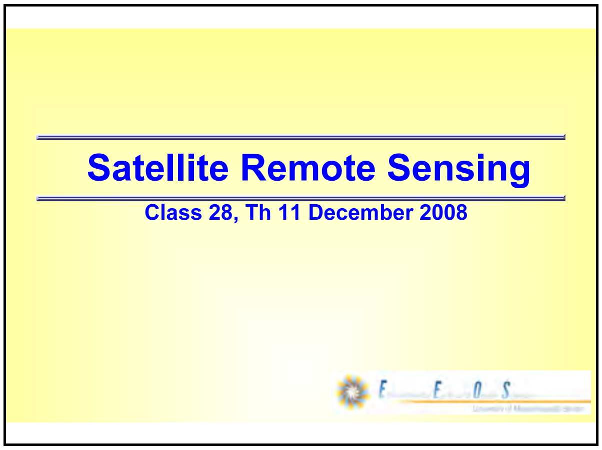
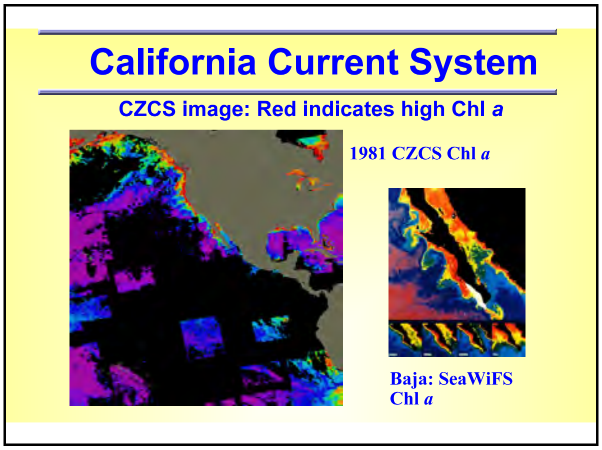


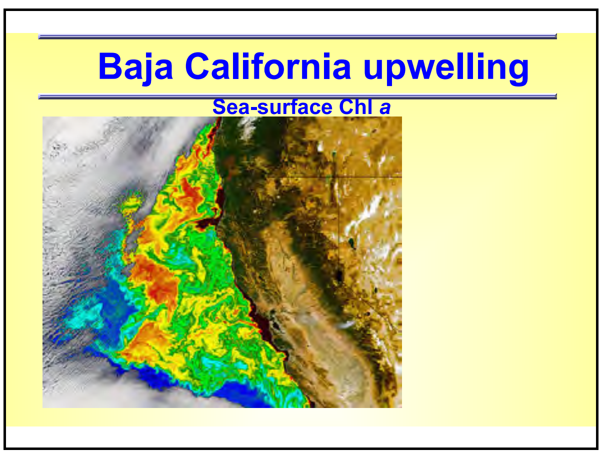
Slide 1 Satellite Remote Sensing

NOTES:



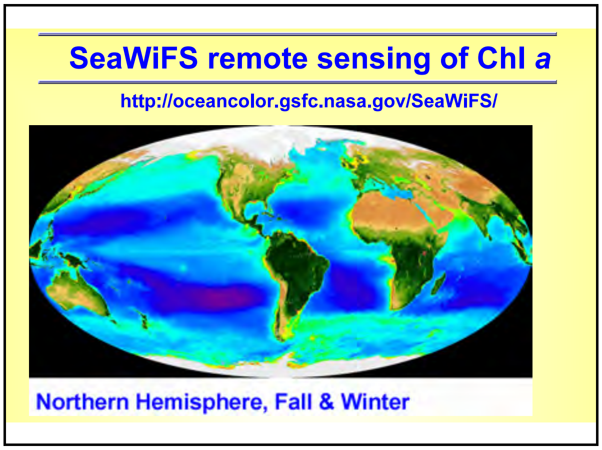
Slide 2 California Current System

NOTES:



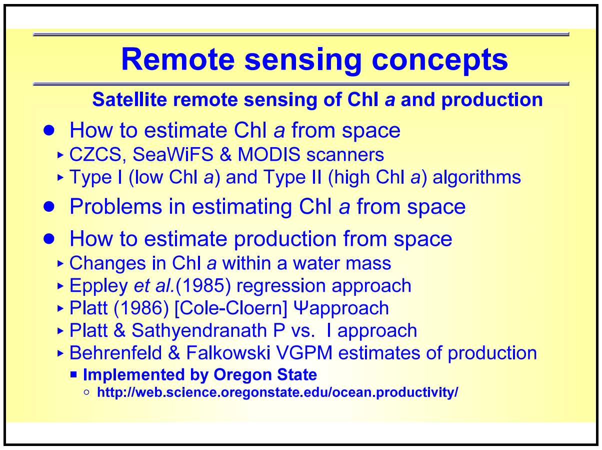
Slide 3 Baja California upwelling

NOTES:



