The Ecology of Iron Enhanced Ocean Productivity

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- **Focus**: Upper-ocean ecology, not carbon sequestration

  Mechanisms & implications

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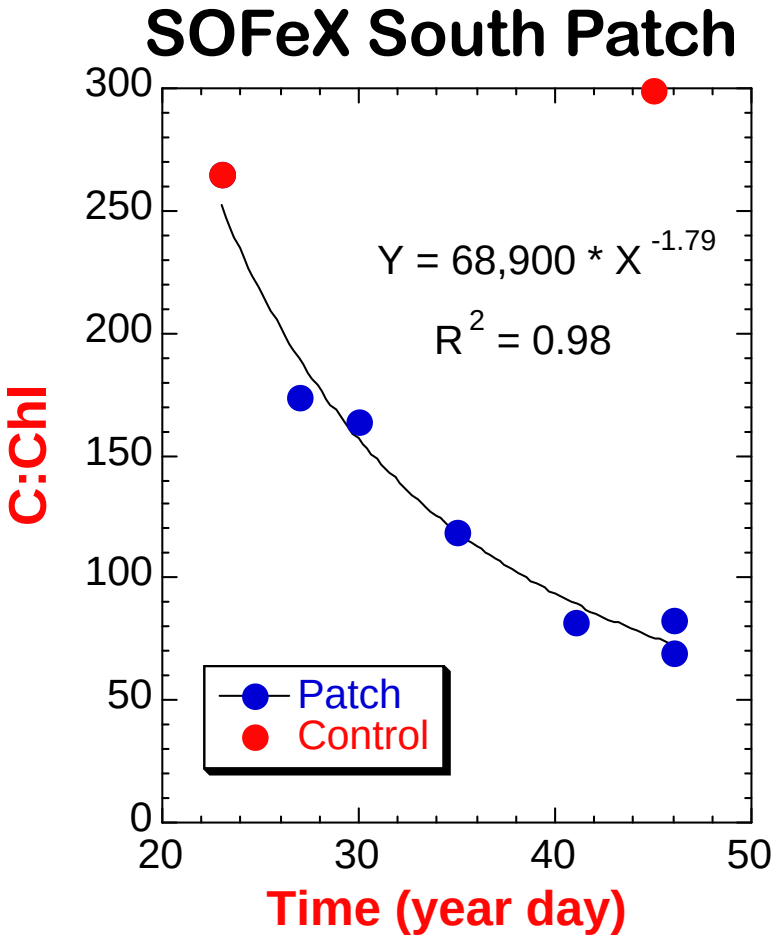
Units of Biomass Response

