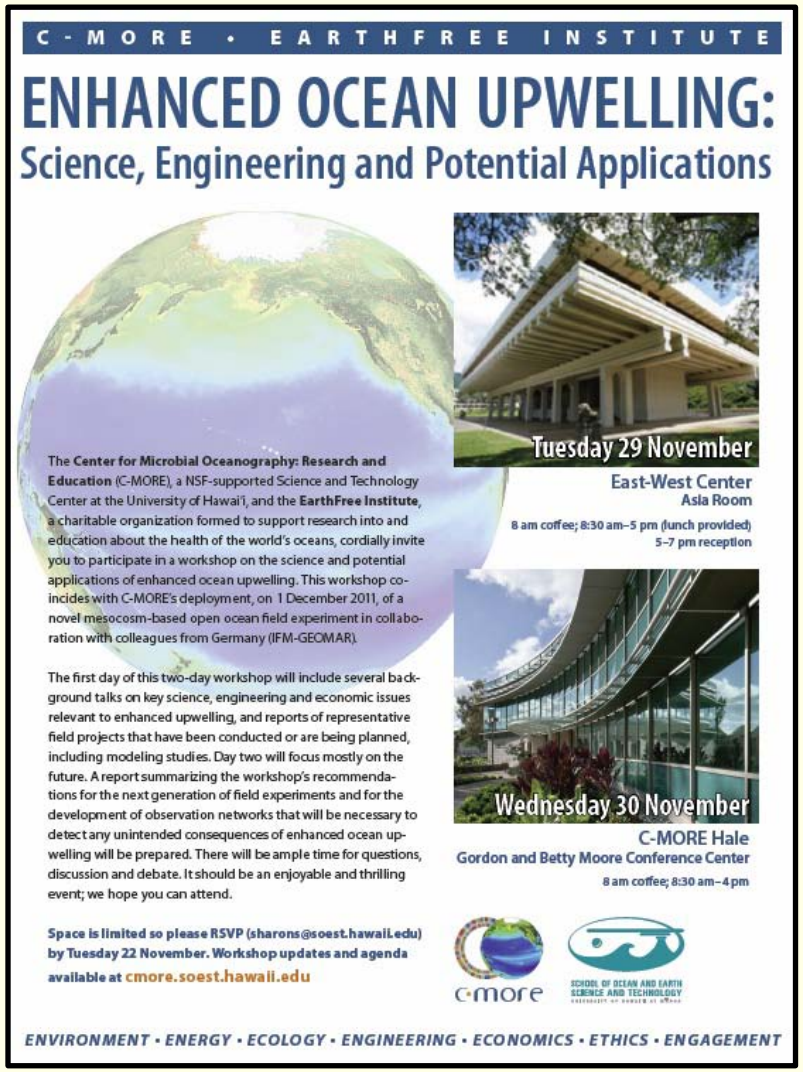
Potential Environmental Consequences of Enhanced Ocean Upwelling

Dave Karl, Daniela Böttjer, Tara Clemente, Steve Poulos, Sam Wilson, Karin Björkman and Sarah Searson

UH Manoa
C-MORE/SOEST



A NEW SUBDISCIPLINE?

- **Ocean science and society**
- **Coupled natural-human systems**
- **Economics and sustainability**
- **Education and public outreach**

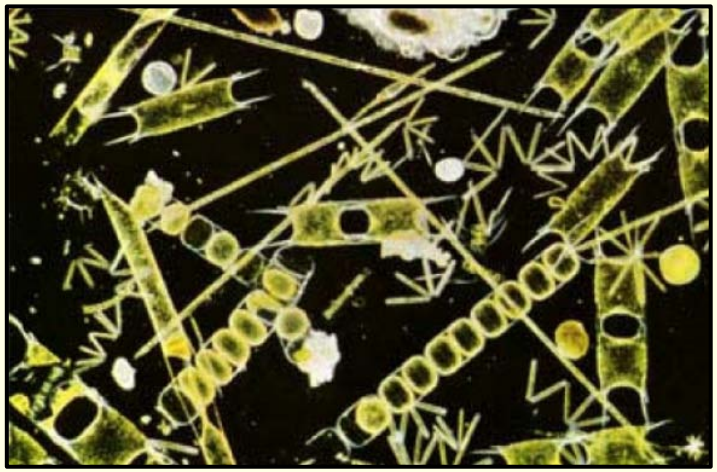
November 2011

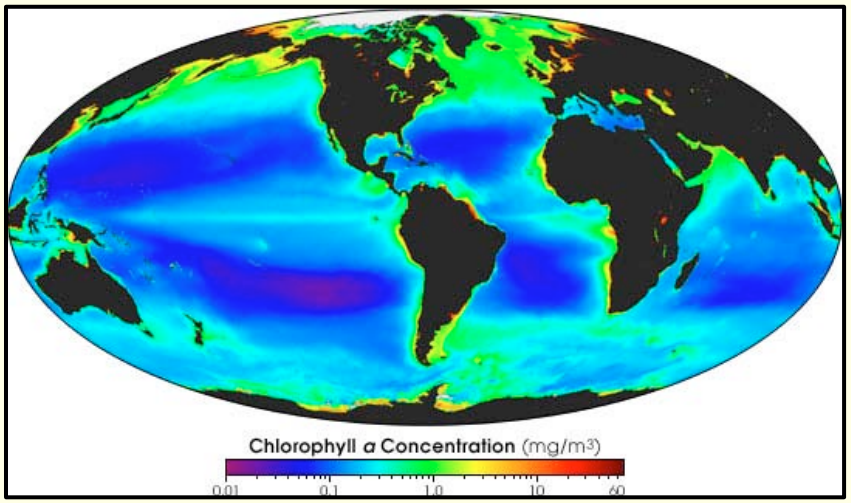
Agenda and presentations available at:

http://cmore.soest.hawaii.edu/events/enhanced_upwelling_nov_2011_video1.htm

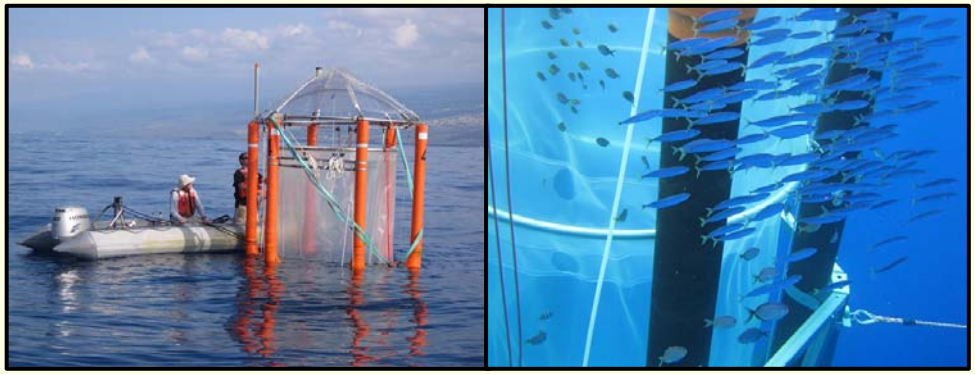
http://cmore.soest.hawaii.edu/events/enhanced_upwelling_nov_2011_video2.htm

Take Home Message

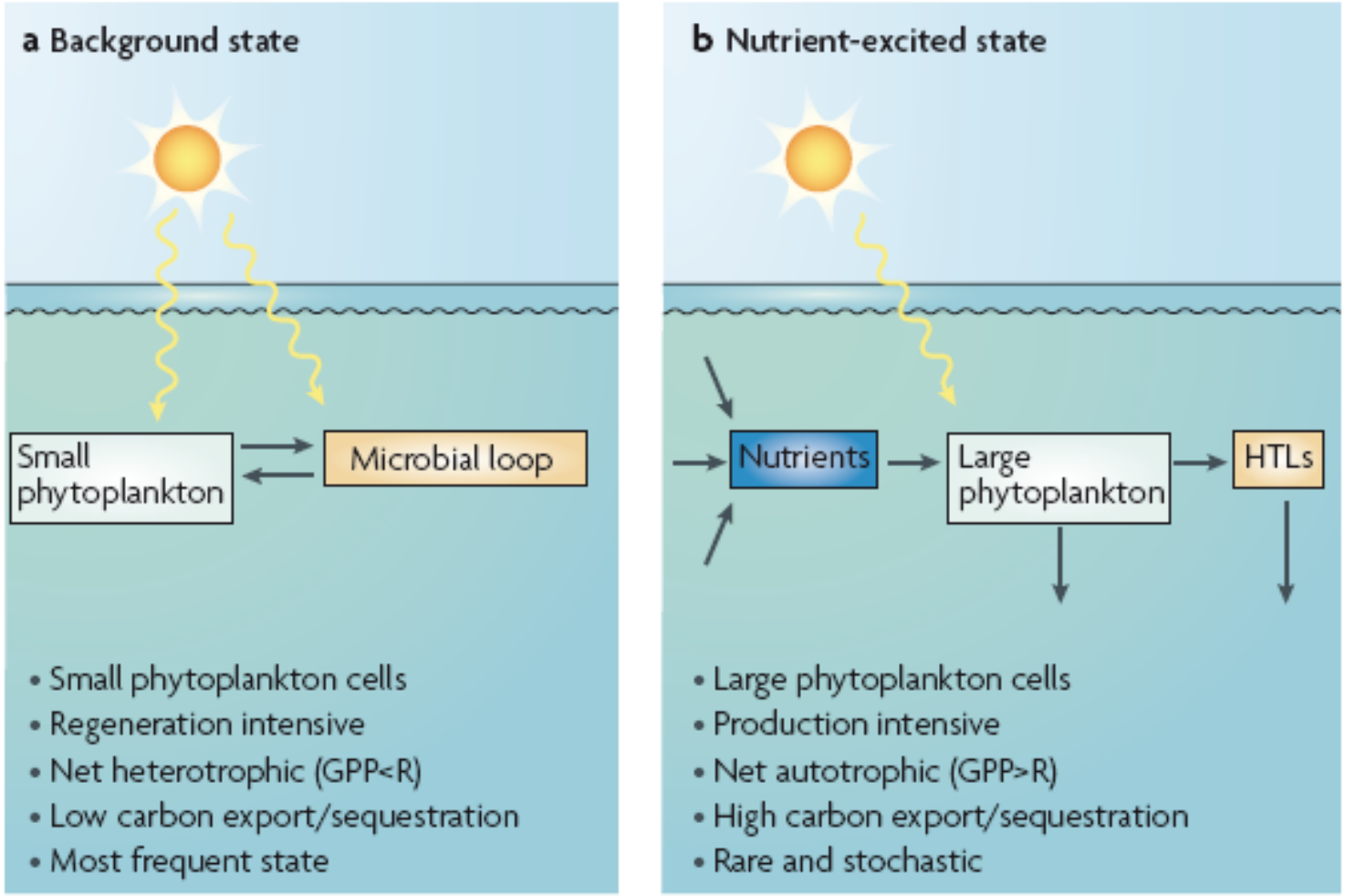




NUTRIENTS + LIGHT
= PHYTOPLANKTON



- Oceanographic theory and prediction
- Results from field experiments



Karl 2007

Nature Reviews | Microbiology

Vol. 332: 63–75, 2007 | MARINE ECOLOGY PROGRESS SERIES Mar Ecol Prog Ser | Published March 5

OPEN ACCESS

Metabolic response of oligotrophic plankton communities to deep water nutrient enrichment

Patricia M. McAndrew[1,*], Karin M. Björkman[1], Matthew J. Church[1], Paul J. Morris[1,3], Nicholas Jachowski[1,4], Peter J. le B. Williams[2], David M. Karl[1]

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OPEN ACCESS

Phytoplankton response to deep seawater nutrient addition in the North Pacific Subtropical Gyre

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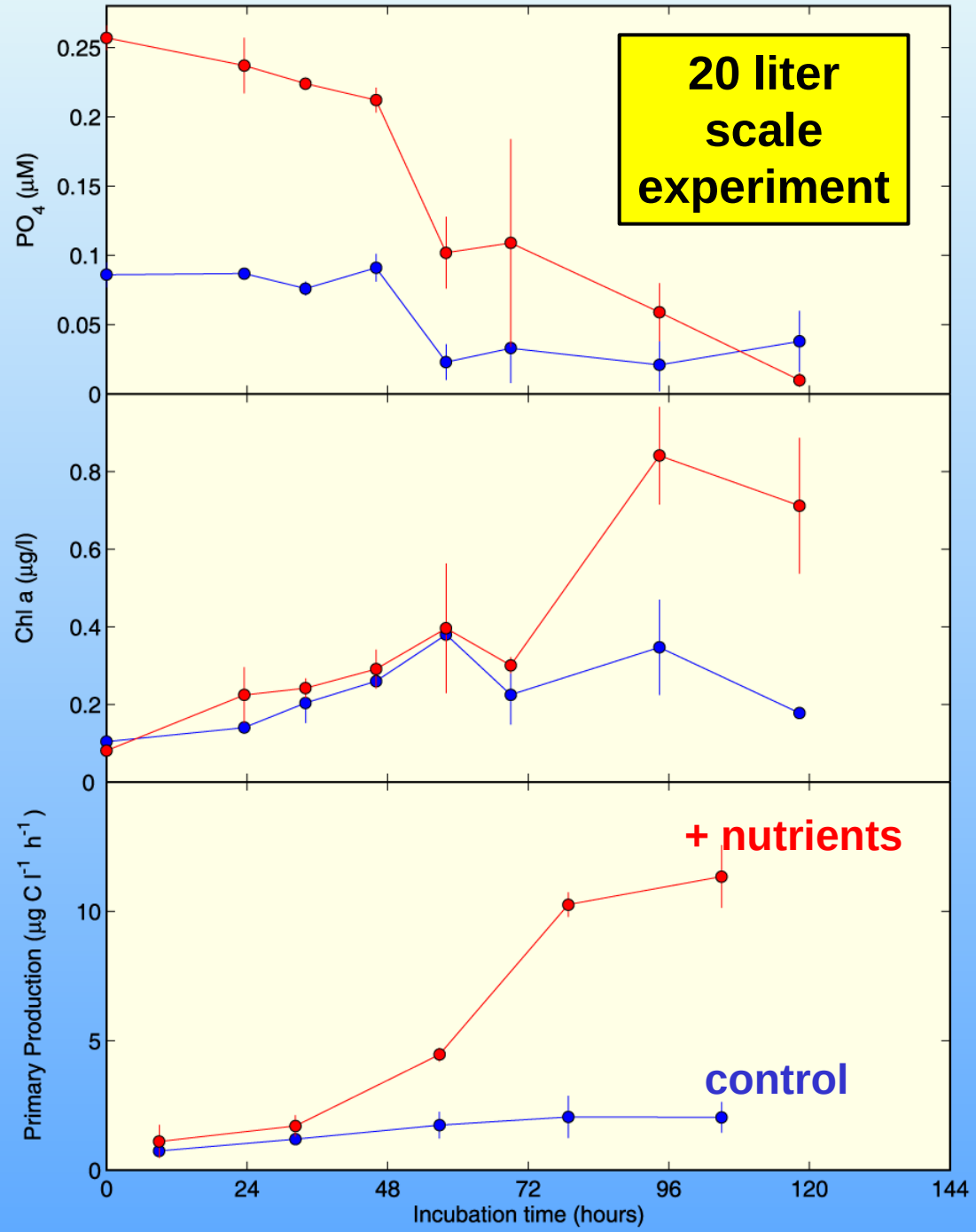
[2]*Present address:* School of Environmental Sciences, University of Liverpool, Liverpool L69 3GP, UK

20 liter scale field experiments



RESULTS

- Add N + P + Si + Fe + vitamins → bloom

  No surprises there!

- Chl a and c increase, divinyl chl a/b do not

  A "diatom" bloom!

- Eukaryotic algae outgrow their predators

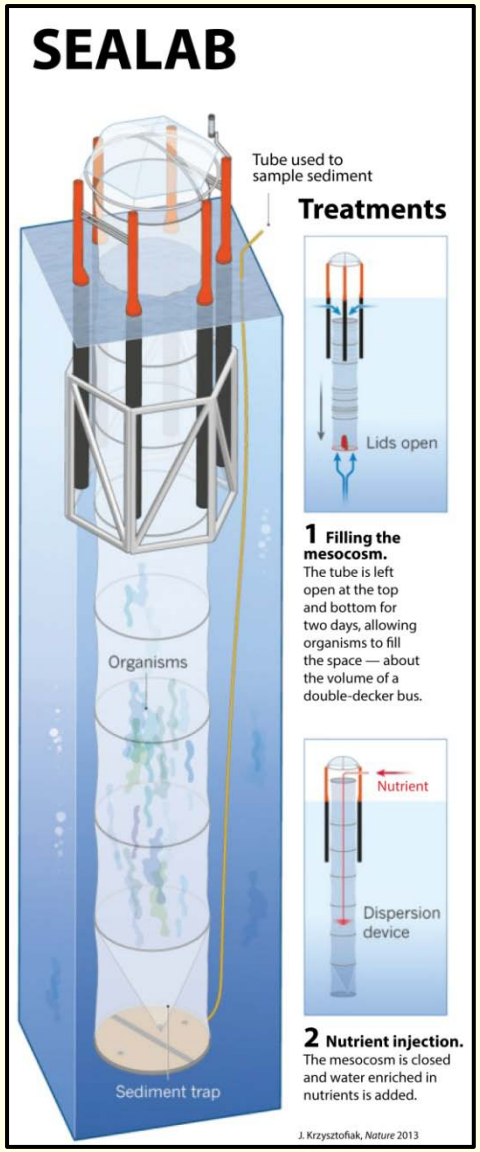
Can we control the bloom?

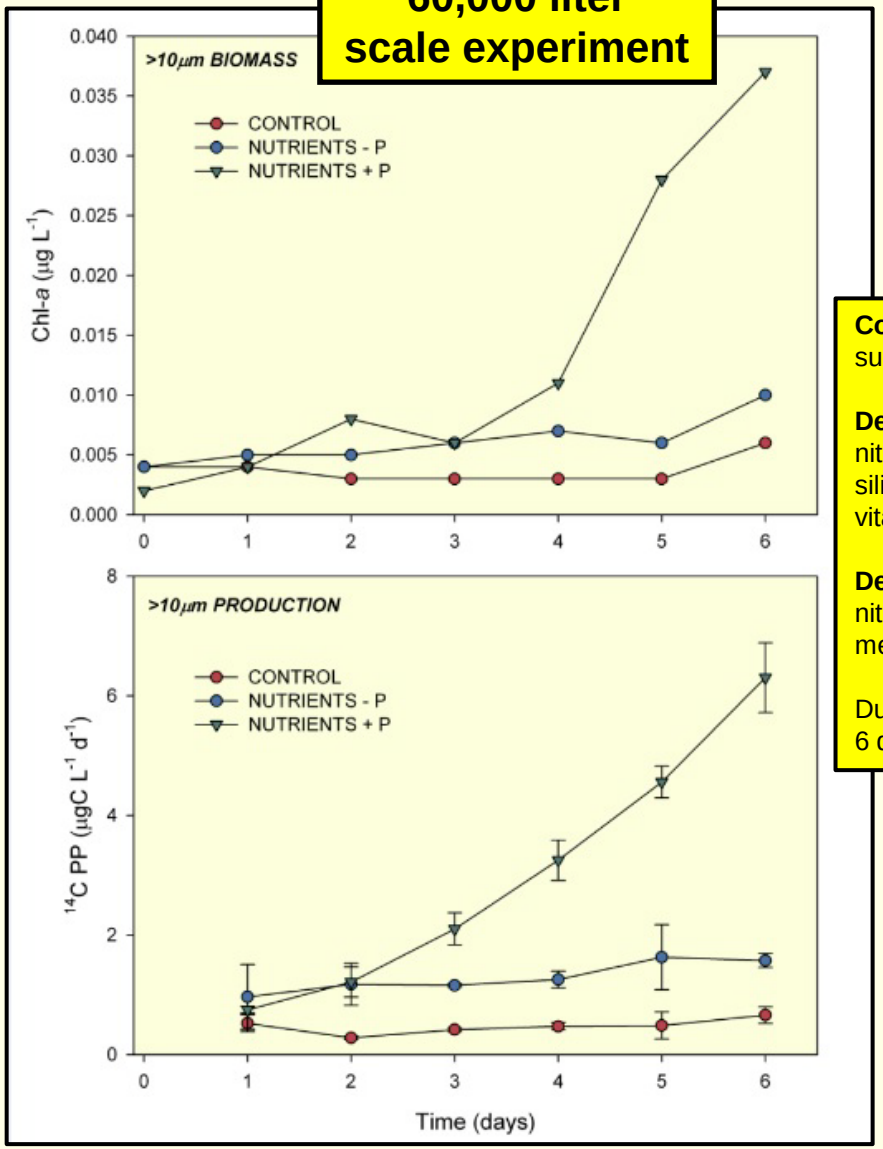
BAG-I
(Biogeochemistry And Genomes)

- 60,000 liter scale
- Experimental manipulation of nutrients
- C-MORE/BEACH-IFM collaboration

Dec 2011

60,000 liter scale experiment





Control
surface seawater only

Deep-sea Nutrients (+P)
nitrate, phosphate, silicate, trace metals and vitamins

Deep-sea Nutrients (-P)
nitrate, silicate, trace metals and vitamins

Duration of experiment: 6 days

PEAK P?

