Phytoplankton Production: New Data from Autumn and Plans to Parameterize and Test Models

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POLAR NIGHT PROJECT:

Overarching Hypothesis:

the onset of darkness induces a cascade of physiological changes that alters the functional role of autotrophic and heterotrophic microplankton.

Specific Hypotheses:

Primary production will be significantly higher than predicted by models based on springtime physiology

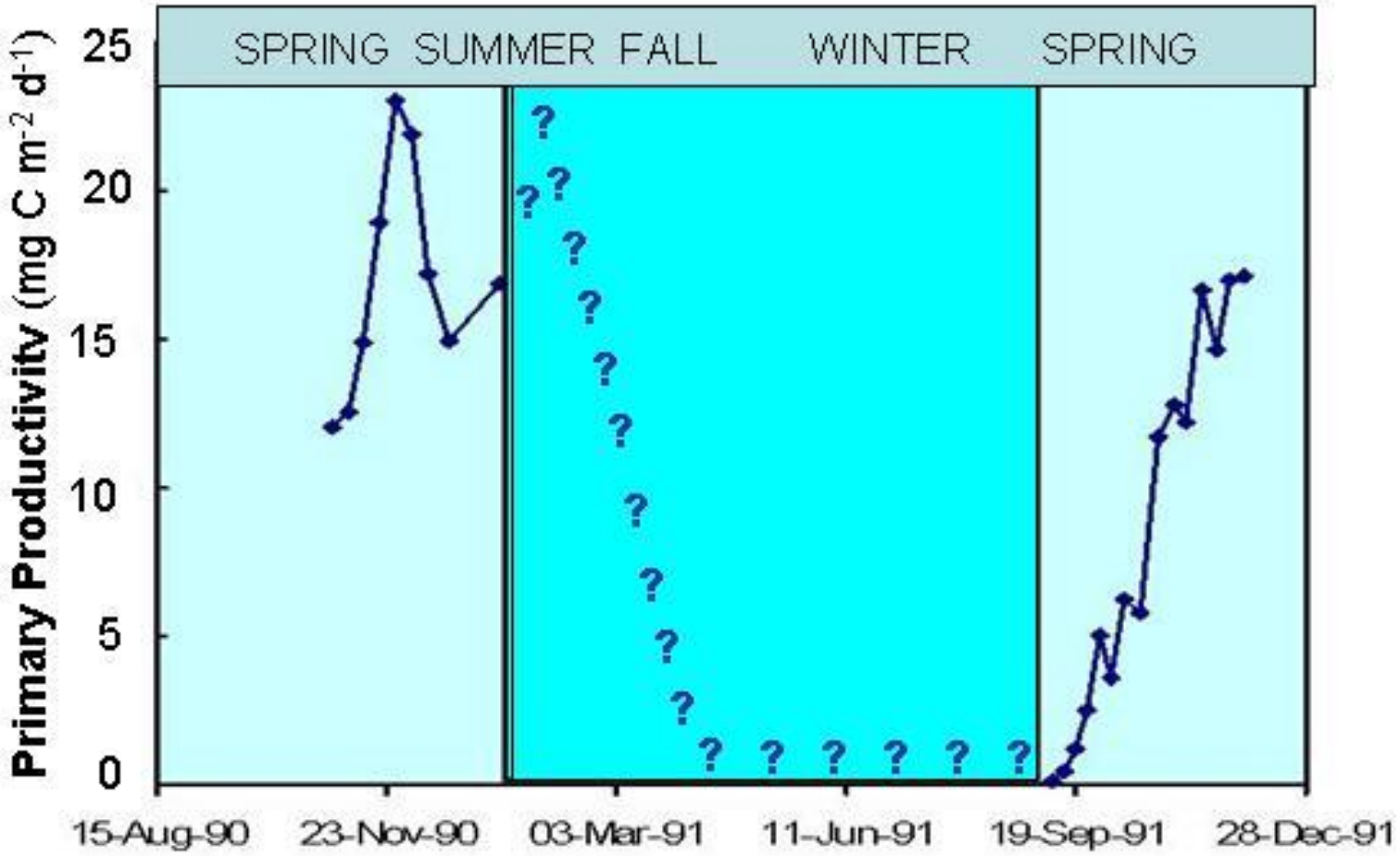


Figure 3. PPR in L. Bonney showing the temporal period when data have never been collected.

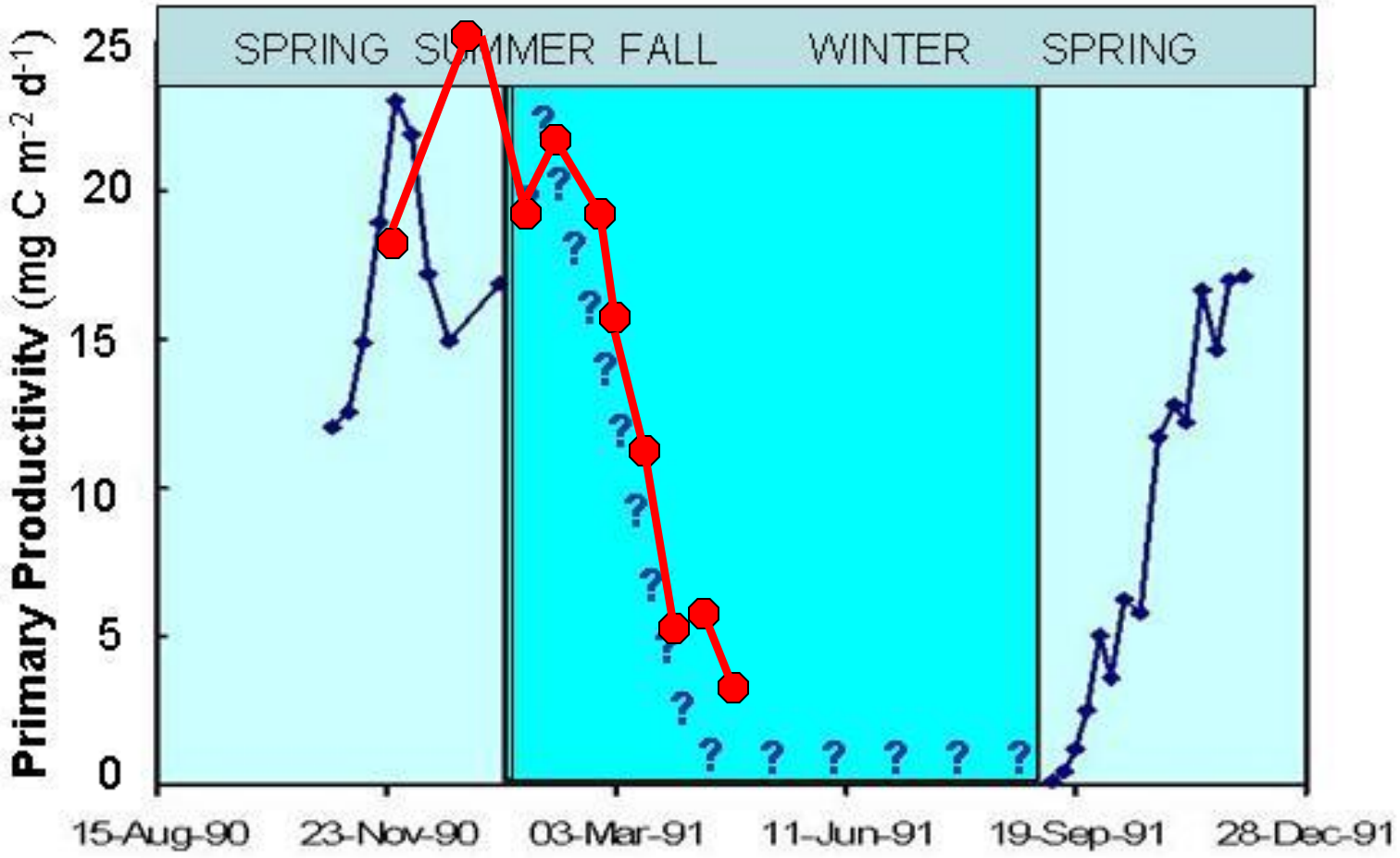
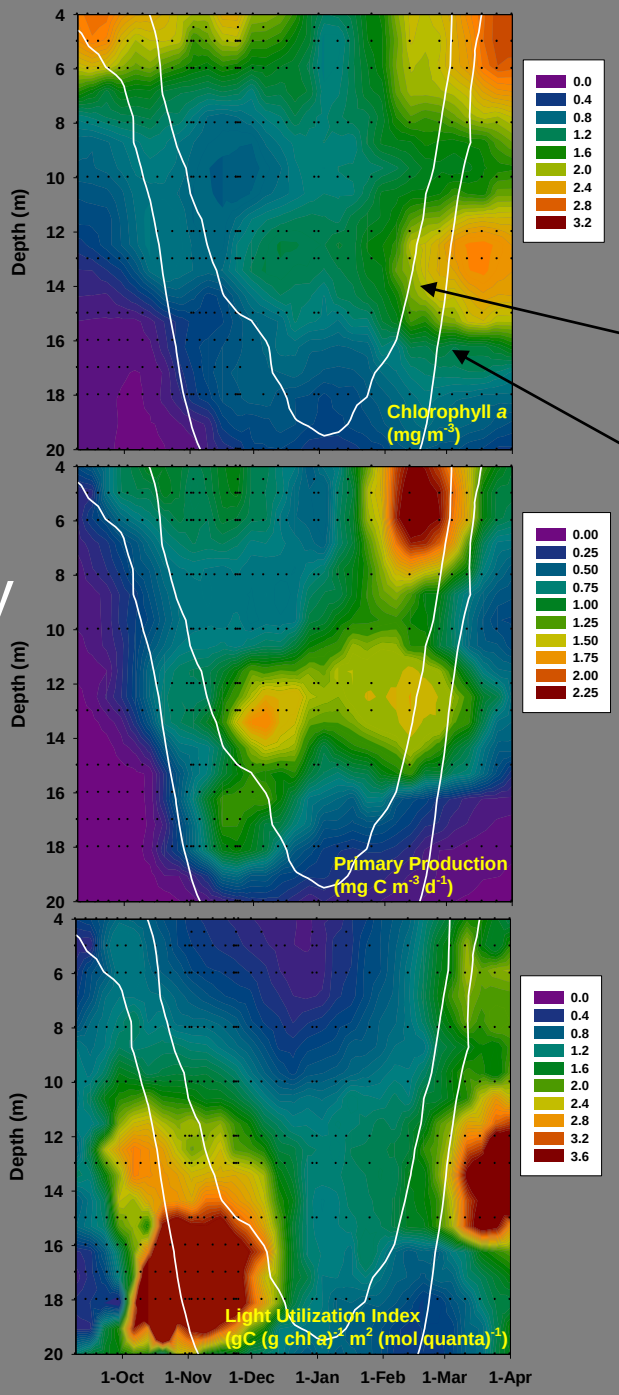


Figure 3. PPR in L. Bonney showing the temporal period when data have never been collected.