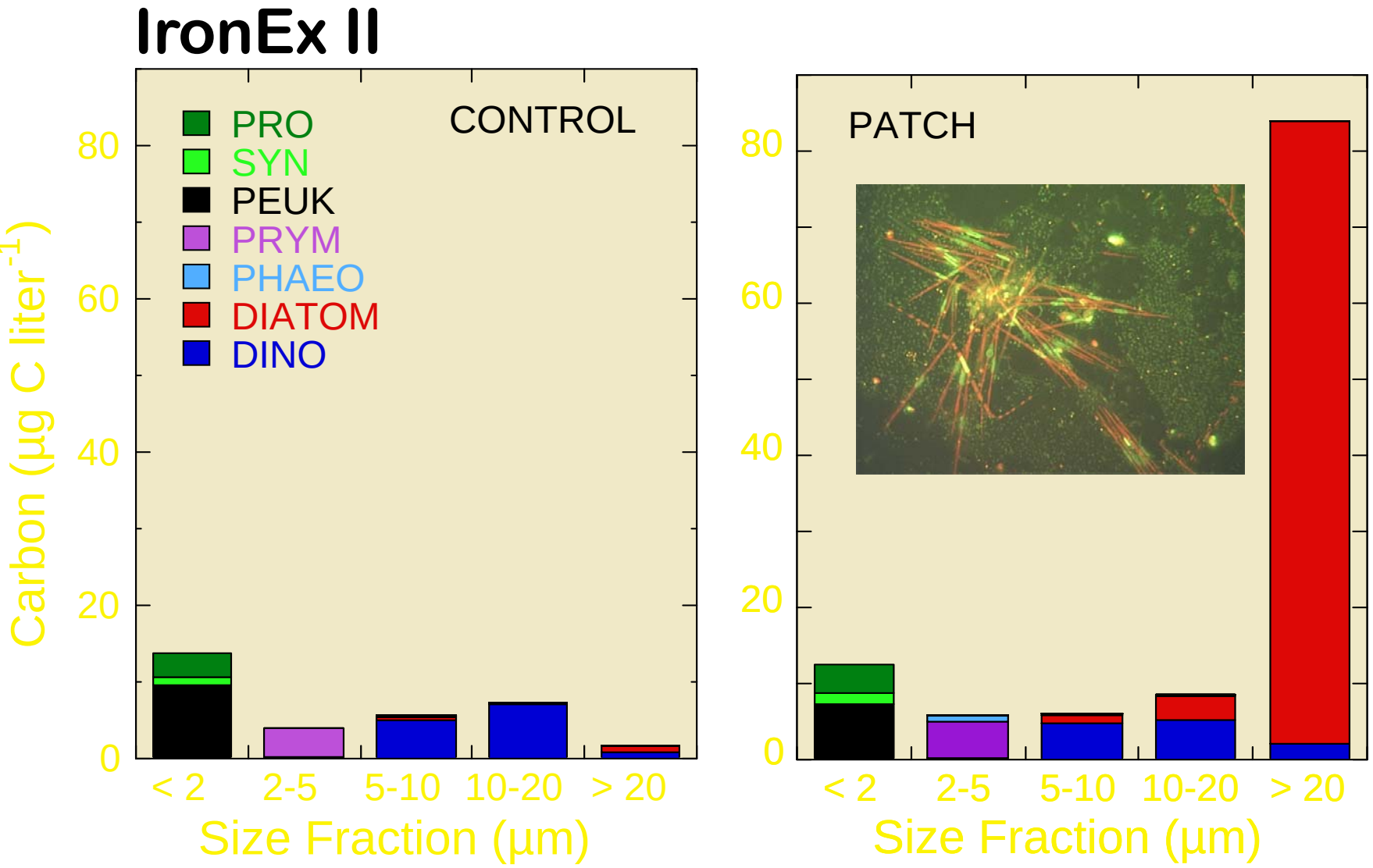


	Patch Increase	
	IronEx II	SOFeX
Chl *a*	16-20 X	20 X
Phyto-C	4-5 X	2 X

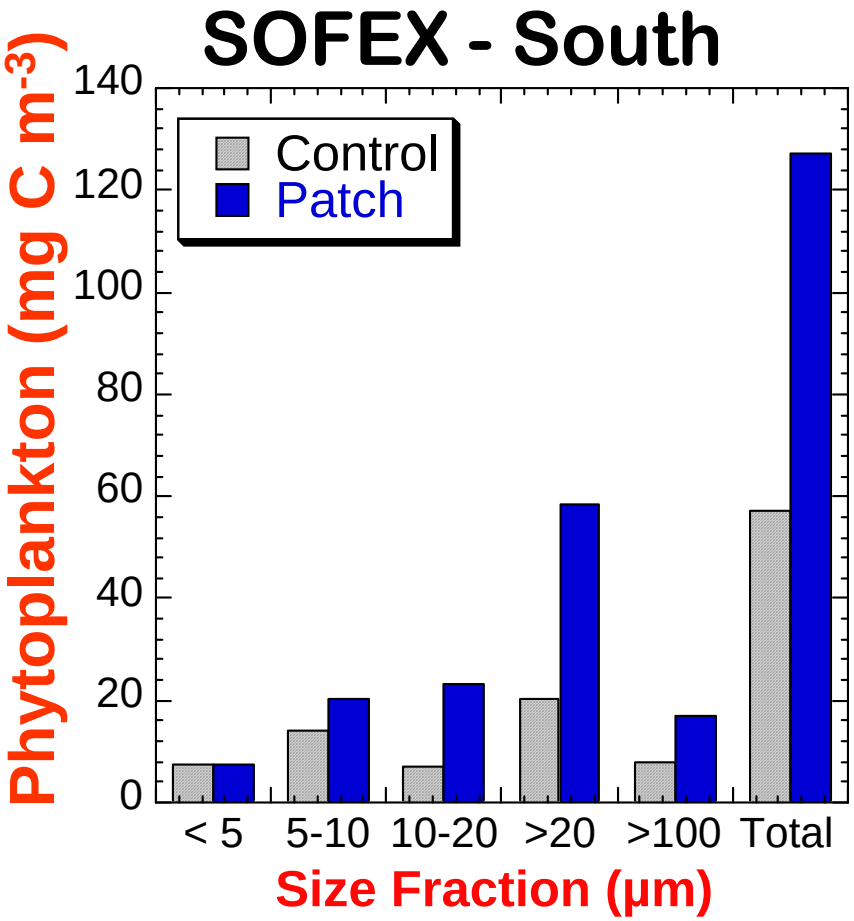
Overstating the case

