Modeling the Ecosystem Response and Carbon Cycle to Iron Enrichment in the Equatorial Pacific

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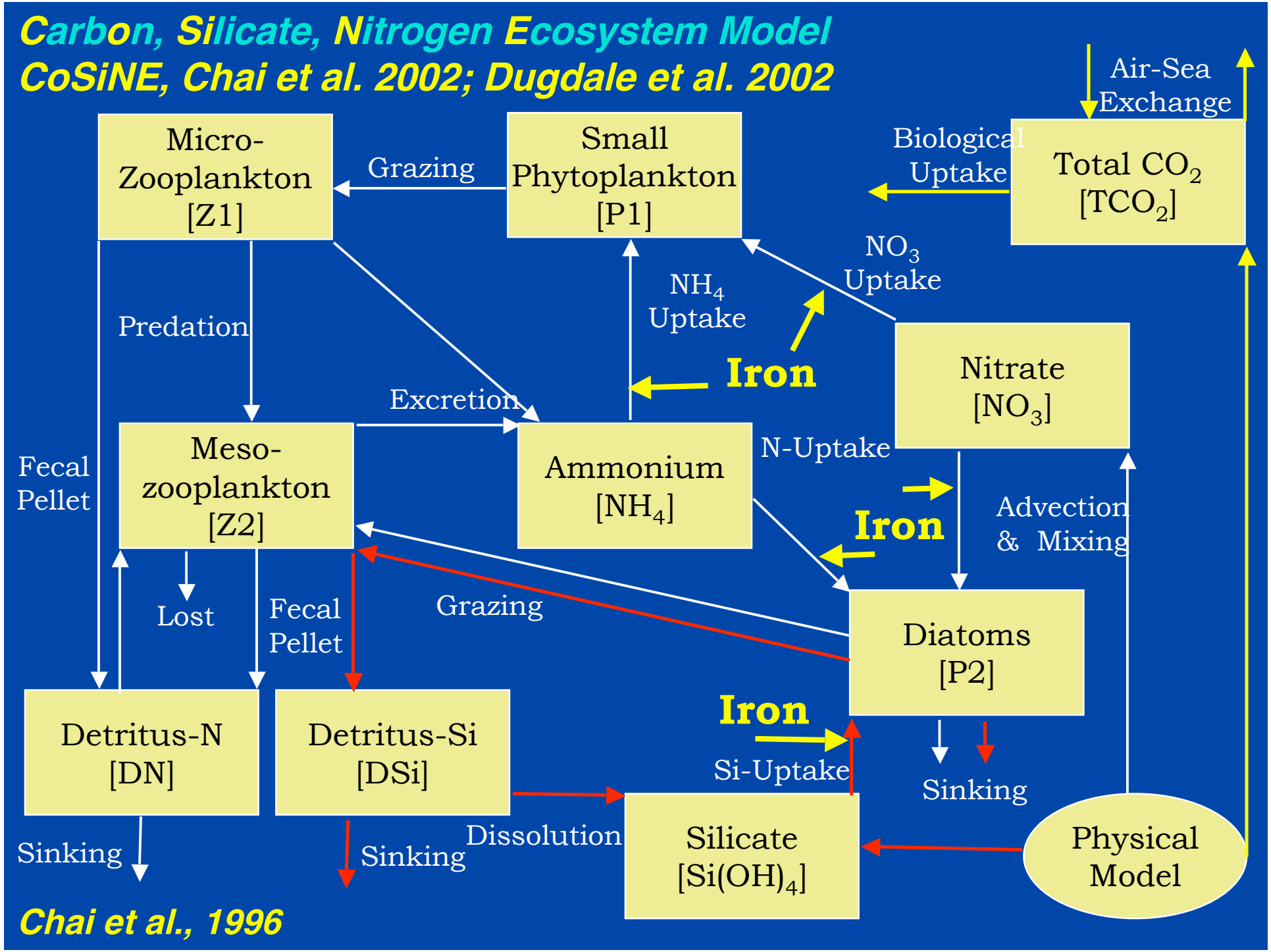
Motivation of Modeling

- Test Response of Ecosystem Models
- Investigate Long-term Consequences
- Carbon Fluxes
- Design Experiments
- No Environmental Risks


Carbon, Silicate, Nitrogen Ecosystem Model
CoSiNE, Chai et al. 2002; Dugdale et al. 2002
Air-Sea Exchange
Micro-Zooplankton [Z1]
Grazing
Small Phytoplankton [P1]
Biological Uptake
Total CO_2 [TCO_2]
NO_3 Uptake
NH_4 Uptake
Predation
Iron
Nitrate [NO_3]
Excretion
Meso-zooplankton [Z2]
Ammonium [NH_4]
N-Uptake
Fecal Pellet
Iron
Advection & Mixing
Lost
Fecal Pellet
Grazing
Diatoms [P2]
Iron
Detritus-N [DN]
Detritus-Si [DSi]
Si-Uptake
Sinking
Sinking
Dissolution
Sinking
Silicate [$Si(OH)_4$]
Physical Model
Chai et al., 1996

