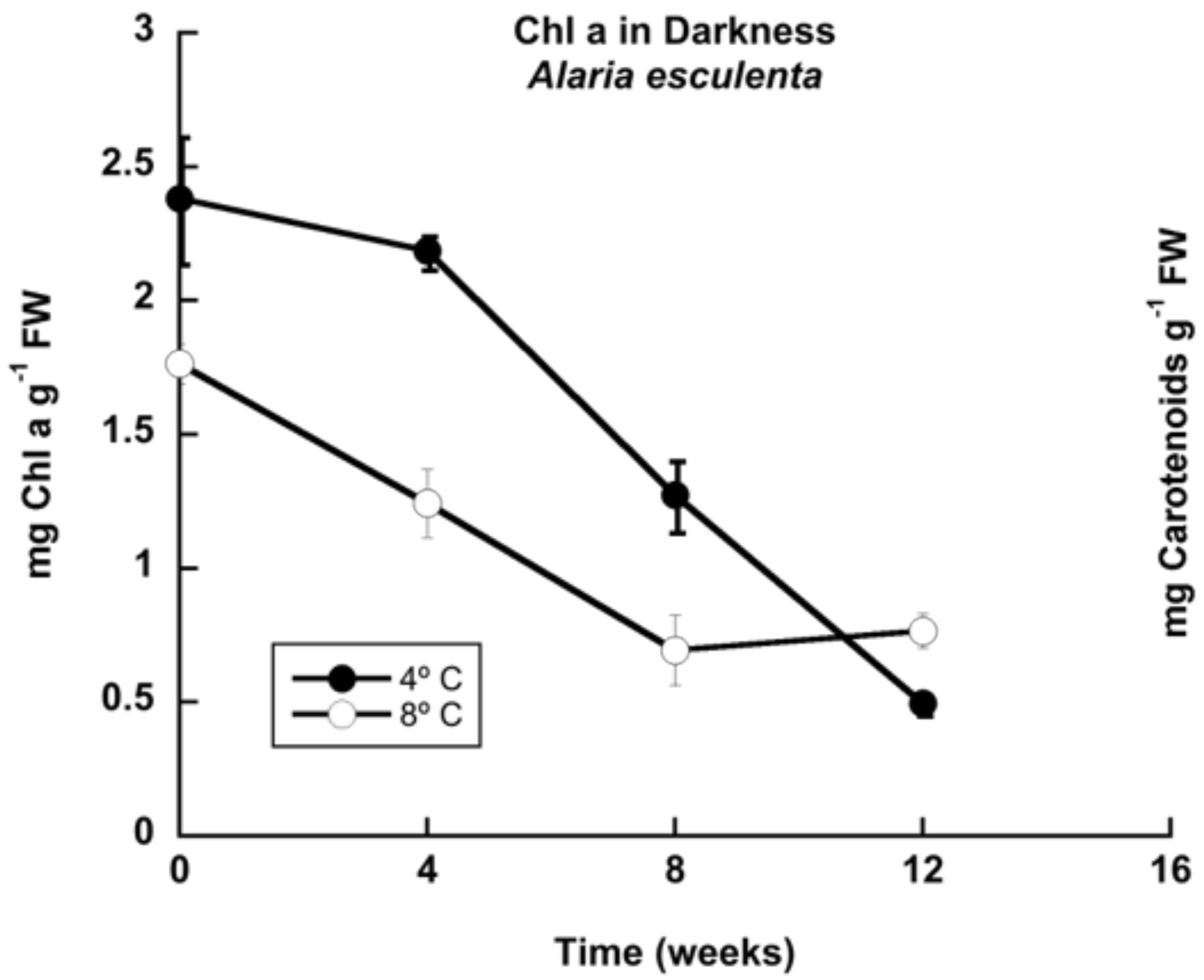
Sac. latissima

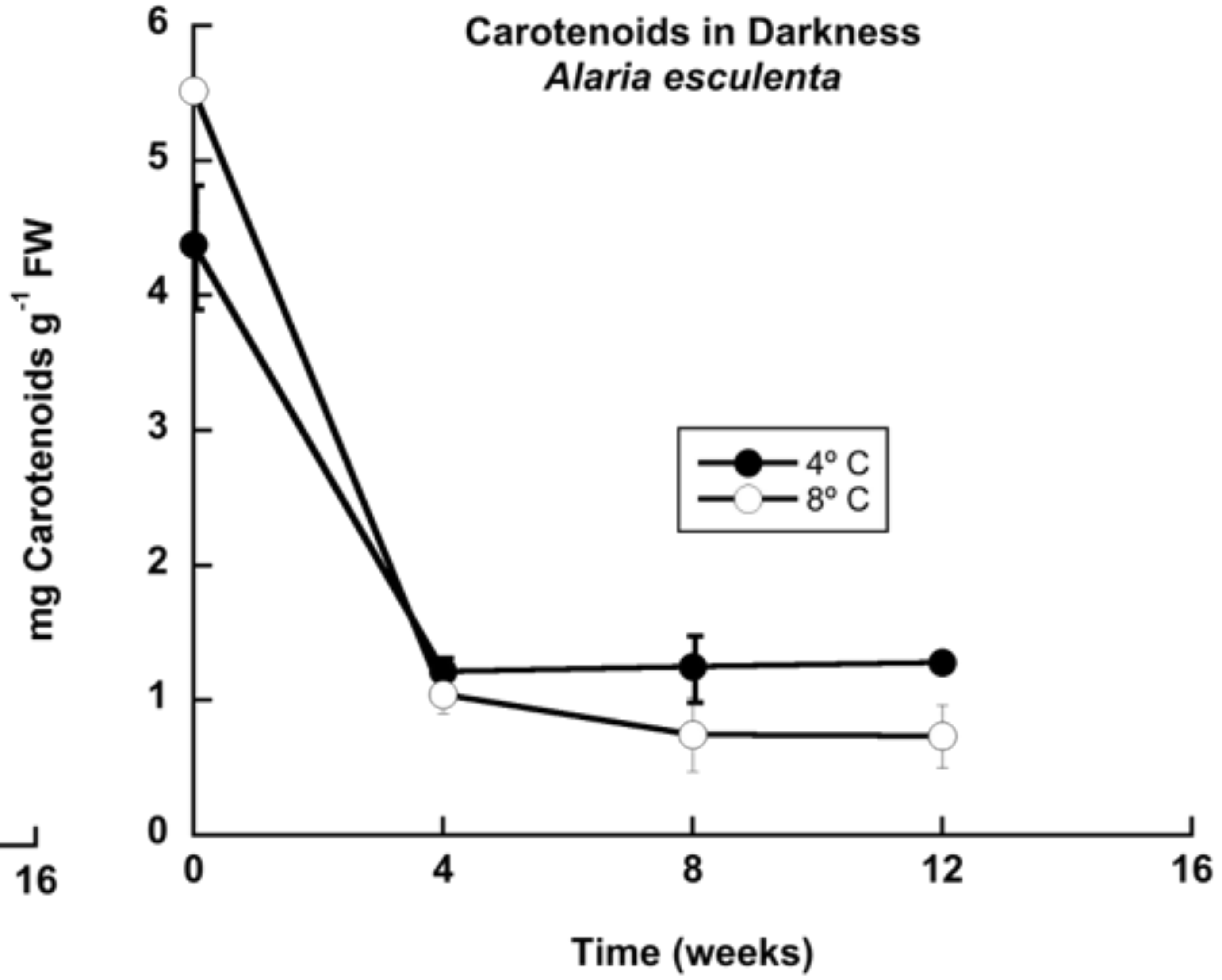
Phycodrys rubens

Ptilota gunneri

OVERWINTERING…







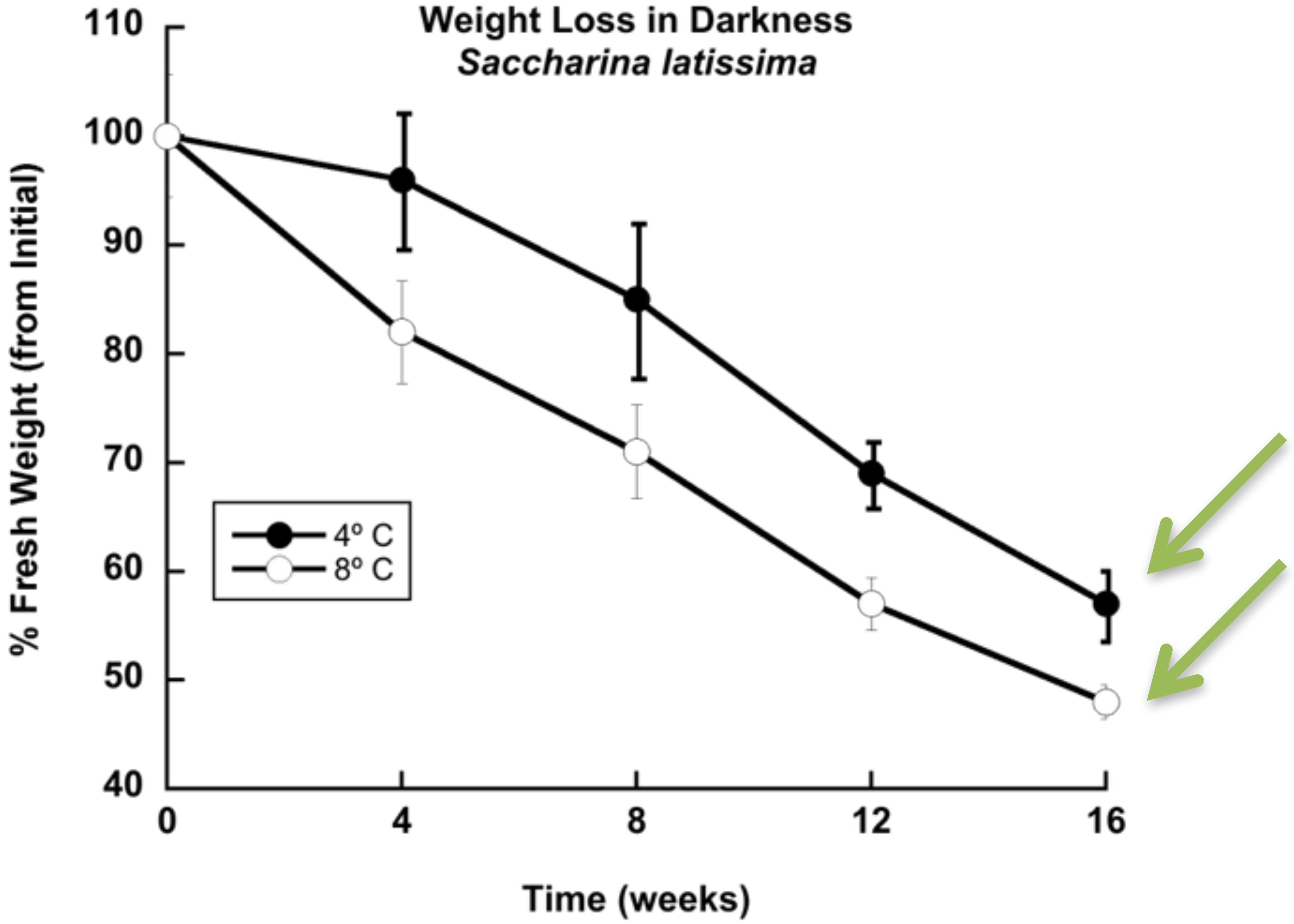
Warm means:

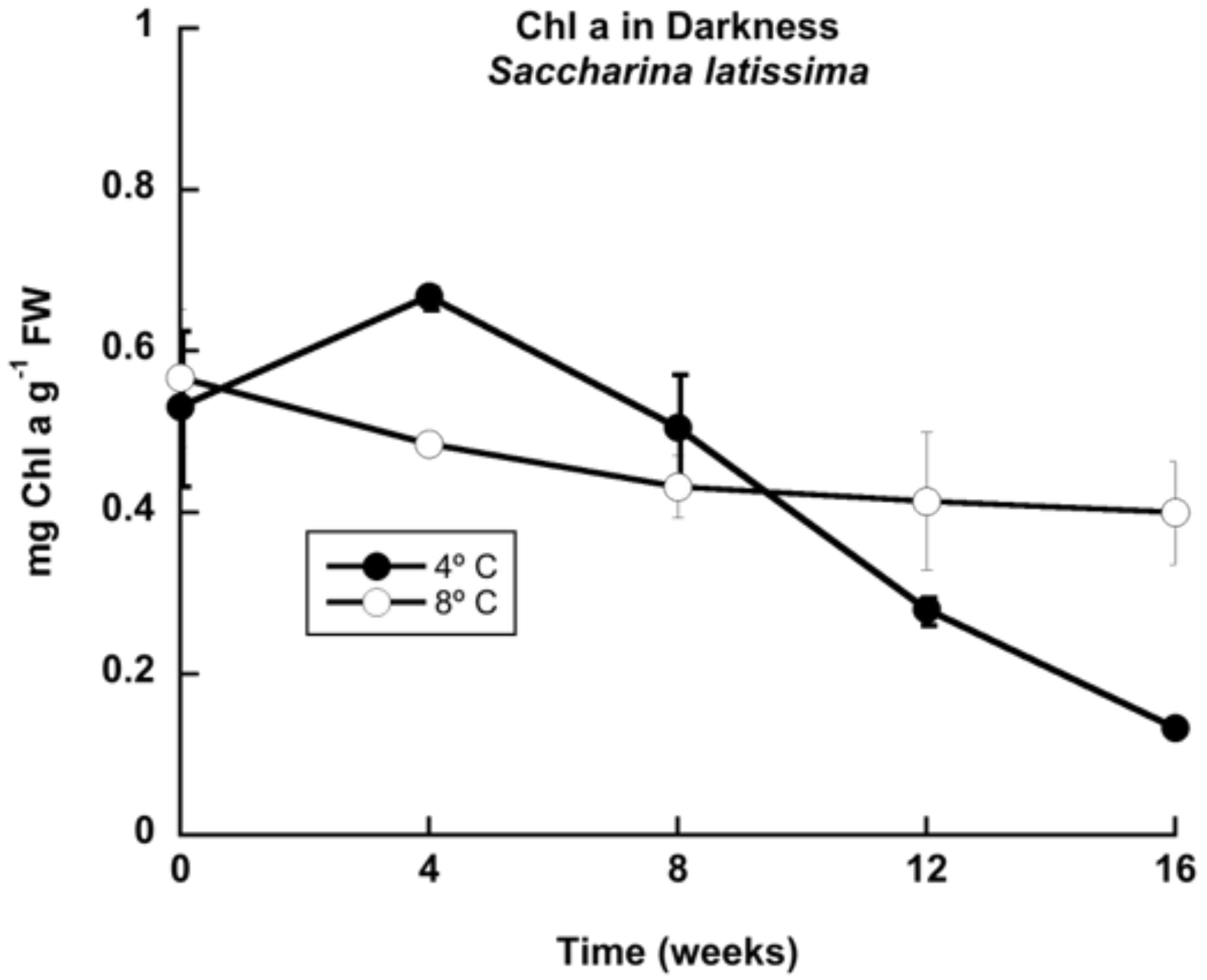
- Up to x4 respiration rate
- Only 50% Gross Photosynthesis (O_2)
- No survival

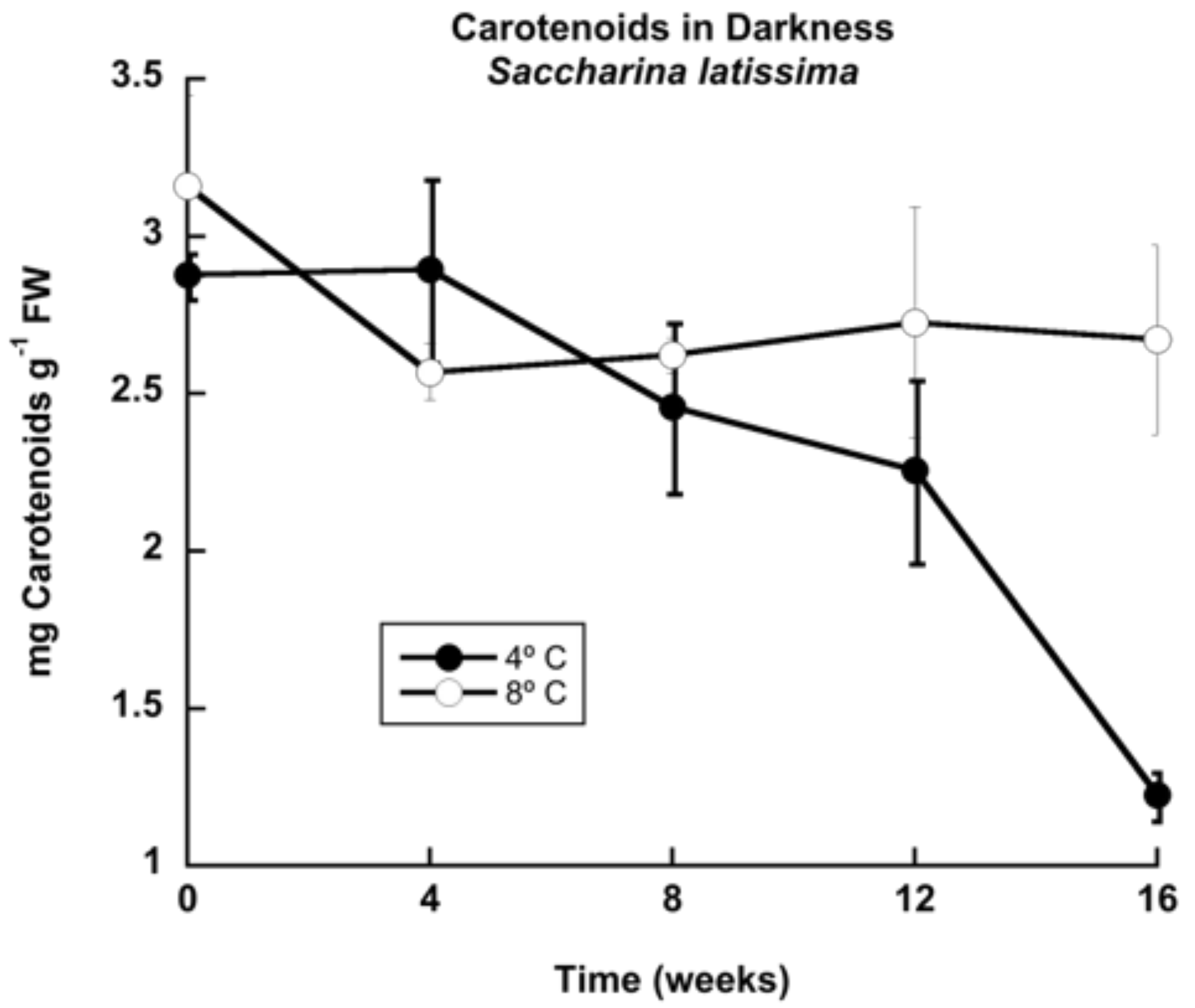
Alaria esculenta 3.5° C

Alaria esculenta 8° C

OVERWINTERING…







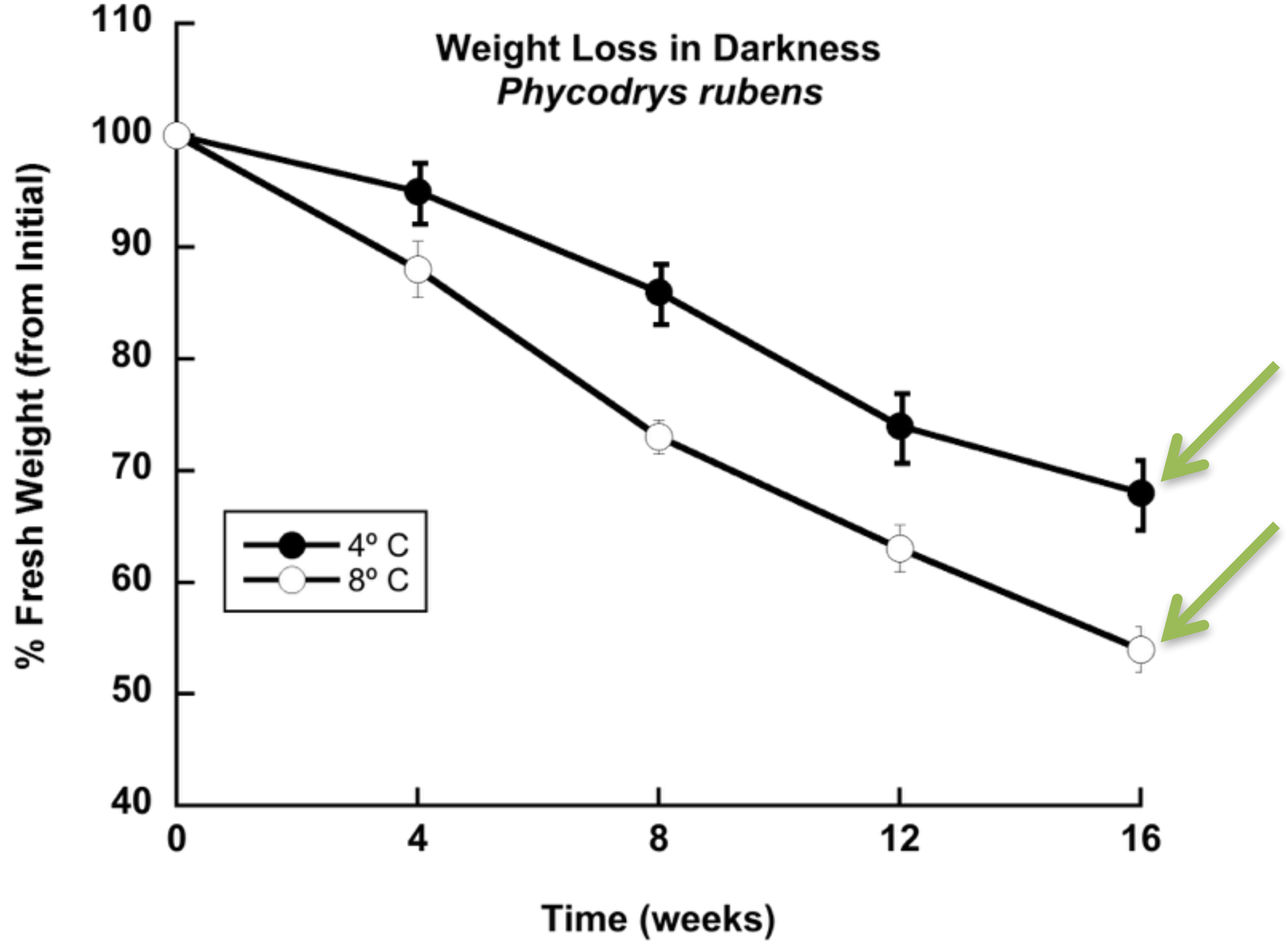
Warm means:

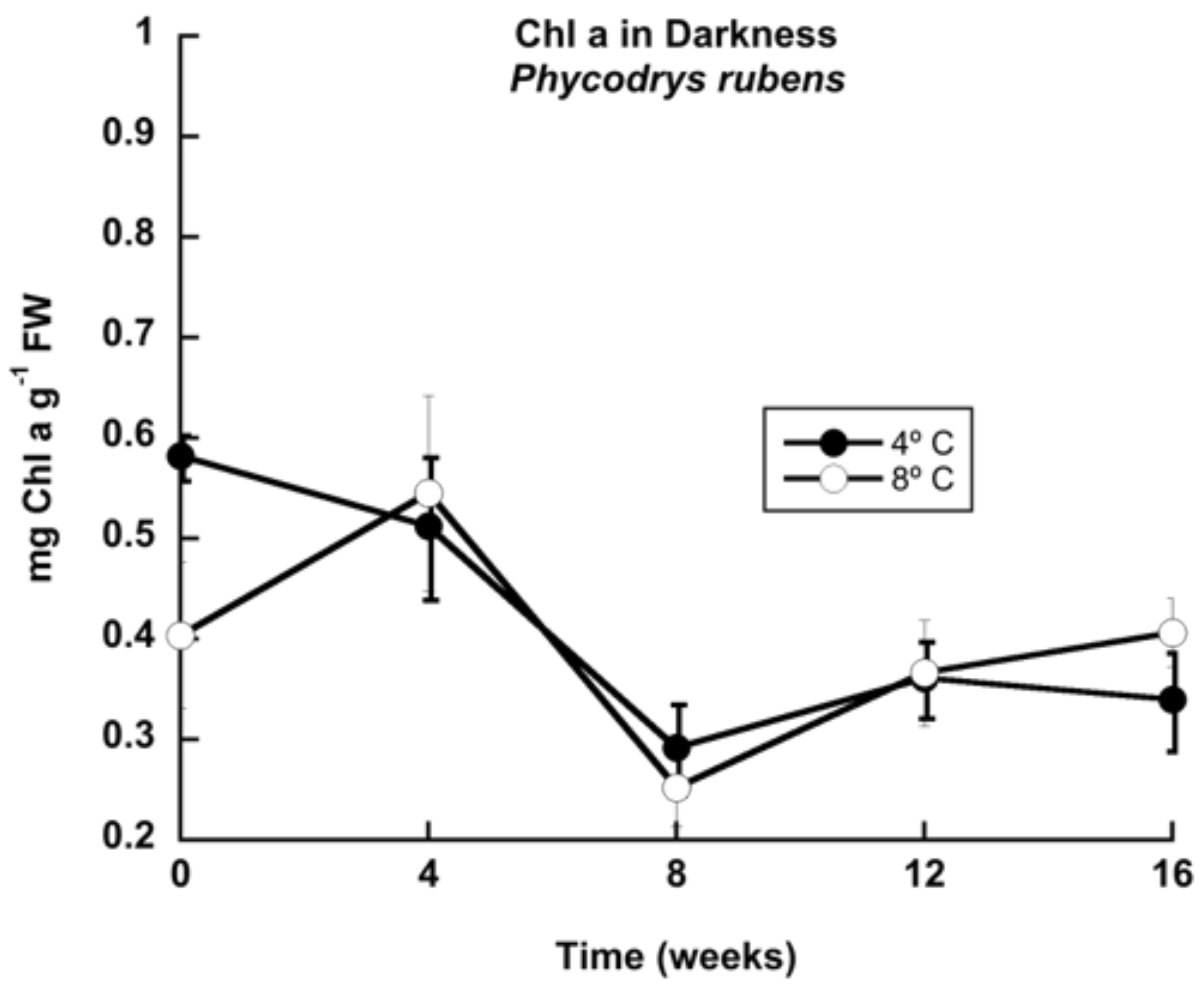
- similar respiration rate
- Only 25% Gross Photosynthesis (O_2) during recovery
- Lower survival (?)

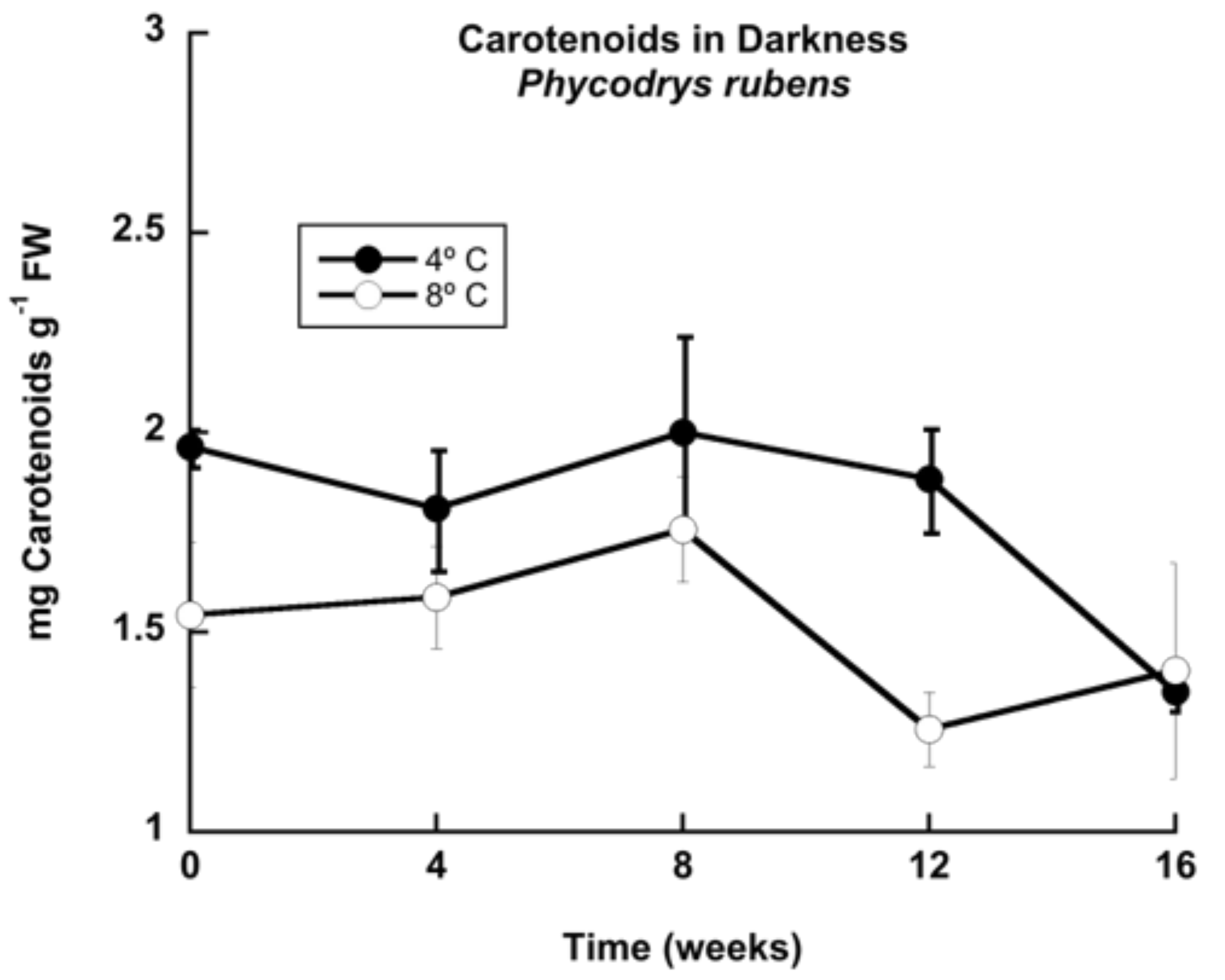
Saccharina latissima 3.5° C

Saccharina latissima 8° C

OVERWINTERING…



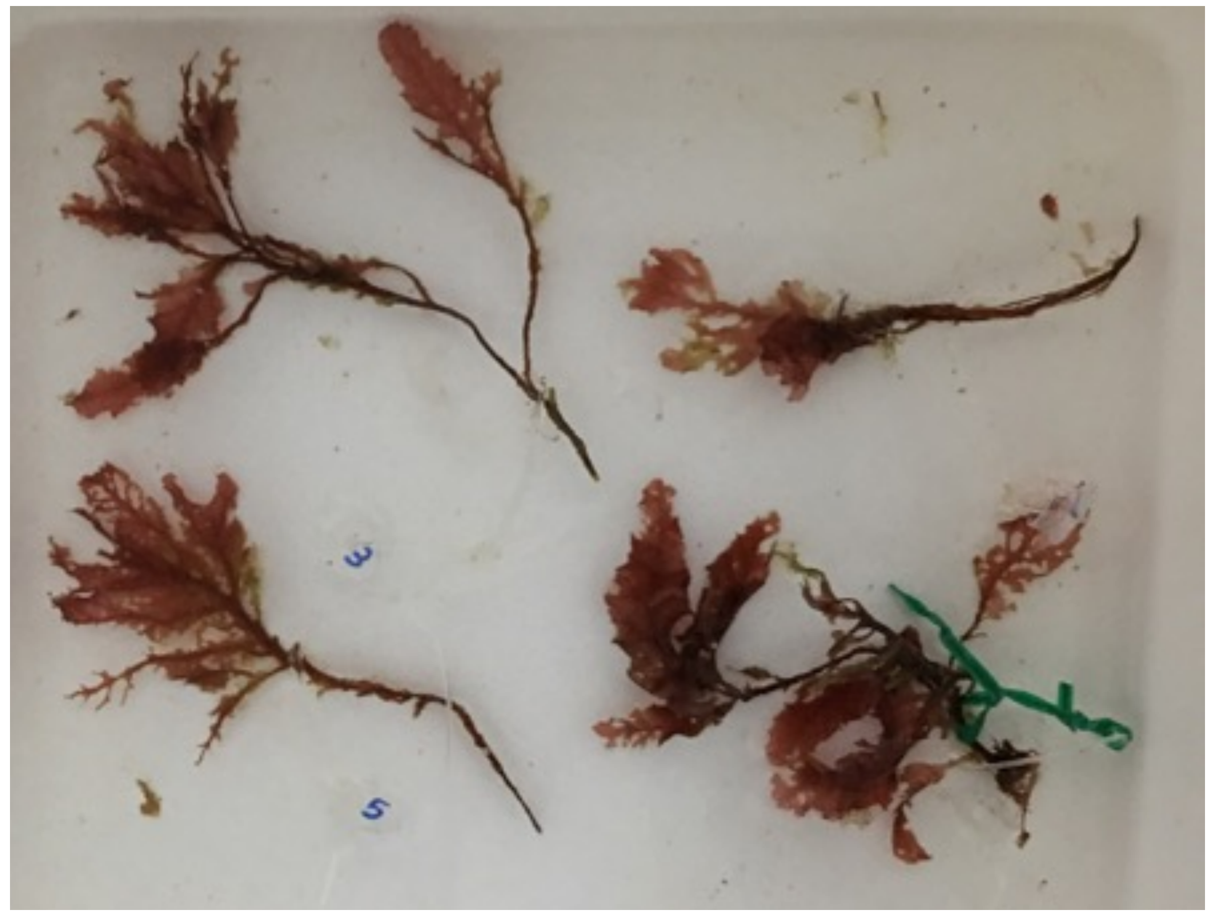




<u>Warm means:</u>

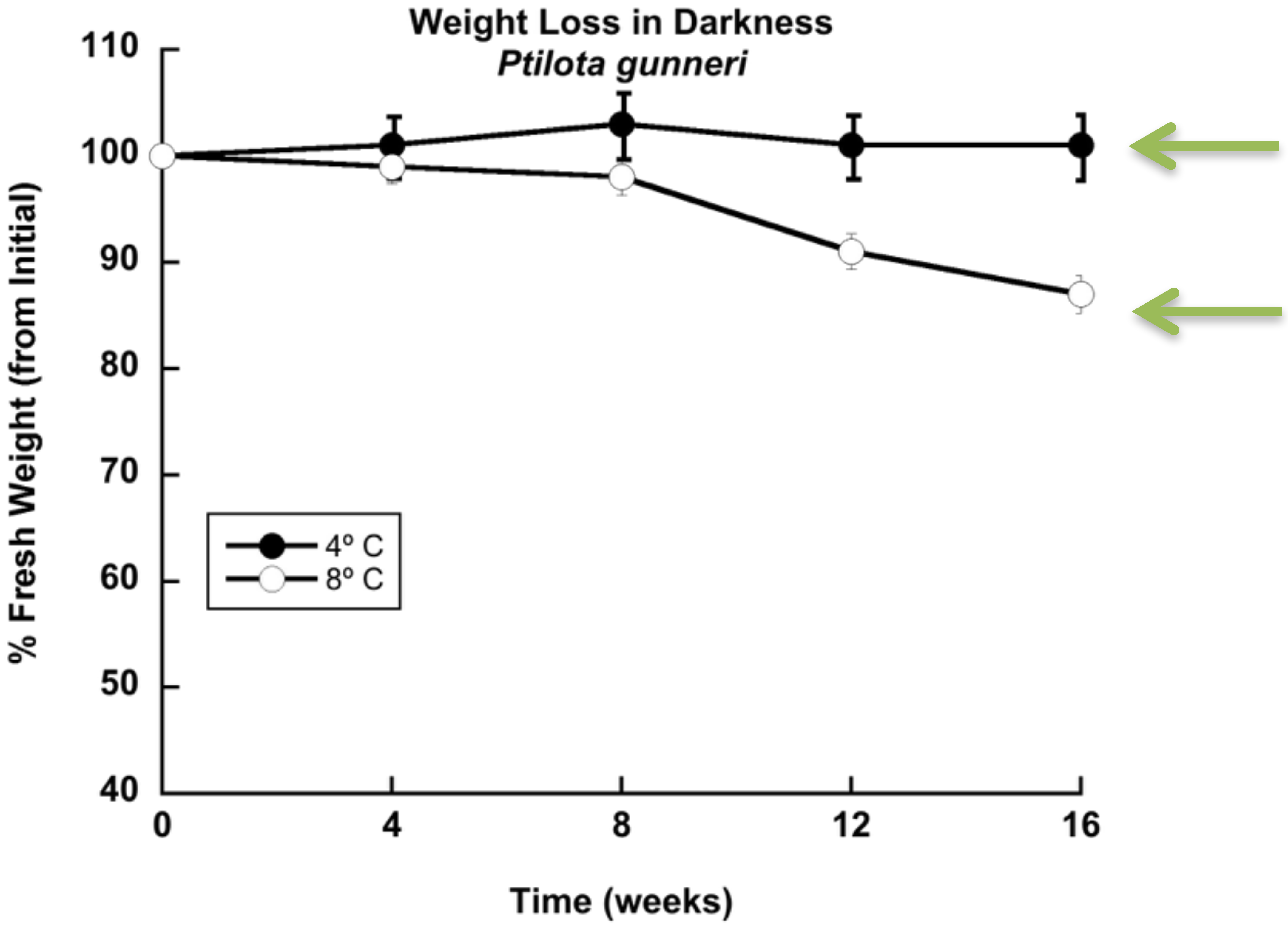
- similar respiration and photosynthetic (O_2) rates
- Temp benefits in light

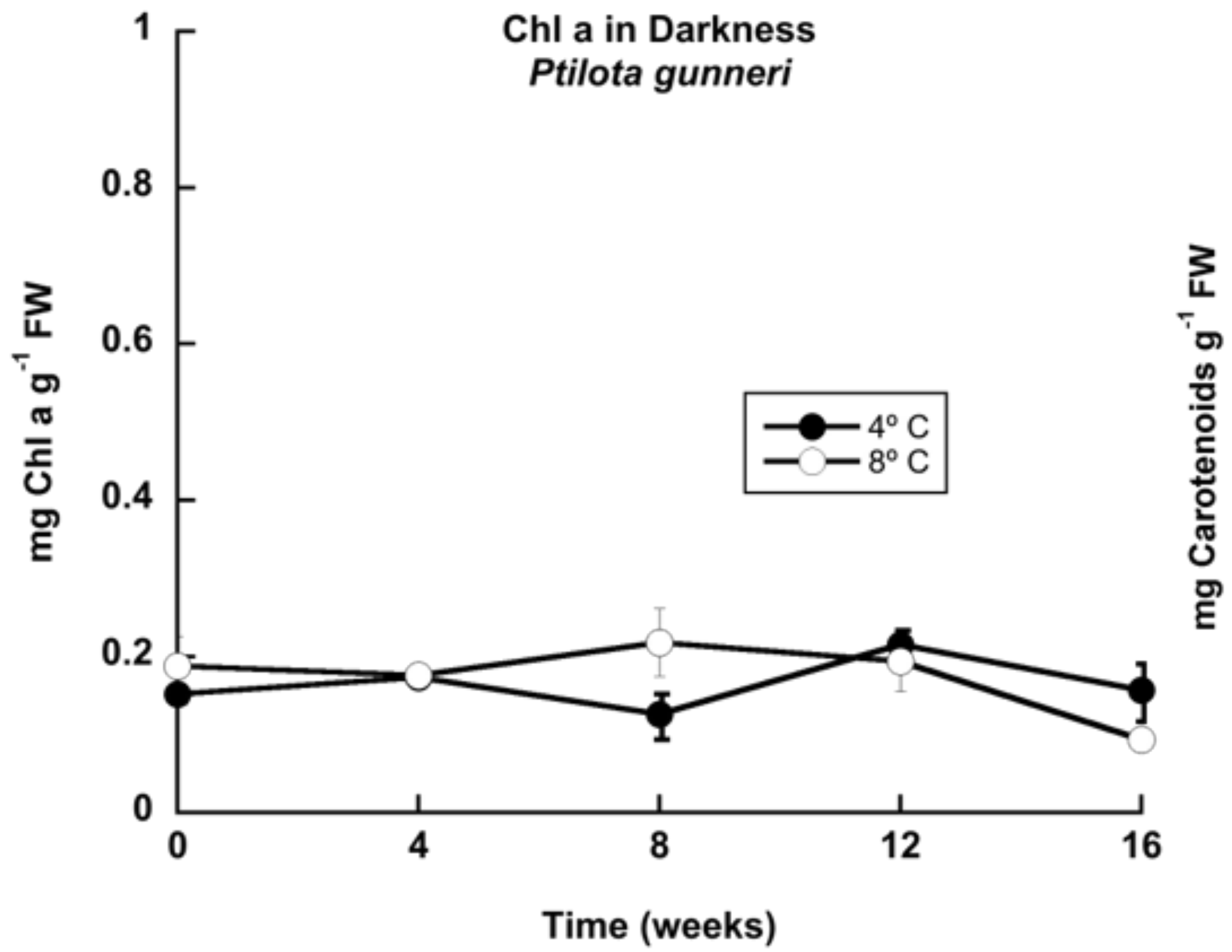
Phycodrys rubens 3.5° C

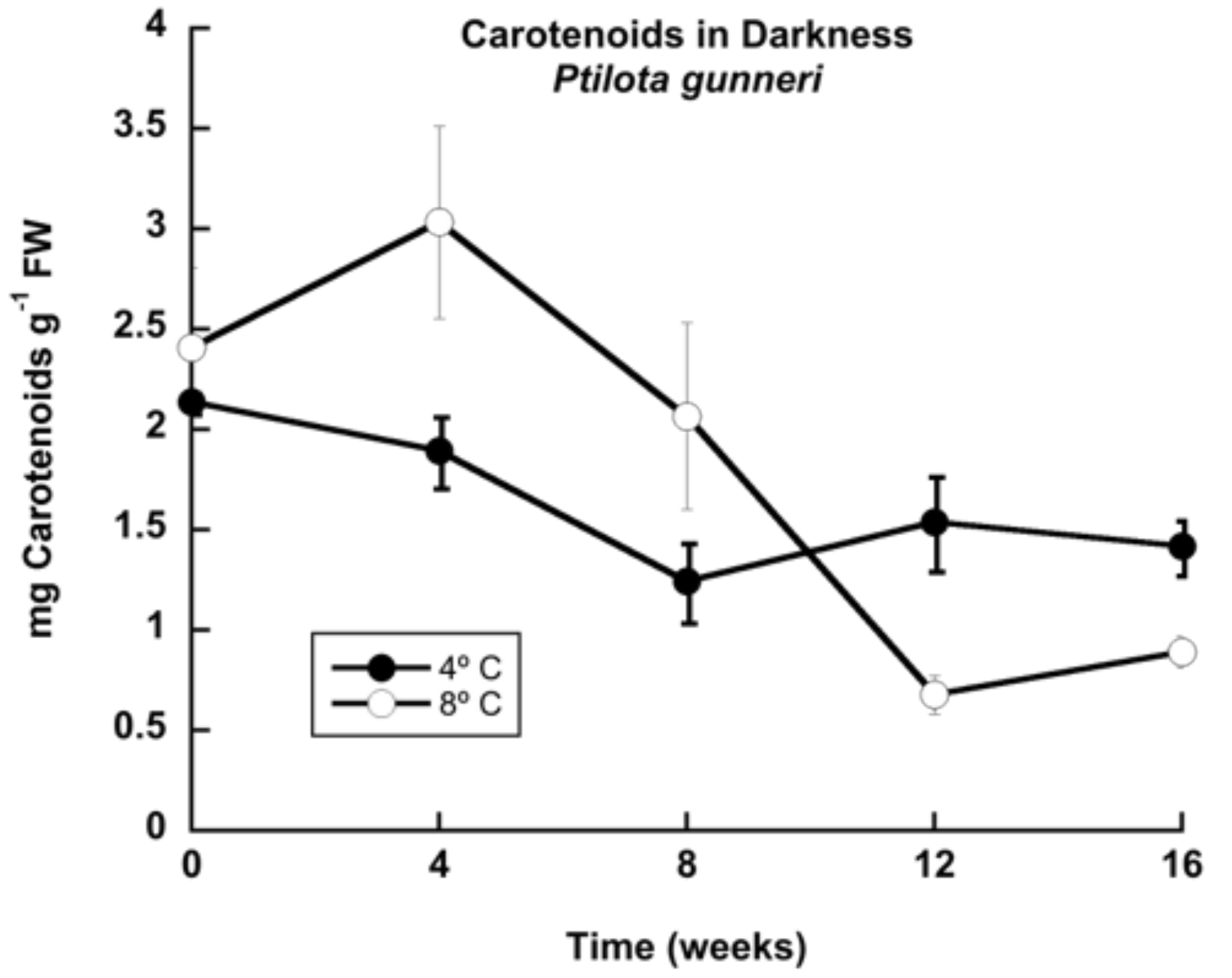


Phycodrys rubens 8° C

OVERWINTERING…







<u>Warm means:</u>

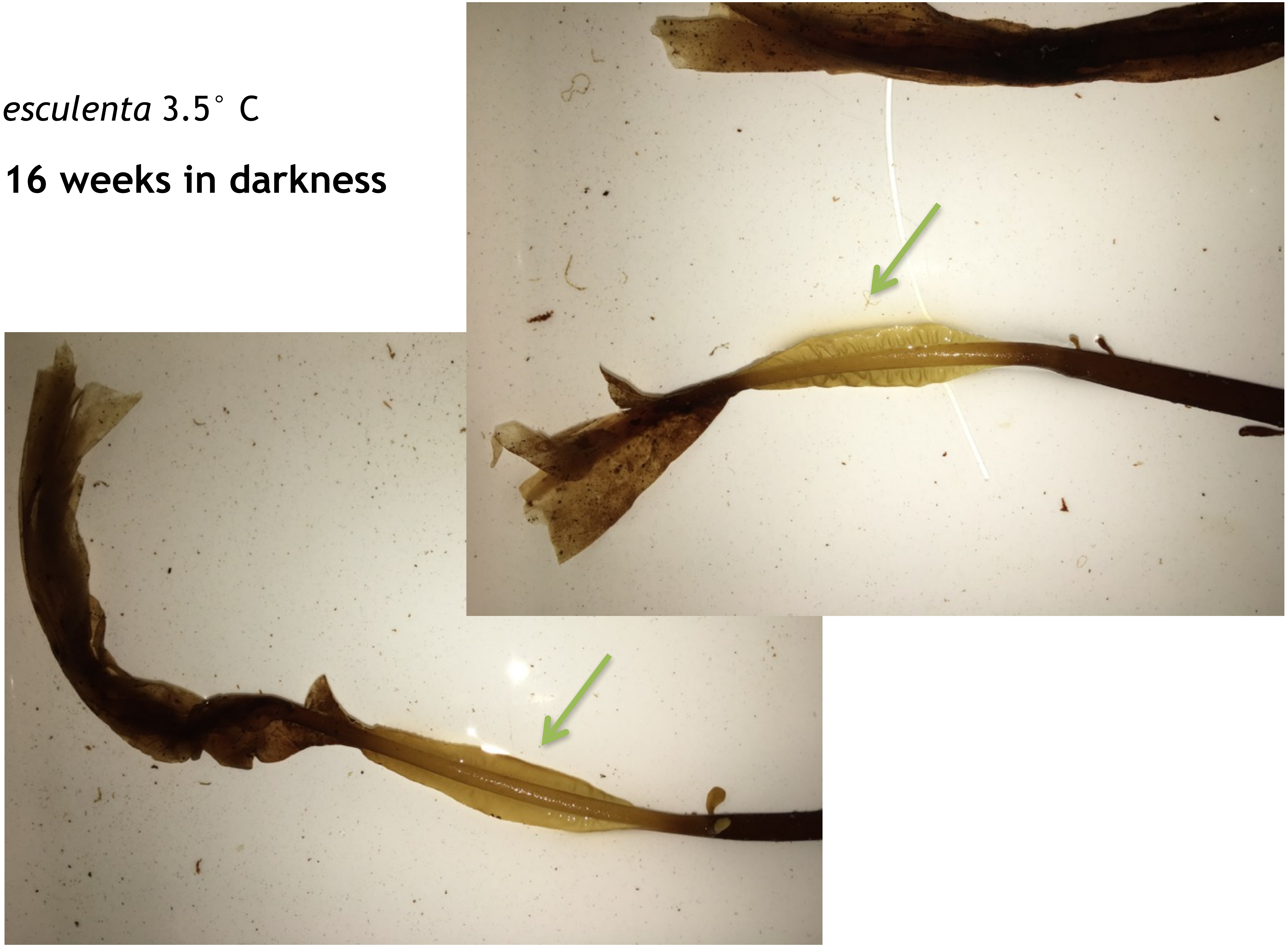
- Up to 50% reduction in photosynthetic (O_2) rate, but not affecting recovery
- Errr, …and that´s it

Ptilota gunneri 3.5° C

Ptilota gunneri 8° C

Alaria esculenta 3.5° C

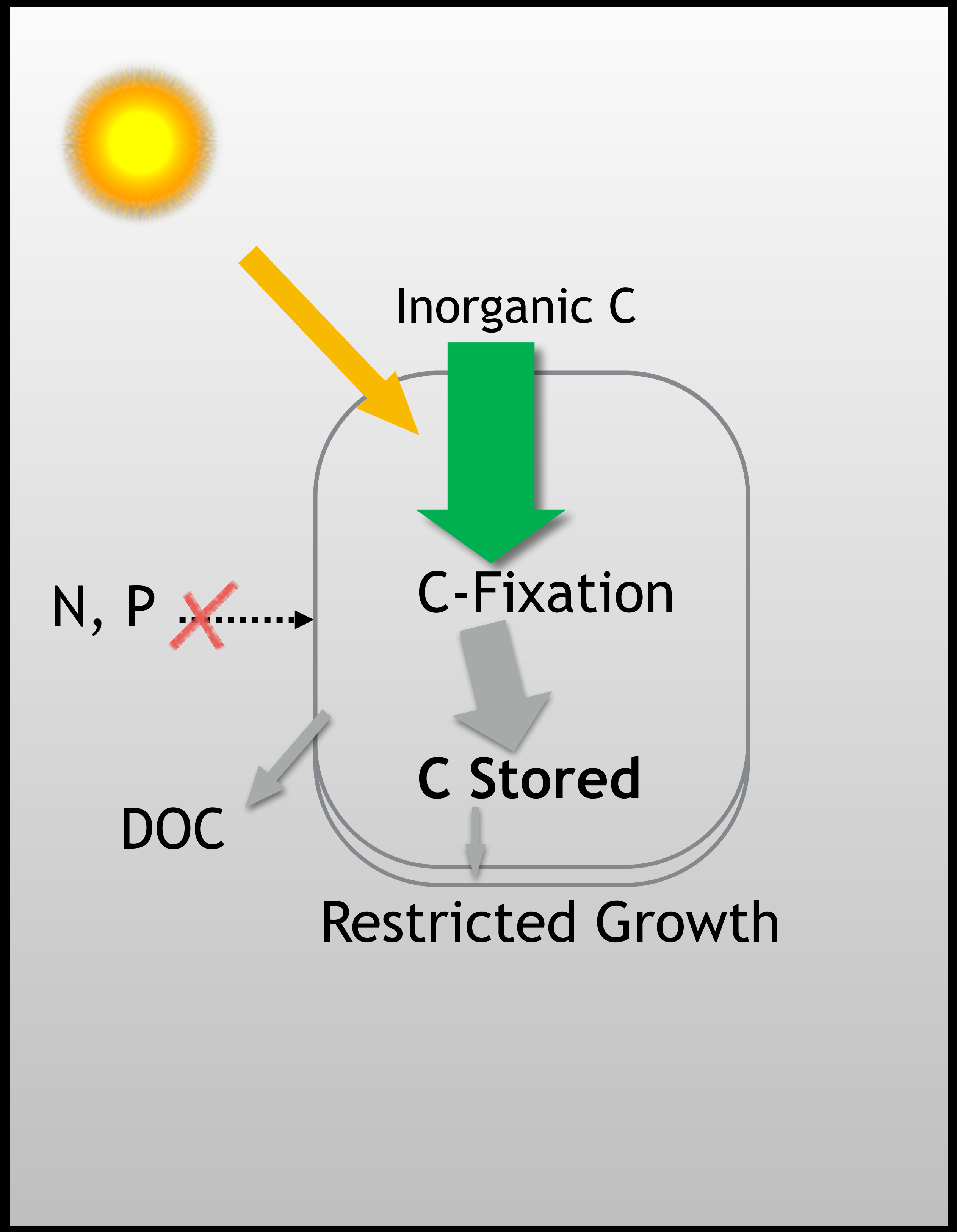
After 16 weeks in darkness



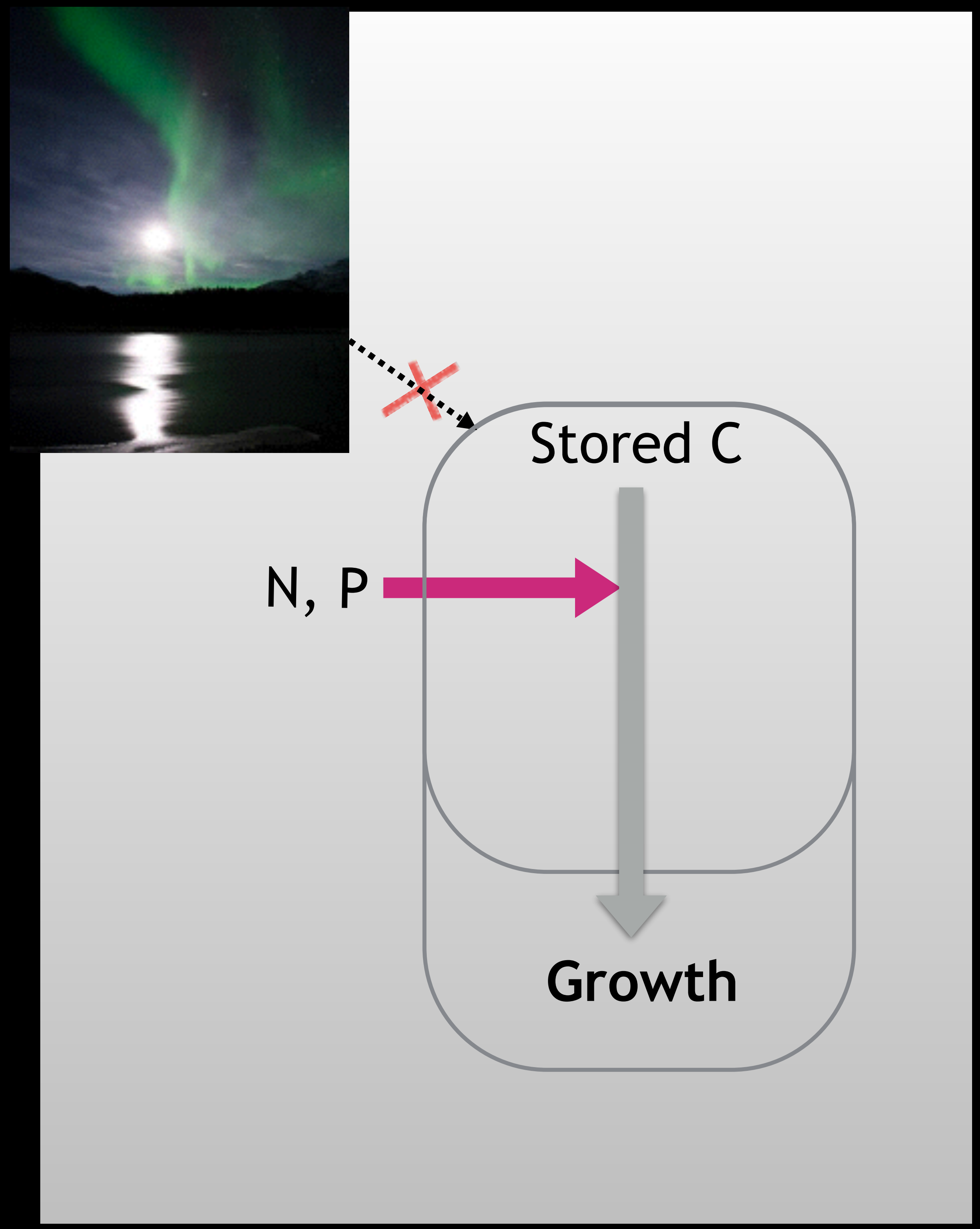
… two months later

THE CLASSIC MODEL

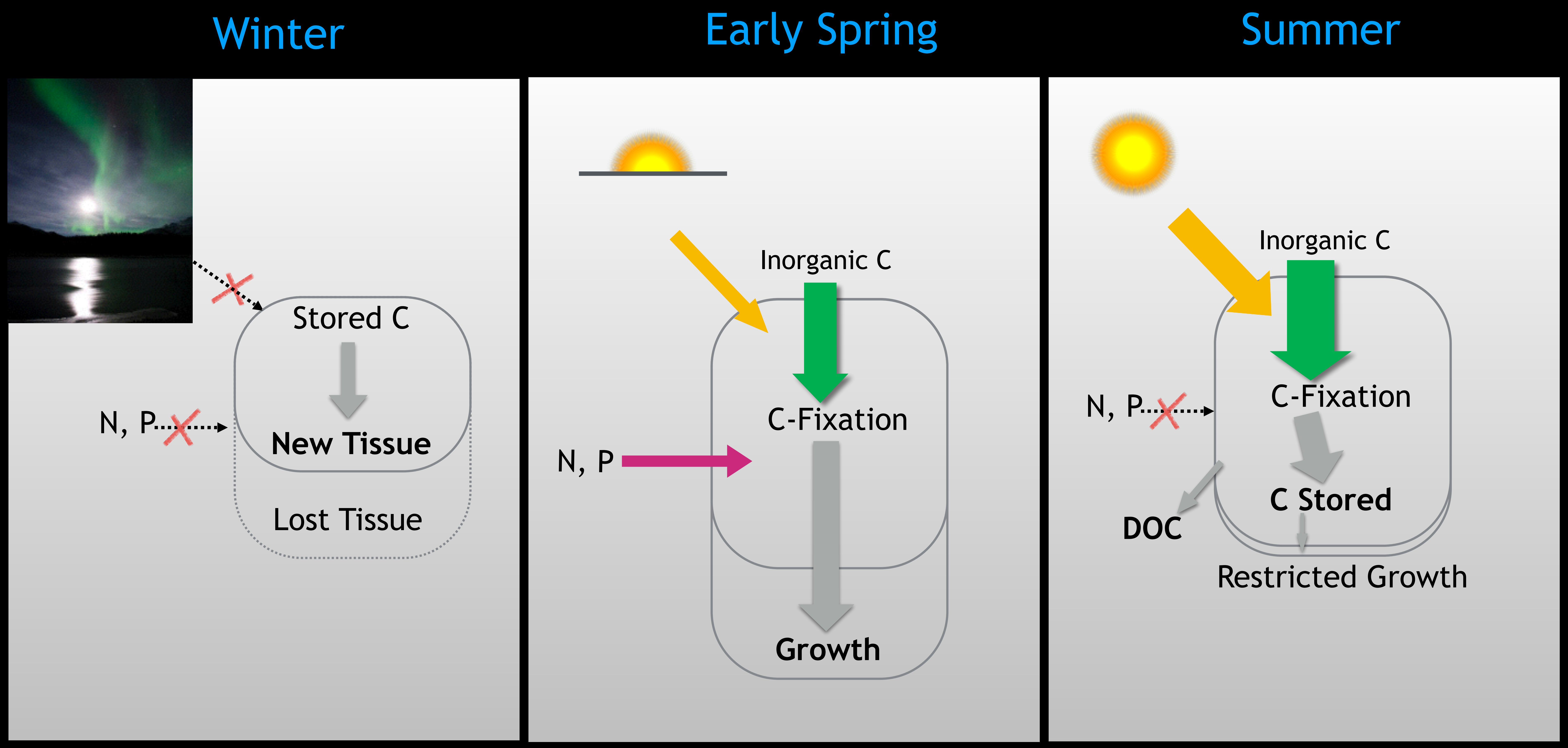
Summer



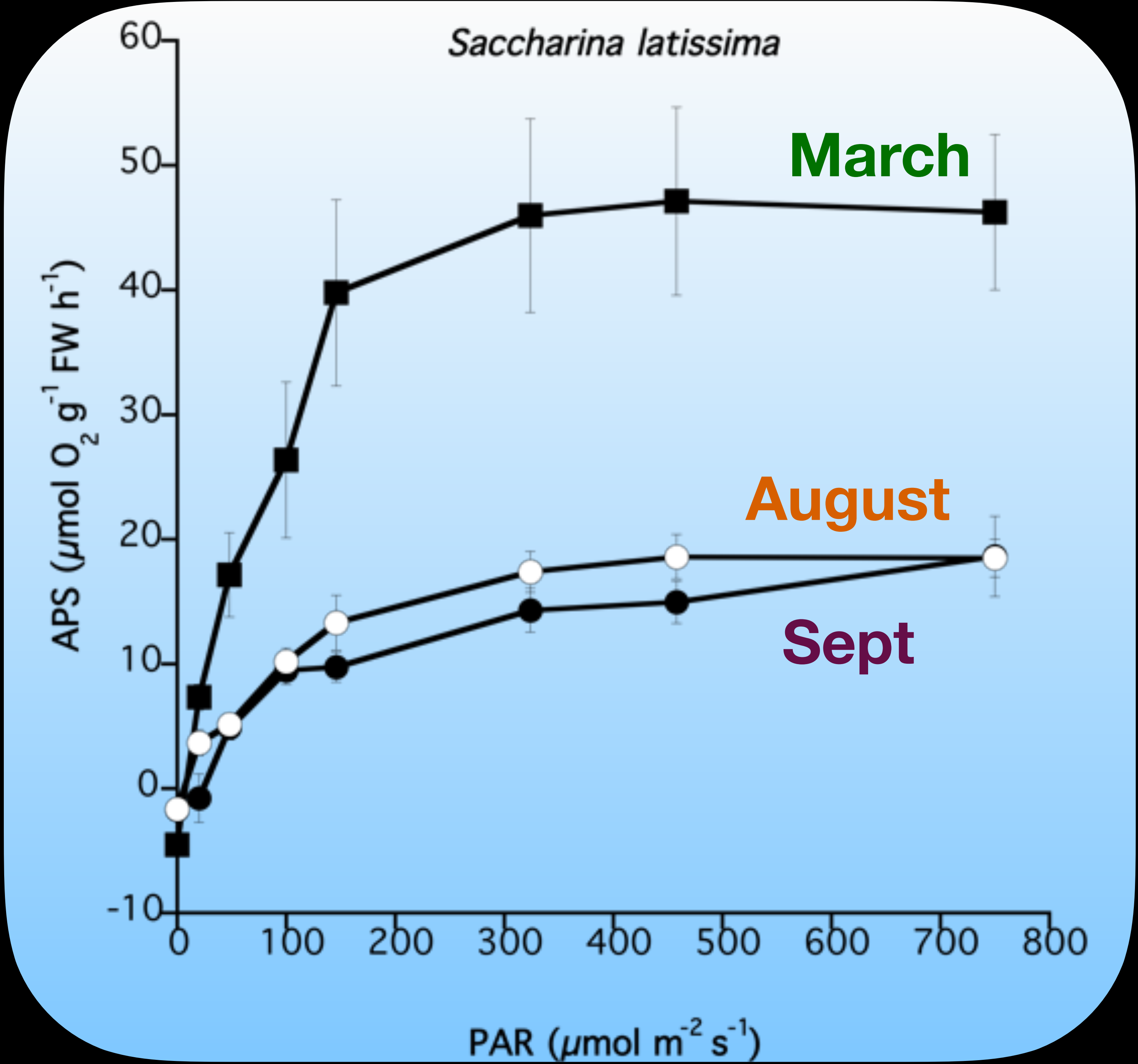
Winter

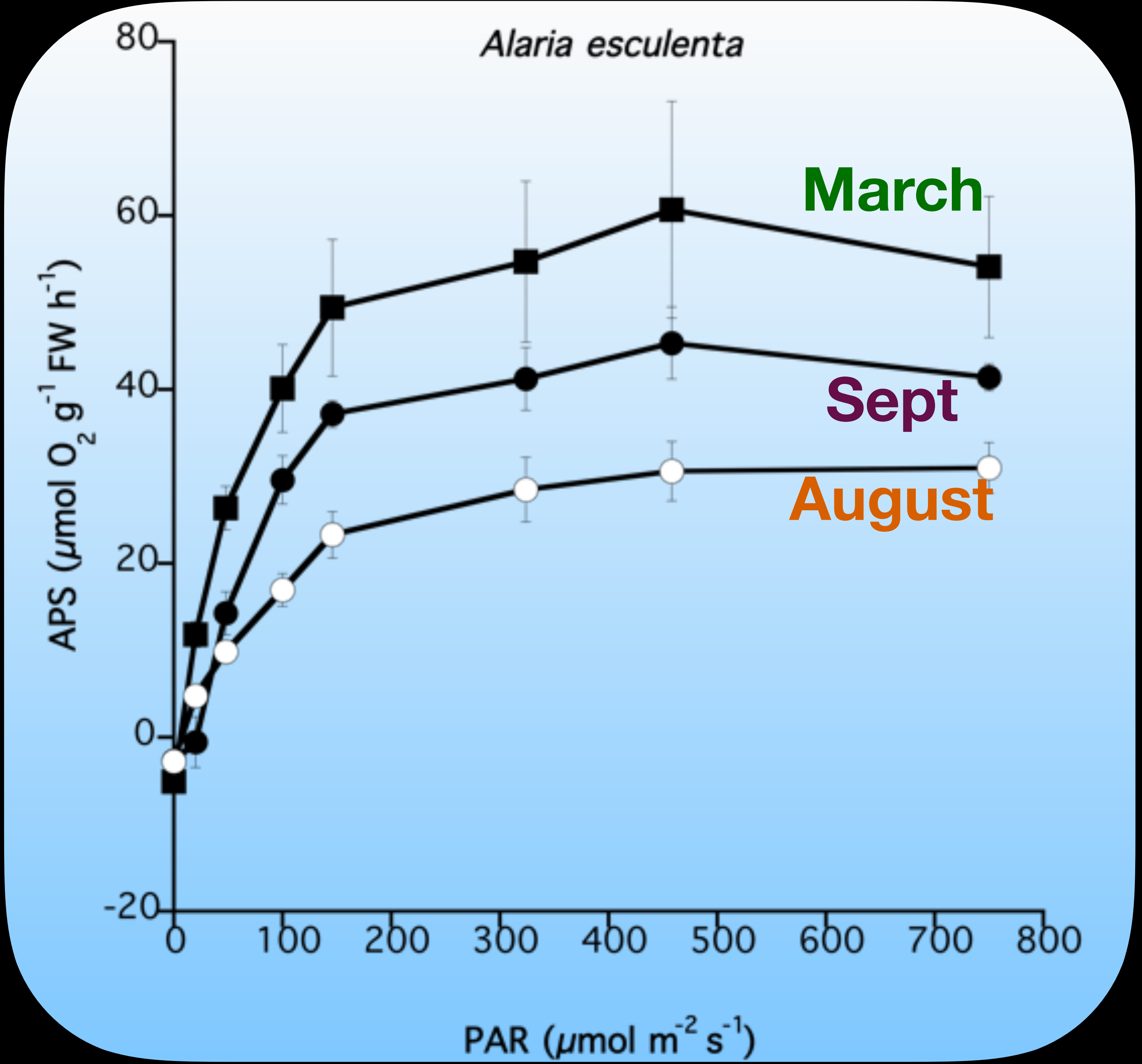


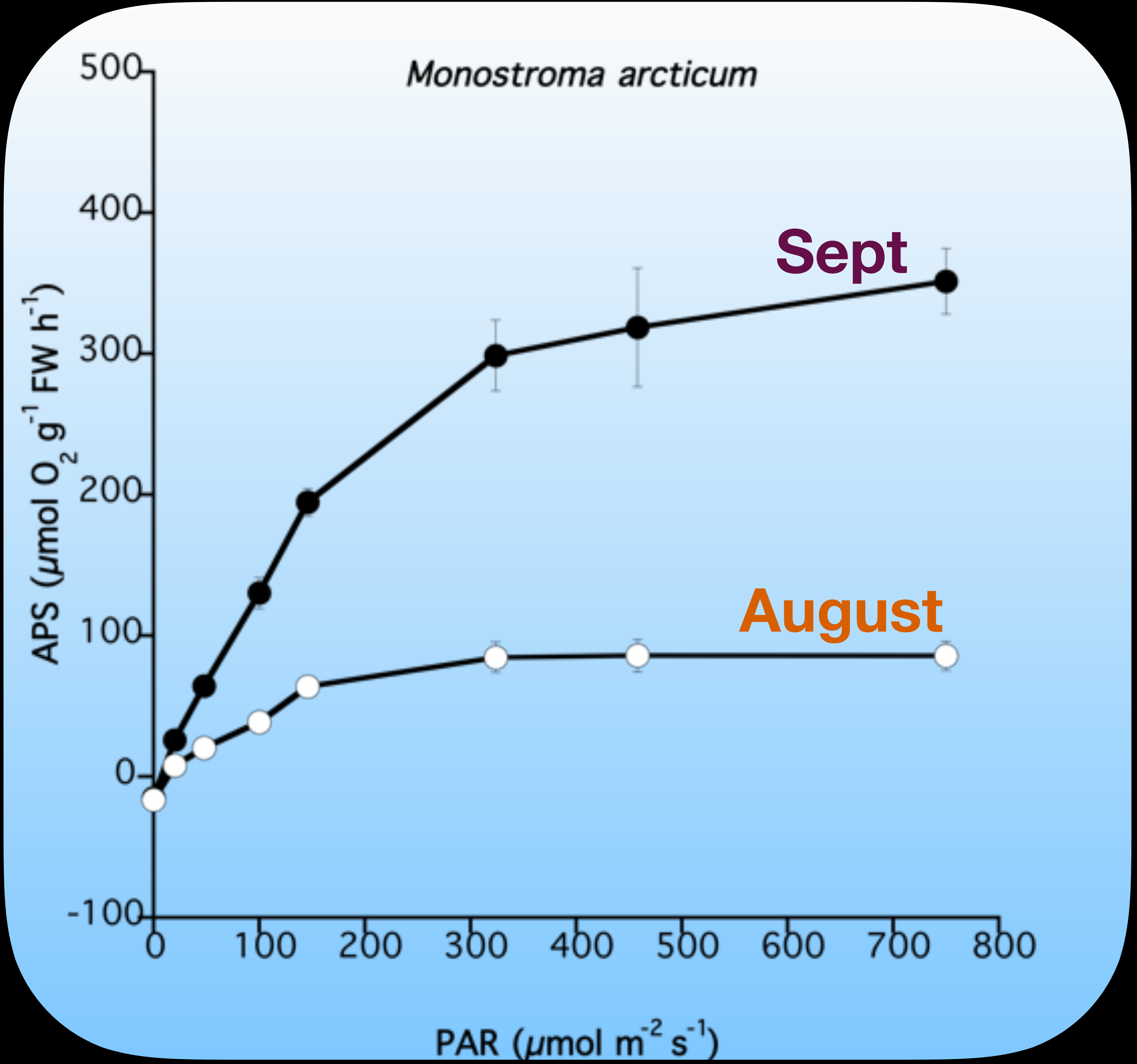
A NEW MODEL PROPOSED

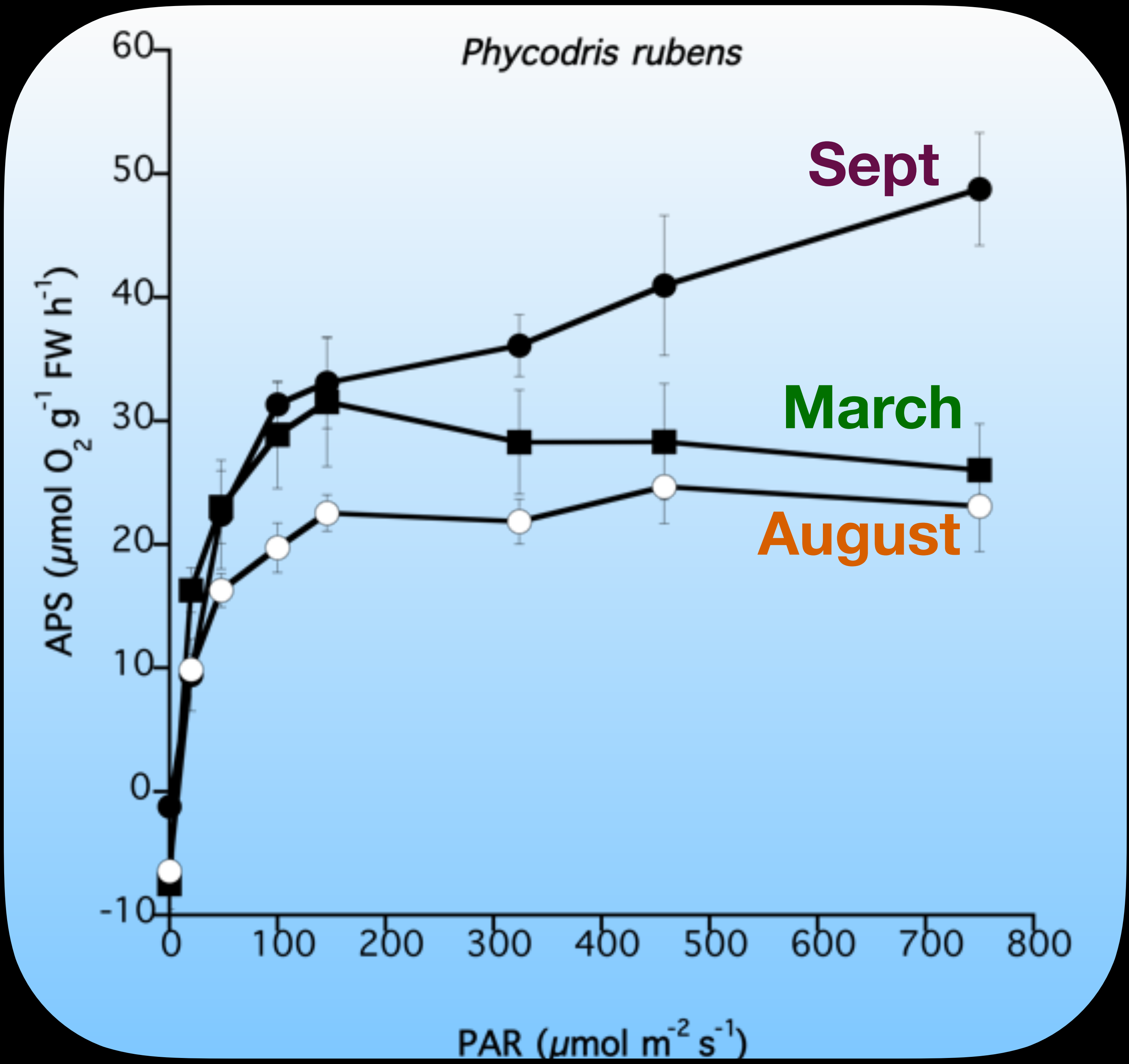


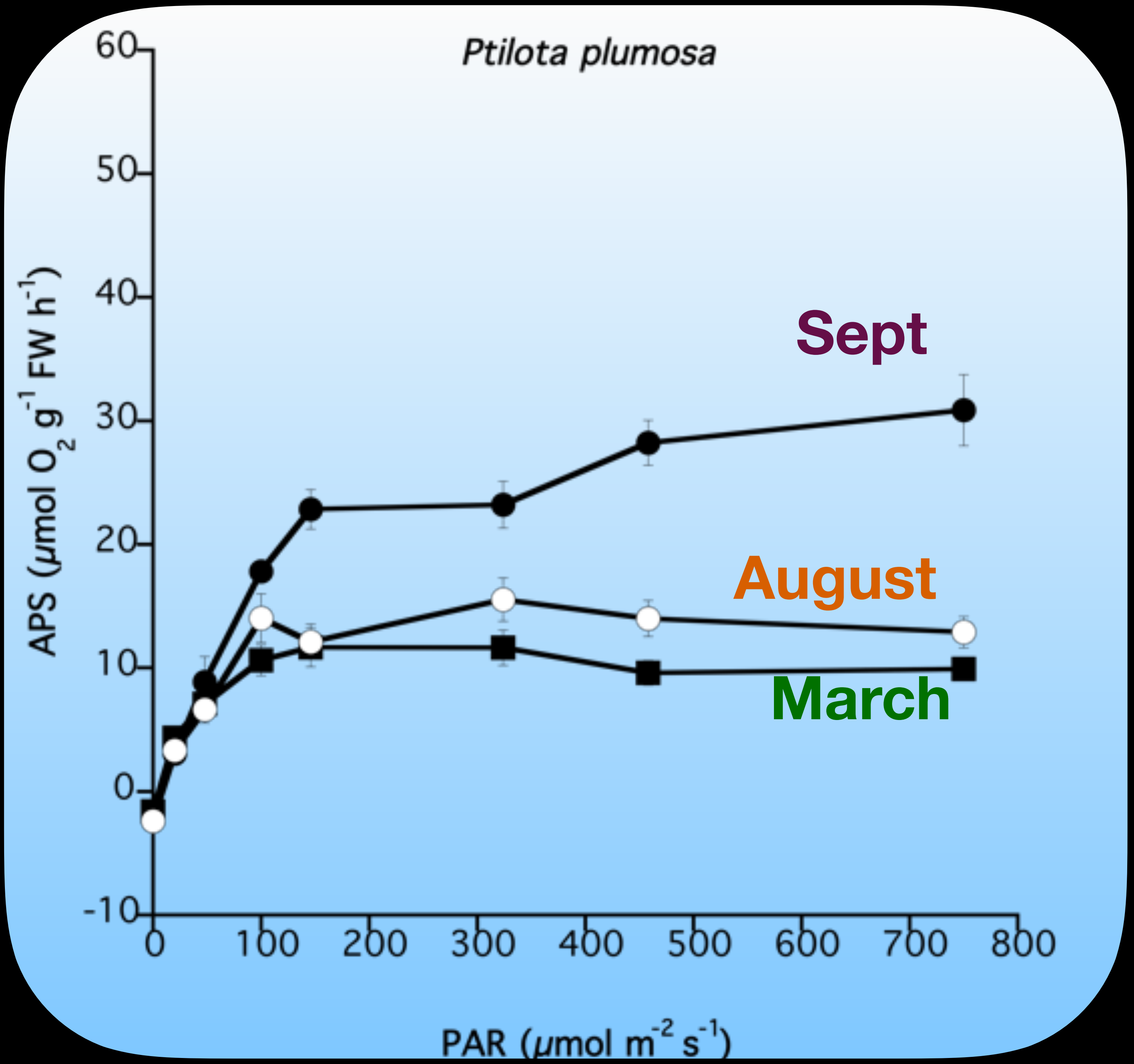
Seasonal P-I curves of field material (5-8 m depth)











TAKE-HOME MESSAGES

1. Arctic seaweeds are different and respond different
2. Temperature and CO_2 affect in species-specific ways (winners and losers)
3. Warm winters pose a threat on survival

Special thanks to:

AWI Seaweeds Group
Diving Team