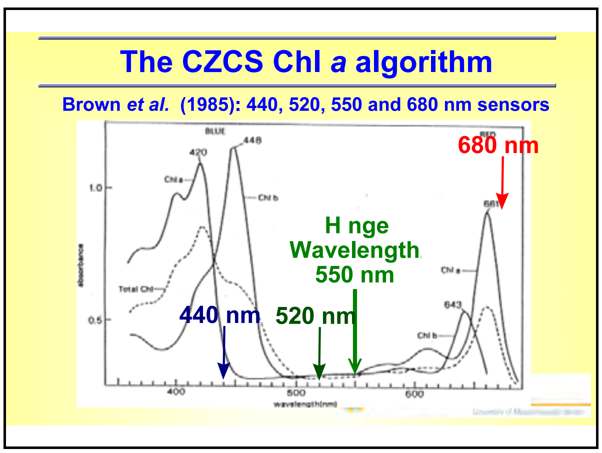
Slide 4 SeaWiFS remote sensing of Chl a

NOTES:



Slide 5 Remote sensing concepts

NOTES:

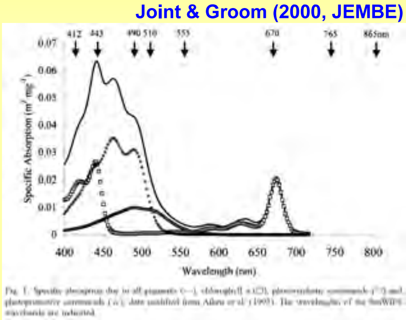


Slide 6 The CZCS Chl a algorithm

NOTES:

SeaWiFS sensors

Joint & Groom (2000, JEMBE)



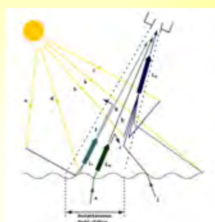
Slide 7 SeaWiFS sensors

NOTES:

Problems for Remote Sensing

Sensors detect to ≈1 optical depth

- Sensors detect only to 1 optical depth
  - Subsurface chlorophyll maxima never detected
- Cyanobacterial accessory pigments absorb at 550 nm
- Coccolithophorid blooms

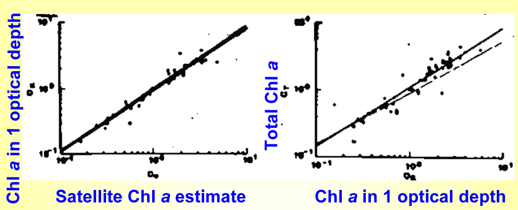


Slide 8 Problems for Remote Sensing

NOTES:

Estimating water-column Chl *a*

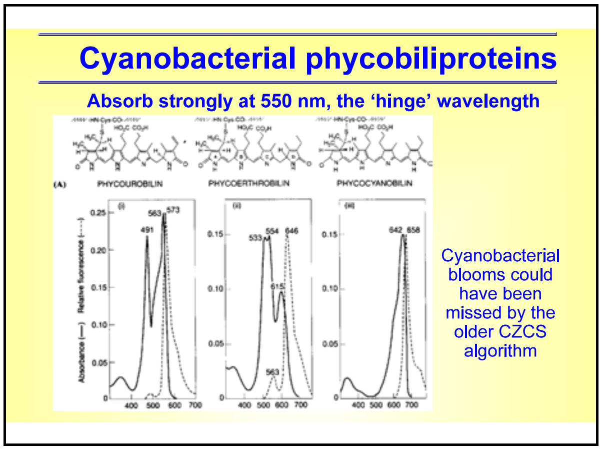
Eppley *et al.* (1985): note log-log scale