3D Circulation-Ecosystem Modeling

Modular Ocean Model (MOM)

Basin scale, coarse resolution (1°), 50 years simulation

Regional Ocean Model System (ROMS)

Basin scale, finer resolution (1/2°), 50 years simulation

Basin scale, finer resolution (12.5-km), 16 years simulation

Central California Upwelling System (ROMS)

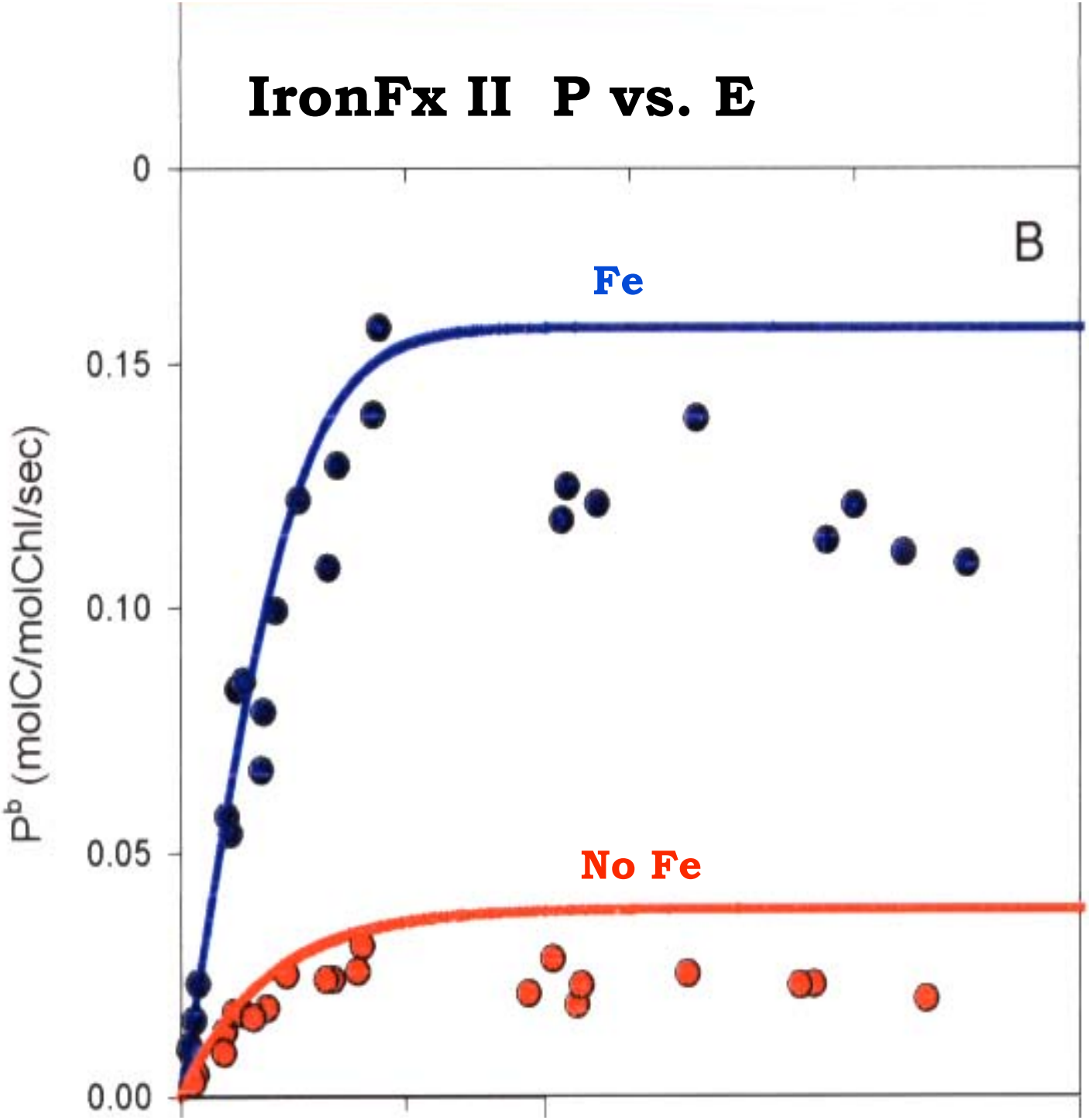
15-5-1.5 Km resolution, 1998 - 2003, and 2006

West Coast of the North America (NCOM)