CHL-a
(mg m^{-3})

Primary Productivity
(mgC m^{-3} d^{-1})

Light Utilization Index
(gC $(gChl\text{-}a)^{-1}$ m^2 $(mol\ quanta)^{-1}$)



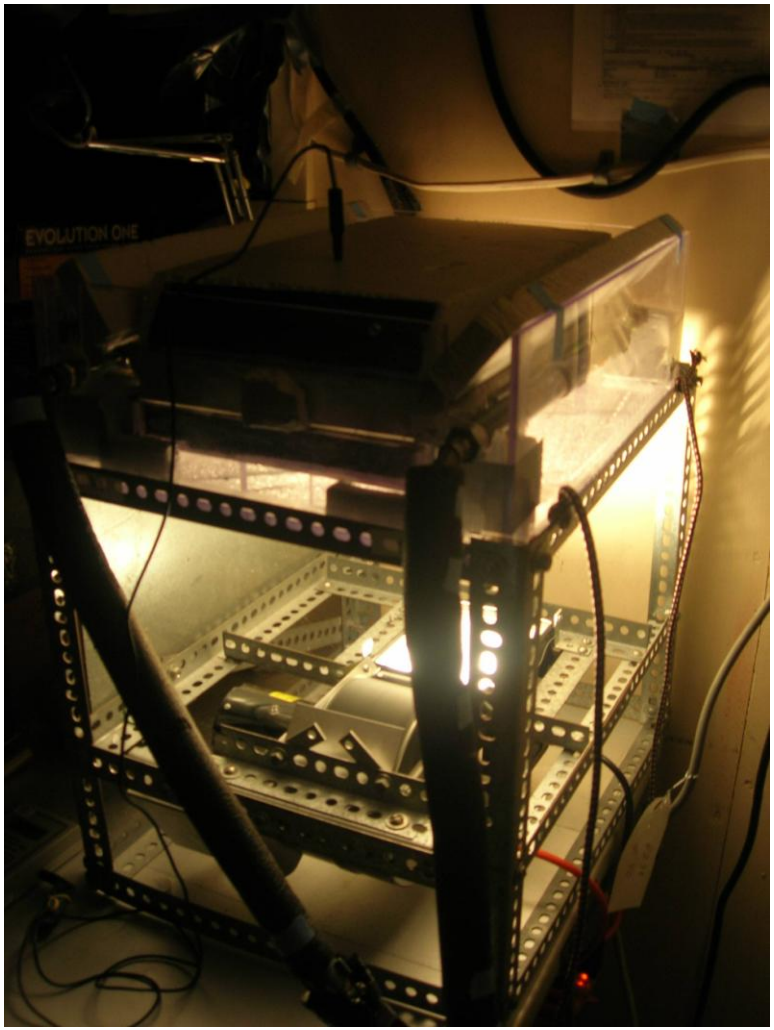
East Lobe Bonney
("growing season")

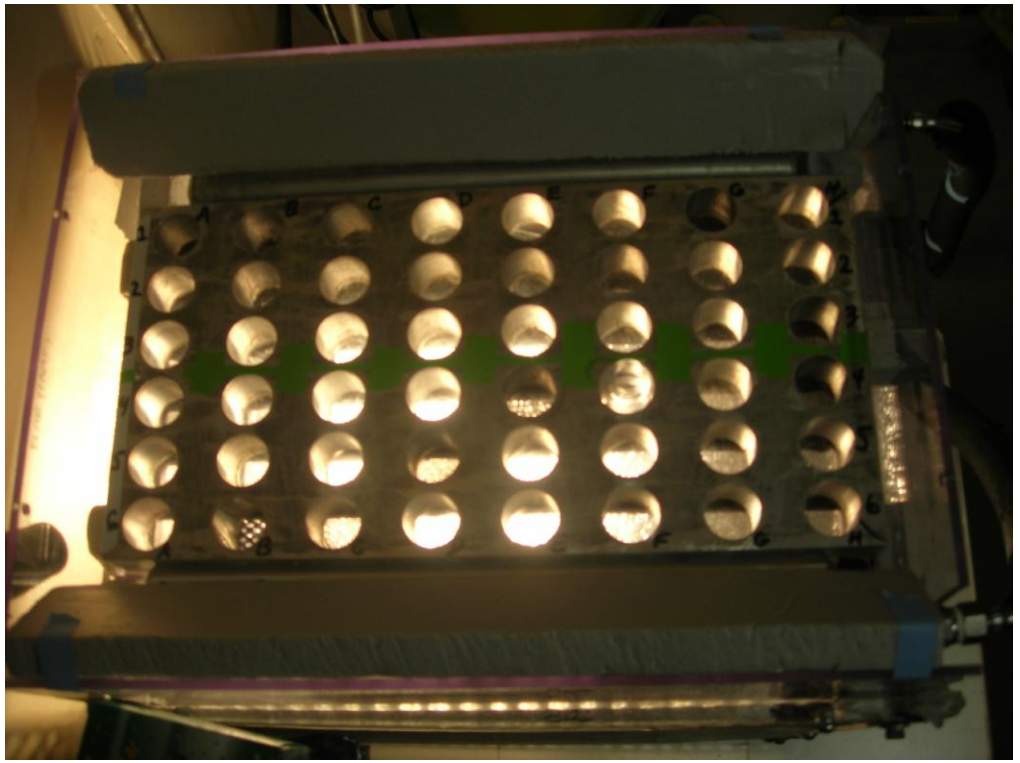
0.5mol quanta m^{-2} d^{-1}

0.25mol quanta m^{-2} d^{-1}

PHOTOSYNTHESIS VS. IRRADIANCE EXPERIMENTS:

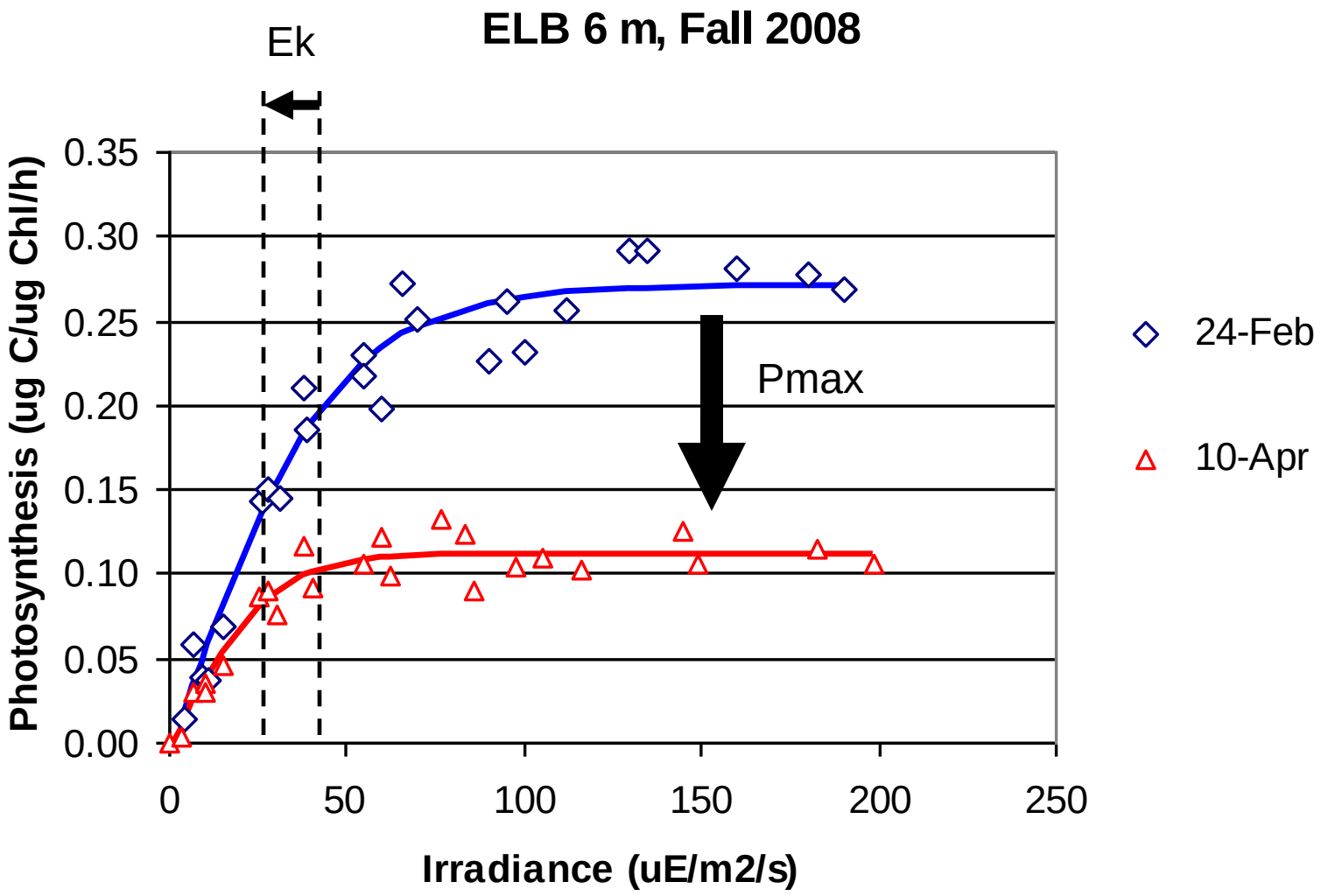
"Photosynthetron" – water-cooled incubator with multiple light levels





(top view, open)

Acclimation to decreasing light during Autumn in Lake Bonney: Reducing Excess Photosynthetic Capacity