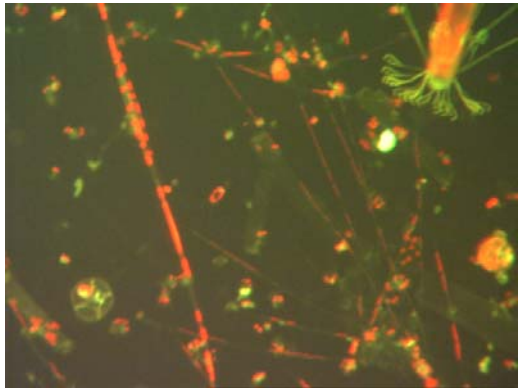
Growth interpretations

Phytoplankton Community Response



Phytoplankton Community Structure



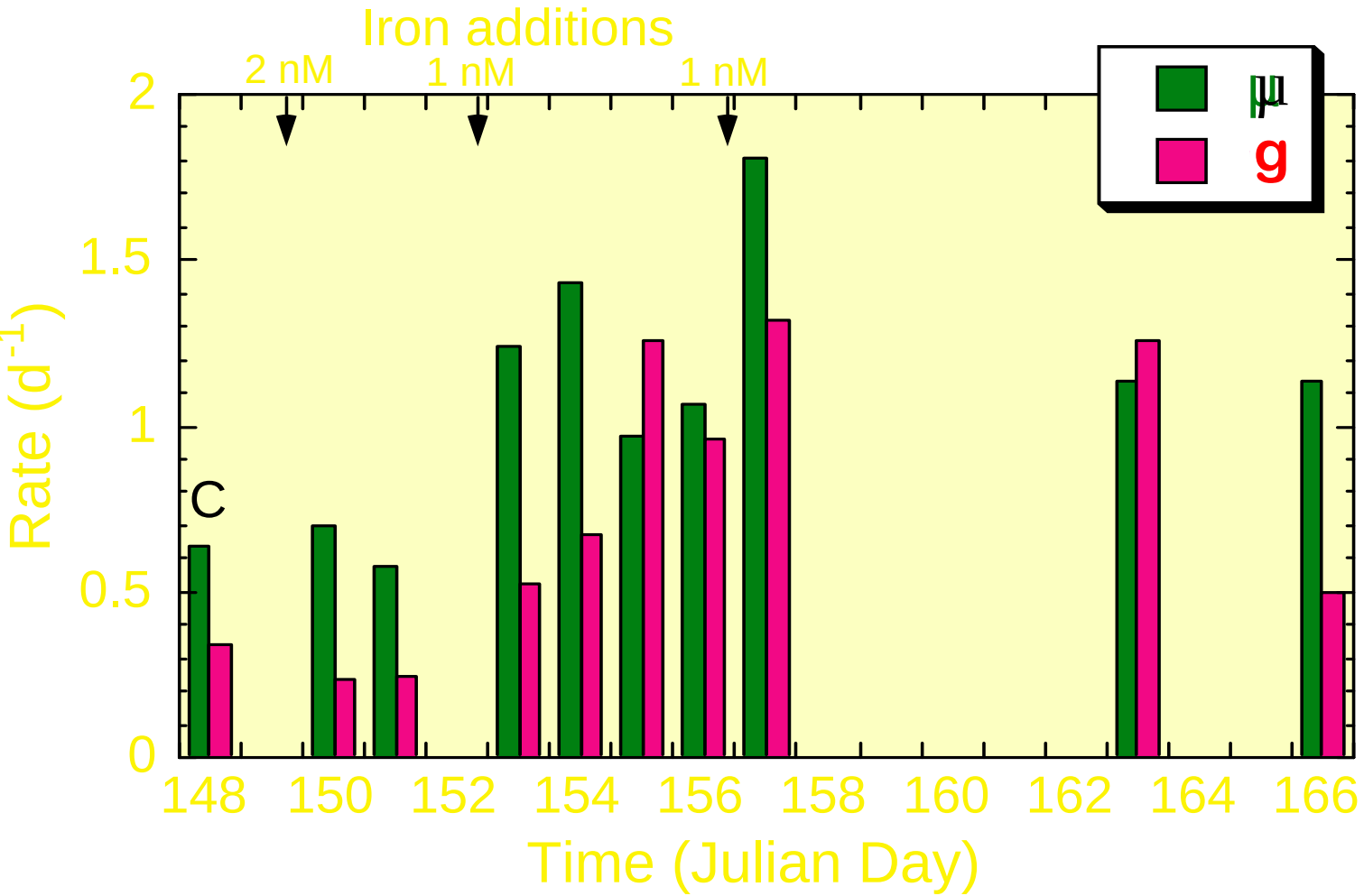