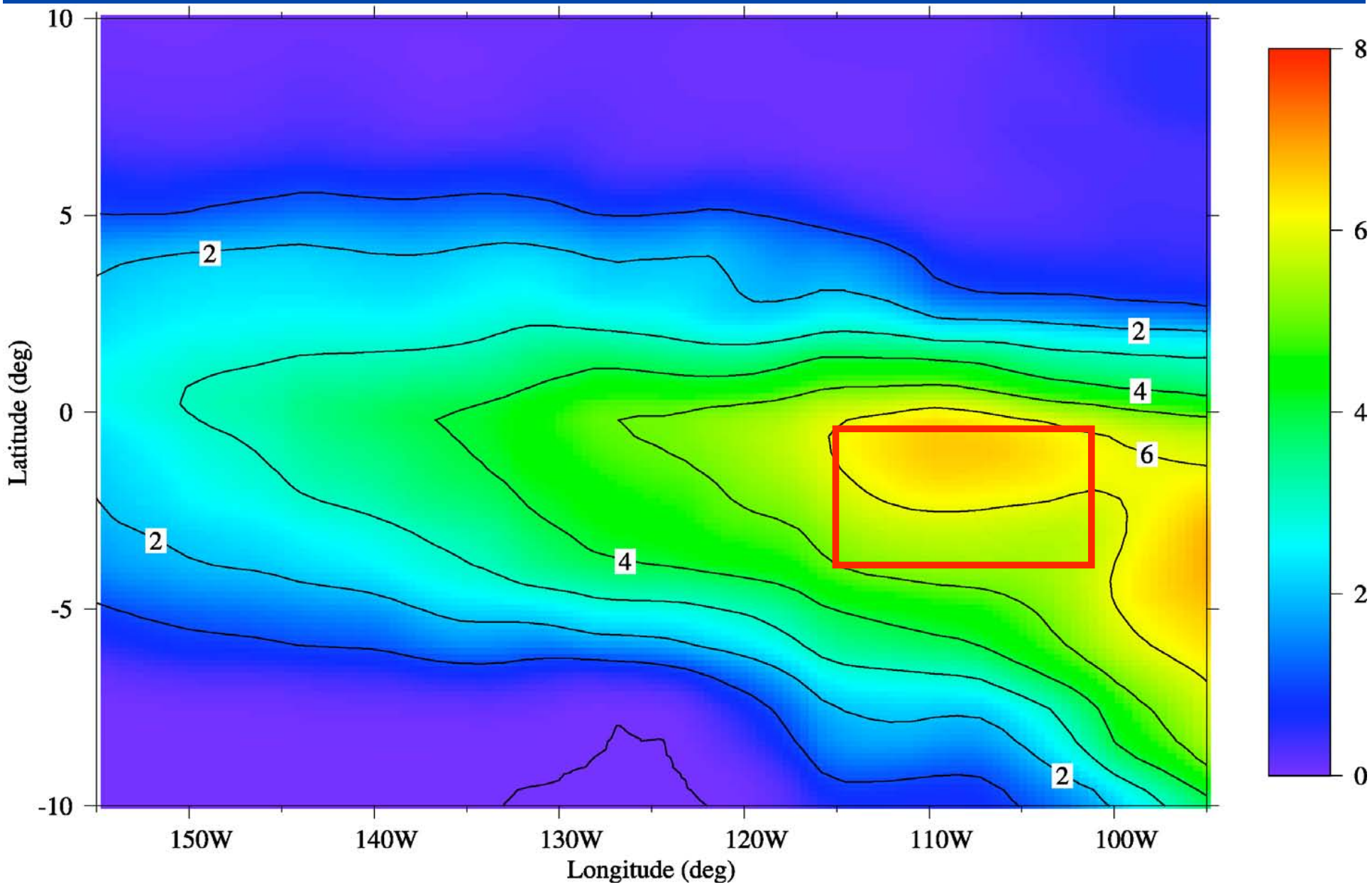
9 Km with physical data assimilation, 1998 - present

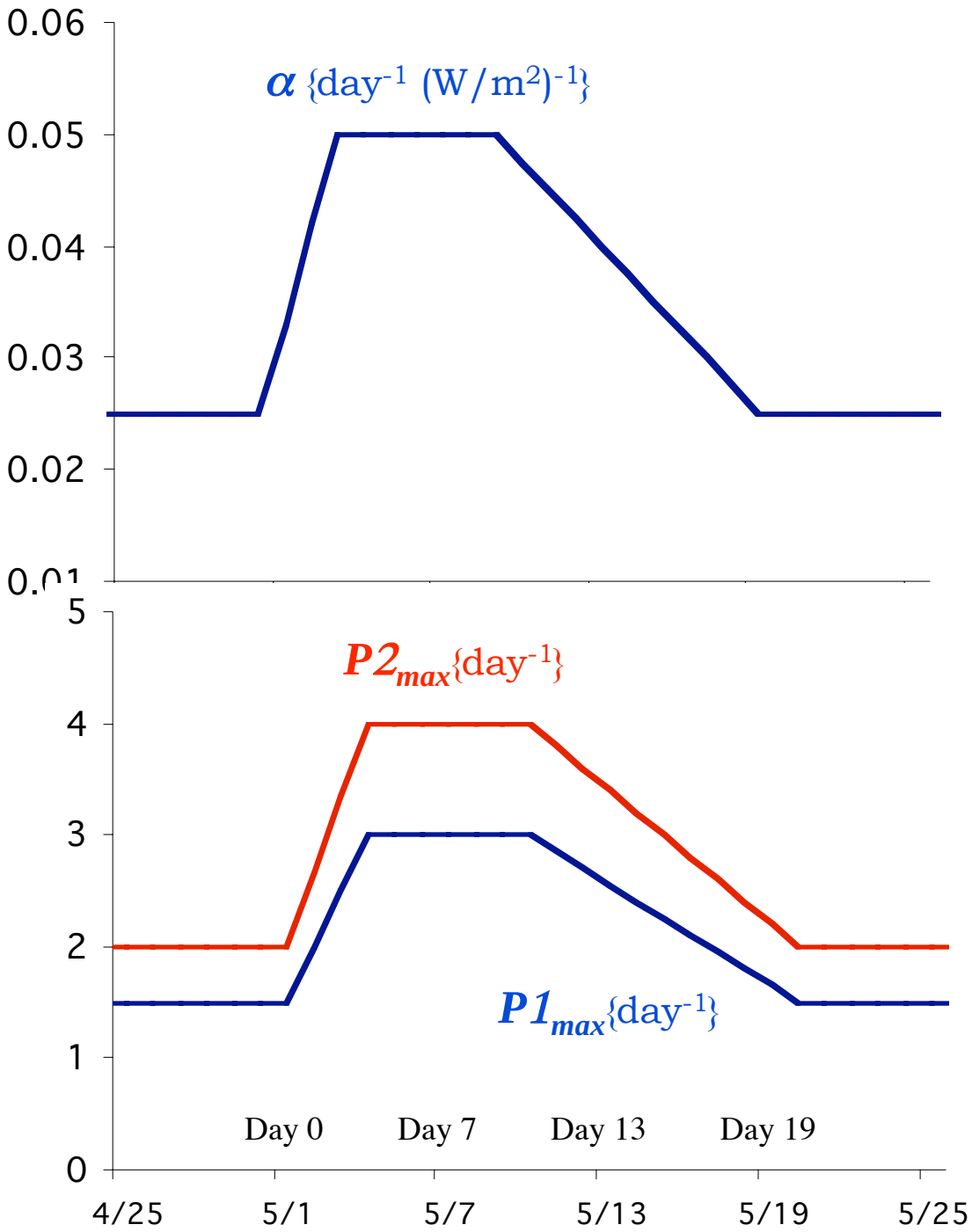
Gulf of Maine (POM)

3 Km resolution, 2002 - present


IronFx II P vs. E
B
Fe
No Fe
P^b (molC/molChl/sec)
0
0.15
0.10
0.05
0.00

Surface NO_3 Concentration - Annual Mean



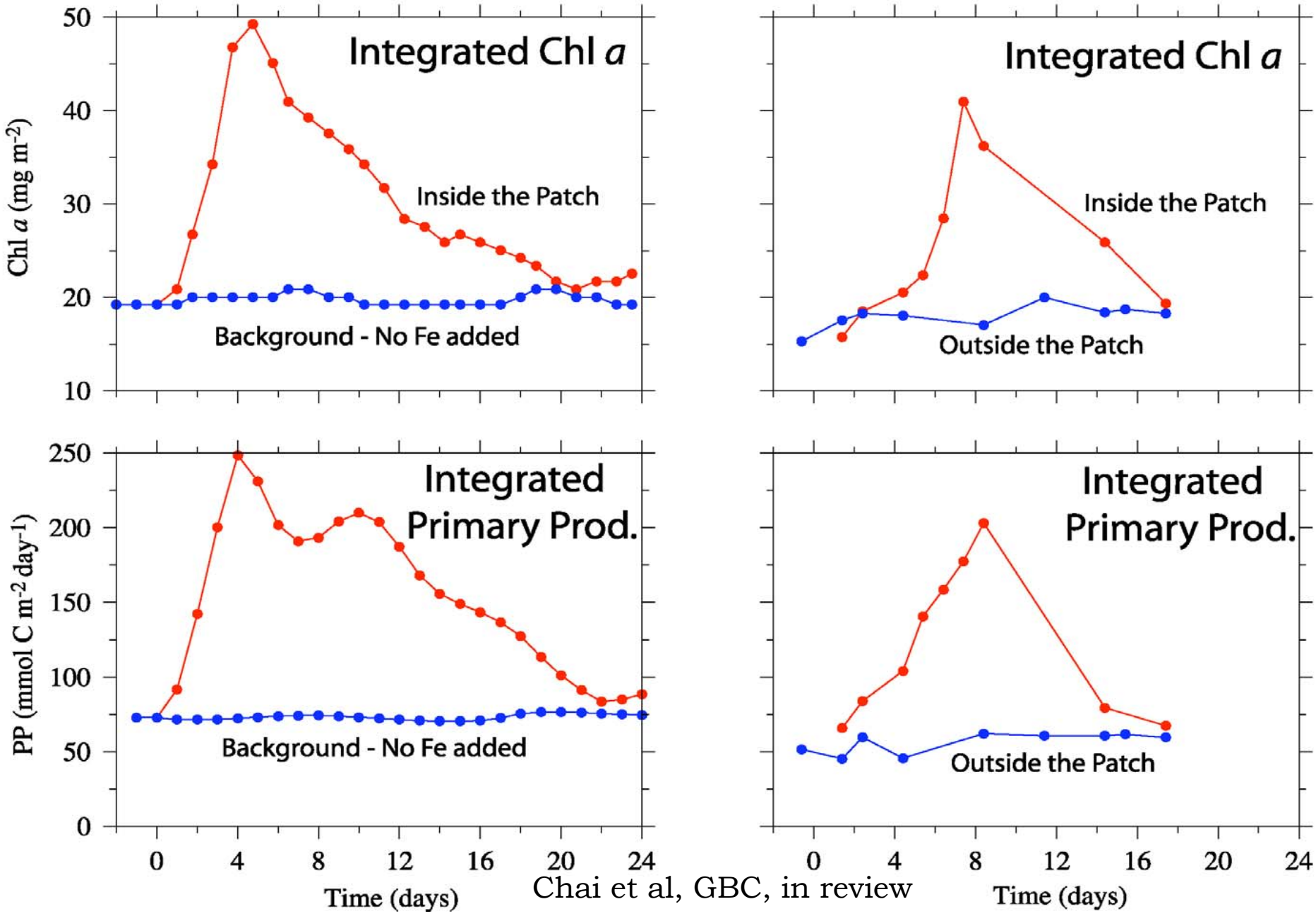


Temporal Change of α *and* P_{max}

Chai et al, GBC, in review

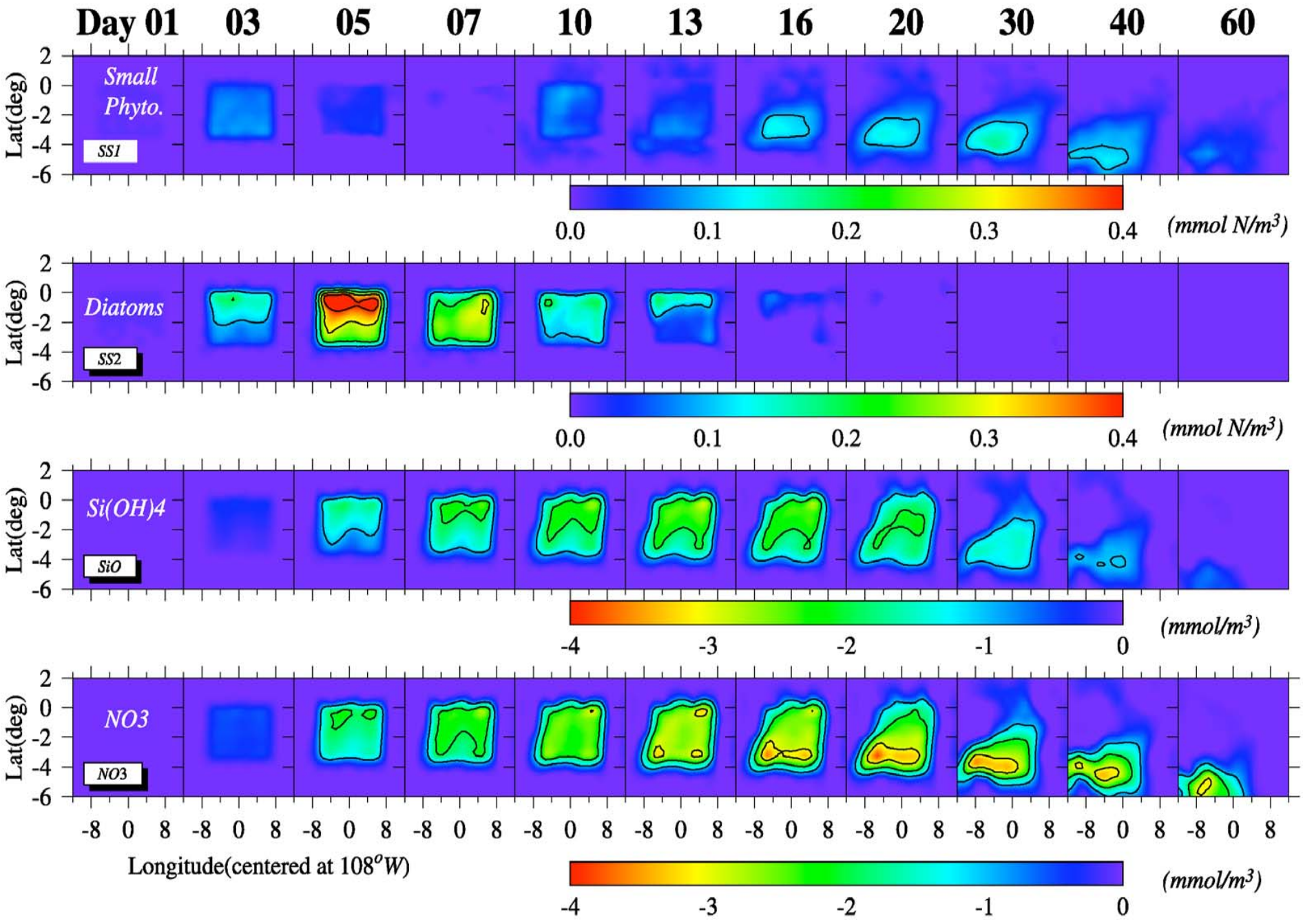
Modeled Fe Fertilization

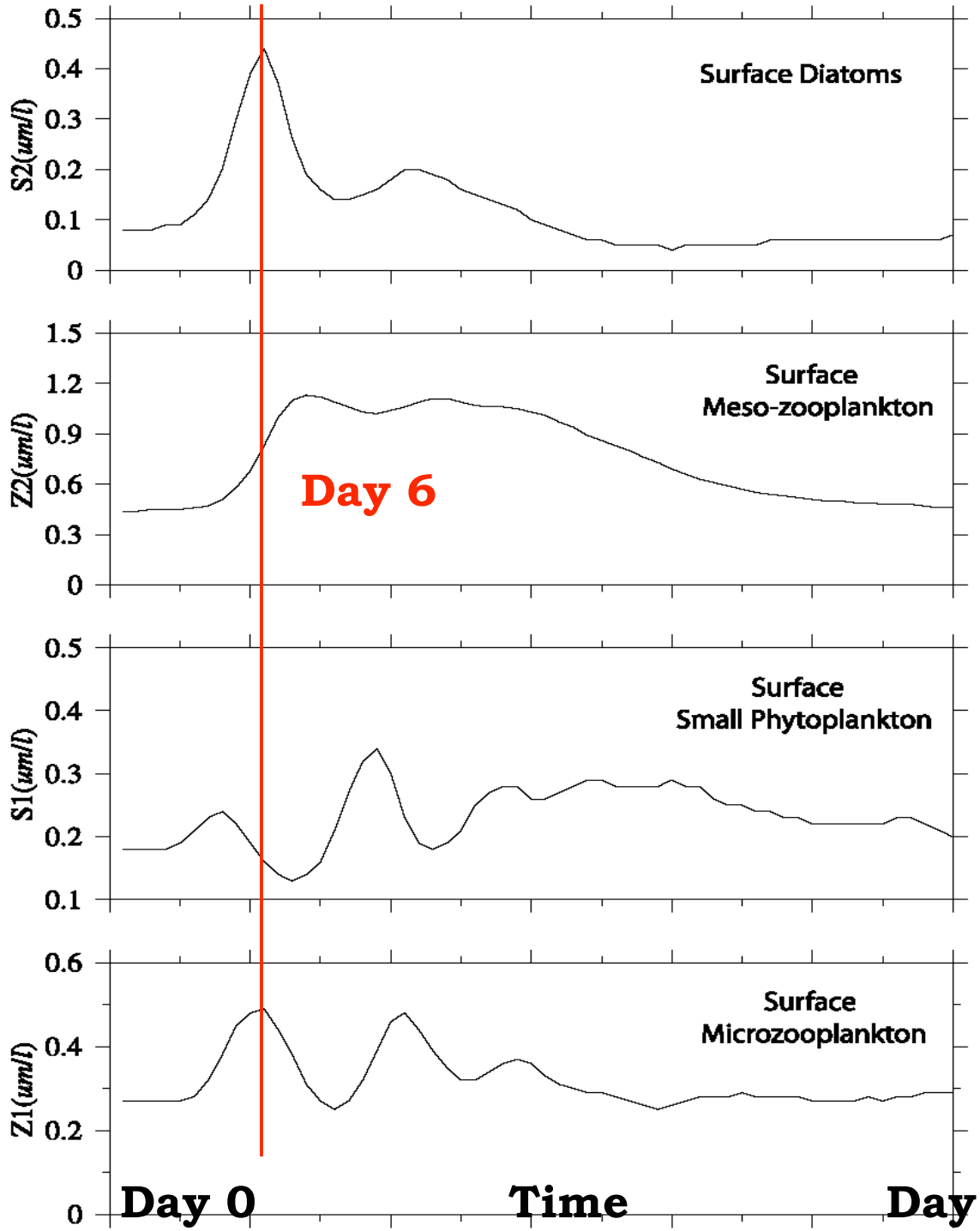
IronEX II Results



Chai et al, GBC, in review

Surface Anomaly Fields due to the Iron Addition (Iron - Normal)





Chai et al
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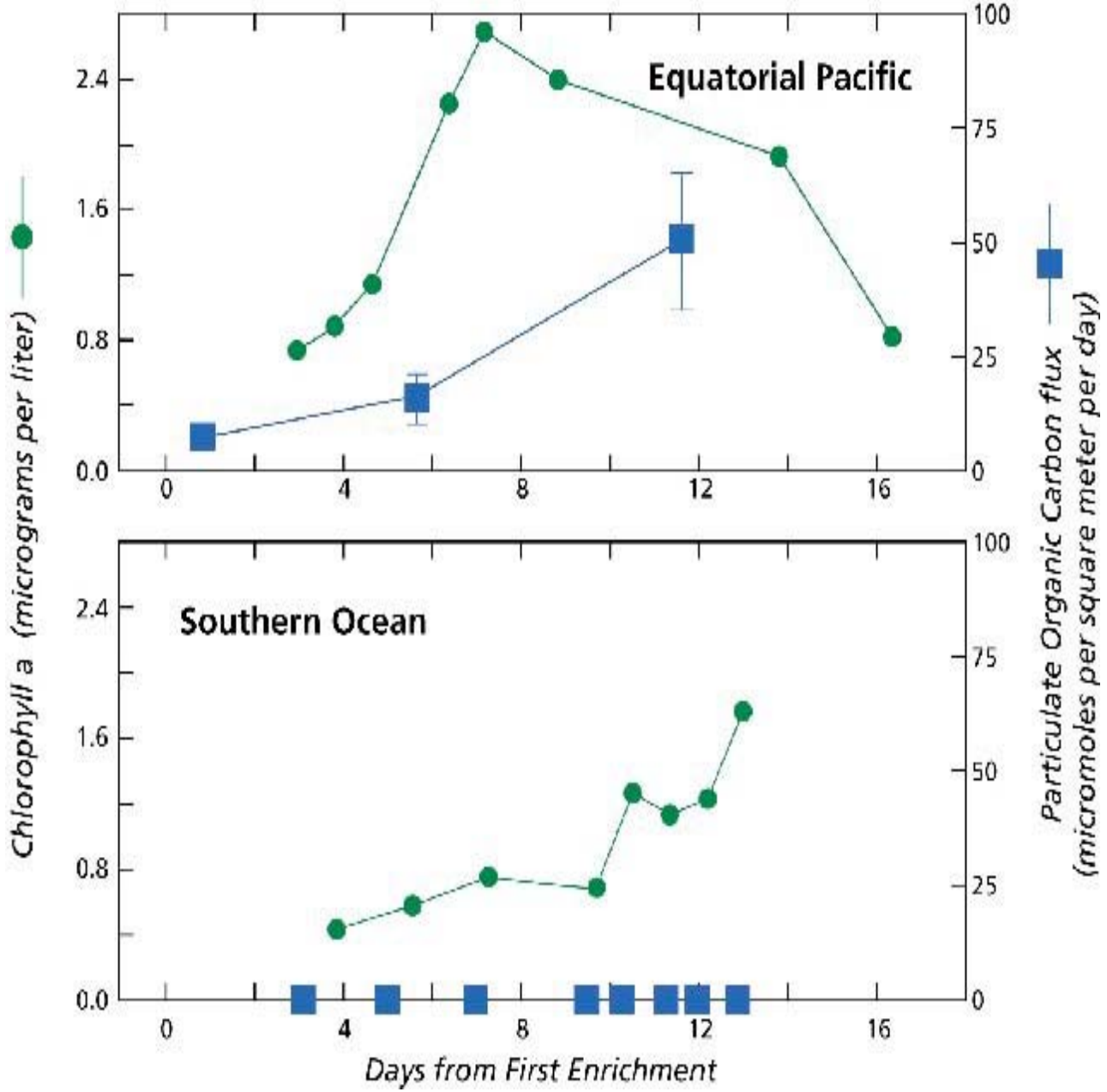
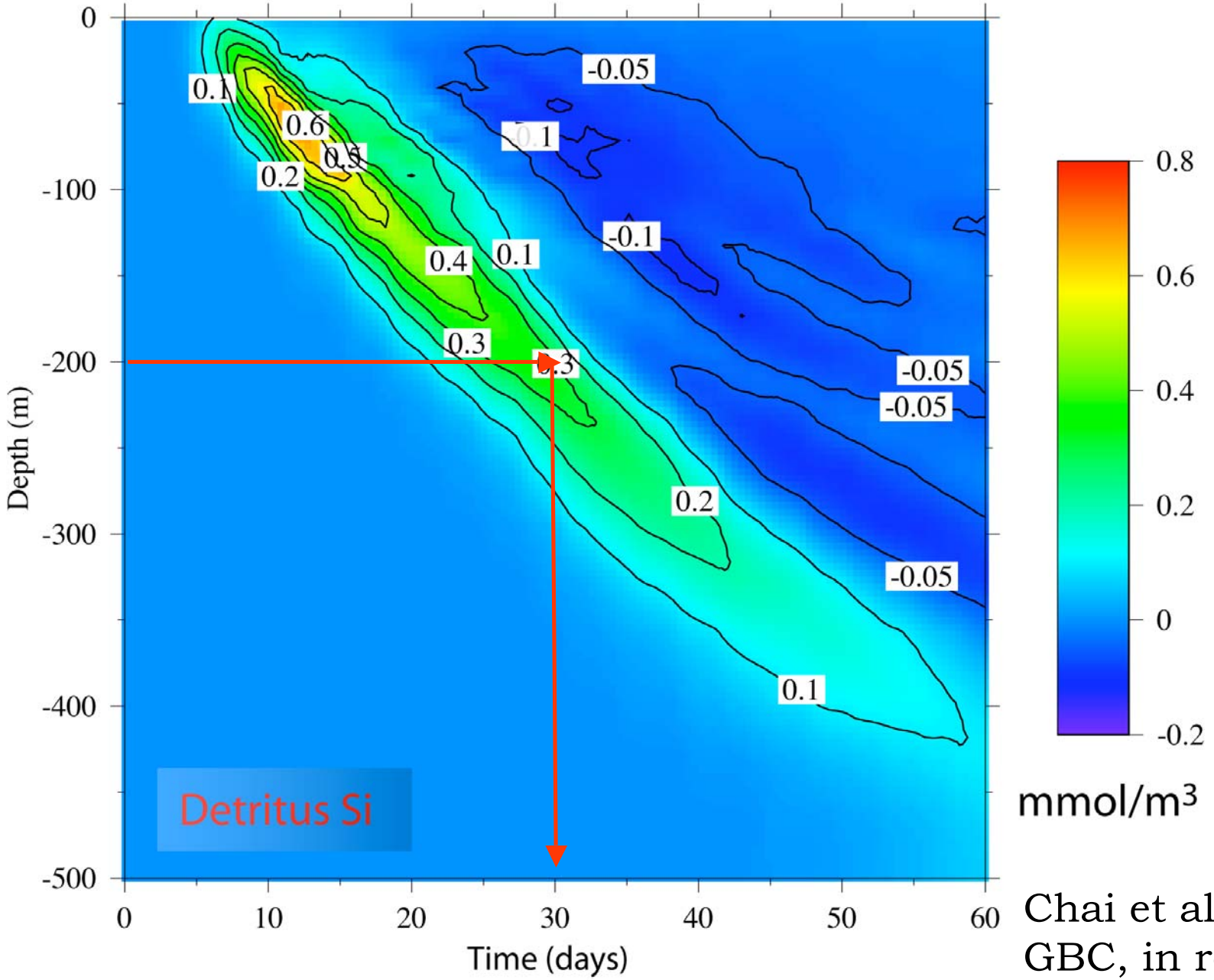


Data from K. Busseler, WHOI

Comparisons of Productions and Ratios

	f- ratio	**New** Production (mmol C m^{-2} day^{-1})	**Primary** Production (mmol C m^{-2} day^{-1})	**Export** Production (mmol C m^{-2} day^{-1})	**e-** ratio
No Iron	0.37	26.5	72.2	22.5	0.31
Iron Added	0.49	92.8	188.6	51.3	0.27

Detritus Si Anomaly in the Center of the Fe Patch



Chai et al
GBC, in review

Conclusions

- Need More Research on Iron Fertilization
  - Marine Ecosystem Response to Anthropogenic Perturbation
- Modeled Ecosystem Response to Iron Addition
  - Nutrients, Chl *a*, PP, and TCO_2
- Interaction Between Phytoplankton and Zooplankton
  - Diatoms Increase First, Small Phytoplankton Lasts Longer
- Increase of Vertical Carbon Fluxes
- The System Needs about 90 days to Recover