Optical depth=1/k, with k for PAR

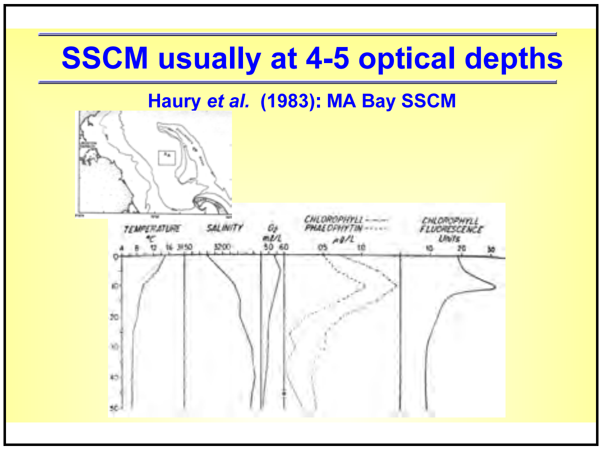
Slide 9 Estimating water-column Chl a

NOTES:



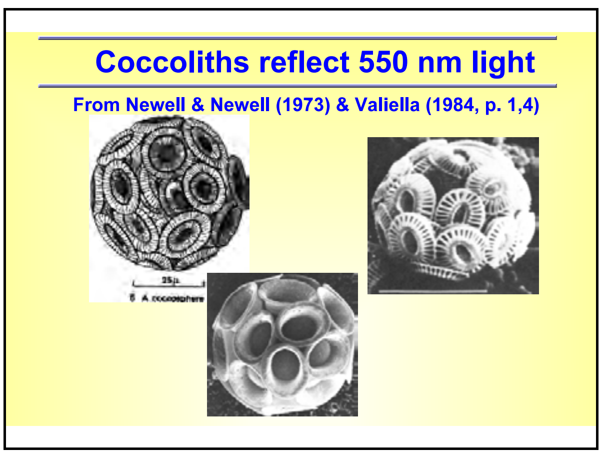
Slide 10 Cyanobacterial phycobiliproteins

NOTES:



Slide 11 SSCM usually at 4-5 optical depths

NOTES:

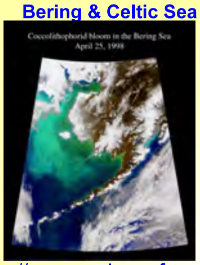


Slide 12 Coccoliths reflect 550 nm light

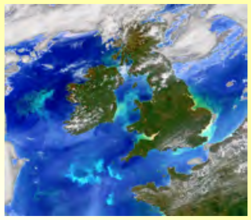
NOTES:

Coccolithophorid blooms

Bering & Celtic Sea SeaWiFS True color images



http://oceancolor.gsfc.nasa.gov/SeaWiFS/BACKGROUND/Gallery/beringsea.jpg



http://oceancolor.gsfc.nasa.gov/SeaWiFS/BACKGROUND/Gallery/celticsea.jpg

Slide 13 Coccolithophorid blooms

NOTES:

Estimating production from space

Different approaches

- Directly estimate changes in Chl *a* concentration from different images
- Regress primary production *vs.* Chl *a* (Smith *et al.* 1982, Eppley et al. 1985, Perry 1986)
- Bioptical models:
  - Include I_o and an estimate of water-column average quantum yield ψ 'psi' (Eppley *et al.* 1985, Platt 1986)
  - Platt & Sathyendrenath (1988): include SSCM
  - Behrenfeld & Falkowski VGPM model & Howard-Yoder models (differ in estimating mixed-layer depth)
  - Behrenfeld et al. (2005): Carbon-based models & phytoplankton physiology from space (Global Biogeochemical Cycles *19*: 1006)

Slide 14 Estimating production from space

NOTES:

Direct estimates of production

Using d(Chl a)/dt to estimate production

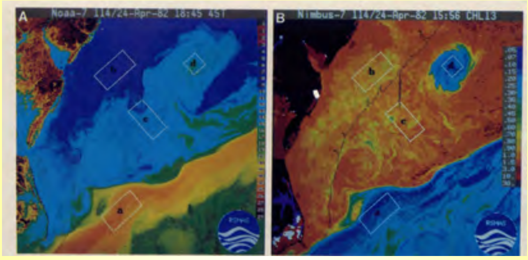
- Brown *et al.* (1985) calculated production during the North Atlantic bloom
  - 4 regions: shelf, slope, Gulf stream and Gulf Stream warm core ring
  - Assumed C:Chl *a* ratio and monitored changes in estimated Chl a. with high precision
- Abbott and Zion (1985) calculated phytoplankton growth rates in California upwelling region.
  - Used satellite-tracked drogues to estimate time water had traveled between 2 points
  - assumed difference in satellite-derived Chl *a* was due to phytoplankton growth