Nature, 6 Oct 2011

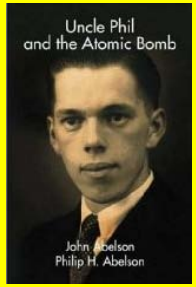
P. DIEDERICH/NYT/REDUX/EYEVINE

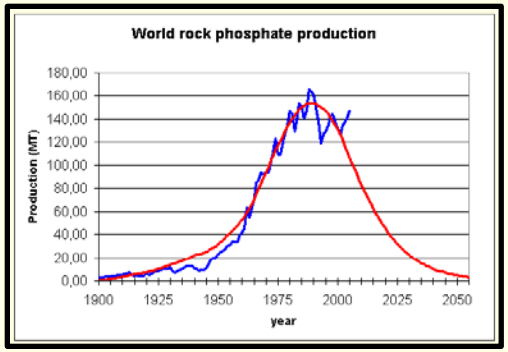
Phosphate is mined to produce fertilizers for crops, but phosphorus leaching into water supplies is an environmental hazard.

A broken biogeochemical cycle

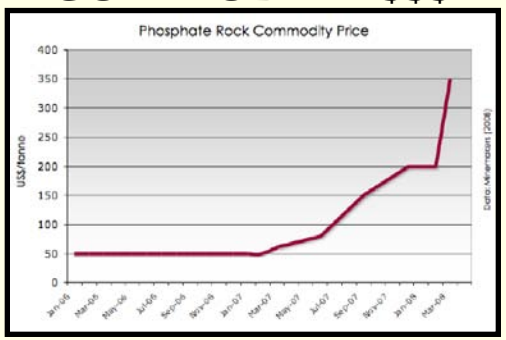
Excess phosphorus is polluting our environment while, ironically, mineable resources of this essential nutrient are limited. **James Elser** and **Elena Bennett** argue that recycling programmes are urgently needed.

***Science* Editorial**
26 March 1999
"A Potential Phosphate Crisis"
Philip H. Abelson
Scientist extraordinaire

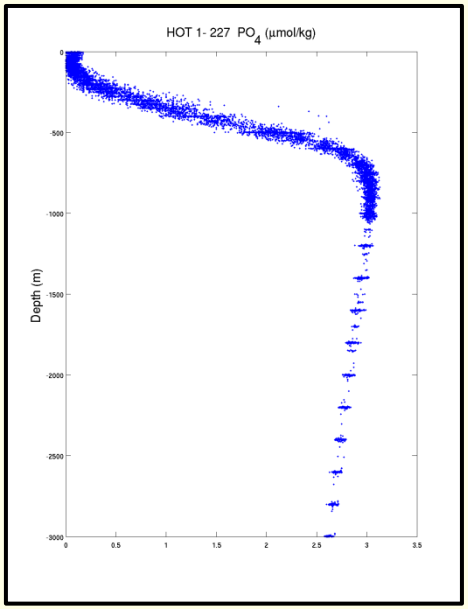


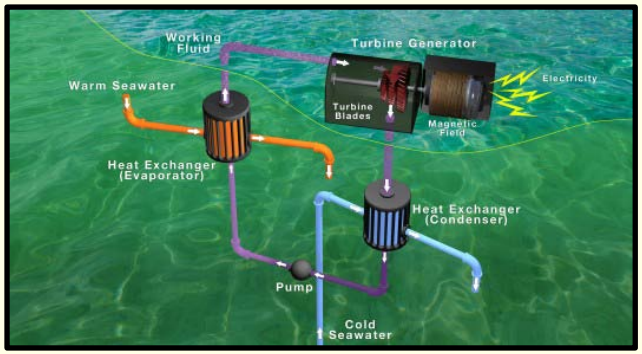


COMMODITY $$$



P RECOVERY FROM THE DEEP BLUE SEA?
Patent pending…



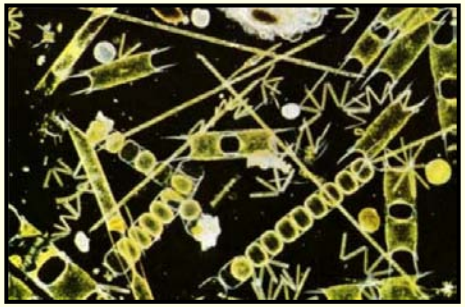


Pump deep sea water (SWAC/OTEC)

Remove/Recover P by "MAGIC"

No P, no bloom,
AND a possible revenue stream to support research

N/P discharge leads to phyto bloom



(Photo: Tara Clemente)