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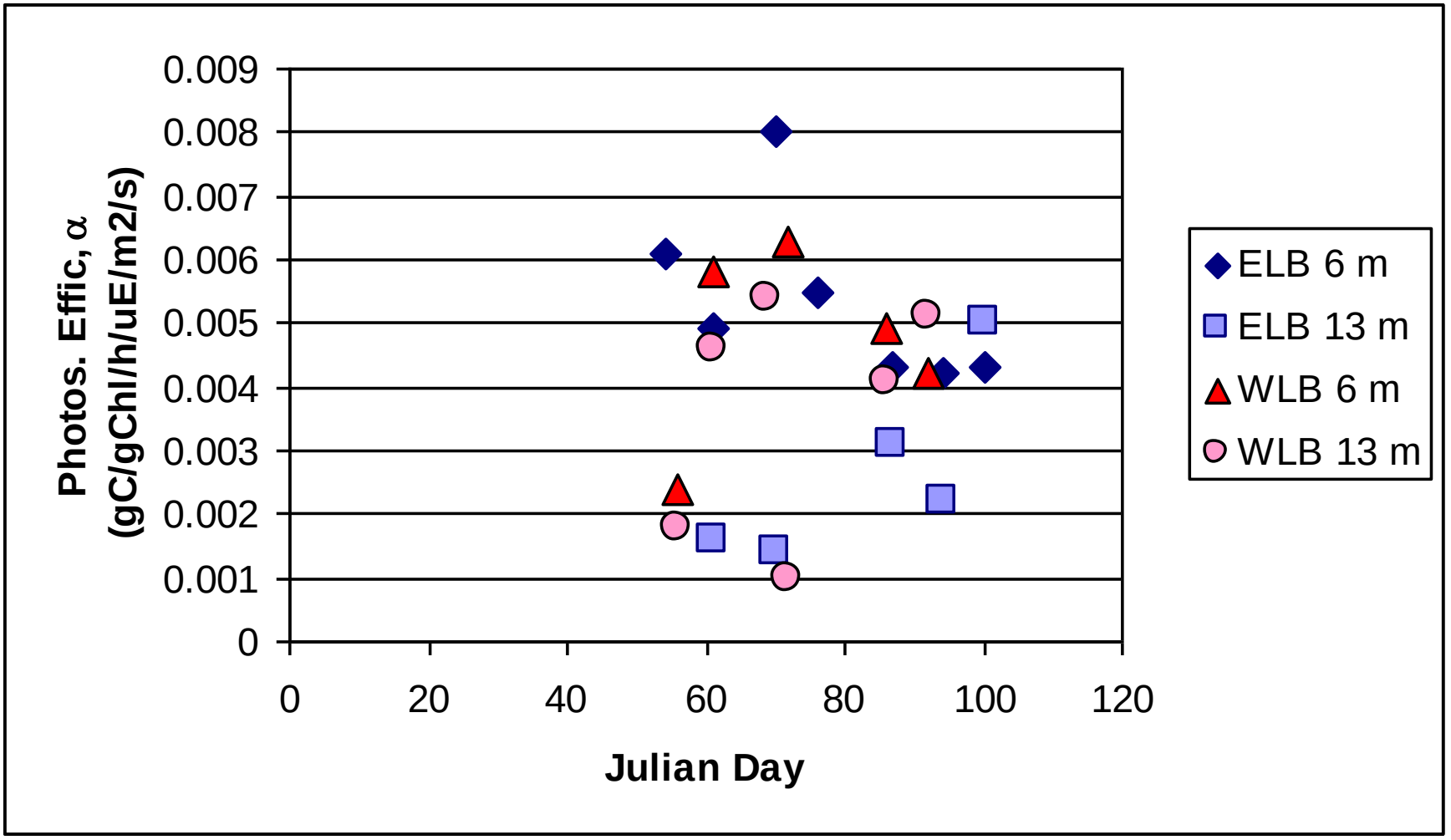
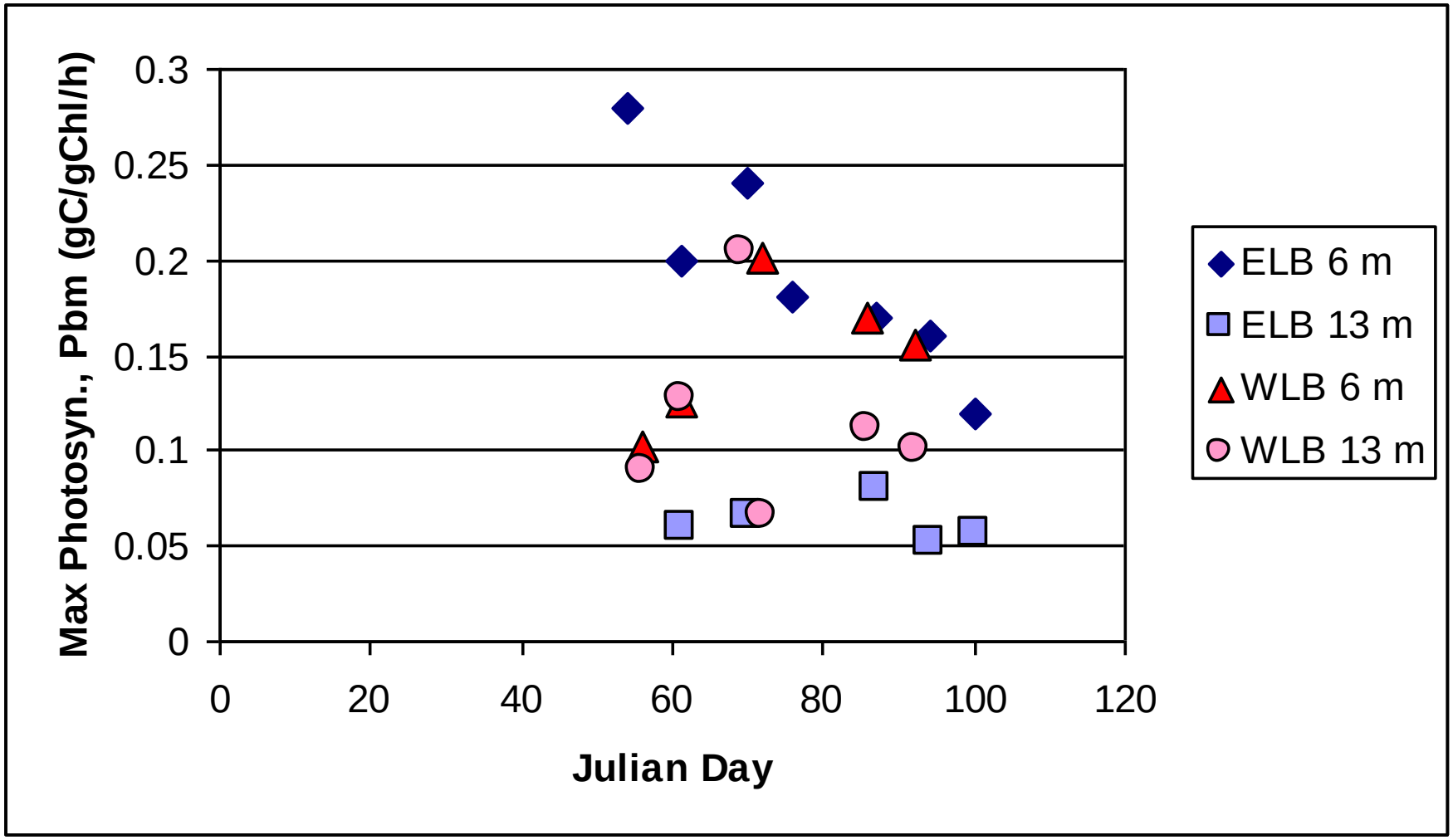
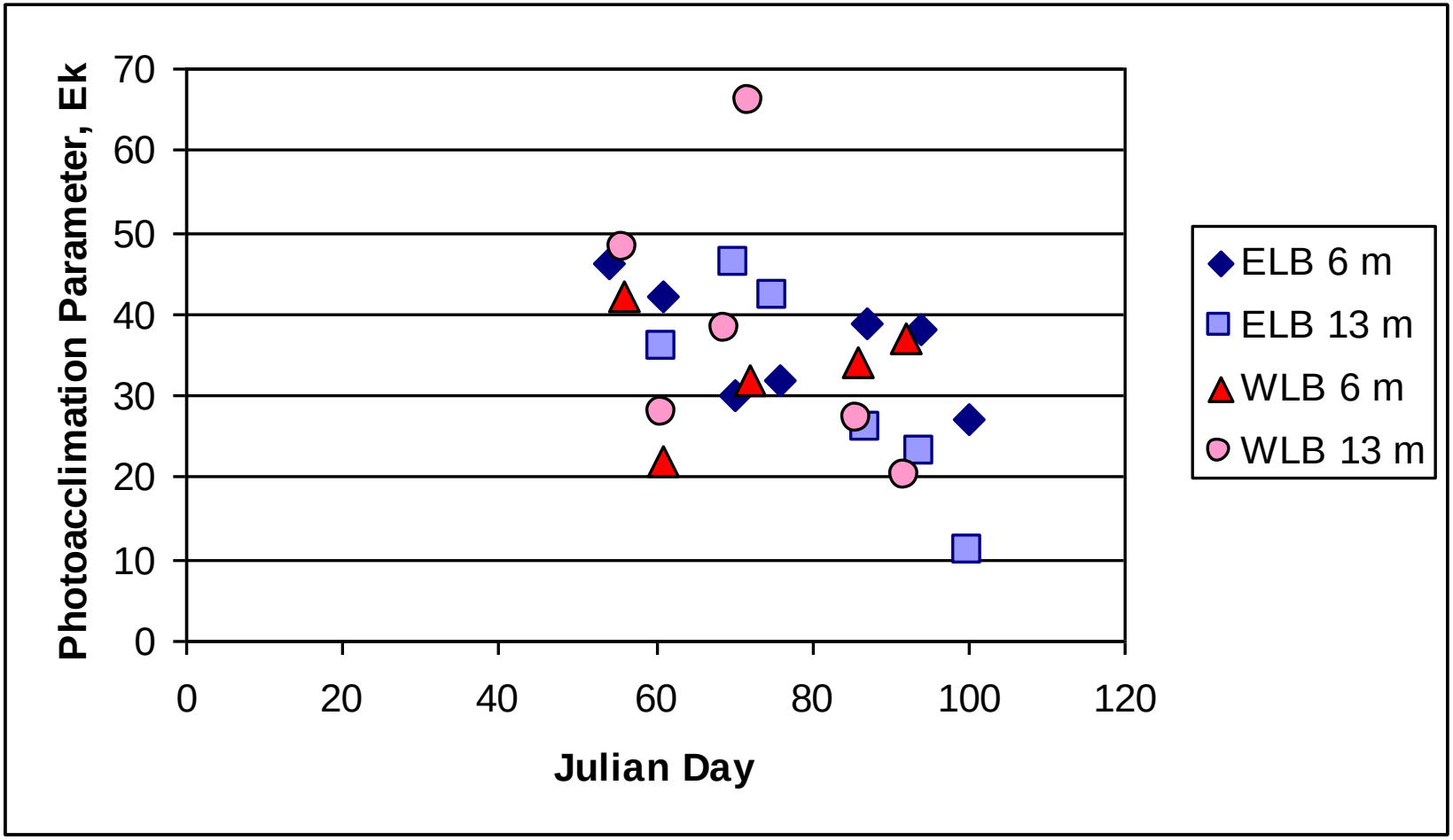
Fall for Lake Bonney – Photosynthetic Efficiency (α)



Fall for Lake Bonney – Max. Photosynthesis (PBm)



Fall for Lake Bonney – Photoacclimation Parameter (Ek)