Slide 15 Direct estimates of production

NOTES:

Estimating production from CZCS time-series images

Brown *et al.* (1985) estimated high slope production



Temperature   Chl *a*

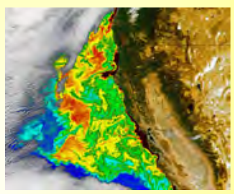
Slide 16 Estimating production from CZCS time-series images

NOTES:

Estimating production from Lagrangian estimates of Chl *a*

California Sea-surface Chl *a*

- Abbott and Zion (1985) calculated phytoplankton growth rates in California upwelling region.
  - Used satellite-tracked drogues to estimate time water had traveled between 2 points
  - assumed difference in satellite-derived Chl *a* was due to phytoplankton growth
  - calculated growth of 0.8 d^{-1}



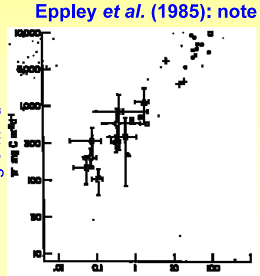
Slide 17 Estimating production from Lagrangian estimates of Chl a

NOTES:

Regression of production on Chl *a*

Eppley *et al.* (1985): note log-log scale

Water-column production mg C m^{-2} d^{-1}



Chl *a* in upper optical depth

Slide 18 Regression of production on Chl a

NOTES:

NE Shelf production

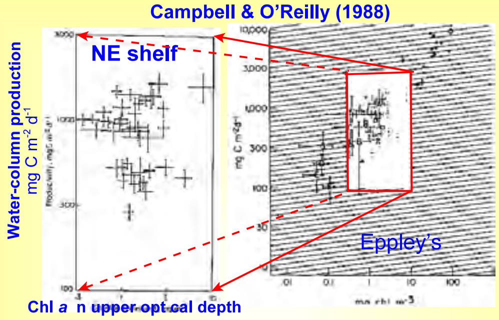
Campbell & O'Reilly (1988); NMFS MARMAP data

Slide 19 NE Shelf production

NOTES:

Eppley's (1985) relationship weak

Campbell & O'Reilly (1988)

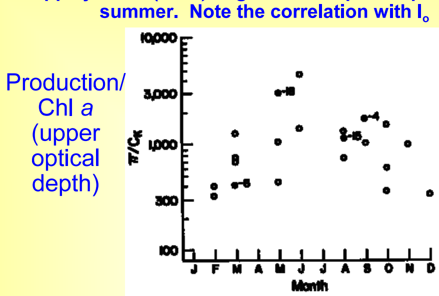


Slide 20 Eppley's (1985) relationship weak

NOTES:

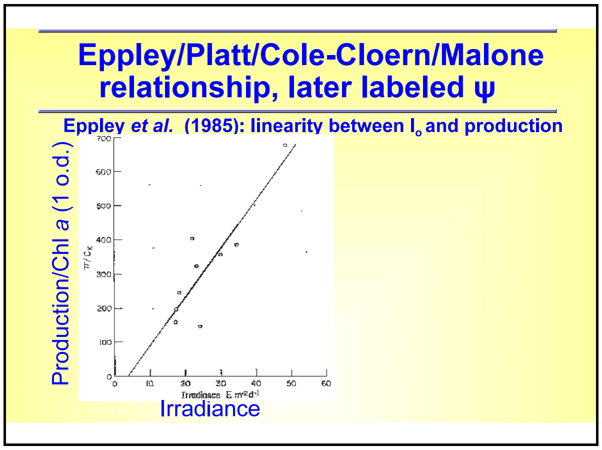
Effects of light on Prod:Chl $a_{(1/k)}$

Eppley *et al.* (1985): higher Chl *a*-specific production in summer. Note the correlation with I_o