	% Diatoms	
	Cont	Patch
IronEx II	4	74
N-SOFeX	5	38
S-SOFeX	66	80

flagellates ==> pennates
pennates ==> centrics
+ silicified ==> less silicified

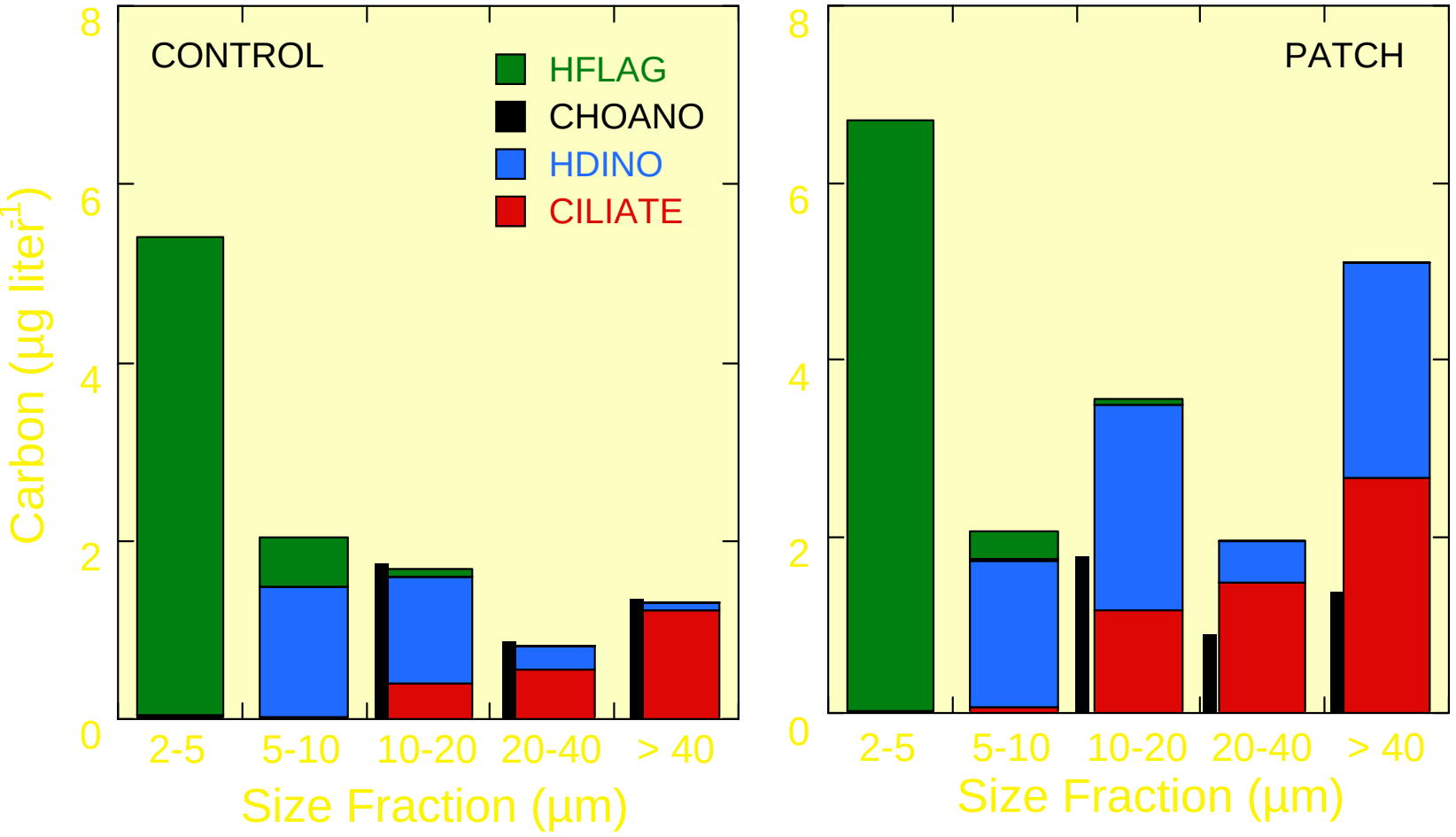
IronEx, N-SOFeX
SEEDS
EisenEx

Growth and Grazing in IronEx II

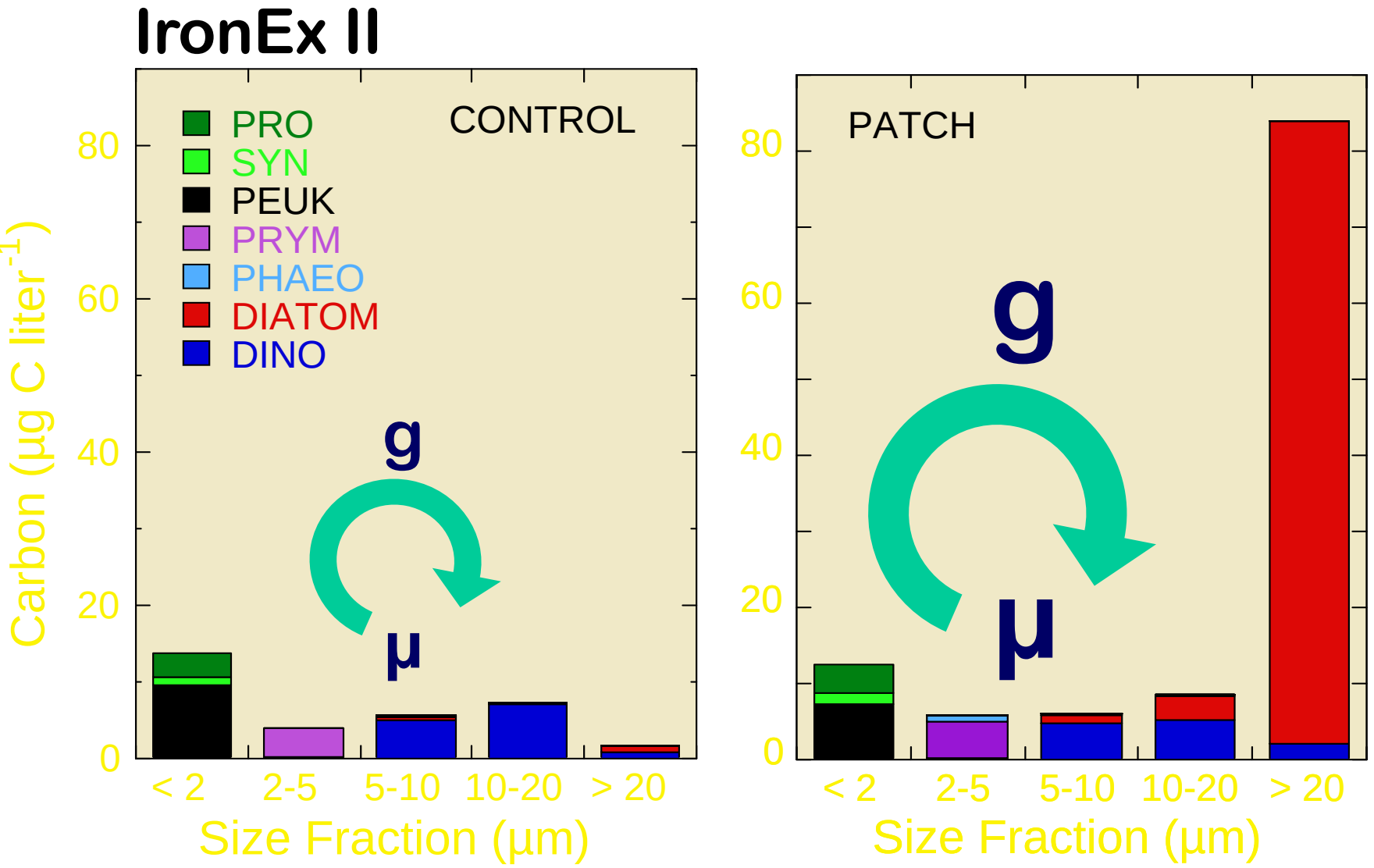


Landry *et al.* (2000)

