

Modelling phytoplankton populations in the ocean: a novel multi-species approach

Anna Hickman
J. Sharples, R. Williams,
S. Dutkiewicz, M. Follows



**Massachusetts
Institute of
Technology**



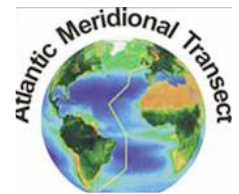
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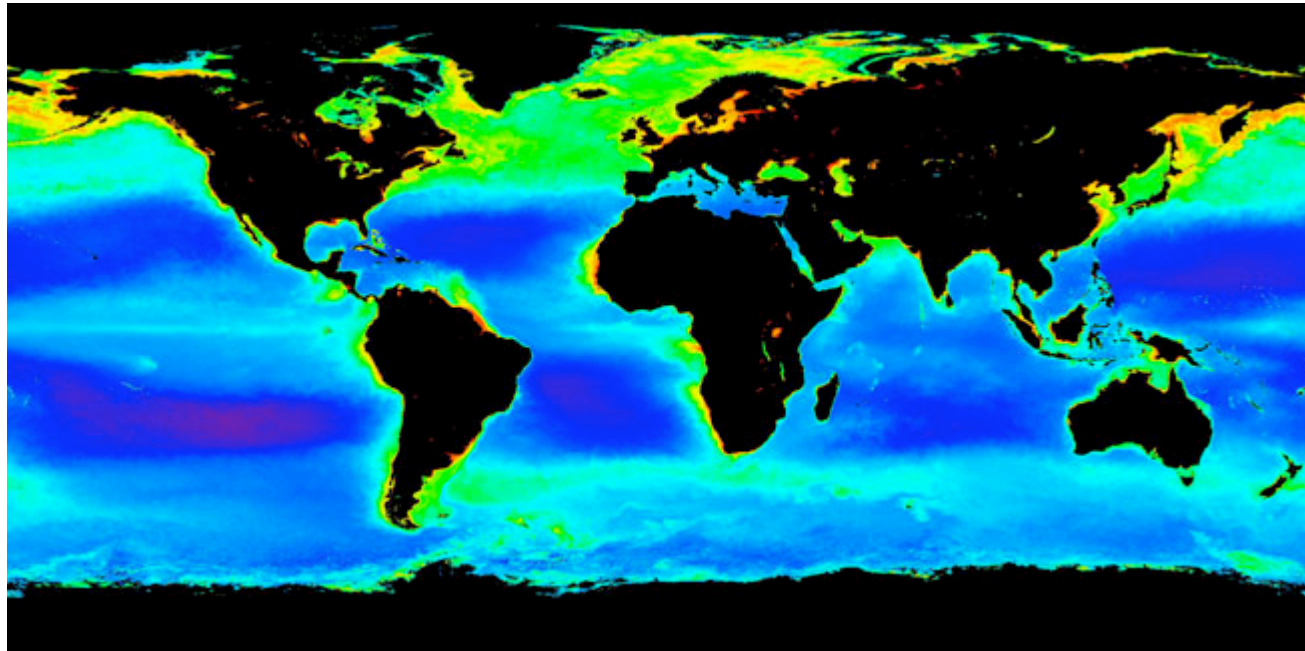
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Oceanographic Laboratory**
NATURAL ENVIRONMENT RESEARCH COUNCIL



Introduction

Why are phytoplankton important?

- ~ 50 % of photosynthesis
- Nutrient and carbon cycles

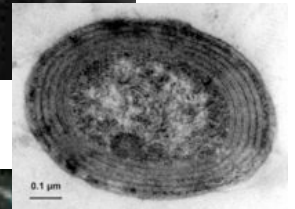


Surface Chl-a

Introduction

Phytoplankton occur where they are well suited to environmental conditions.

- Nutrients (cell size, nutrient type)
- Light (light utilisation)
- ... motility, grazing, sinking rates ...



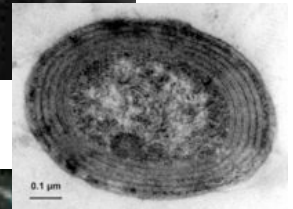
Carbon Cycle

Fisheries

Introduction

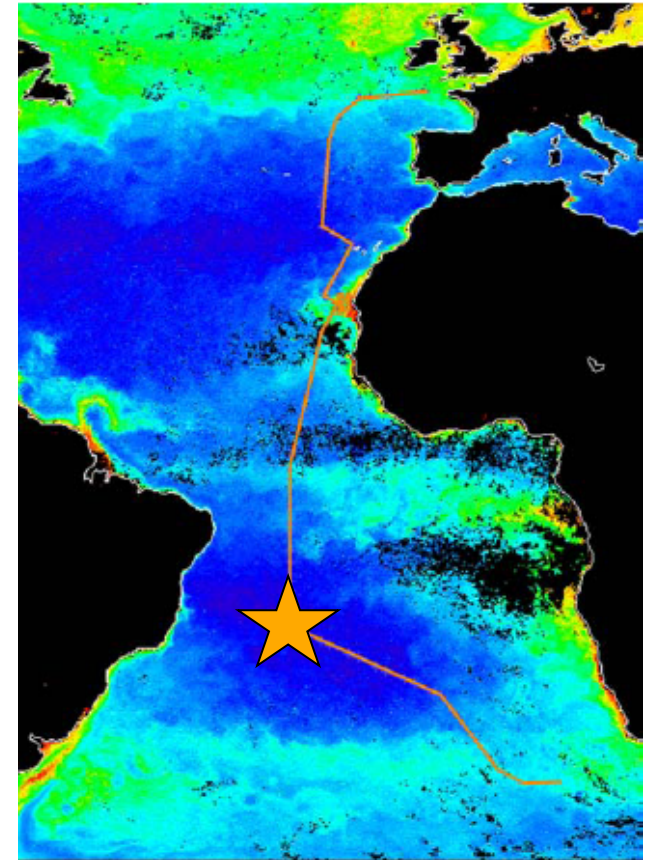
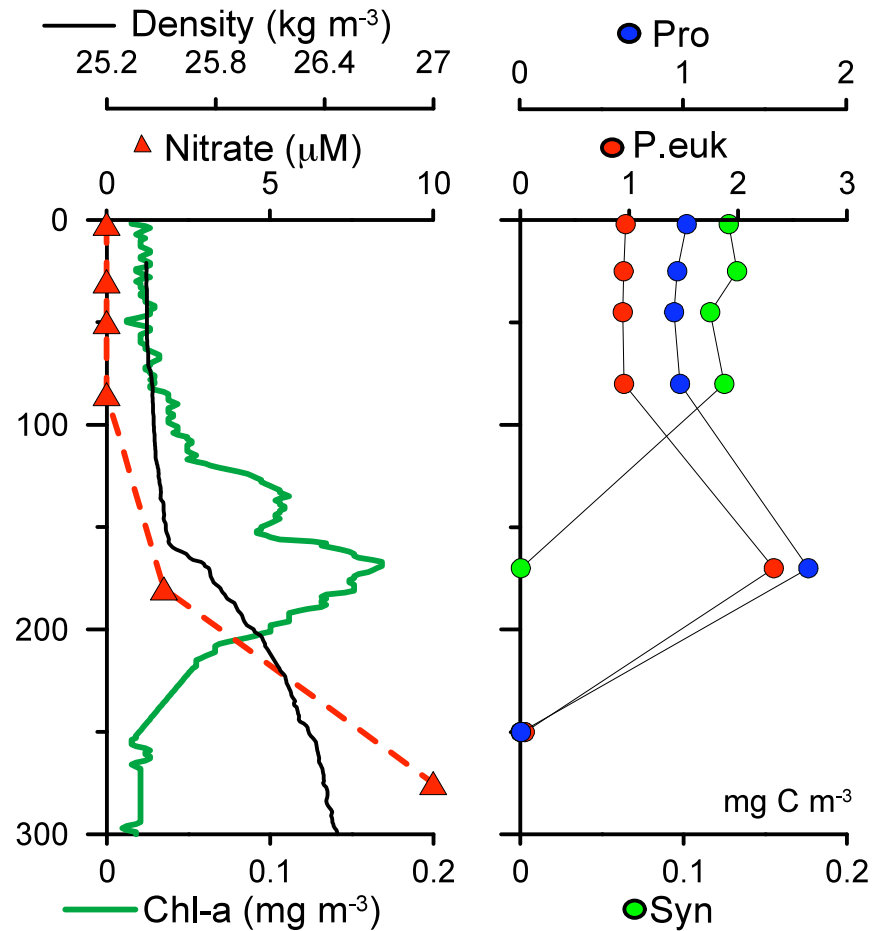
Phytoplankton occur where they are well suited to environmental conditions.

- Nutrients (cell size, nutrient type)
- Light (light utilisation)
- ... motility, grazing, sinking rates ...



Ocean physics (temperature, circulation, mixing) sets environment for growth

Motivation



(Data courtesy: M. Zubkov, J. Heywood)

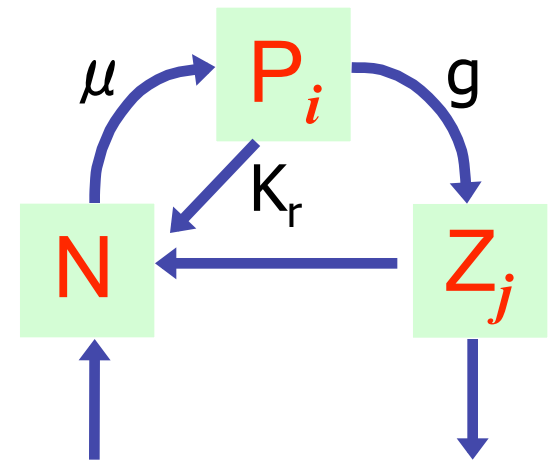
Ecosystem Model

MIT 'Emergent' ecosystem model:

- 10-1000's of phytoplankton

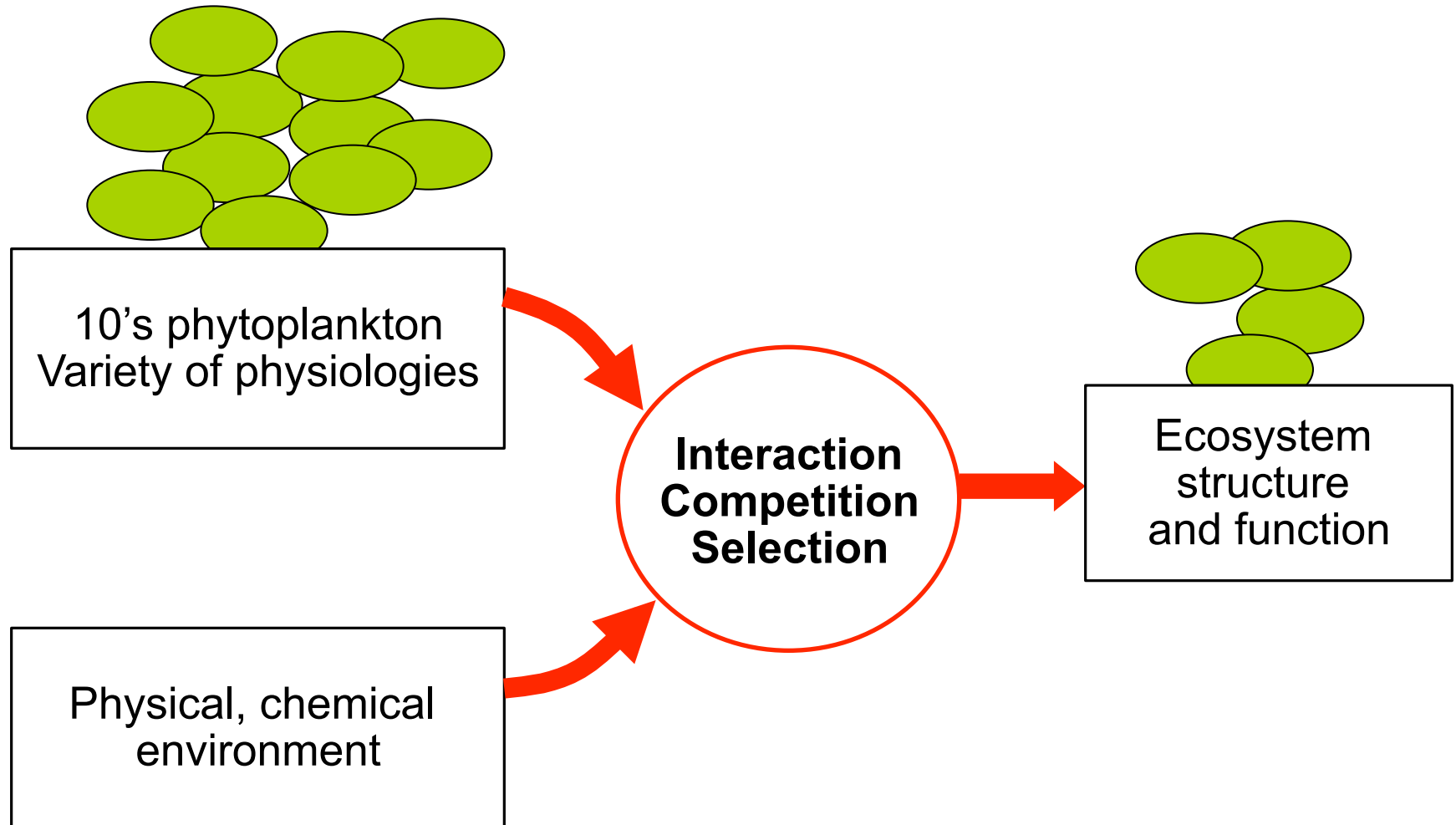
- Temperature
 - Nutrients
 - Light
- } vs. Growth

Random selection
Coin Flips



Riley (1946)

Ecosystem Model



(Follows et al. 2007, Science)

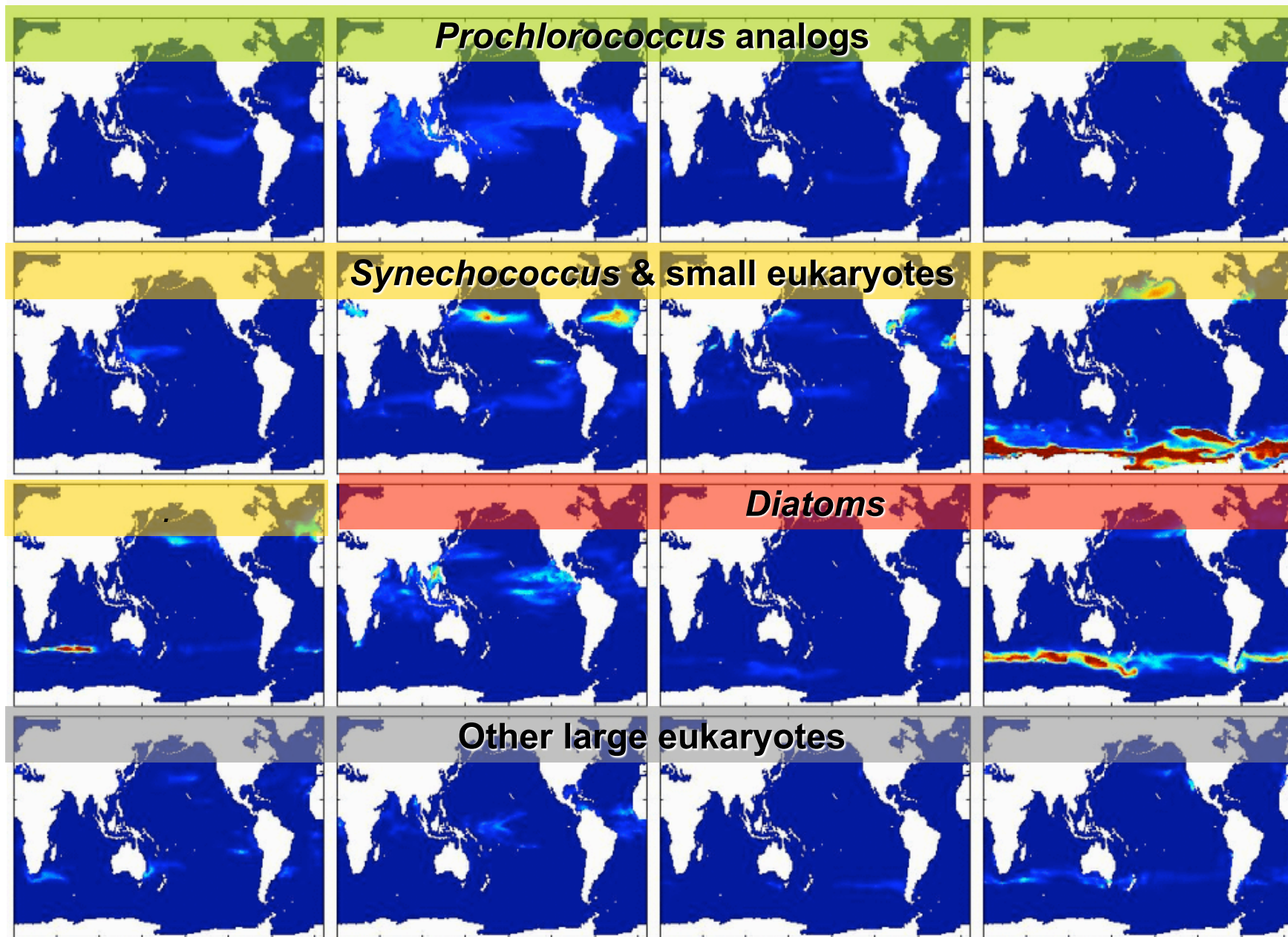
Single ensemble member, all functional types, 0-50m



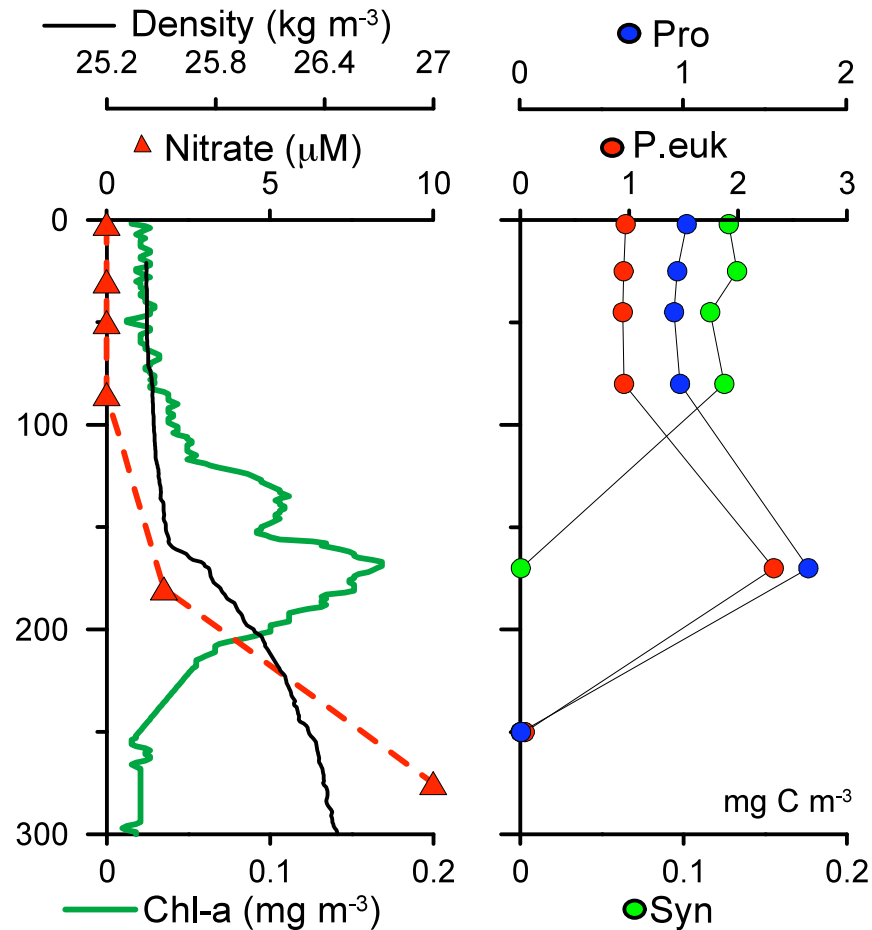
(M. Follows)

Emergent biogeography – 16 most abundant phytoplankton types

(M. Follows)



Motivation

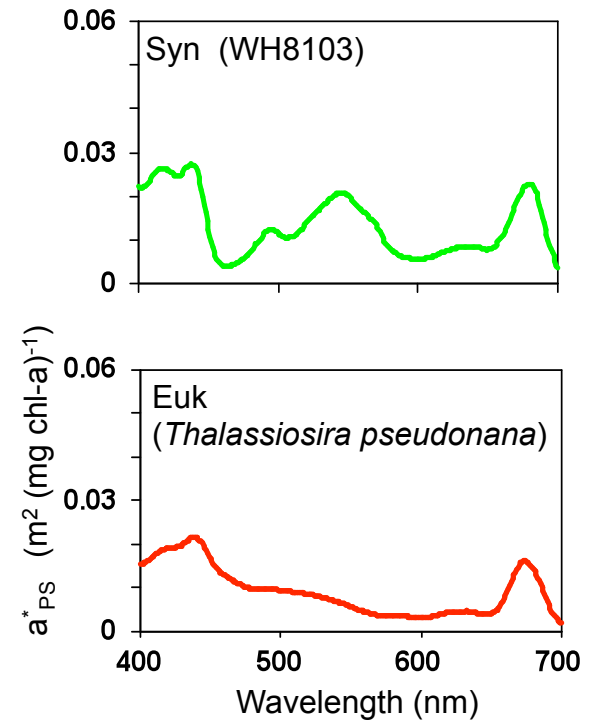
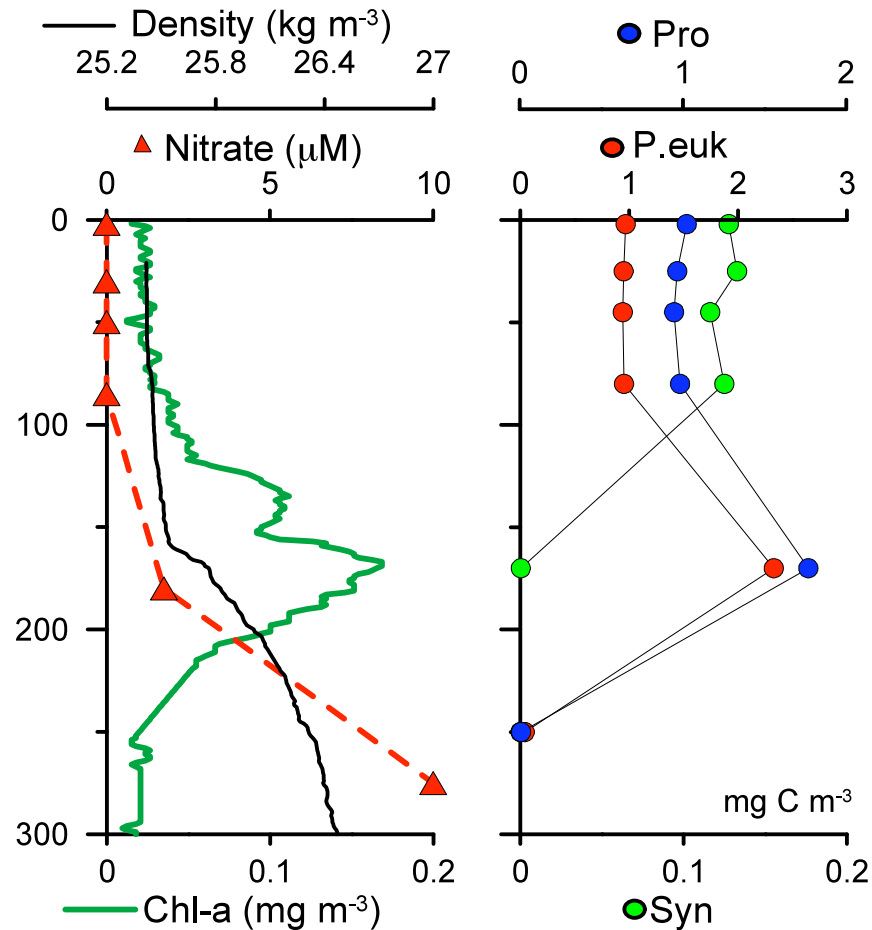


Synechococcus
Prochlorococcus
Picoeukaryotes

(Data courtesy: M. Zubkov, J. Heywood)

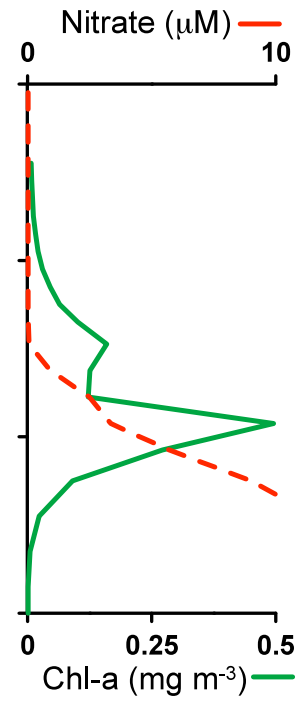
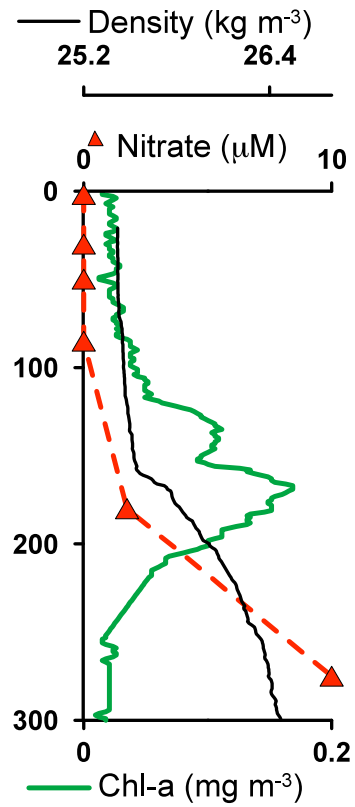
Model Developments

- Photo-physiology
- Pigments (wavelengths of light)



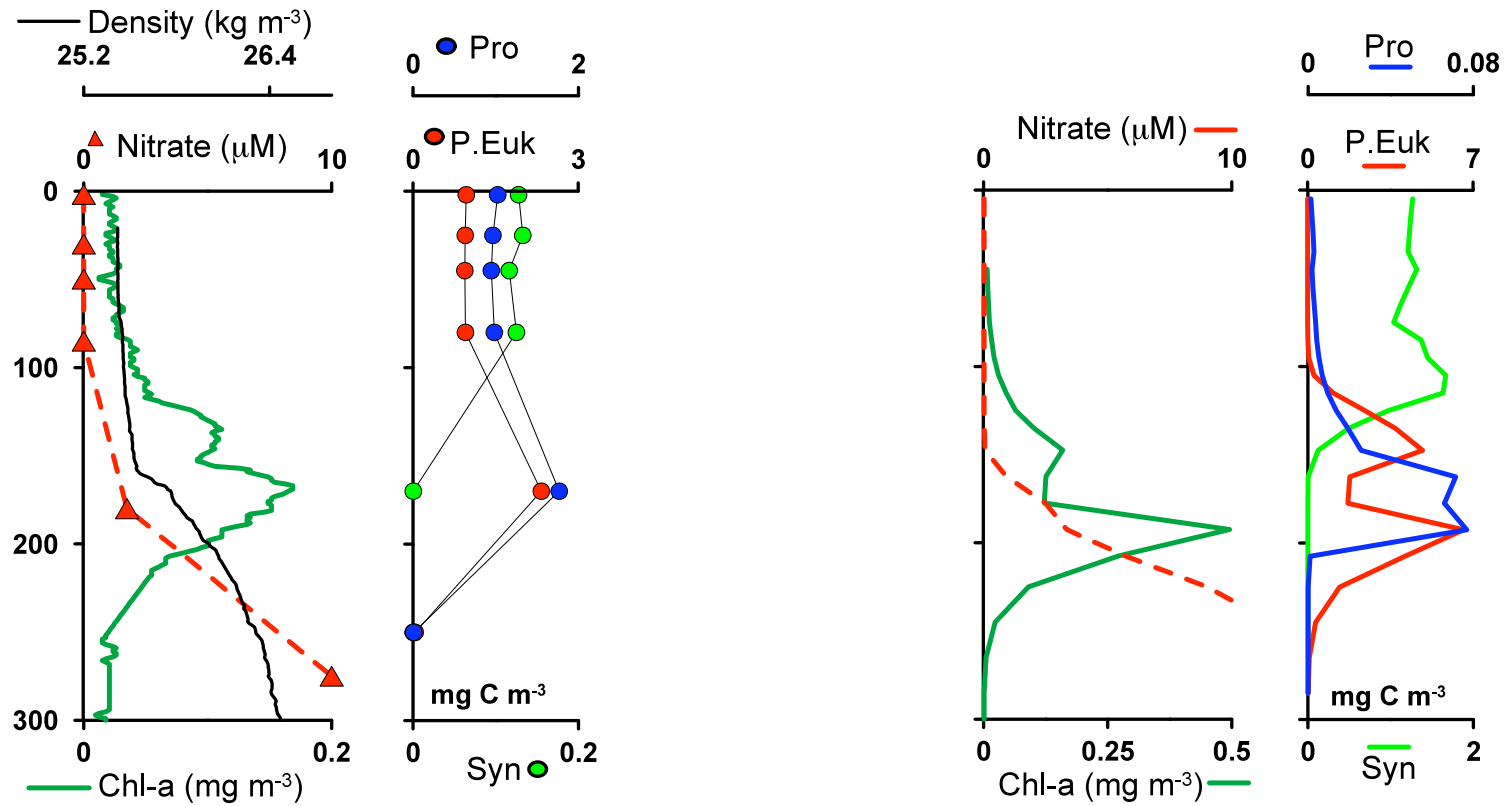
(Data courtesy: M. Zubkov, J. Heywood, D. Suggett, L. Moore)

Model Results



(Data courtesy: M. Zubkov, J. Heywood)

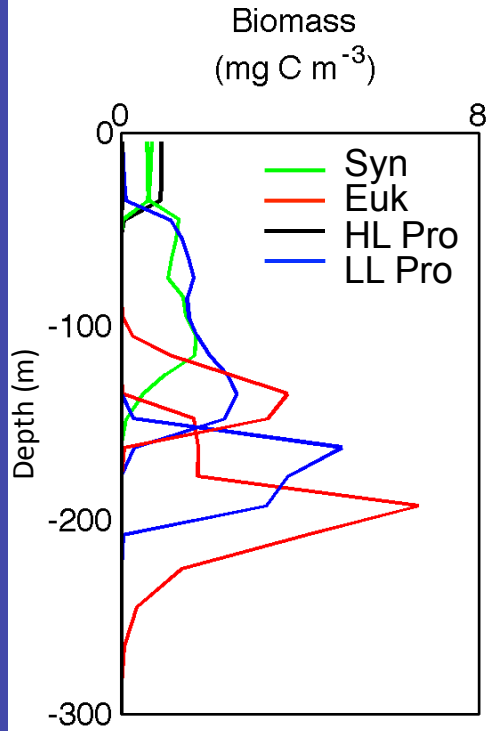
Model Results



(Data courtesy: M. Zubkov, J. Heywood)

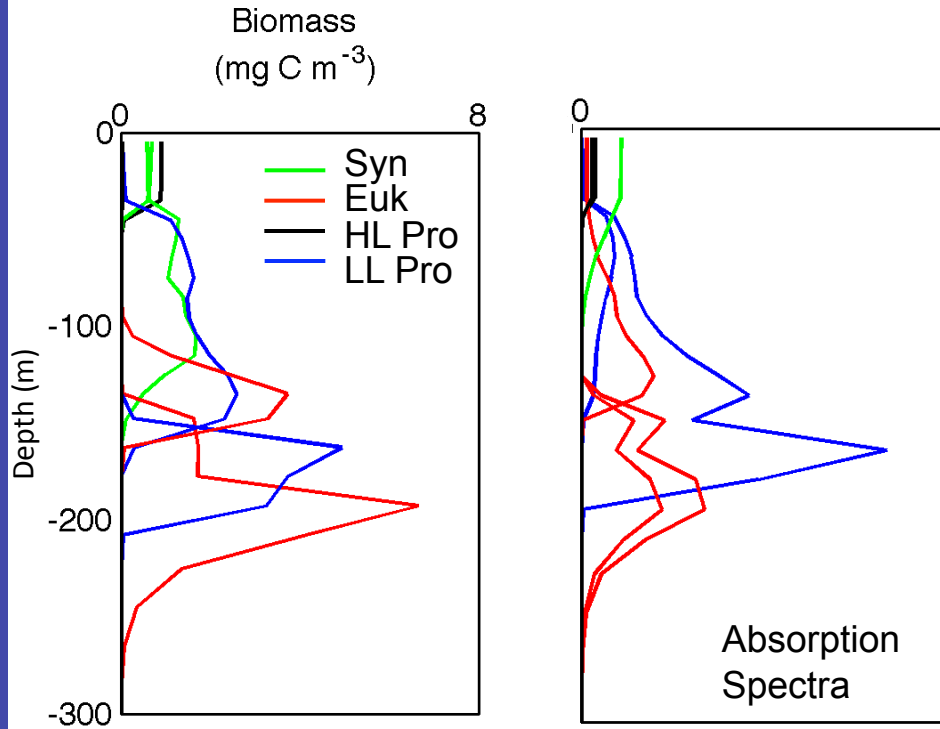
Model Results

Thought Experiments:



Model Results

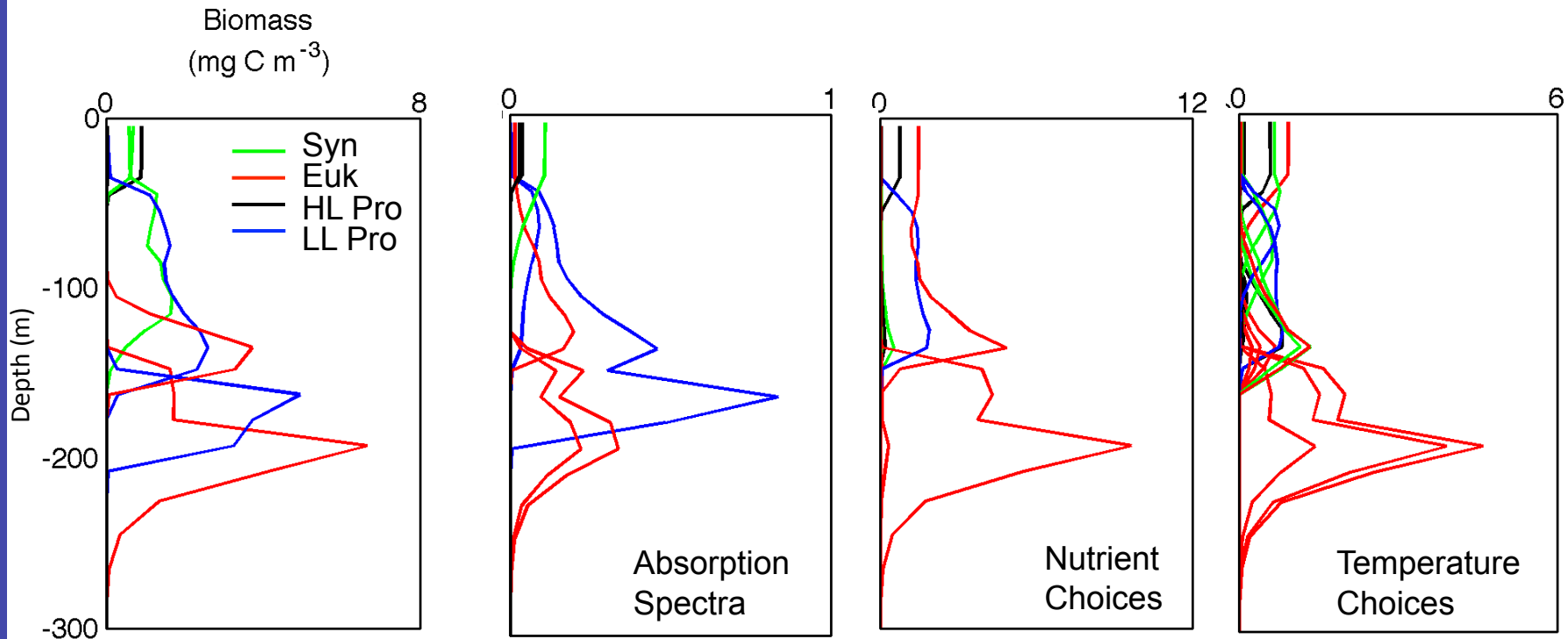
Thought Experiments:



Big & Small
'Pro' & 'non-Pro'

Model Results

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Big & Small
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Summary

Current Work:

- Model reproduces distributions
- Allows investigation of key controls

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- Model reproduces distributions
- Allows investigation of key controls

Understanding complex interactions is critical for predicting effects of long-term change

FUTURE WORK:

Long-term changes:

- Open ocean DEOS (Williams, Hickman)
- Shelf Seas POL / DEOS (Sharples, Holt, Hickman)

Acknowledgements

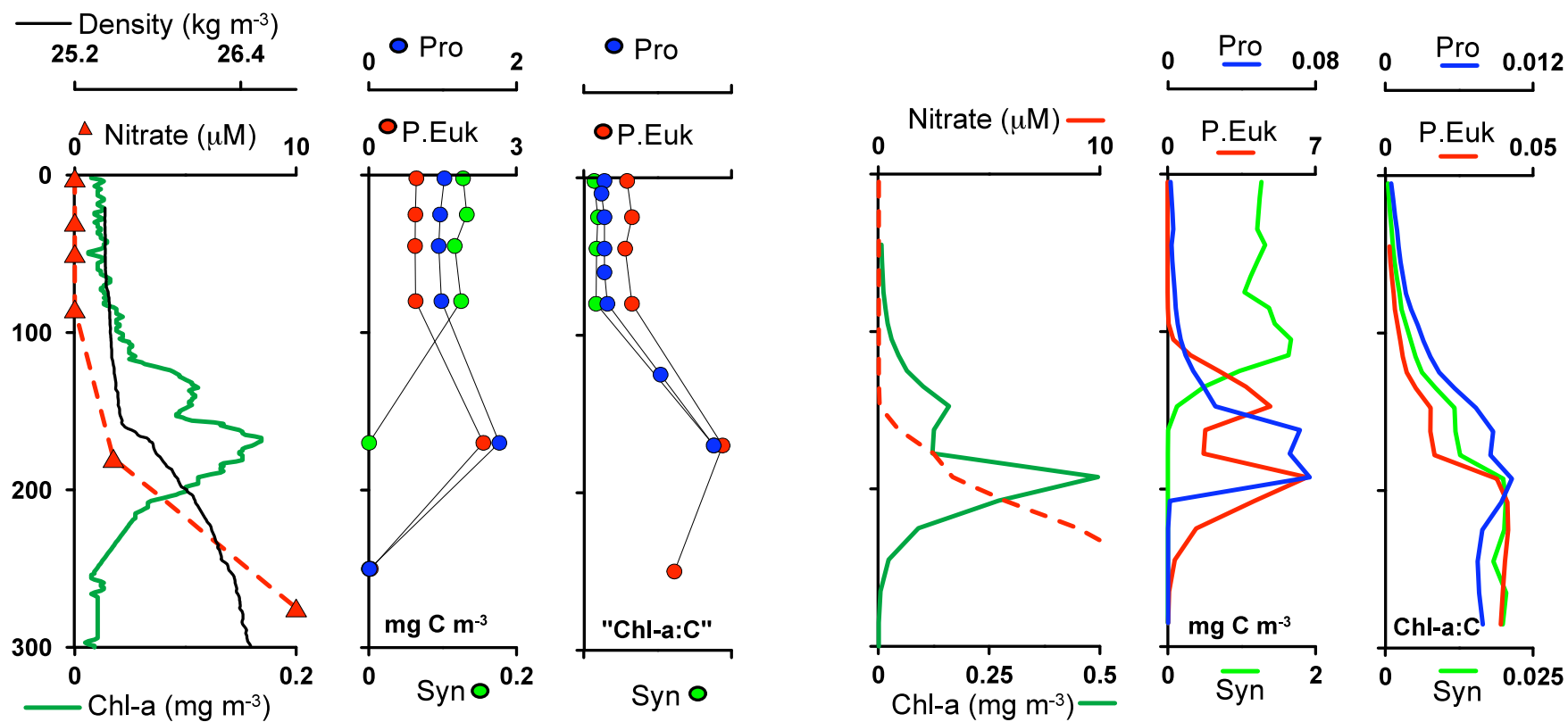
Oliver Jahn, Lisa Moore, Penny Chisholm,
Dave Suggett, Mike Zubkov, Jane Heywood,
Mark Moore, Lorraine Hay, Gerald Moore,
Gavin Tilstone, Malcolm Woodward, Katie
Chamberlain, Andy Rees.

Summary

Model Success:

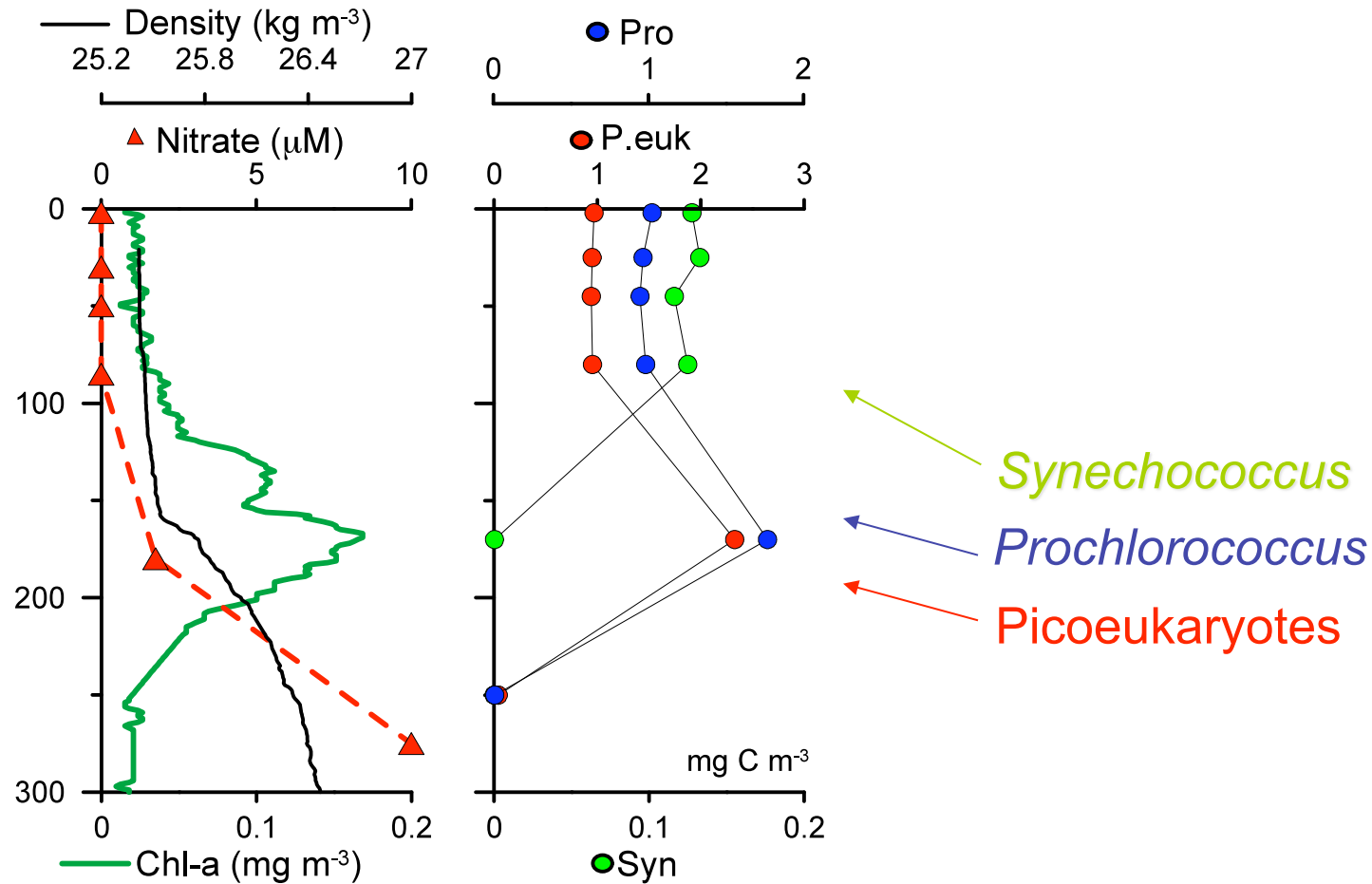
- Model reproduces phytoplankton distributions.
 - S. Atlantic gyre
 - Global Ocean (MIT)
- Interrogation of the model ecosystem
 - Key factors at work
 - Phytoplankton types (Large/small, Diatoms, N₂-fix)
 - Ecological theories (Limiting nutrients)

Results: Spectral Irradiance



(Data courtesy: M. Zubkov, J. Heywood)

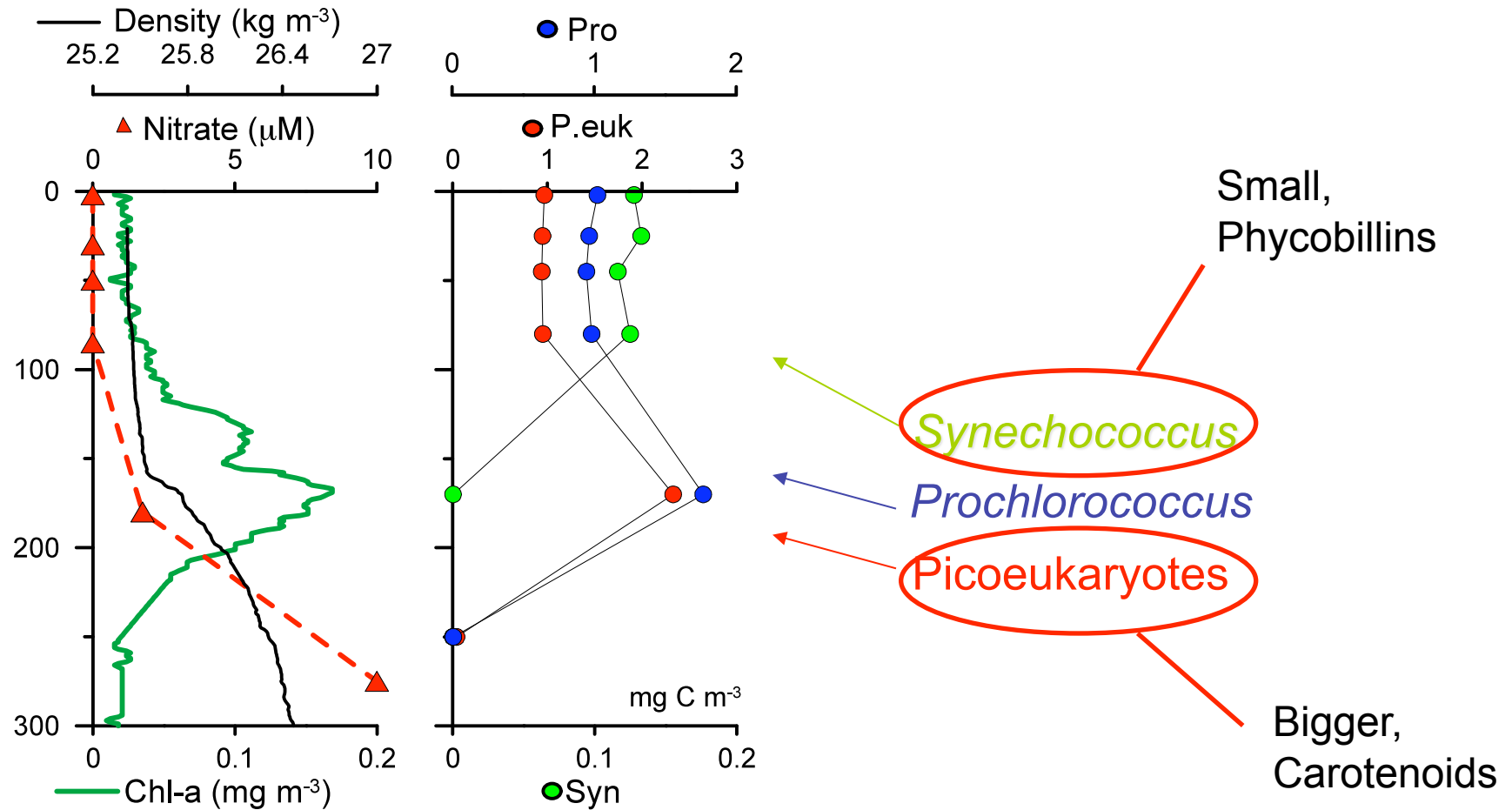
Motivation: South Atlantic Gyre



~ 90 % Chl-a < 2 μm

(Data courtesy: M. Zubkov, J. Heywood)

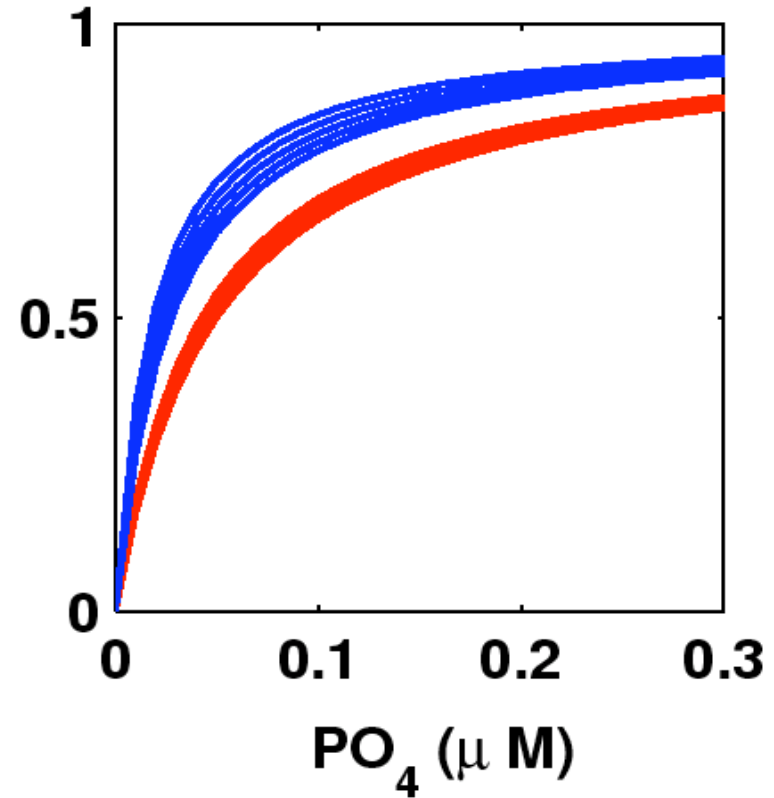
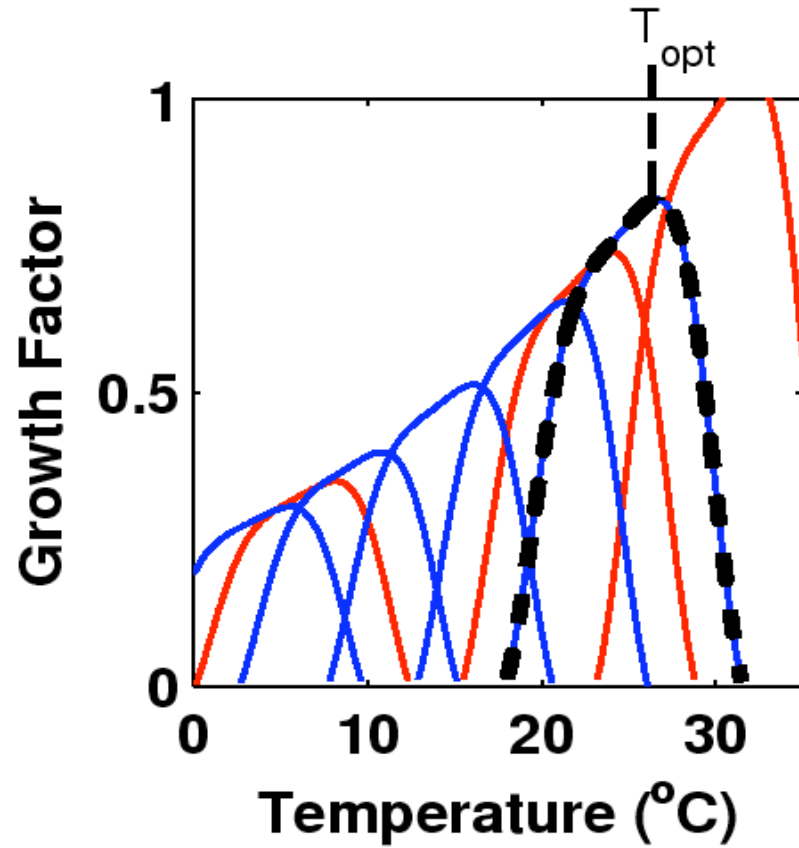
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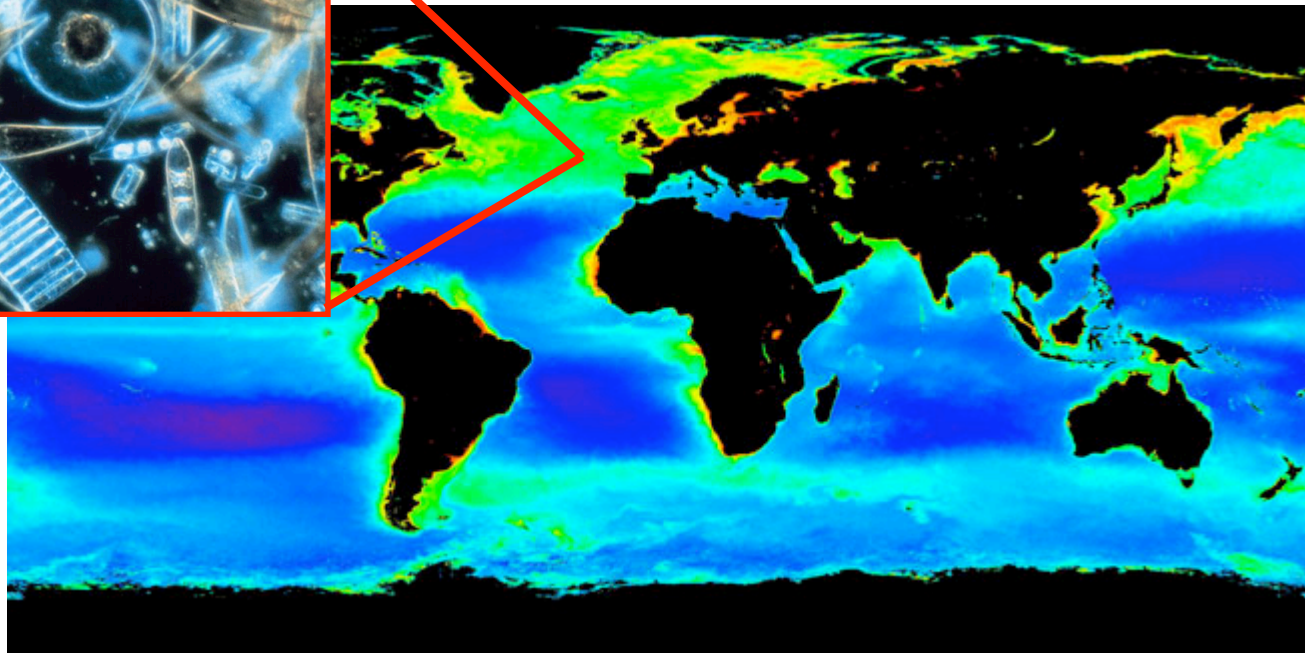
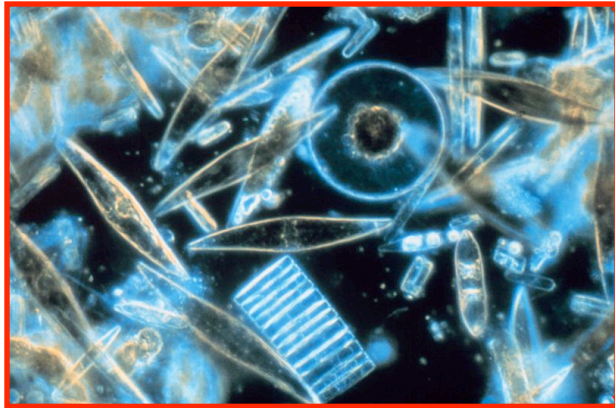
Method: Darwin Ecosystem Model



Introduction

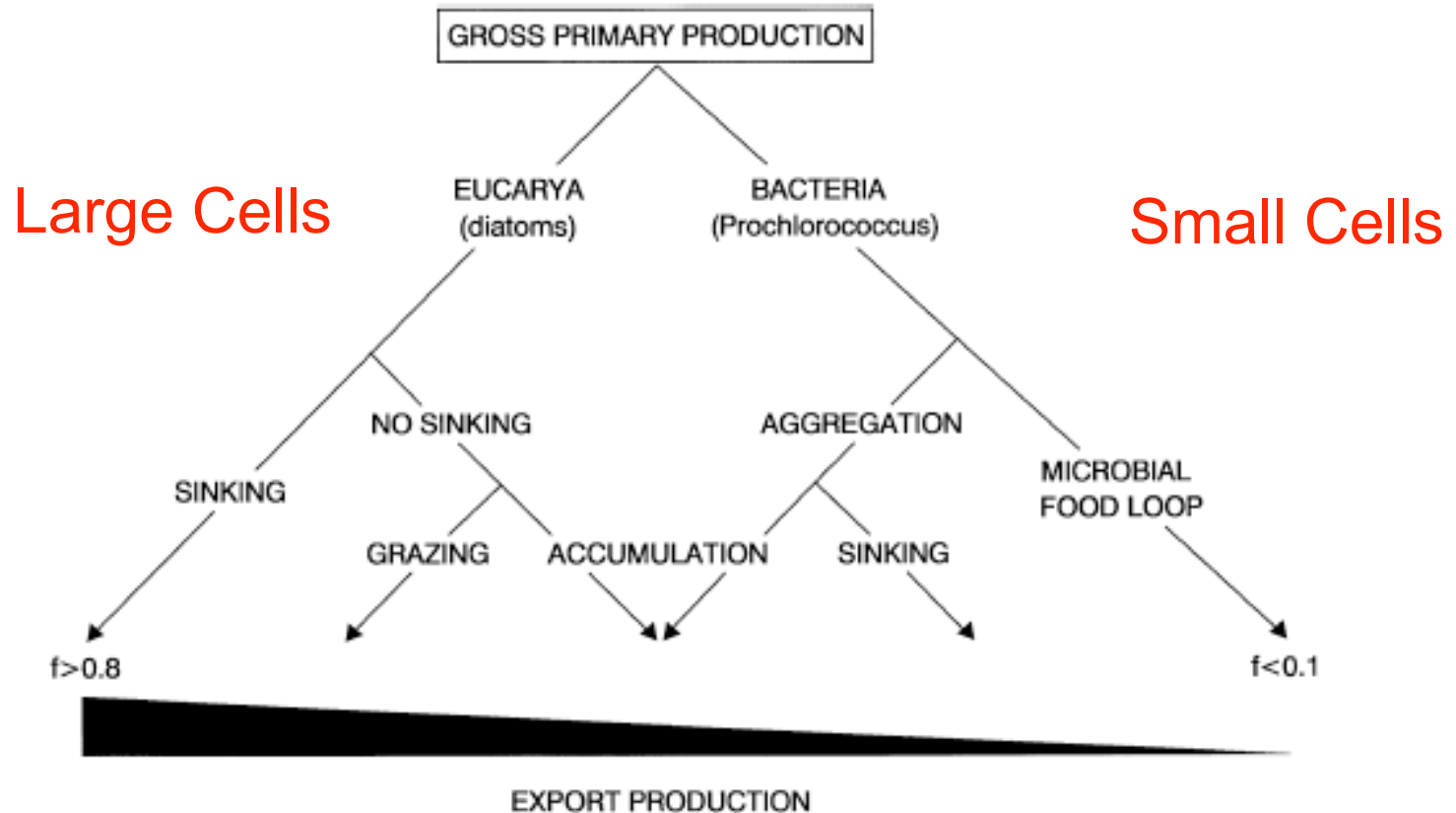
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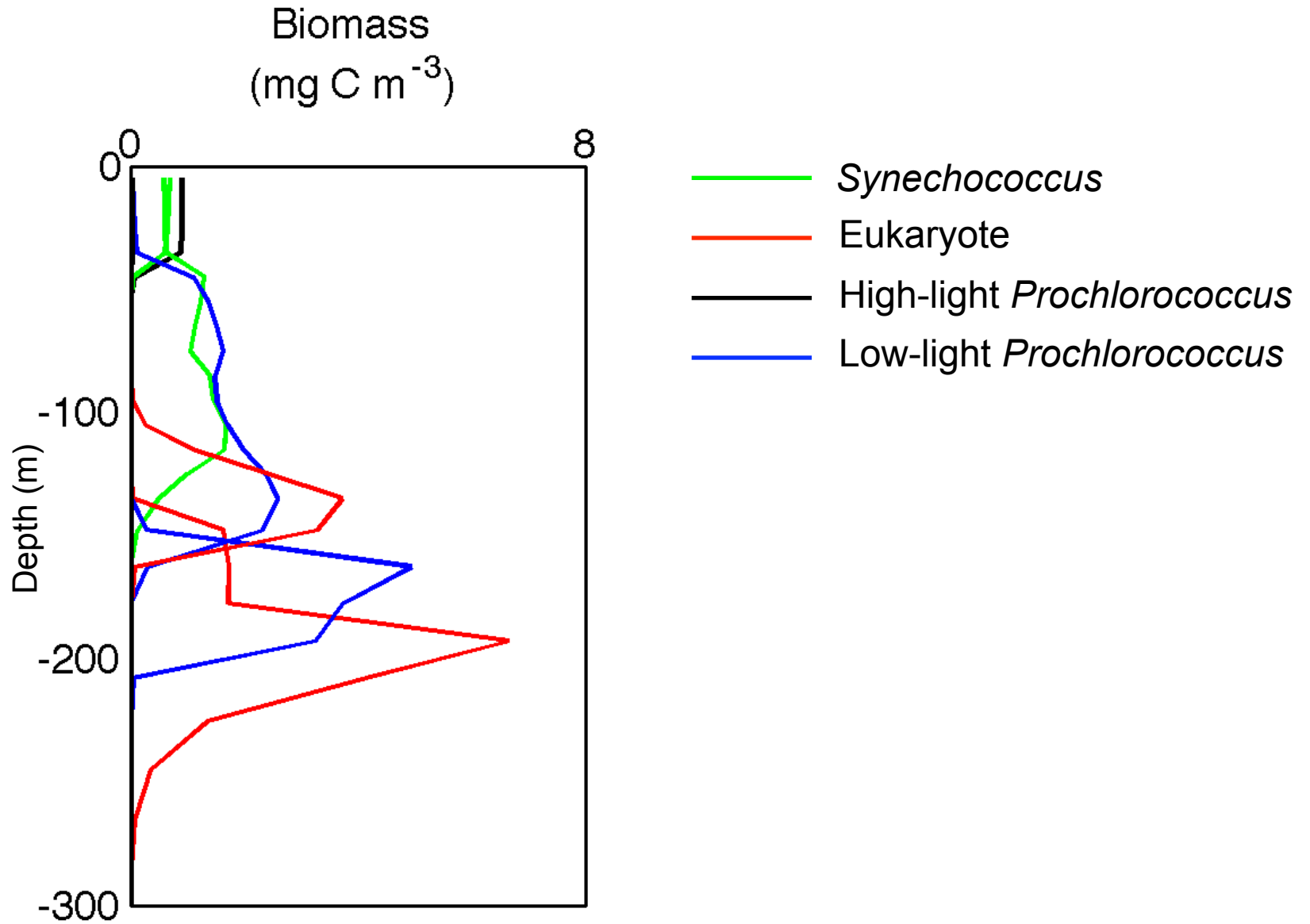
Surface Chl-a

Introduction



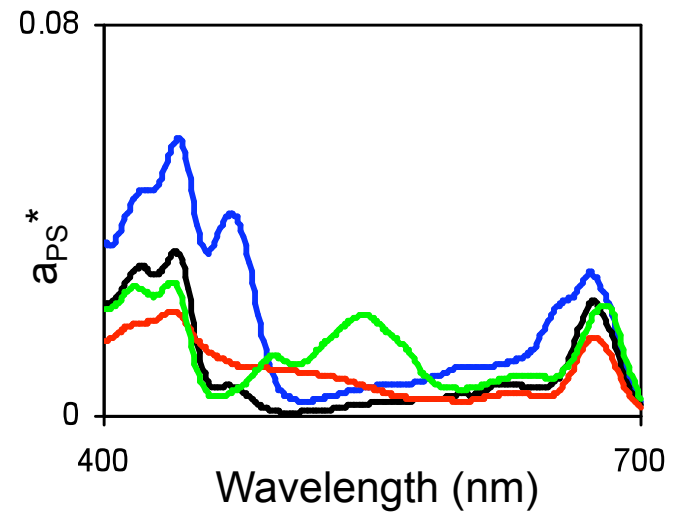
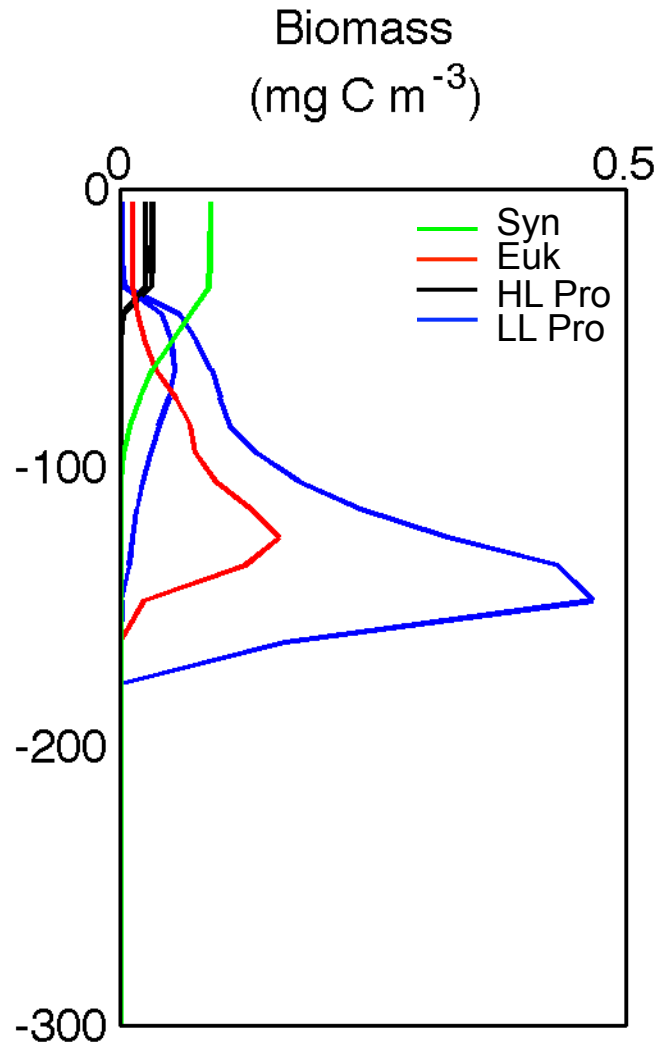
- Carbon Cycle
- Fisheries

Model Results



Model Results

Thought Experiments:



Wavelengths are important

Climatic Changes

HAWAII

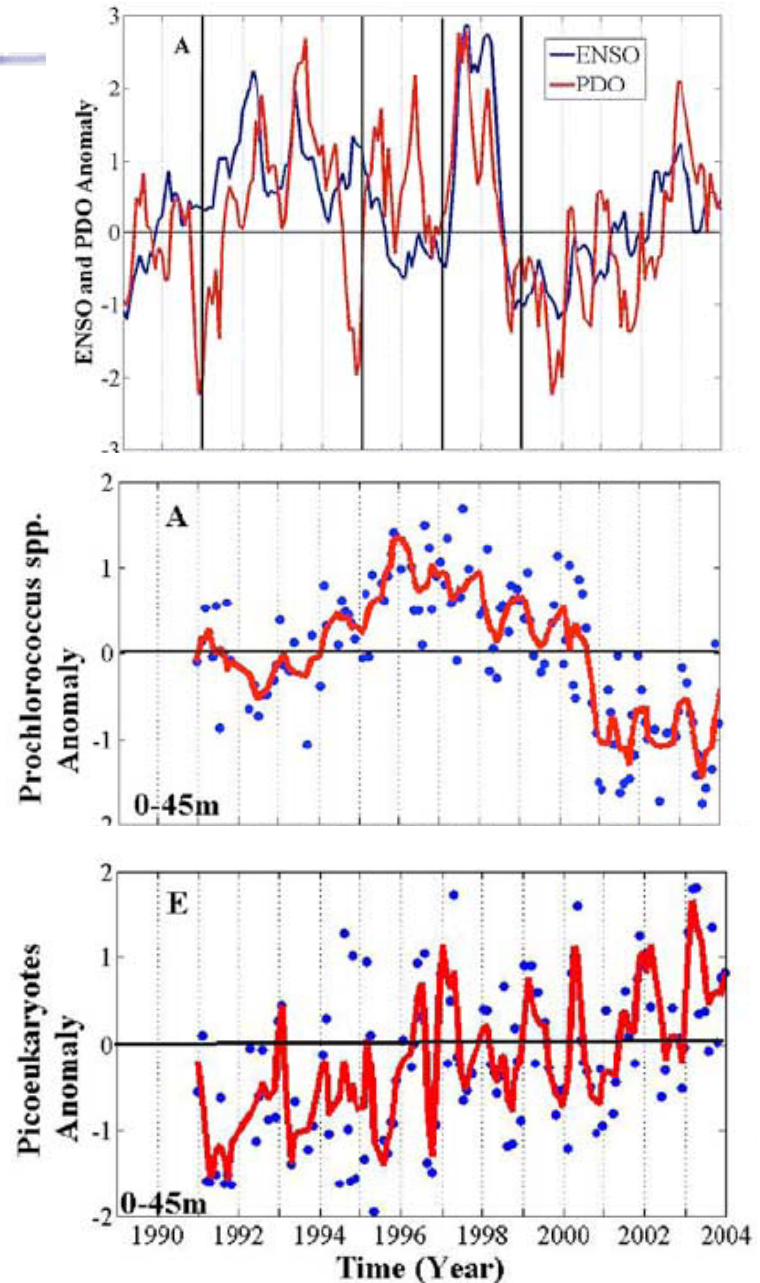
- Long-term changes
shift community structure

Complex interactions

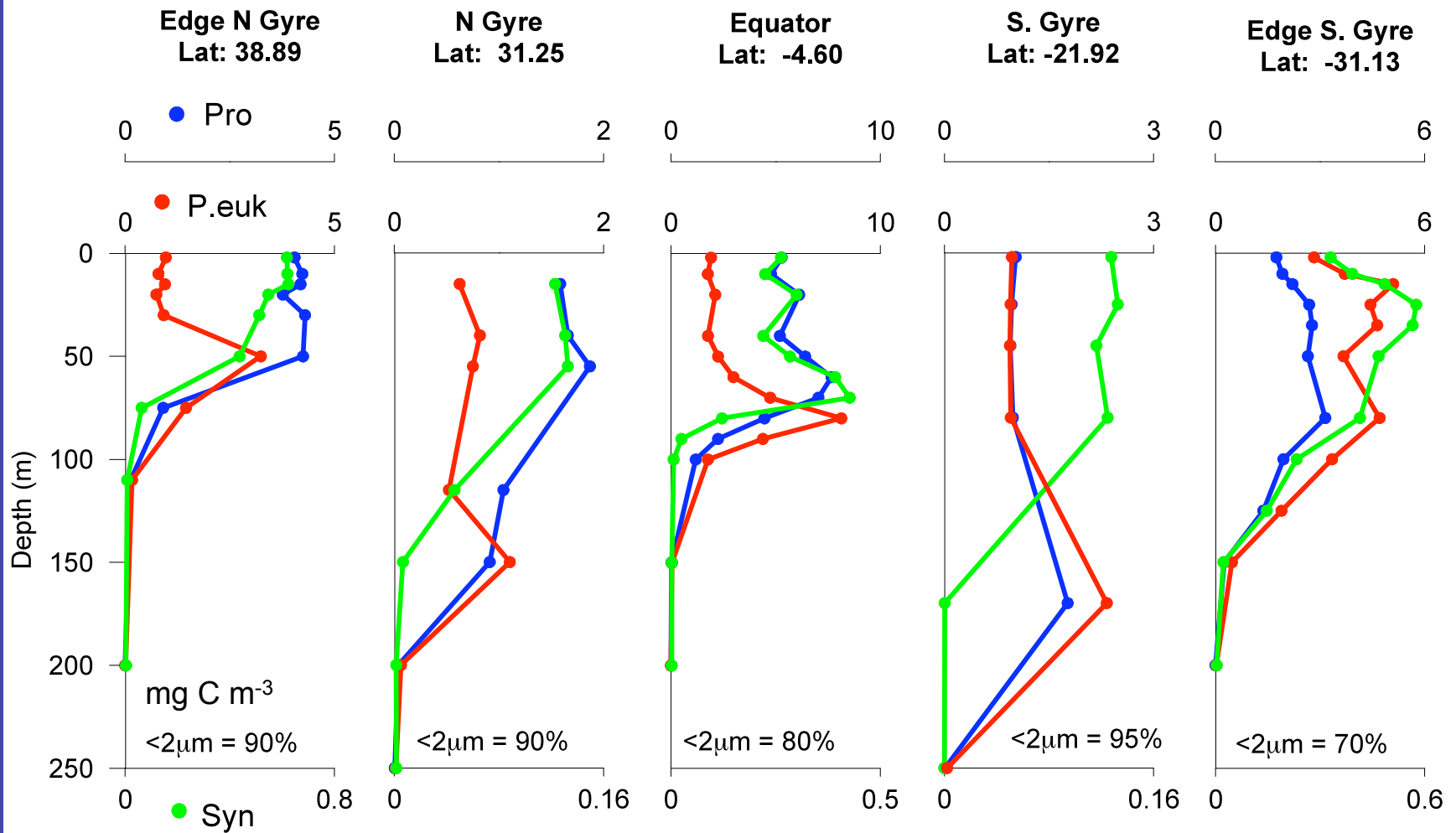
Implications for fisheries and
carbon cycle

Shelf Seas

- POL
- DEOS (Mahaffey, Bailey)



Motivation



(Data courtesy: M. Zubkov, J. Heywood)