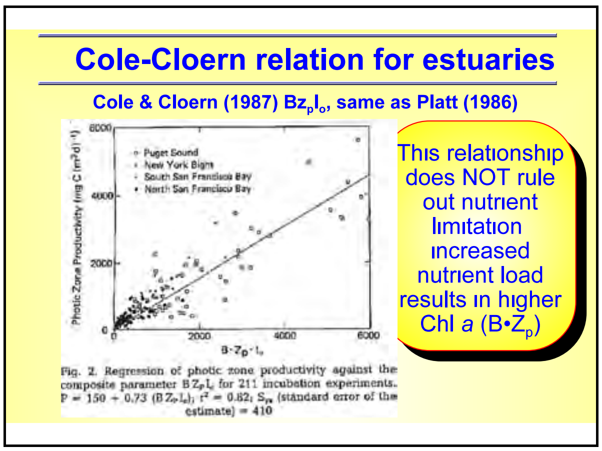
Slide 21 Effects of light on Prod:Chl a(1/k)

NOTES:



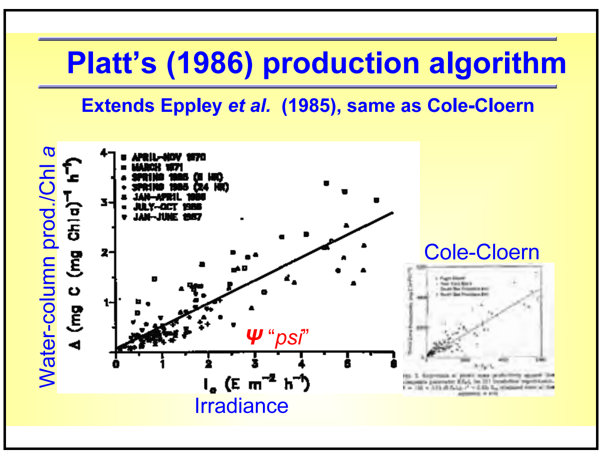
Slide 22 Eppley/Platt/Cole-Cloern/Malone relationship, later labeled ψ

NOTES:



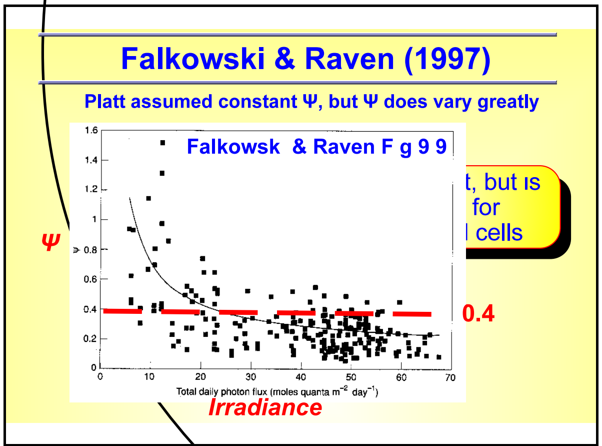
Slide 23 Cole-Cloern relation for estuaries

NOTES:



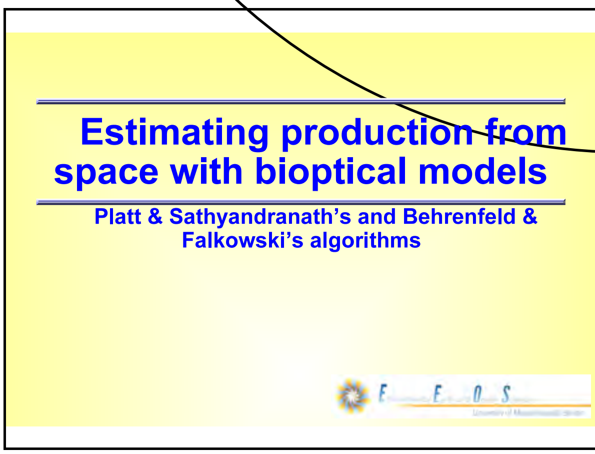
Slide 24 Platt's (1986) production algorithm

NOTES:



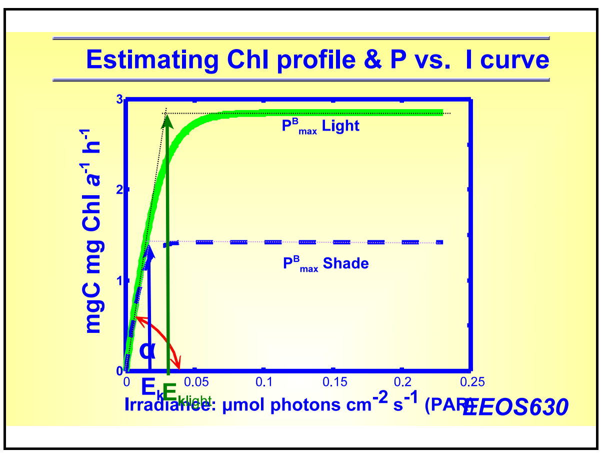
Slide 25 Falkowski & Raven (1997)