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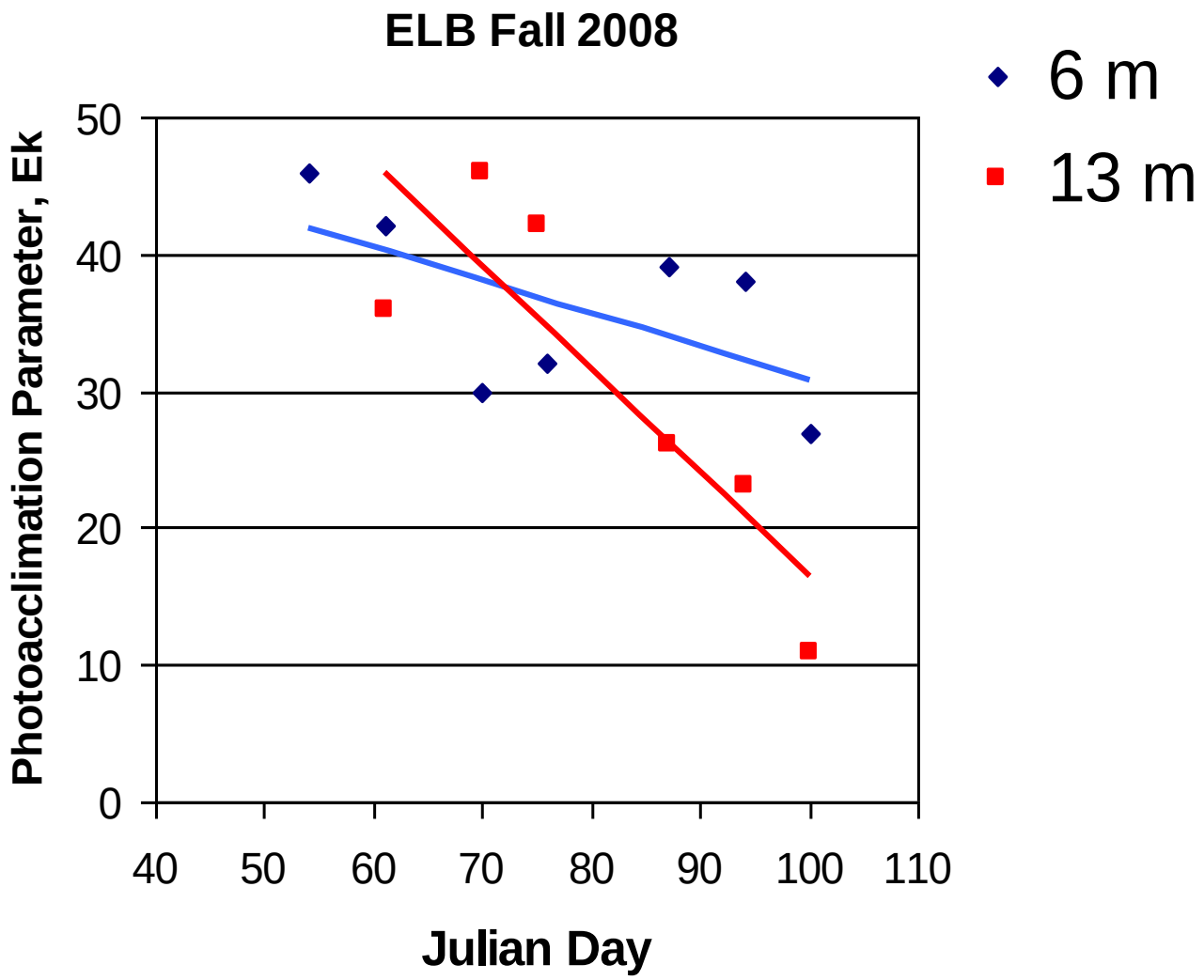

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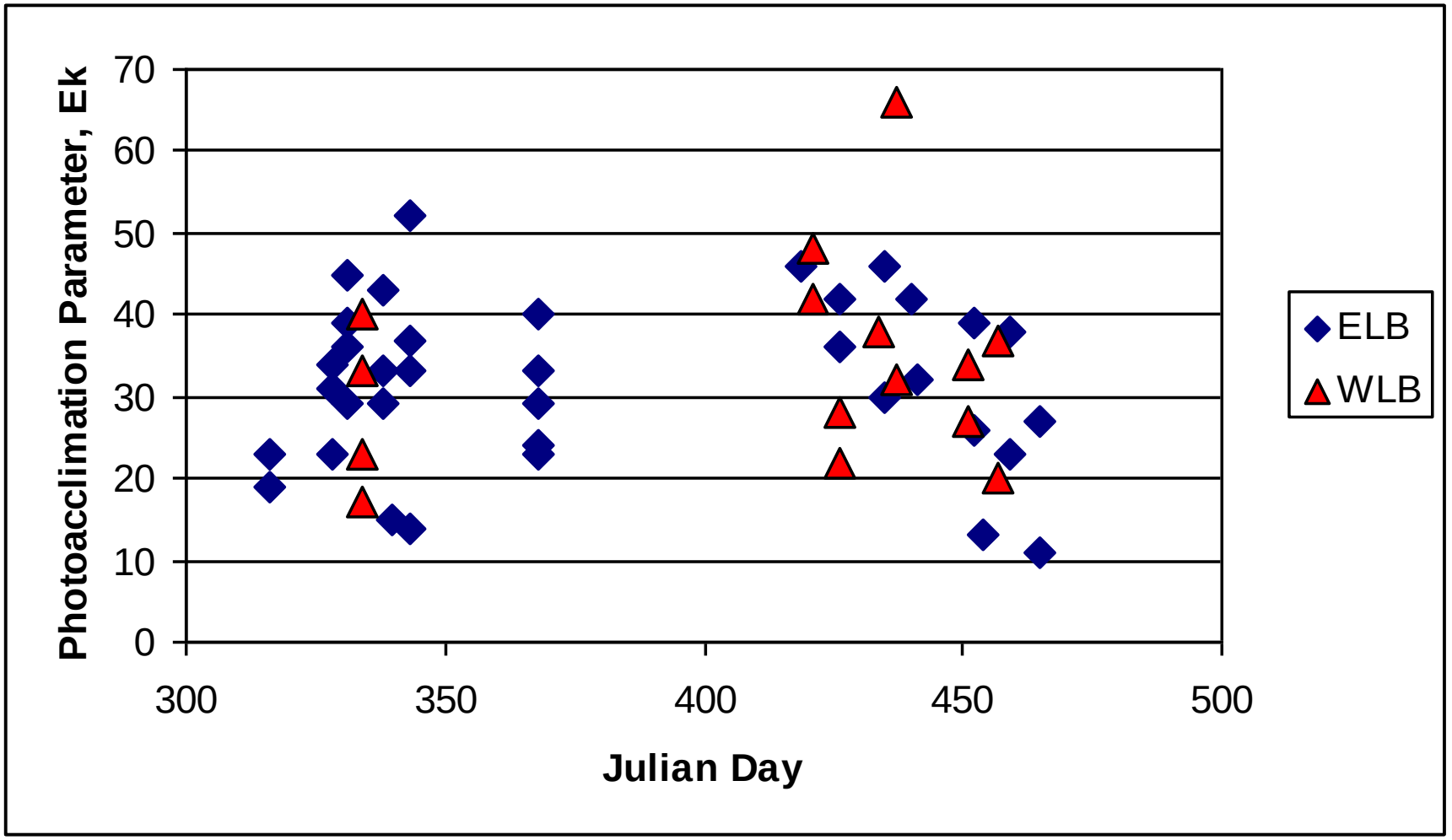
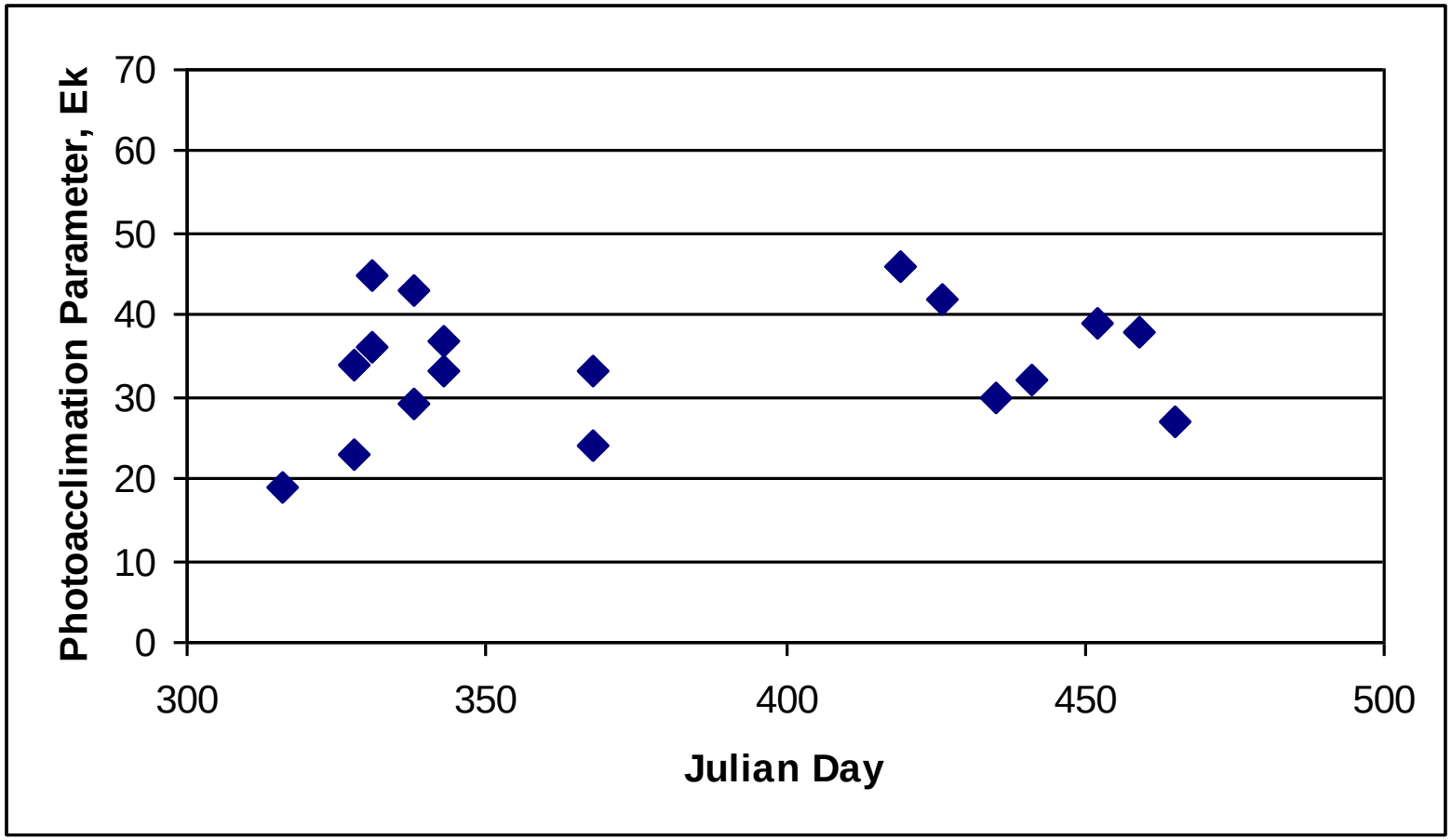
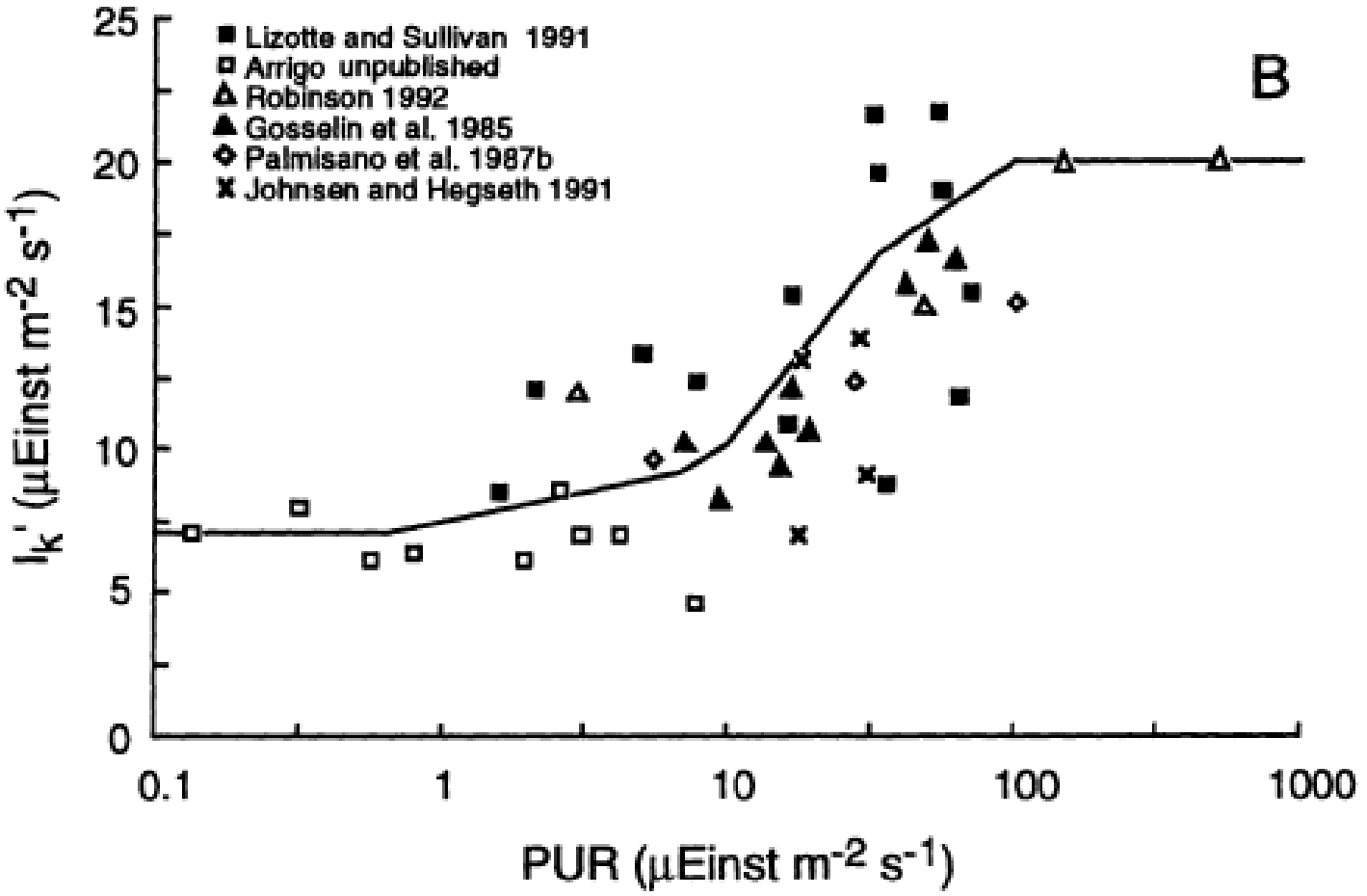
Spring through fall for Lake Bonney



Spring through fall for shallow depths in E. Lake Bonney



Parameterizing Acclimation of Photosynthesis-Irradiance curve
As a Function of average daily irradiance:
Sea Ice Algae Example



Arrigo & Sullivan 1994

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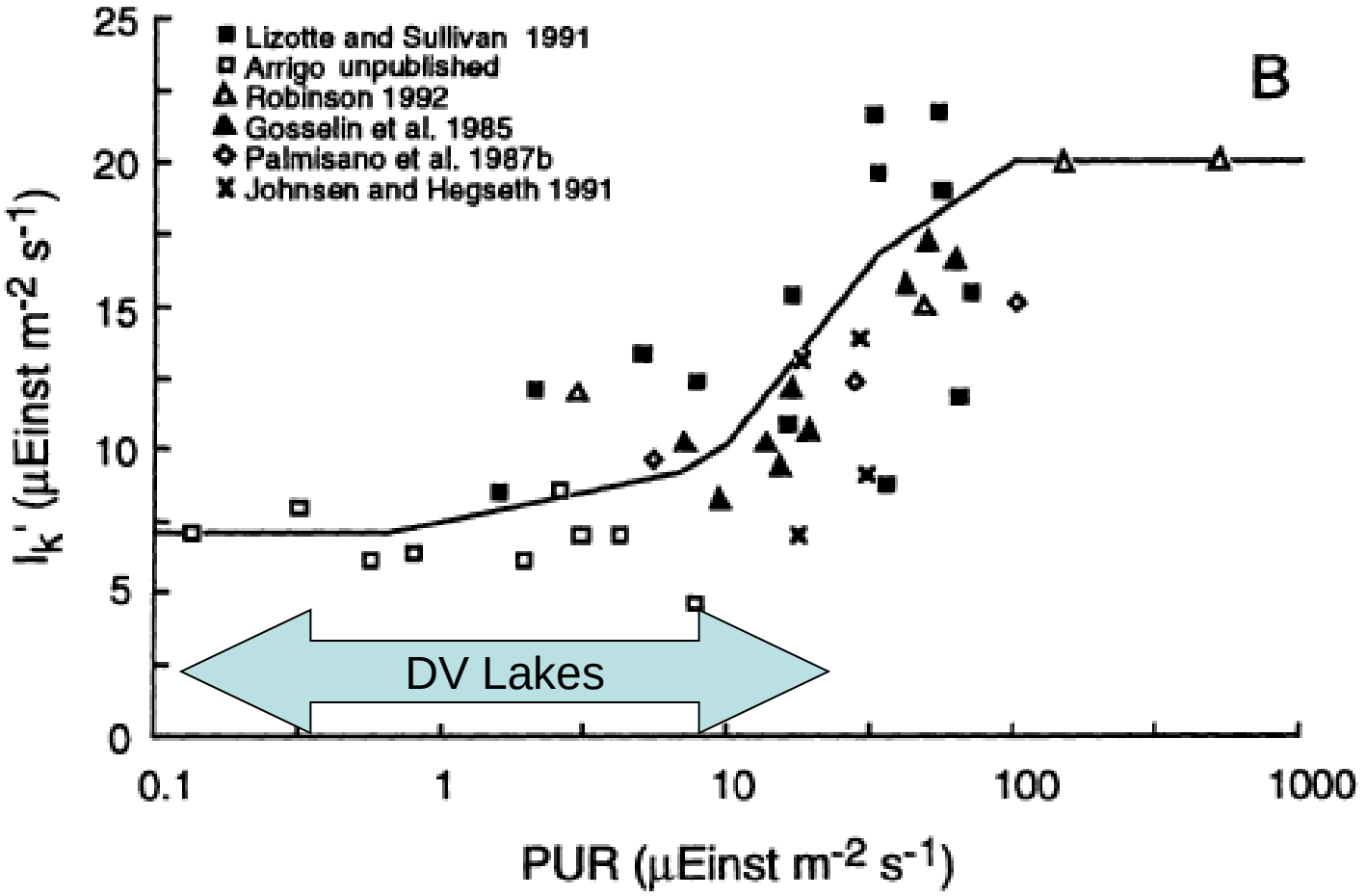
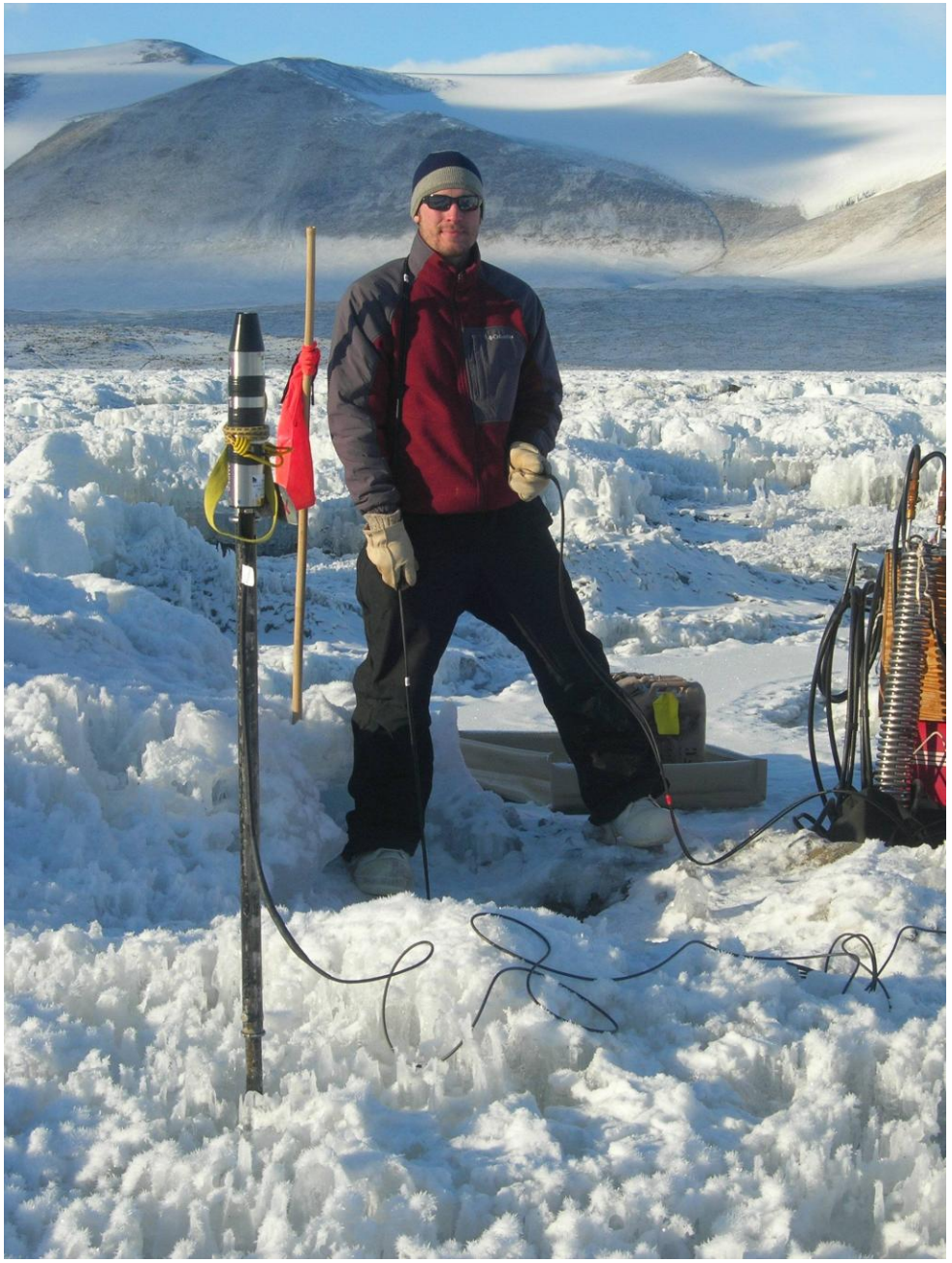
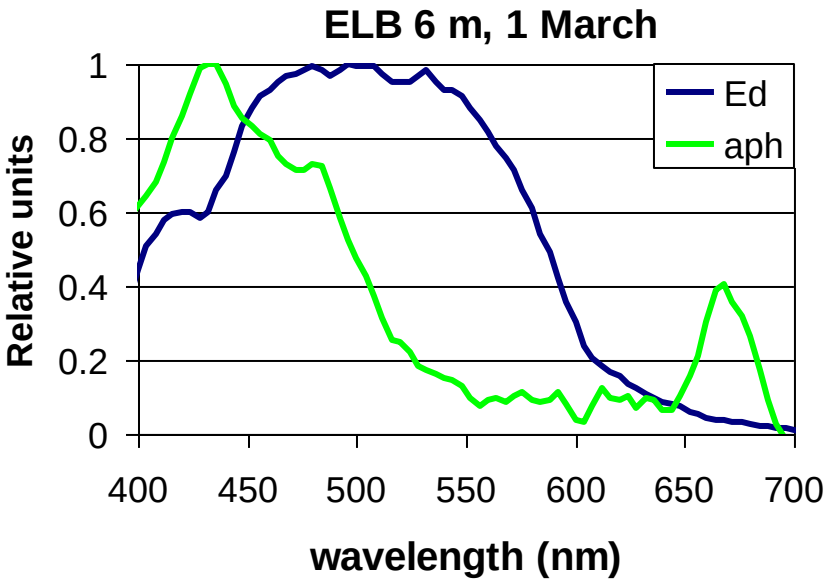


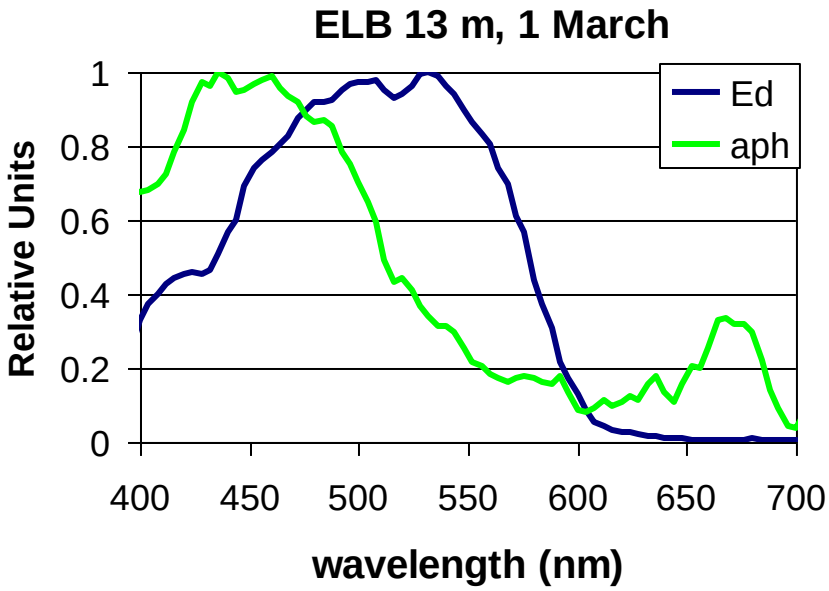
Arrigo & Sullivan 1994

Spectral irradiance and phytplankton light absorption



Photosynthetically Usable Radiation differs by depth and species





PAR = Photosynthetically Available Radiation – integrate under blue line

a_{ph} = phytoplankton absorption spectra

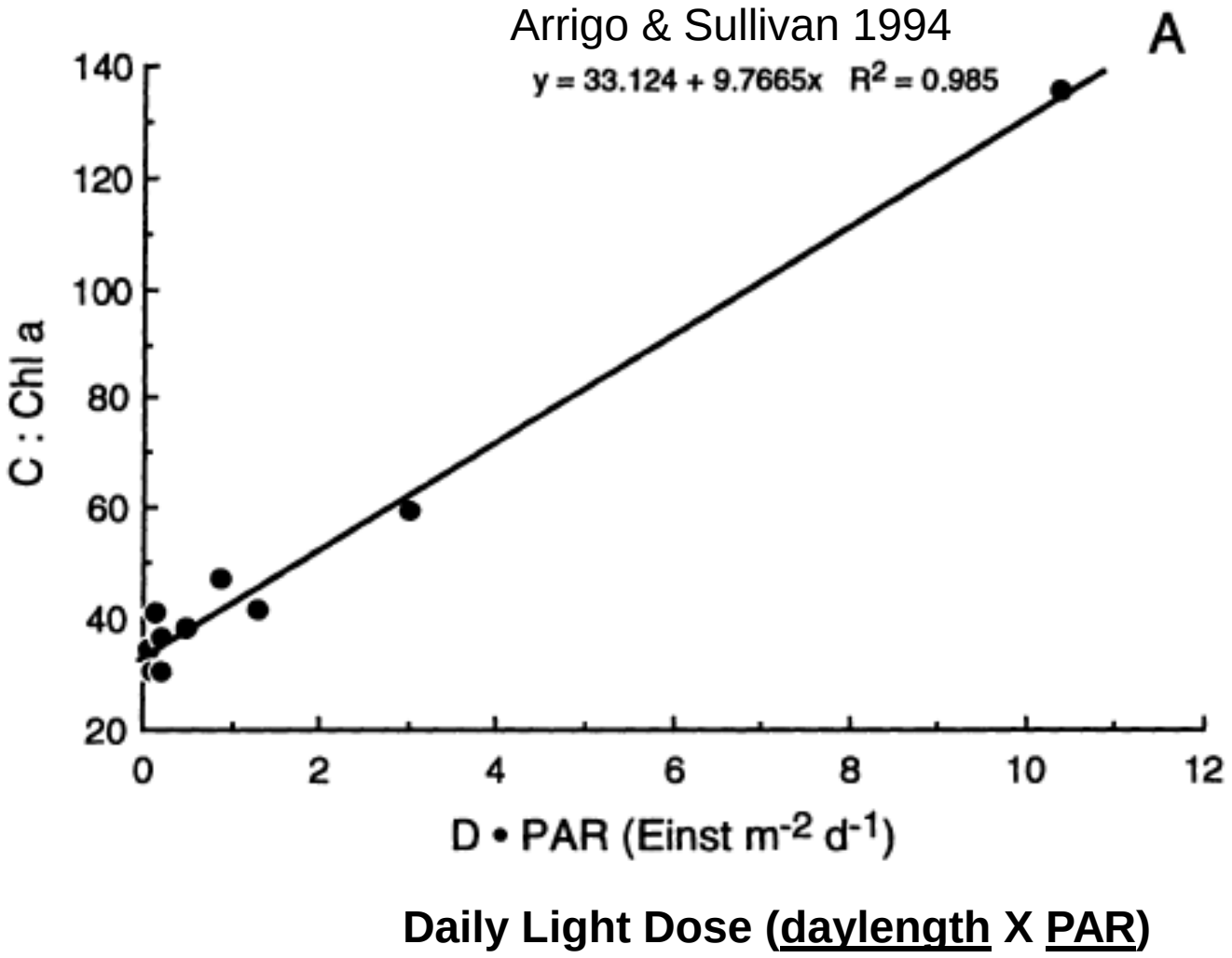
PUR = Photosynthetically Usable Radiation – Weight PAR spectra using a_{ph}

Results:

ELB 6 m: PUR is 45% of PAR

ELB 13 m: PUR is 59% of PAR

50% decrease in Photosynthetic Capacity (per unit Chl) may be Due to C:Chlorophyll ratio decreasing to half the summer value:



Daily Light Dose (<u>daylength</u> X <u>PAR</u>)

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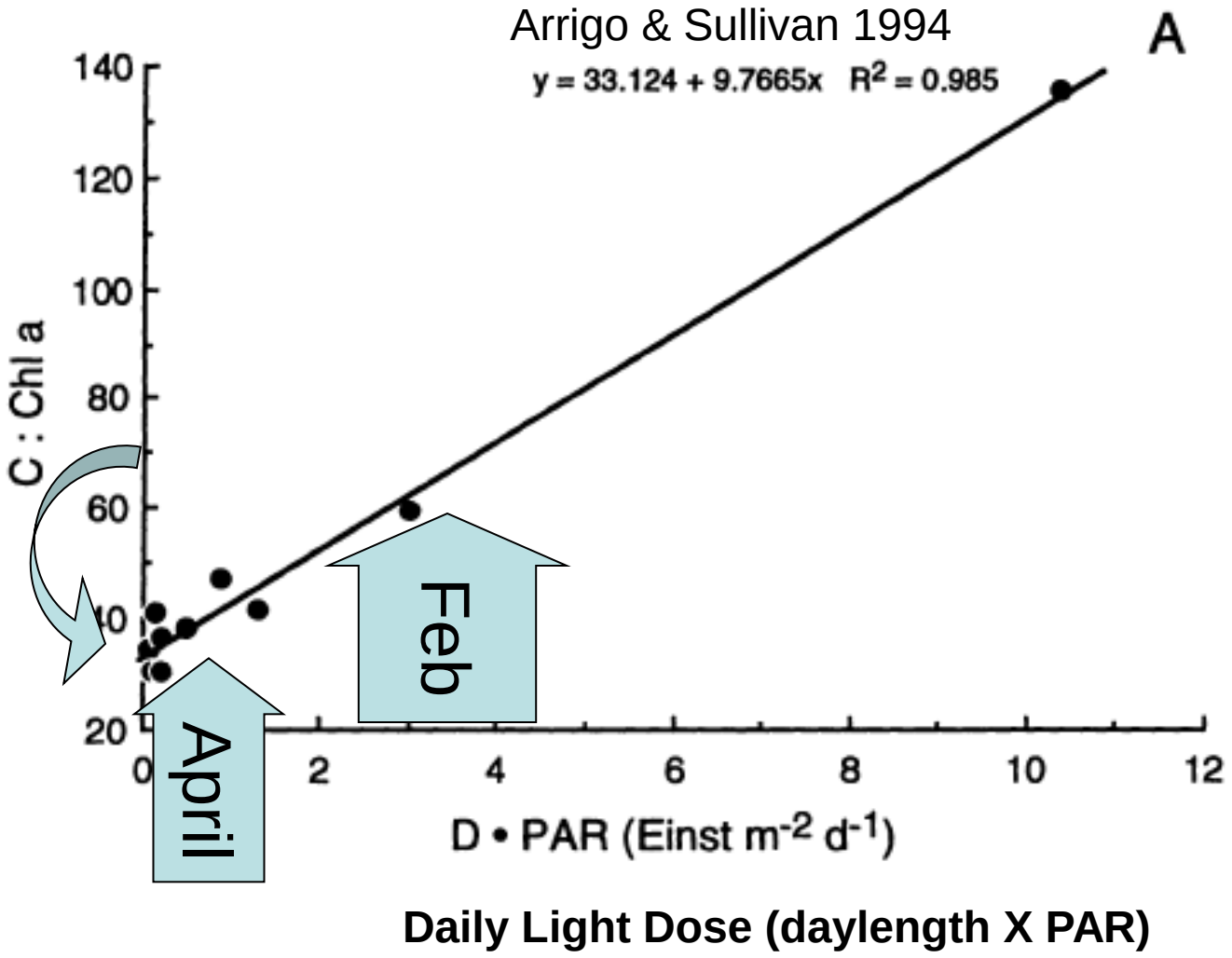
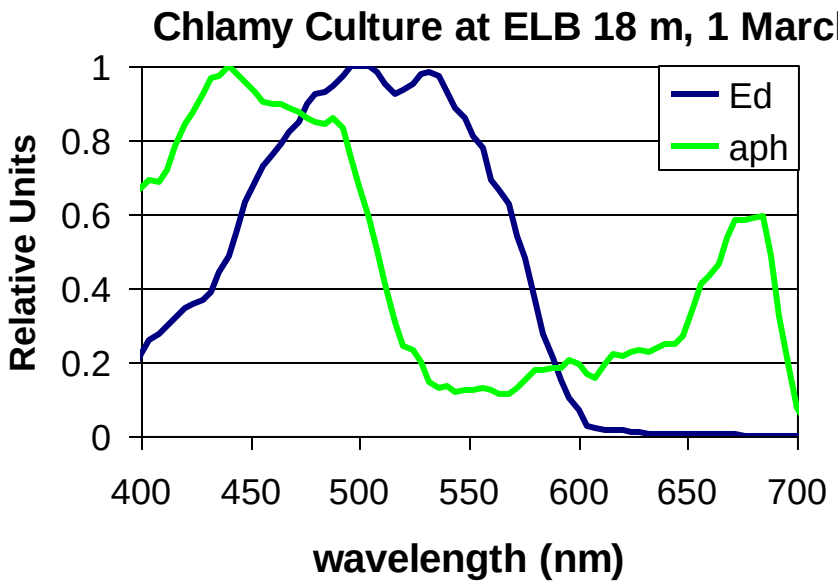


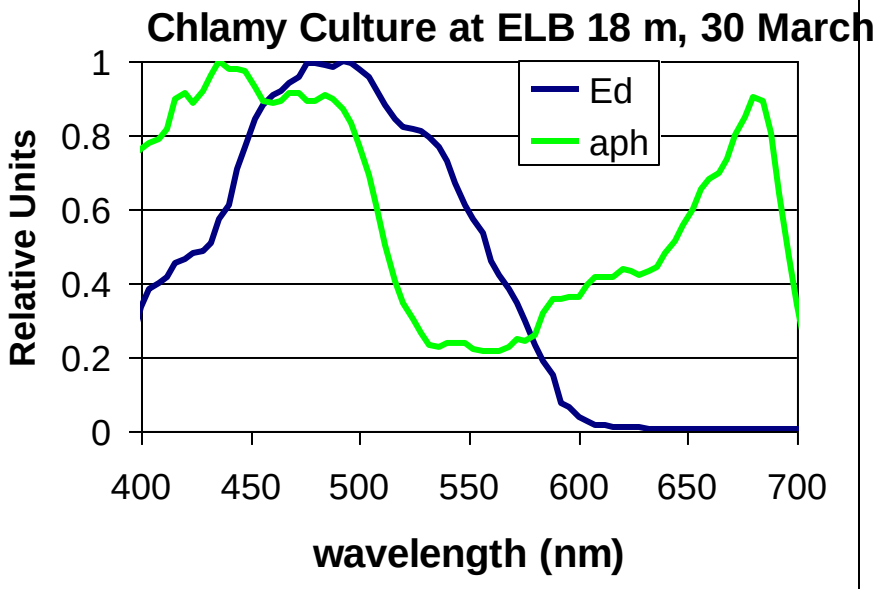
Daily Light Dose (daylength X PAR)

Next Goals:

1. Complete Bio-optical calculations for phytoplankton light absorption and estimate quantum yields

2. Parameterize physiology-based model(s)
   -- Compile data sets for P-I curves, phytoplankton absorption spectra and in situ irradiance spectra
   -- modify Arrigo model (without photoacclimation?) to predict primary production on Limno Run dates
   -- use LTER primary production data for validation





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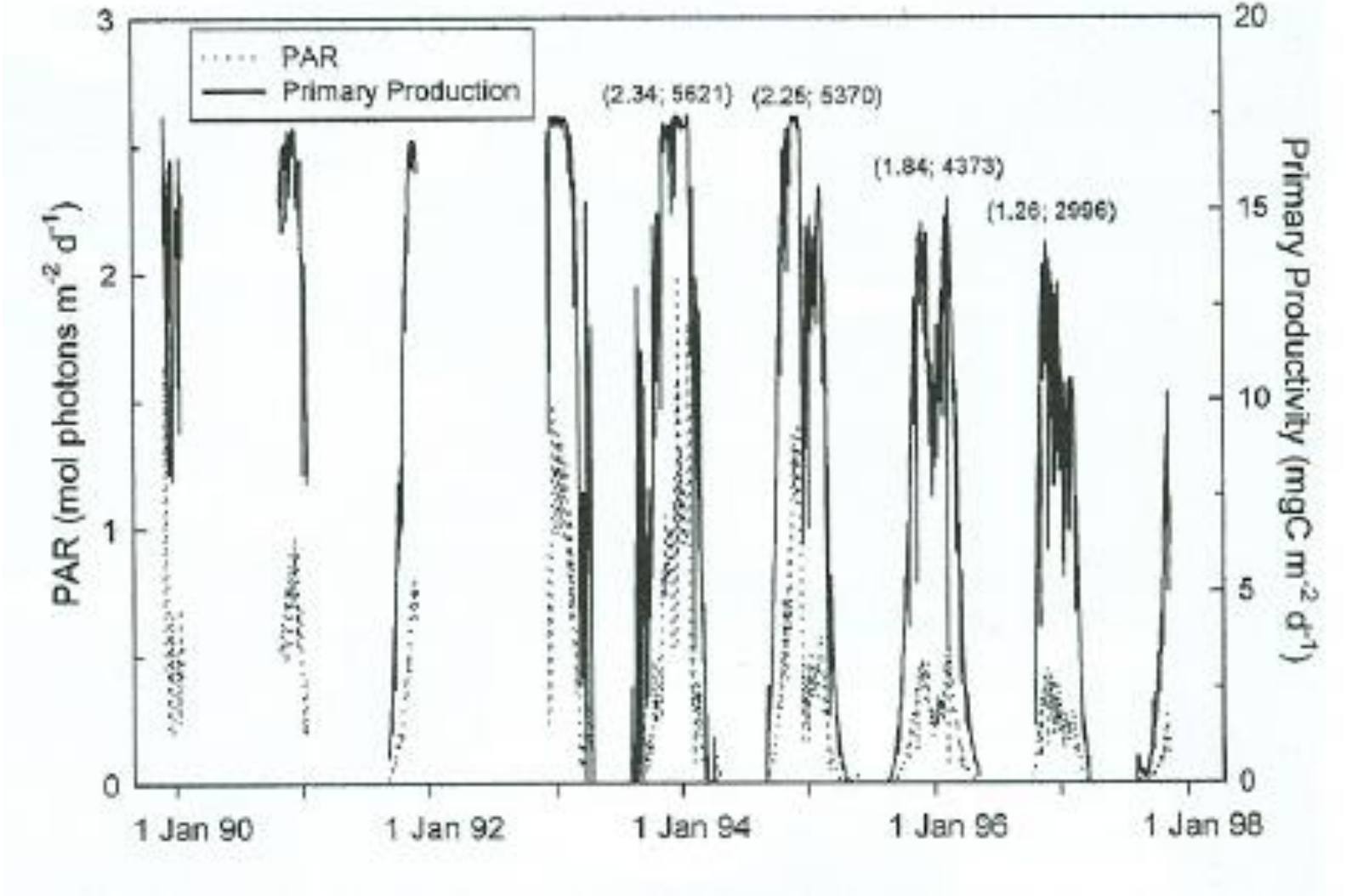
a_{ph} = phytoplankton absorption spectra

PUR = Photosynthetically Usable Radiation – Weight PAR spectra using a_{ph}

Results: Chlamy culture at ELB 18 m:

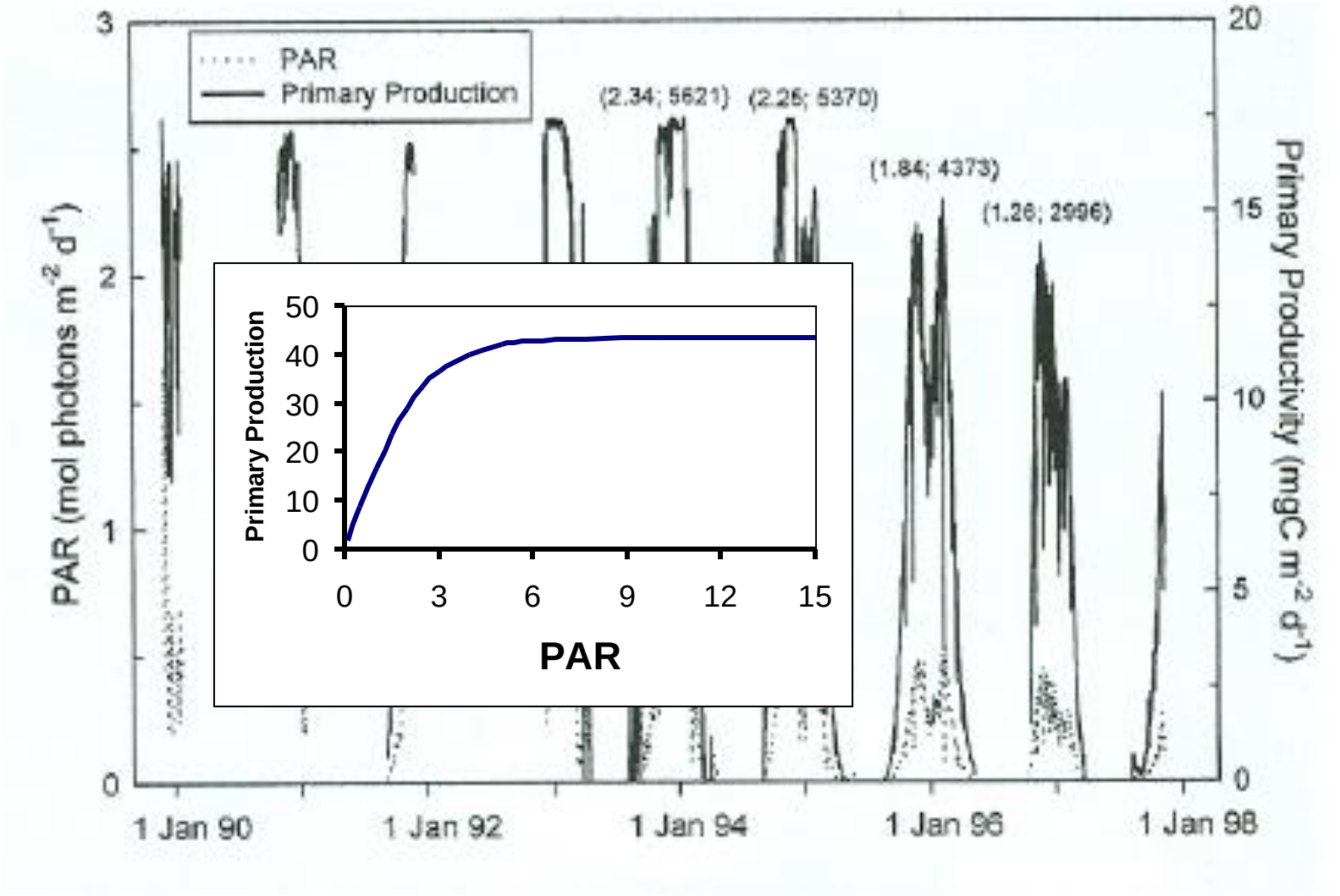
1-3 March: PUR is 53% of PAR

29-30 March: PUR is 66% of PAR



Primary Production = 43.4 * tanh (PAR * 17.5/43.4)

Priscu et al. 1999 Bioscience



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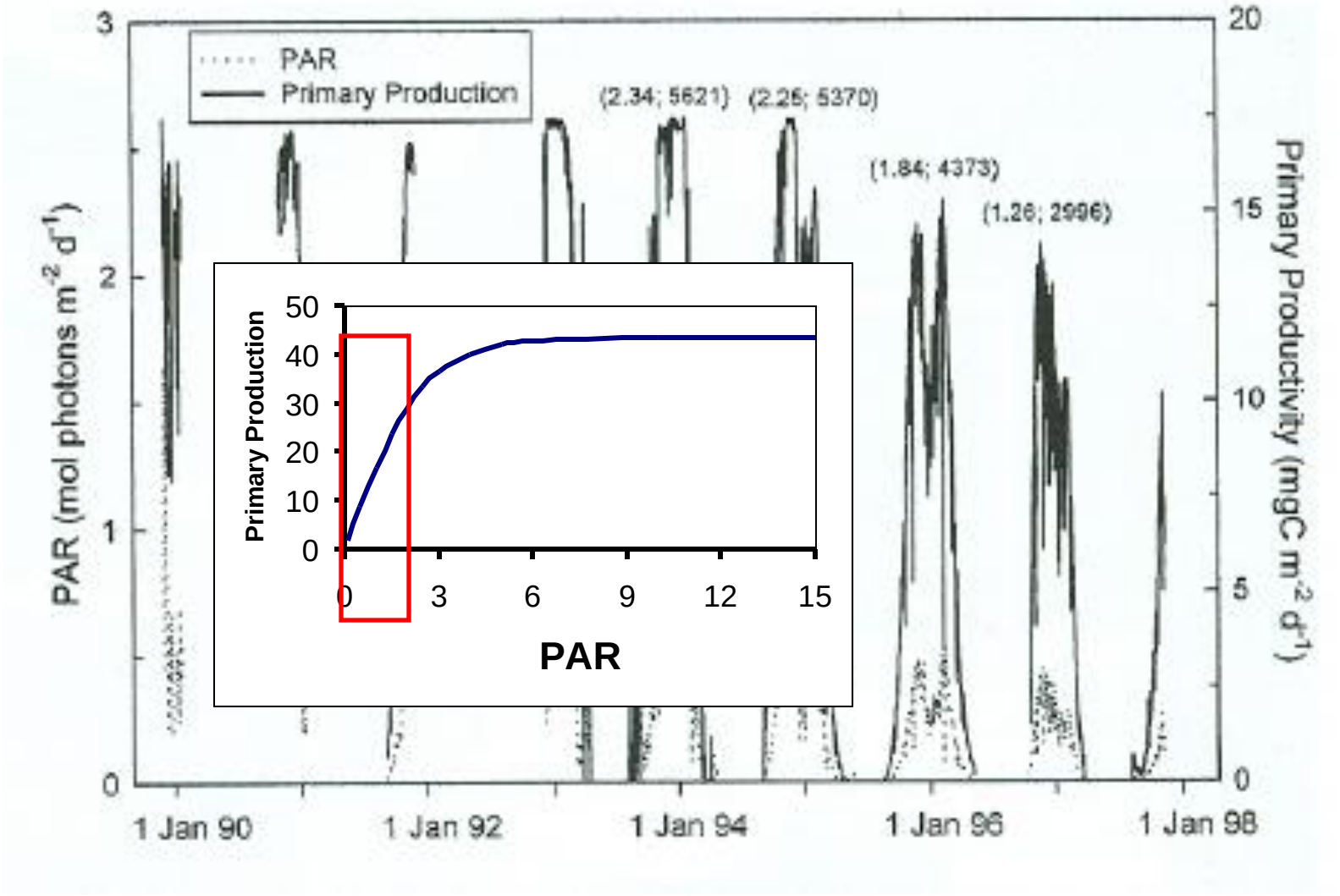

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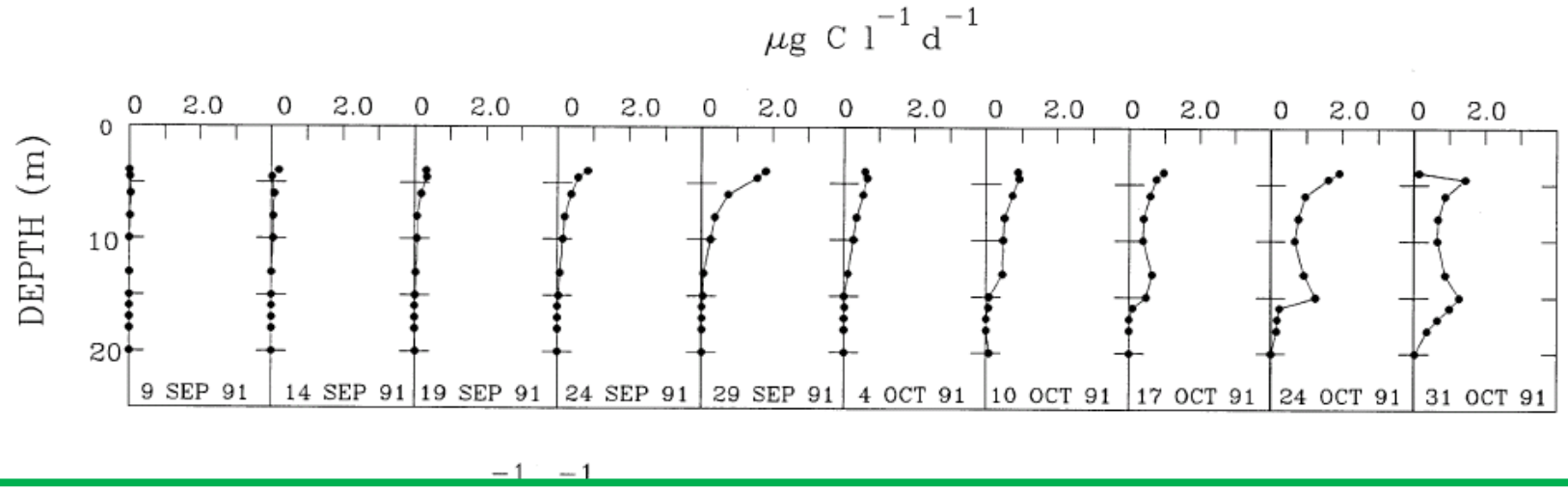

Winfly-1991

Winter-Summer Transition

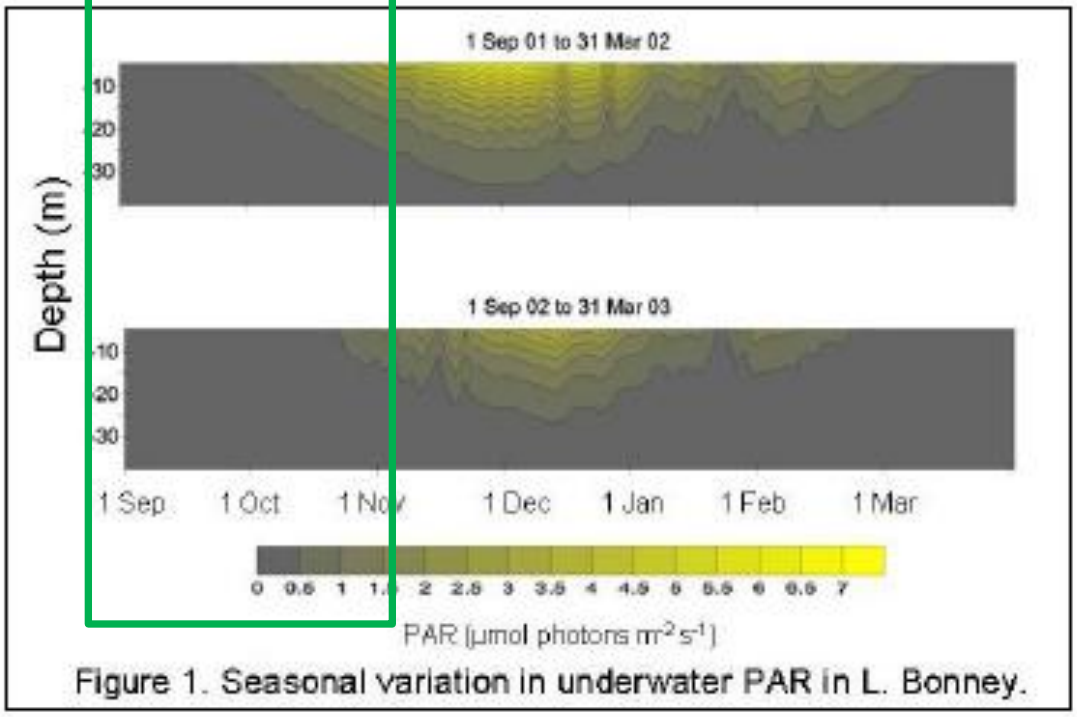

Figure 1. Seasonal variation in underwater PAR in L. Bonney.