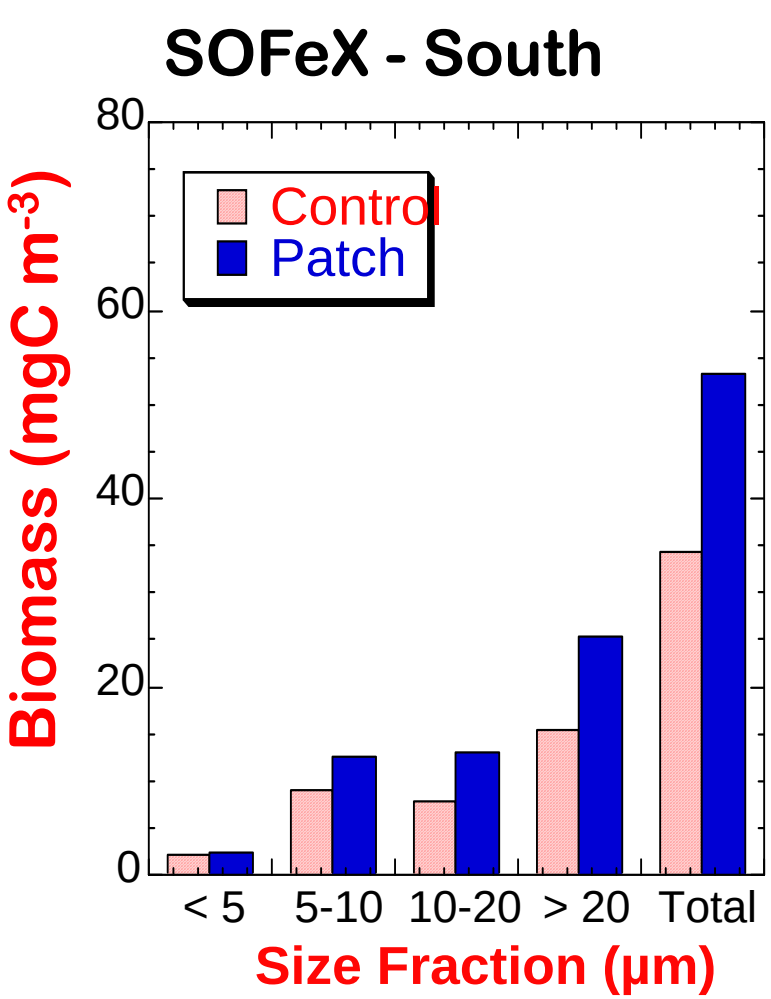
Heterotrophic Protists

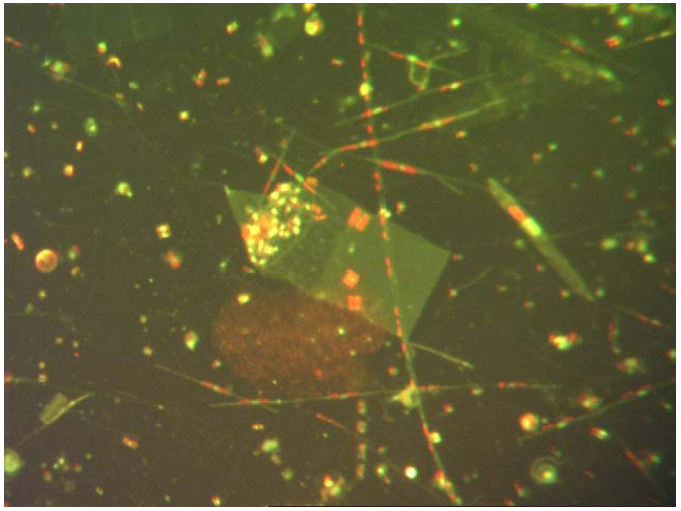


Grazing Regulation



SOFeX Grazers





% PP Grazed:

	SOFeX	IronEx
Initial	44	38
Bloom Peak	90 +	94

Microbial Community Interactions & Sequestration Potential

Strong μ => g enhances nutrient cycling

Diminishes "structural boost" to export ratio

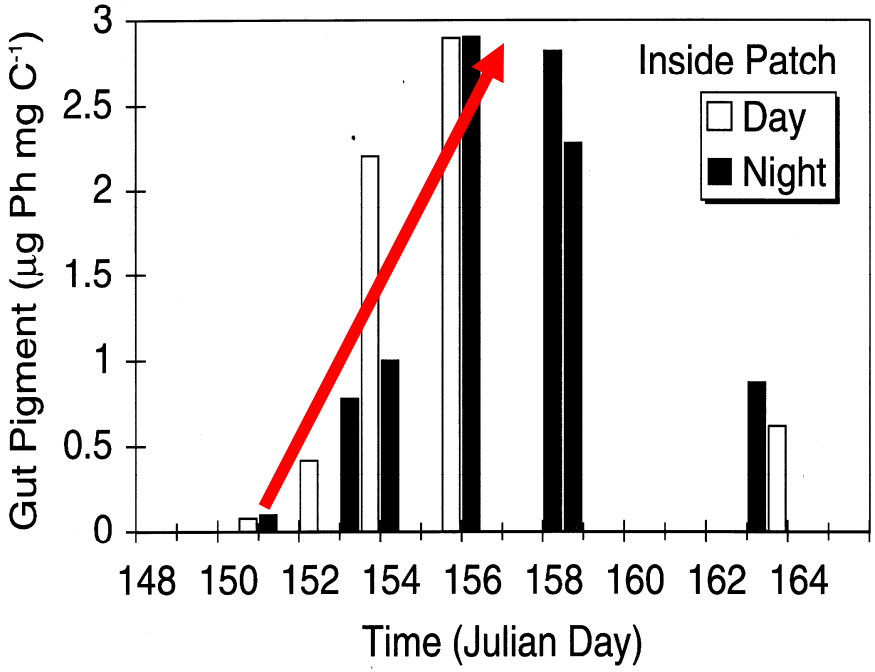
Quality of export -- single cell egesta

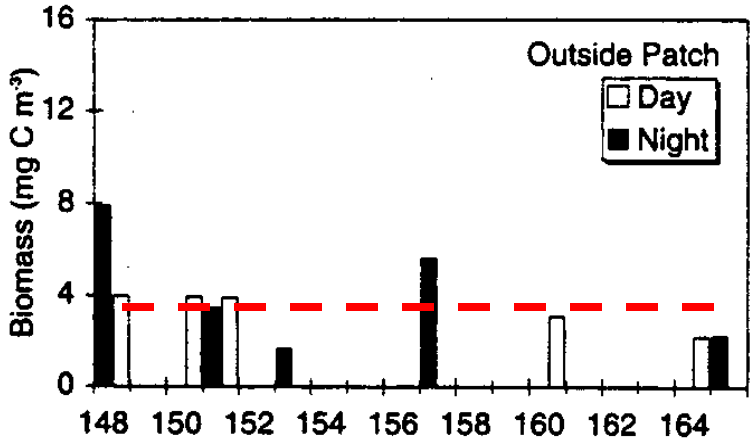
Community shifts -- C:Si export ratio, ballast

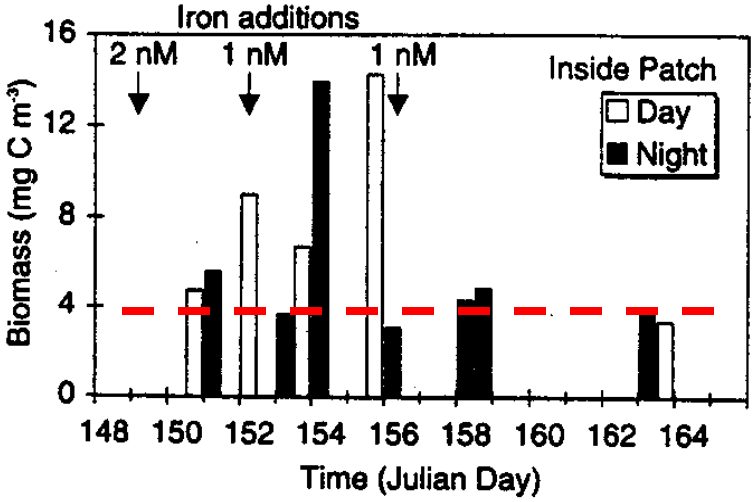
- Different suite of diatoms -- high μ, low Si
- Variable silicification: SOFeX -- 50% Si:C decr

Mesozooplankton

IronEx II: Biomass-specific ingestion of phytoplankton increased ~ 20X







Growth rate implications:

from Chl ingested/mgC and C:Chl ratio and 20% GGE

Double C biomass d^{-1}

MesoZoo Grazing ≈ 10% µ

Rollwagen Bollens & Landry (2001)

Explanations ?

H1: Tightly coupled predatory control

H2: Predators find the patch (scale artifact)

H3: Diatom inhibition of egg hatching success

These are examples of ecological issues that could be reasonably addressed by larger or longer experiments.

Many are not

Full population and numerical responses, complex life histories

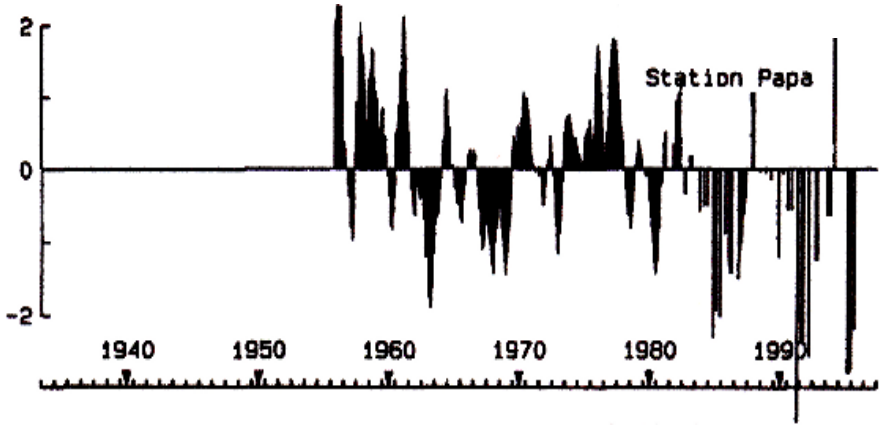
Phenotypic/genotypic selection & adaptations

Cascade and trickle-down effects of larger and longer-lived consumers

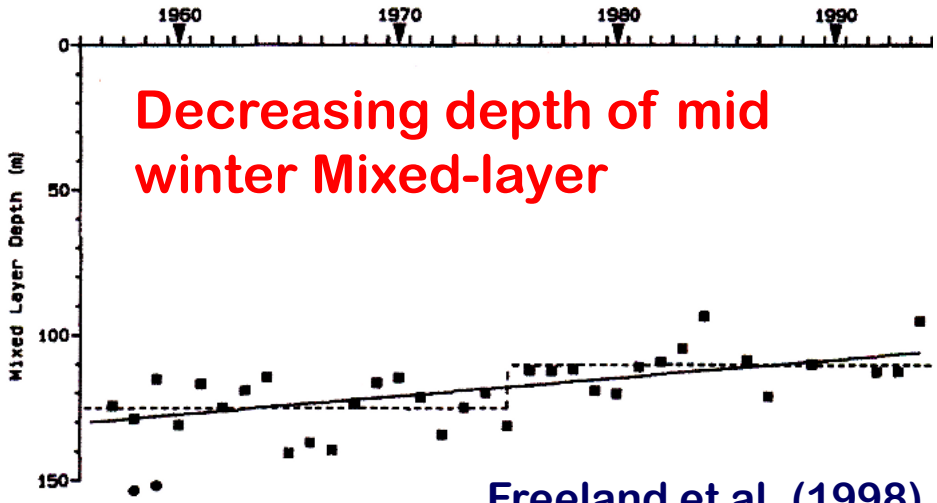
Down-stream effects on adjacent ecosystems

Neocalanus in the Subarctic Pacific

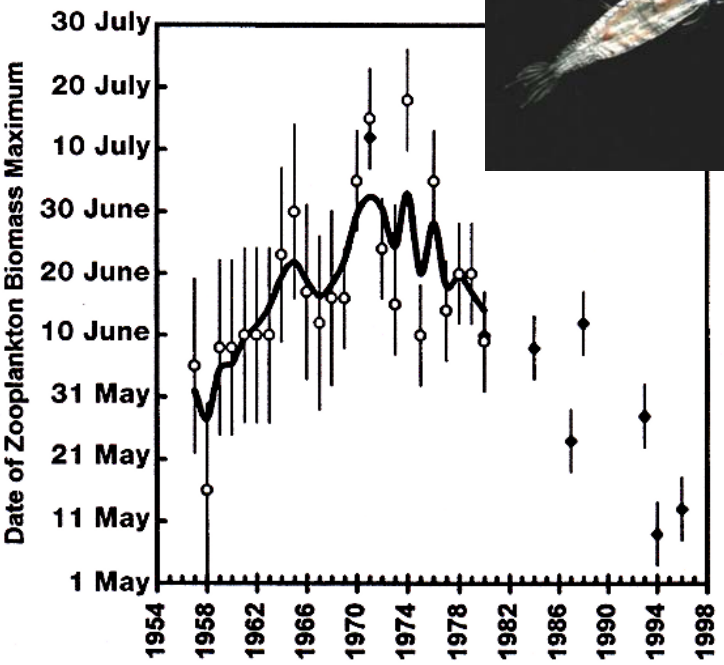
Monthly-averaged surface density anomaly



Decreasing depth of mid winter Mixed-layer



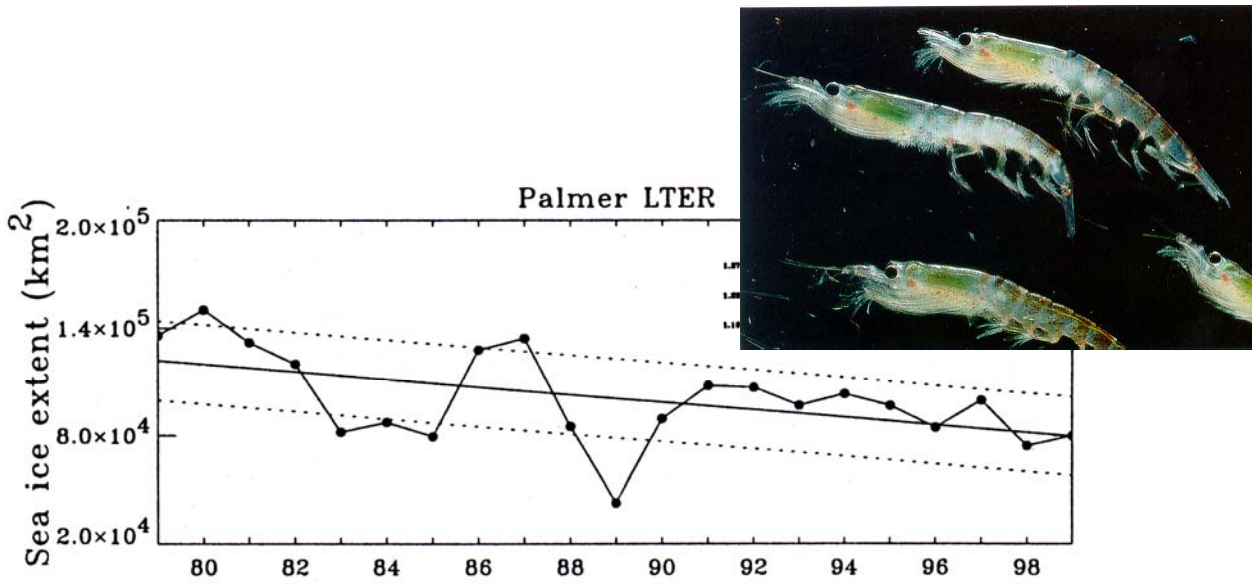
Freeland et al. (1998)
Whitney et al. (1999)



Timing: > 2 month variability in date of maximum biomass, ~1975 trend reversal

Mackas et al. (1999)

Southern Ocean Krill



Recruitment success -- sea ice & diatom blooms

Foraging migrations

Summary

Fe-fertilization experiments have greatly advanced our understanding of open-ocean production ecology. There are clear and recurrent patterns in microbial community response.

Effects on "macro" components of the food web (aka "animals") are poorly known. Extrapolation to relevant temporal & spatial scales is difficult.

Beyond sequestration, we need to better understand the ecology of HNLC regions in the context of a changing ocean.