NOTES:



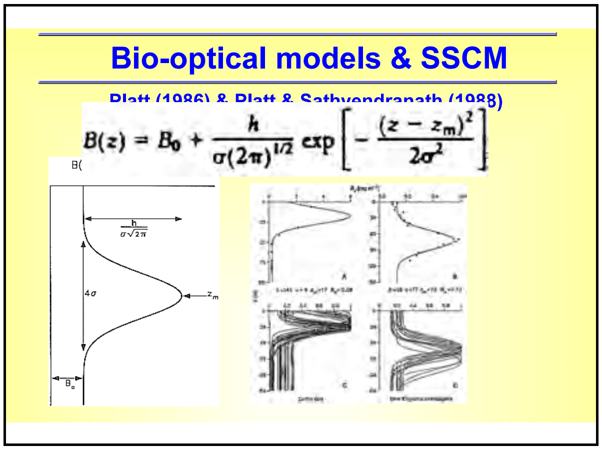
Slide 26 Estimating production from space with bioptical models

NOTES:



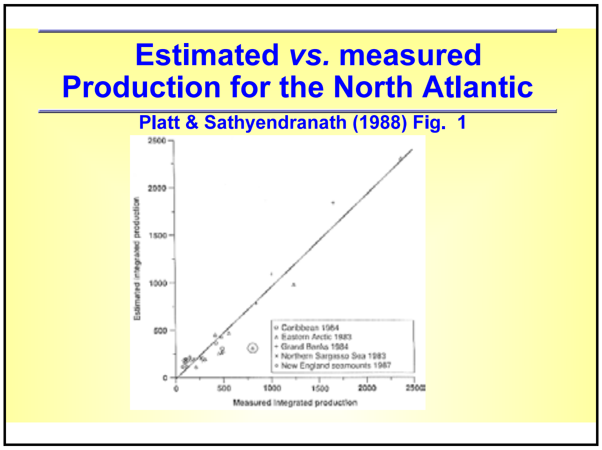
Slide 27

NOTES:



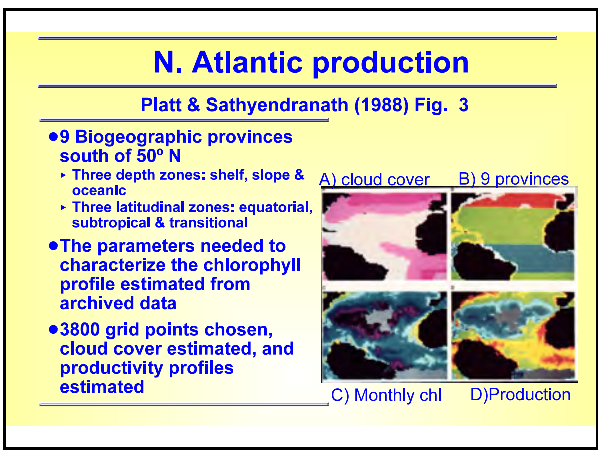
Slide 28 Bio-optical models & SSCM

NOTES:



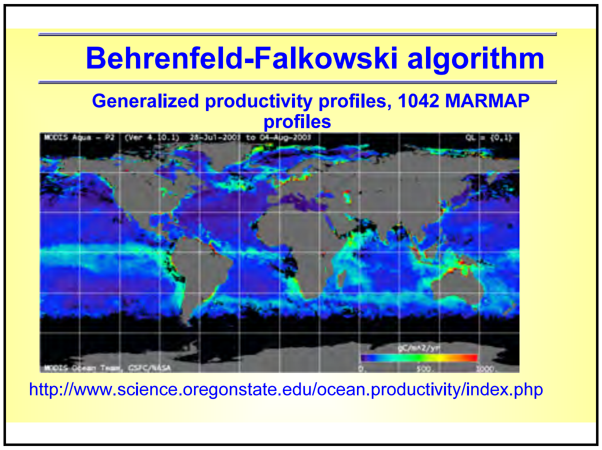
Slide 29 Estimated vs. measured Production for the North Atlantic

NOTES:



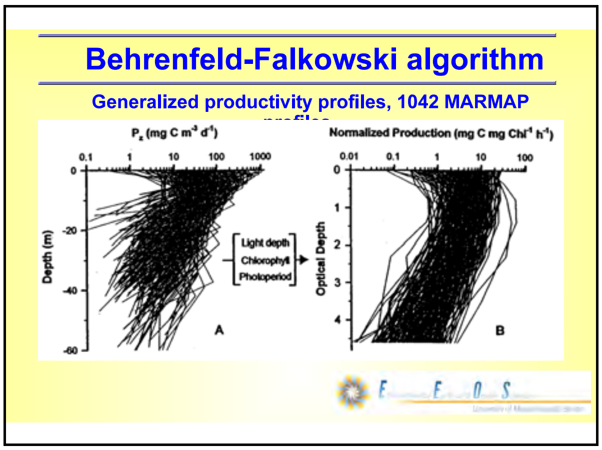
Slide 30 N. Atlantic production

NOTES:



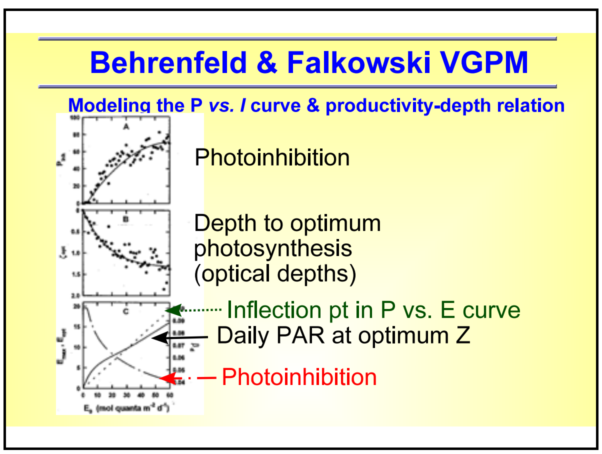
Slide 31 Behrenfeld-Falkowski algorithm

NOTES:



Slide 32 Behrenfeld-Falkowski algorithm

NOTES:

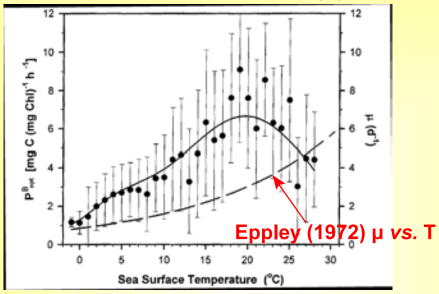


Slide 33 Behrenfeld & Falkowski VGPM

NOTES:

Assimilation number as *f*(temp)

Compared to Eppley (1972)

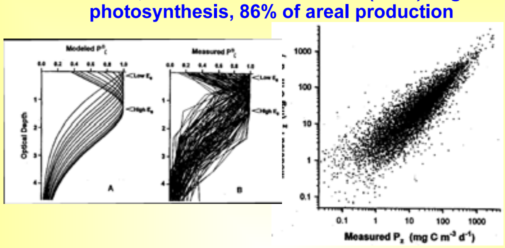


Slide 34 Assimilation number as f(temp)

NOTES:

Est. vs. Observed Productivity

R^2 =79%, Behrenfeld & Falkowski (1997) in gross photosynthesis, 86% of areal production



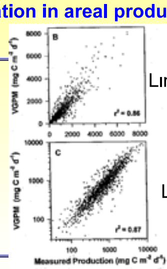
Slide 35 Est. Vs. Observed Productivity

NOTES:

Observed versus modeled areal production

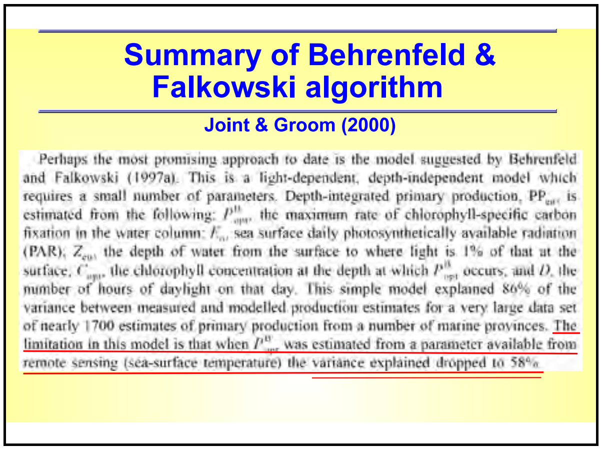
Explains 86-87% of variation in areal production

- Requires knowing or estimating
  - Chl *a* concentration at depth
  - Optimum photosynthetic rate at depth
- These parameters can be estimated from satellite data
  - surface temperature
  - light
  - Chl *a* in upper optical depth



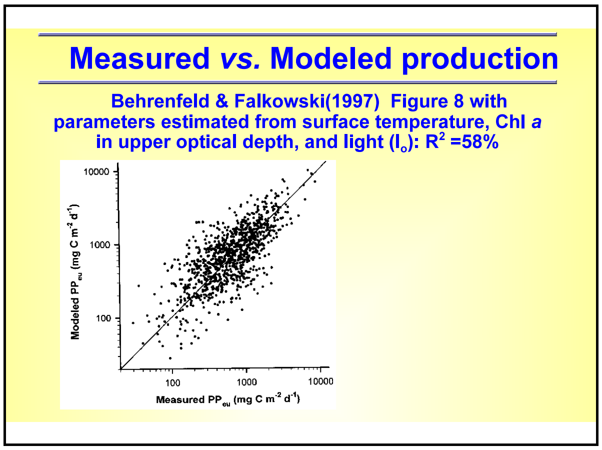
Slide 36 Observed versus modeled areal production

NOTES:



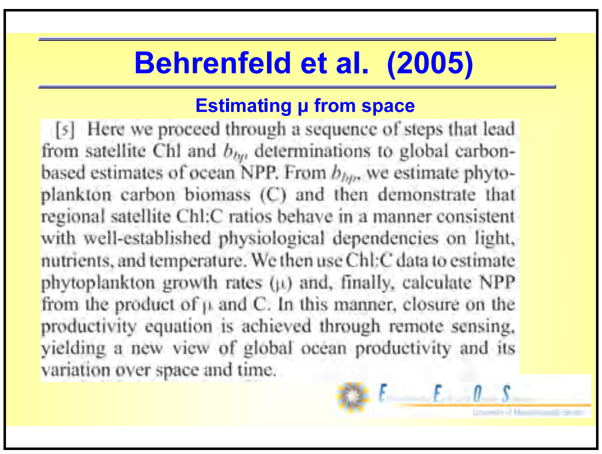
Slide 37 Summary of Behrenfeld & Falkowski algorithm

NOTES:



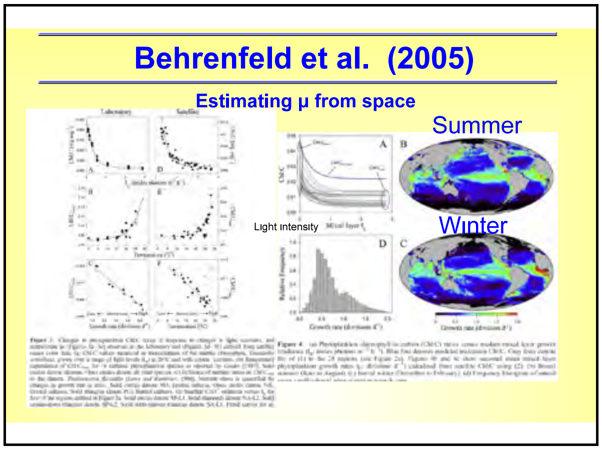
Slide 38 Measured vs. Modeled production

NOTES:



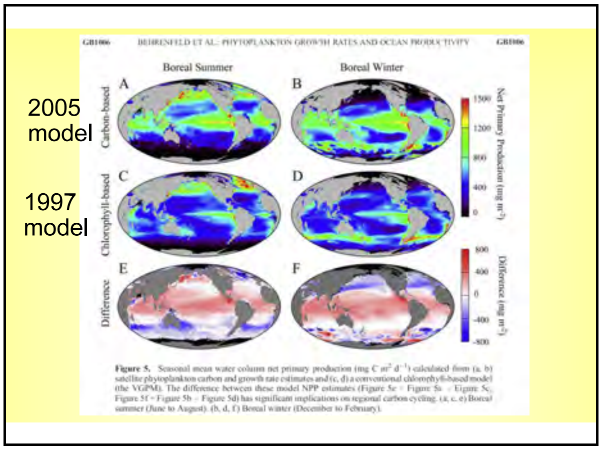
Slide 39 Behrenfeld et al. (2005)

NOTES:



Slide 40 Behrenfeld et al. (2005)

NOTES:



Slide 41

NOTES: