

Ocean fertilization, carbon credits and the Kyoto Protocol

Marian Westley, 11.26.2008



Acknowledgements and a disclaimer:

- **Priti Brahma, of NOAA's Educational Partnership Program**
- **Hernan Garcia of NESDIS**
- **Philip Hoffman of NMFS PSP**

The views described here are solely those of the presenter and not of GFDL, NOAA, DOC or any other agency or institution.

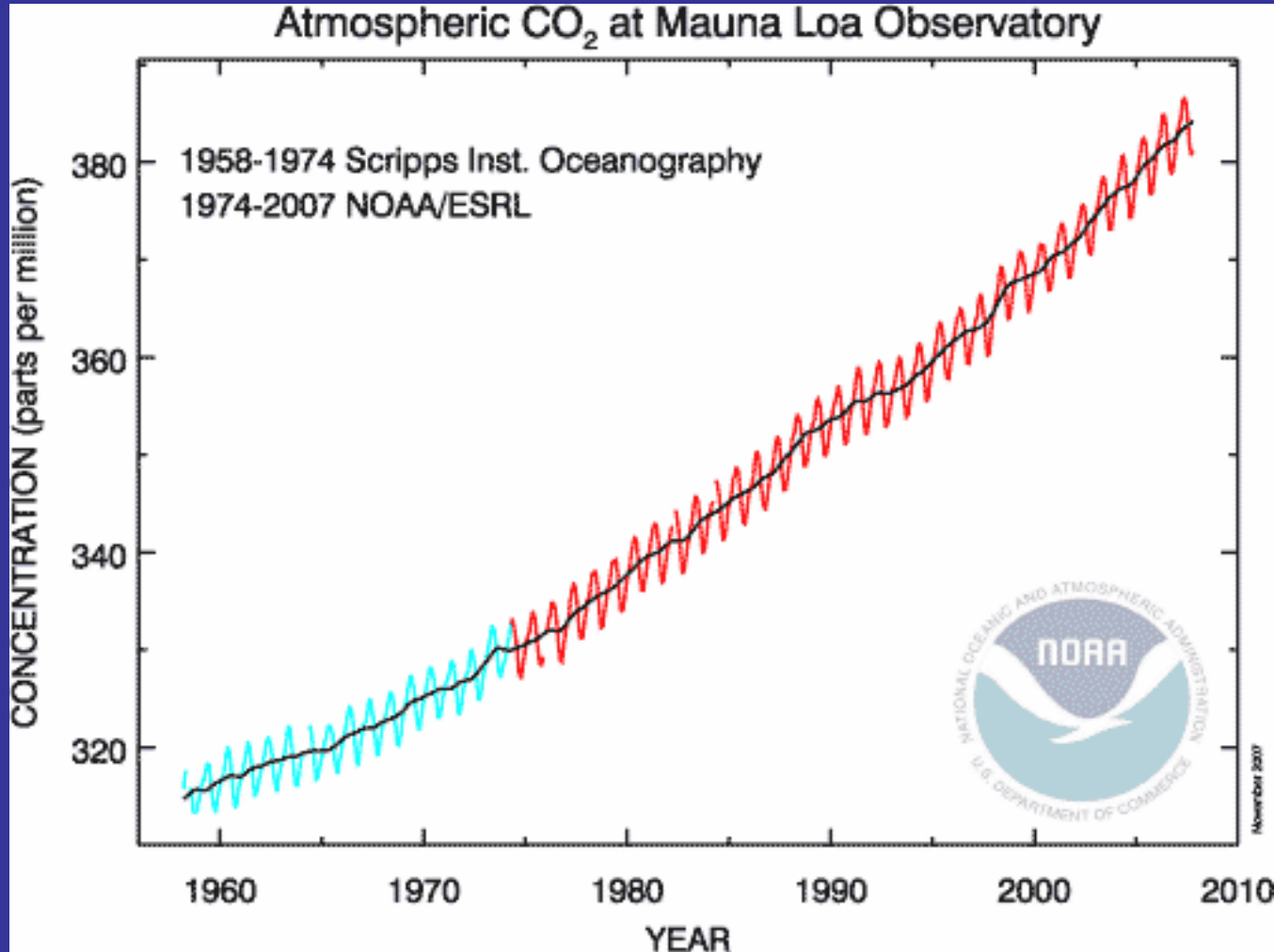


Ocean fertilization, carbon credits and the Kyoto Protocol

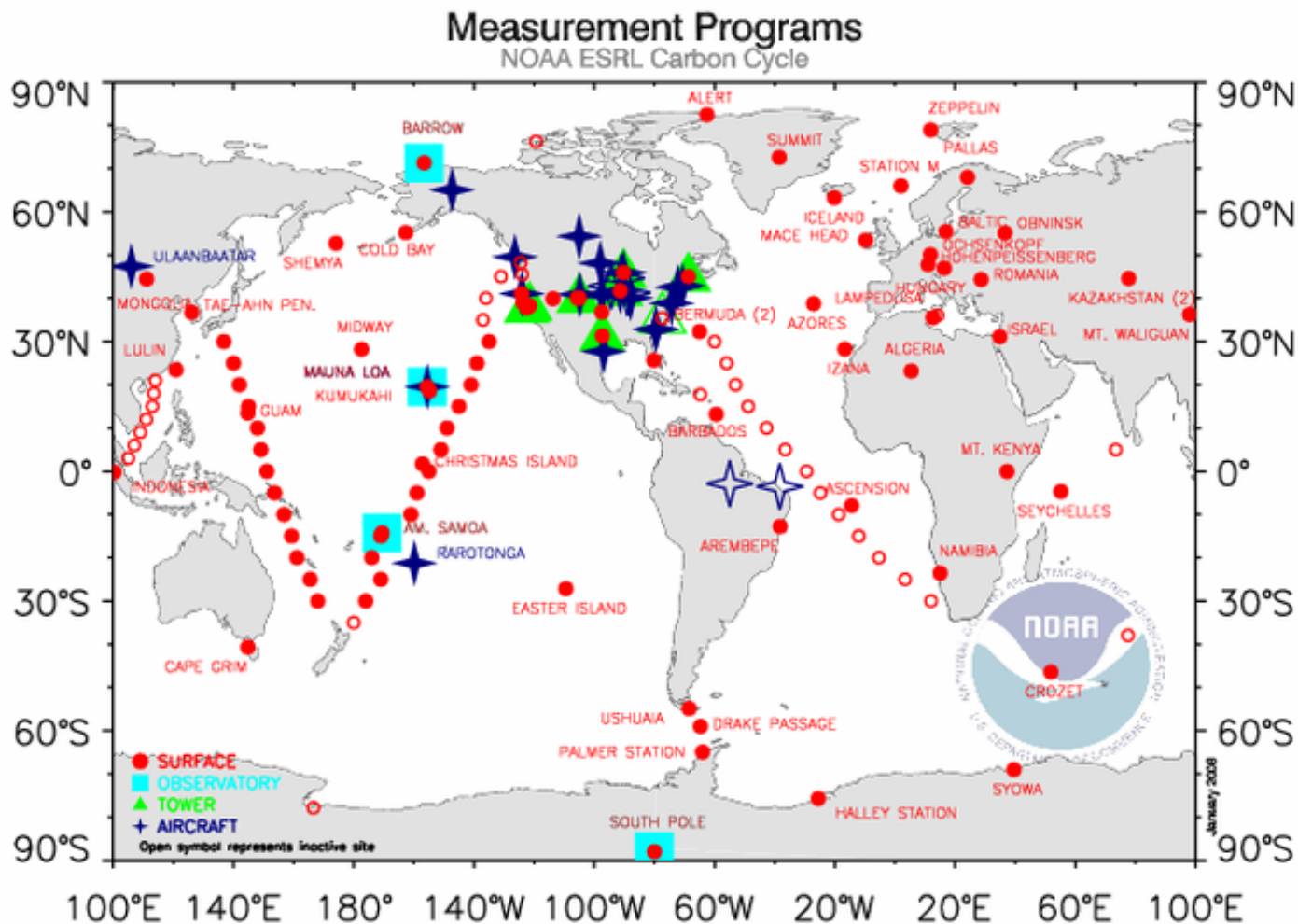
- Introduction to the carbon problem
- Early work on ocean carbon sequestration
- The Kyoto Protocol and carbon trading
- Current plans to sequester carbon in the ocean
- International legal response



CO₂ in the atmosphere is rising...

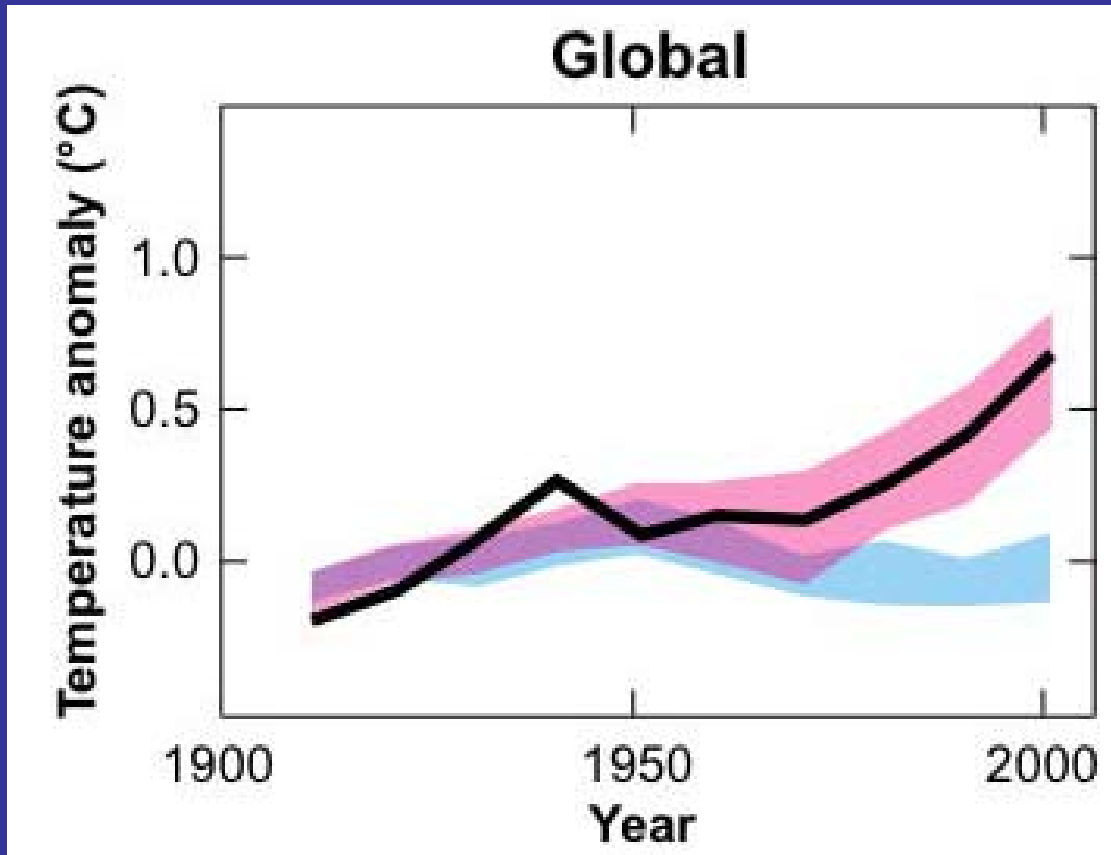


NOAA's carbon monitoring assets



NOAA ESRL Carbon Cycle operates 4 measurement programs. Semi-continuous measurements are made at 4 baseline observatories and from tall towers. Discrete surface and aircraft samples are measured in Boulder, CO. Presently, atmospheric carbon dioxide, methane, carbon monoxide, hydrogen, nitrous oxide, sulfur hexafluoride, the stable isotopes of carbon dioxide and methane, and halocarbon and volatile organic compounds are measured. Contact: Dr. Pieter Tans, NOAA ESRL Carbon Cycle, Boulder, Colorado, (303) 497-8678, pieter.tans@noaa.gov, <http://www.esrl.noaa.gov/gmd/cogg/>.

...and the impact on climate is discernable.



“Human activities are *very likely* the cause of the warming of last 100 years.”

IPCC WGI SPM 2007

Black line: temperature observation from thermometers.

Pink shade: Climate model simulations using all past radiative forcings.

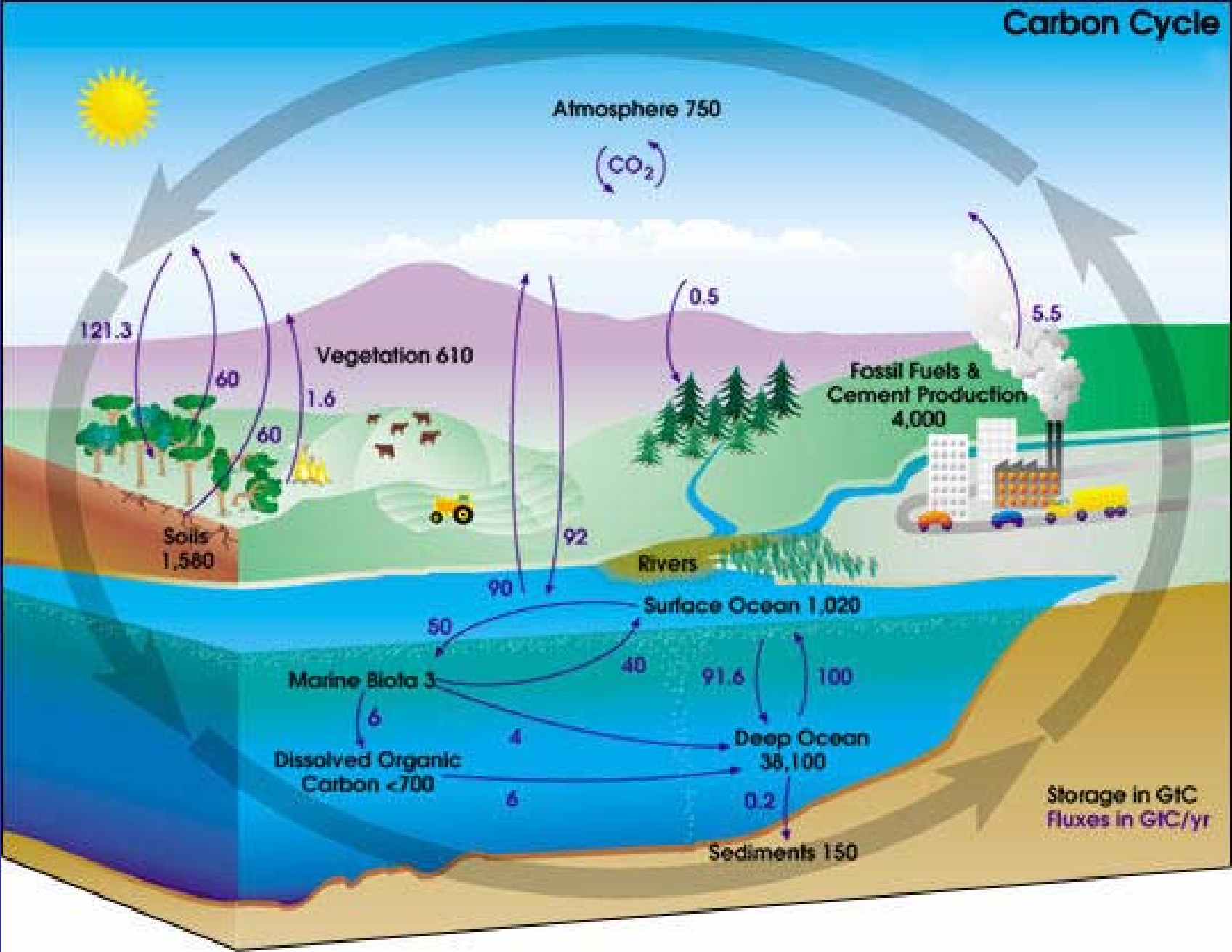
Blue shade: Climate model simulation using only natural forcings (solar, volcanoes).



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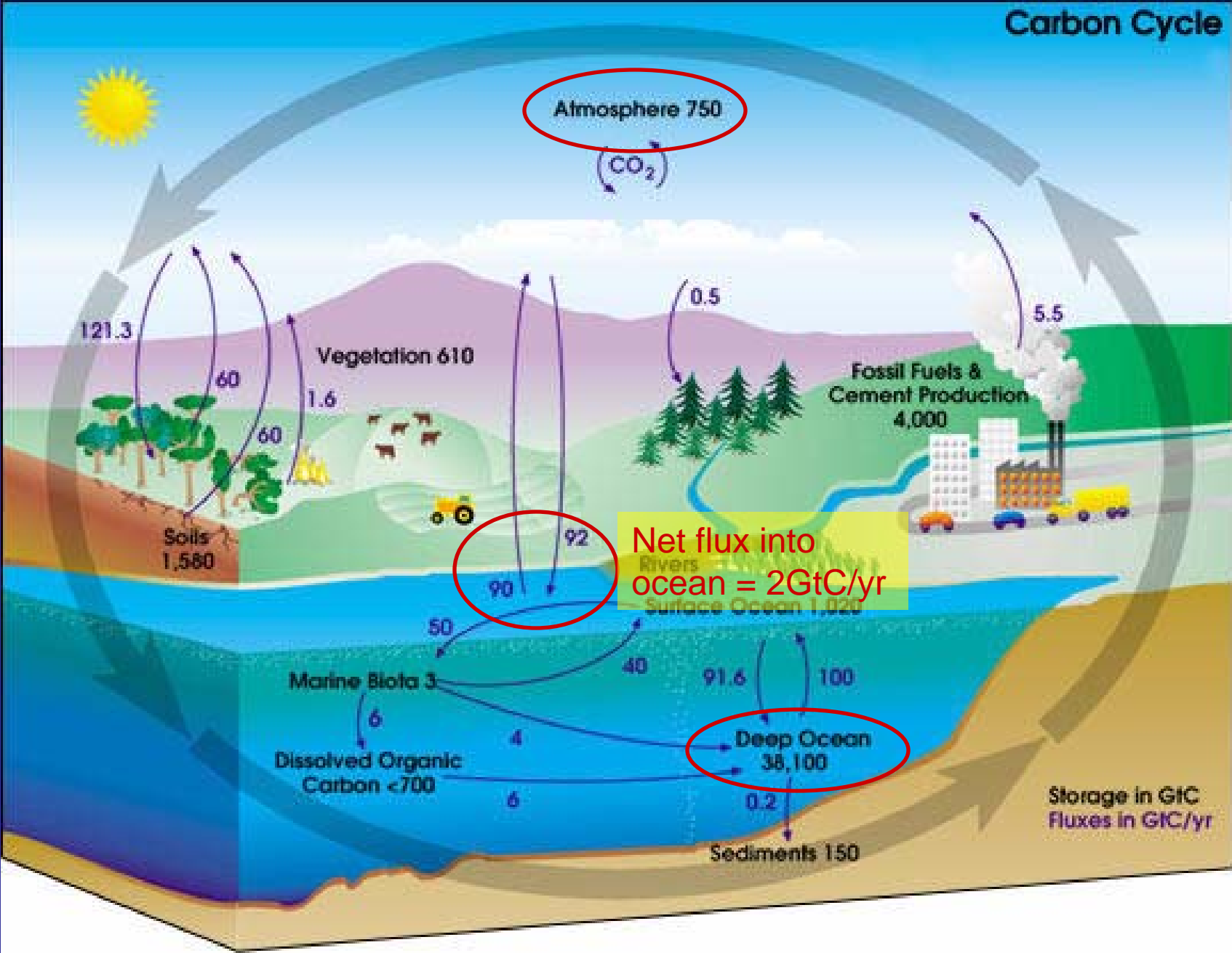


Carbon Cycle



Source: http://earthobservatory.nasa.gov/Library/CarbonCycle/carbon_cycle4.html

Carbon Cycle



Source: http://earthobservatory.nasa.gov/Library/CarbonCycle/carbon_cycle4.html

How much is a gigaton?



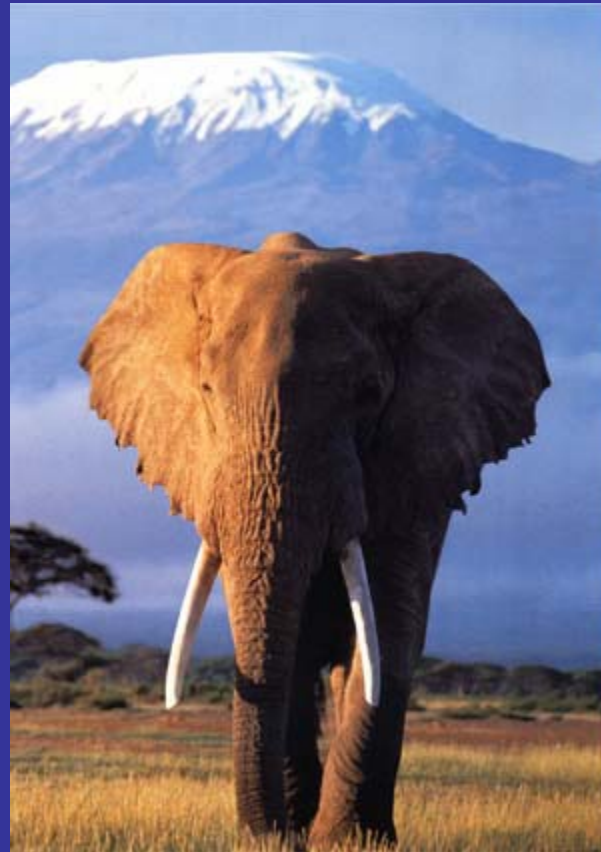
How much is a gigaton?

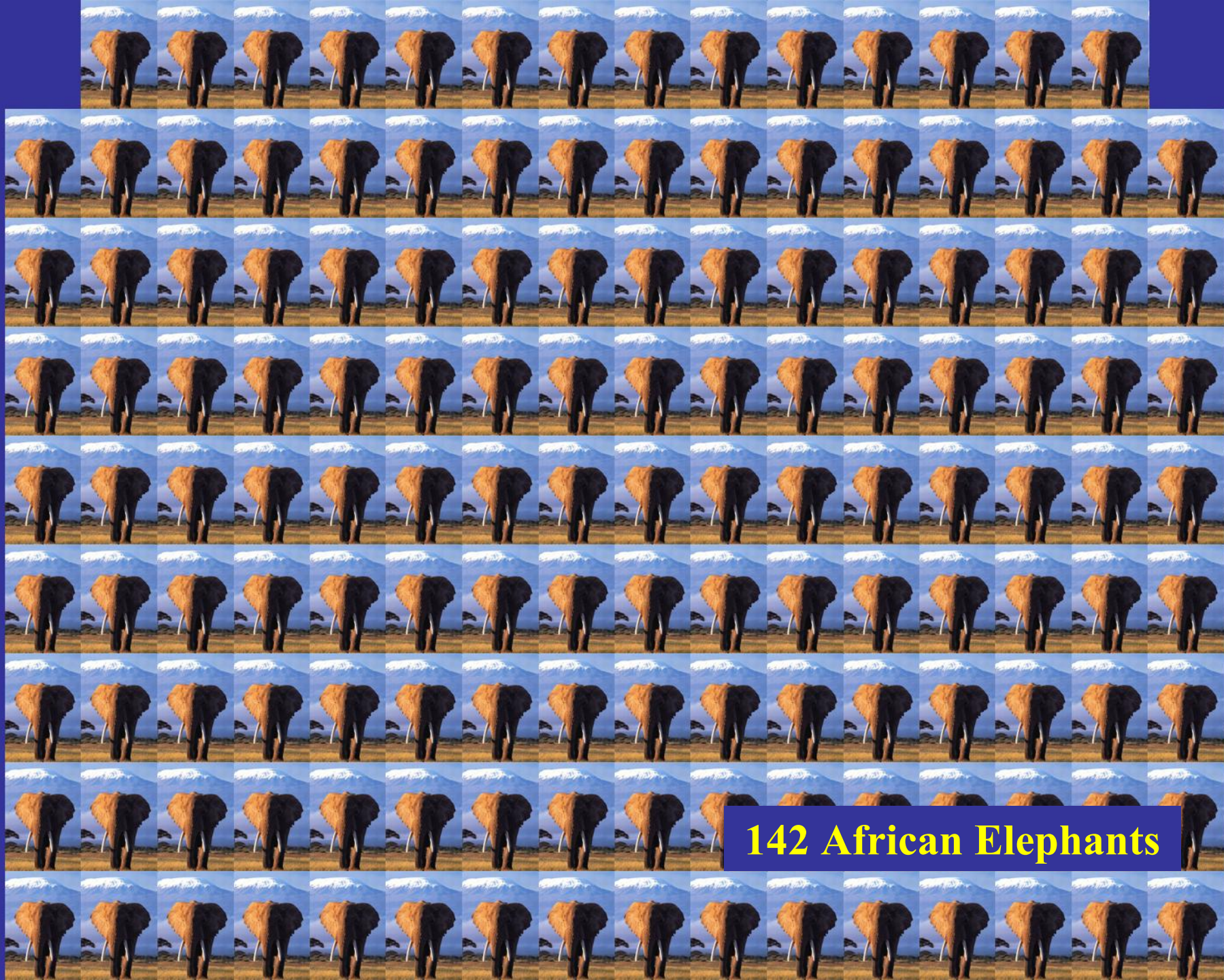
“One gigaton is equal to the weight of about 2750 Empire State Buildings, or about 142 million African elephants.”



How much is a gigaton?

“One gigaton is equal to the weight of about 2750 Empire State Buildings, or about 142 million African elephants.”





142 African Elephants

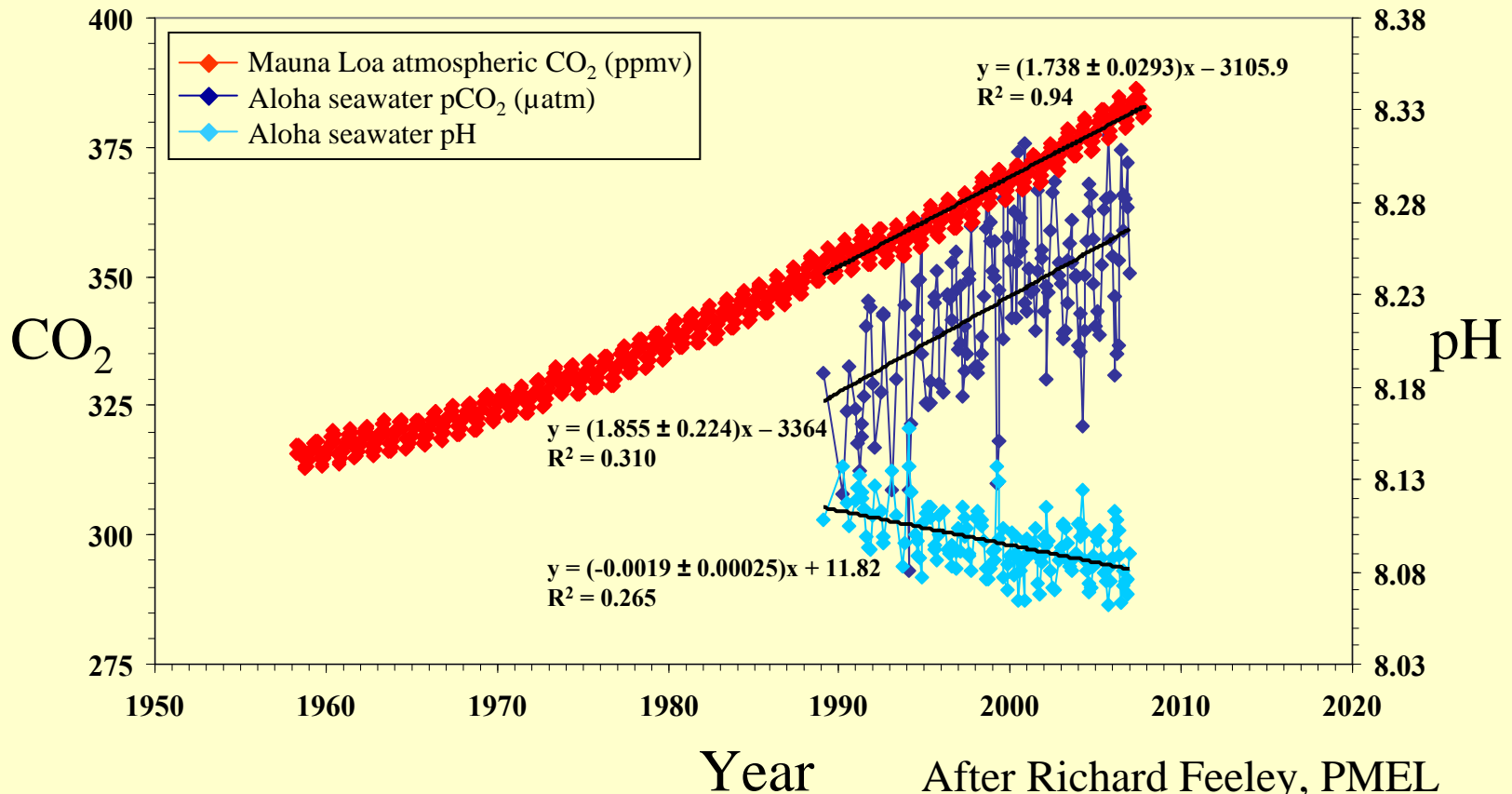
**142 African Elephants: throw them
overboard 2 million times...**



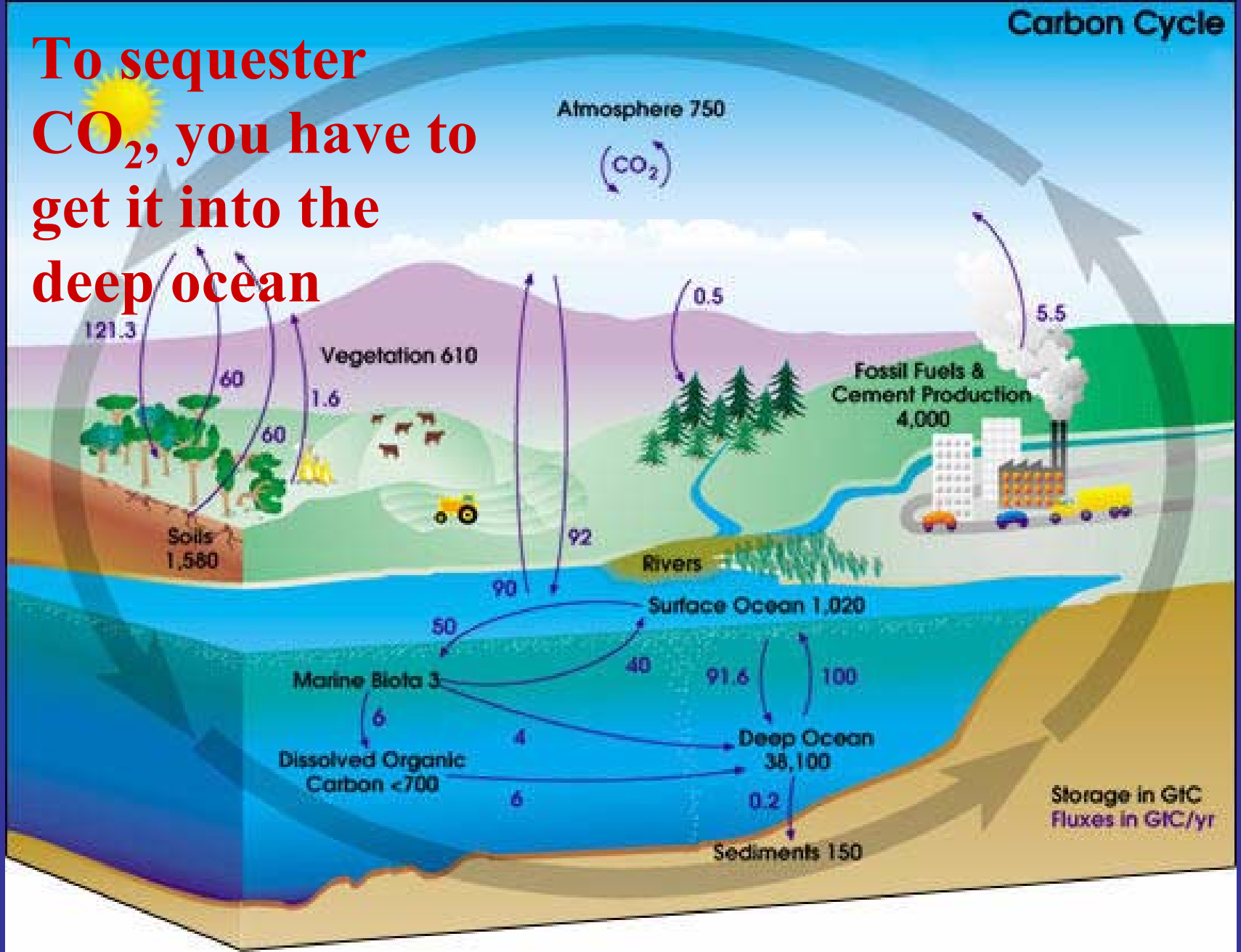
CO₂ dissolving into the ocean:



CO₂ Time Series in the North Pacific



To sequester CO₂, you have to get it into the deep ocean

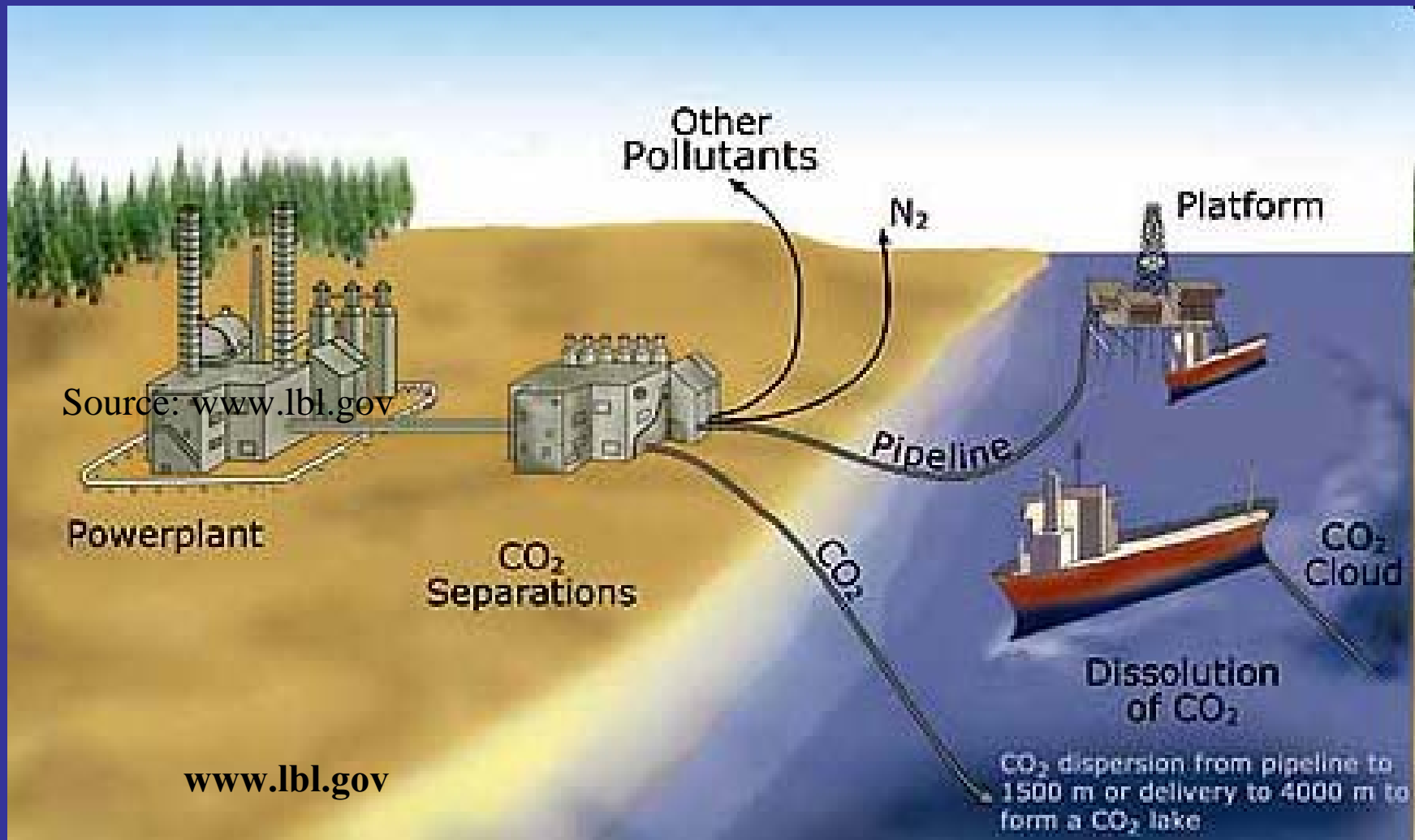


Direct injection of liquefied CO₂

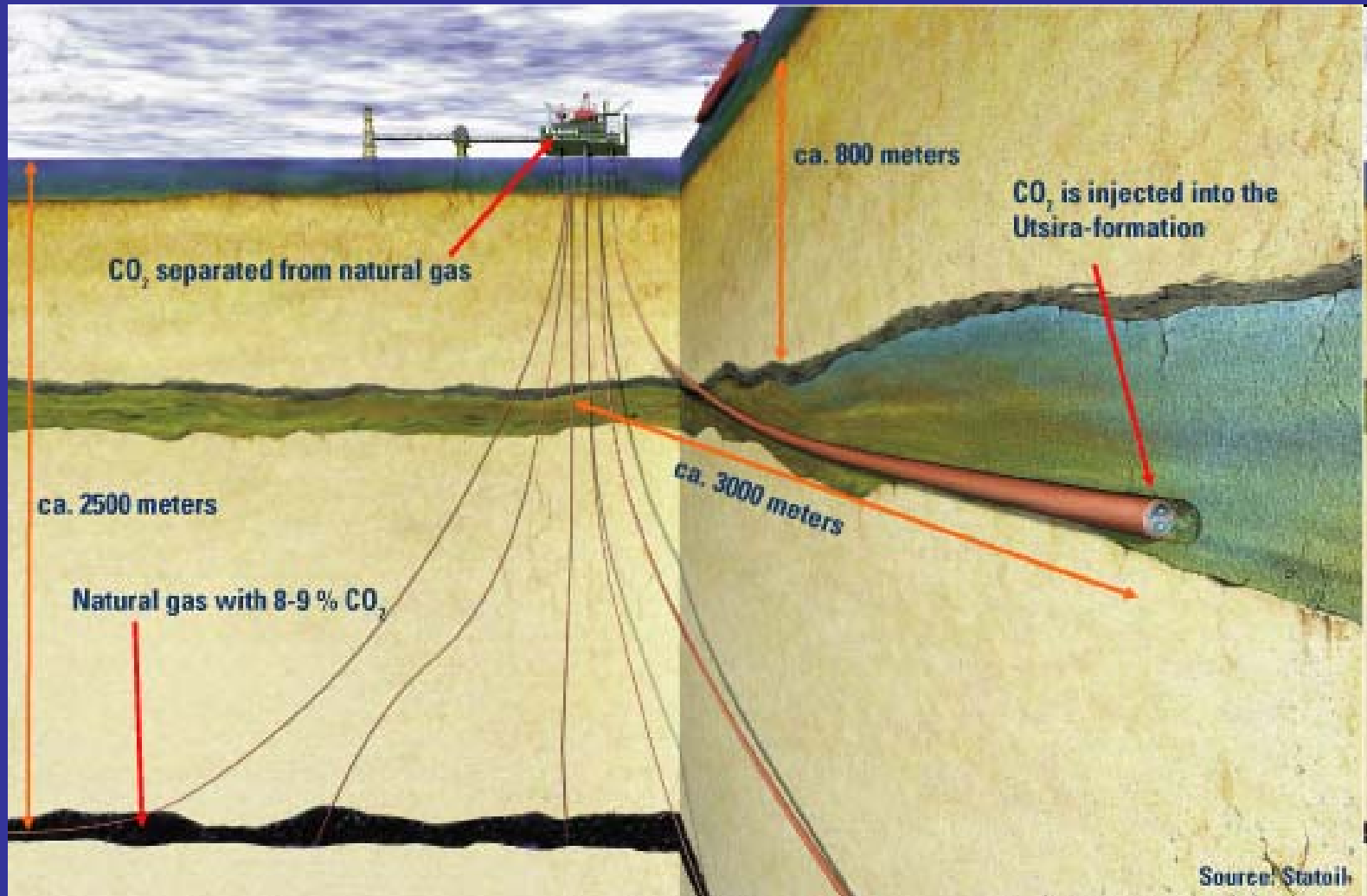
- **First proposed by Marchetti in 1977**
- **Investigated by the DOE and others (modeling studies, small scale trial injections, ecological impacts)**
- **Two pilot studies in Hawaii and in Norway scheduled for 2002 were scrapped following public protest**
- **Unlikely to be revived**



Direct injection of liquefied CO₂

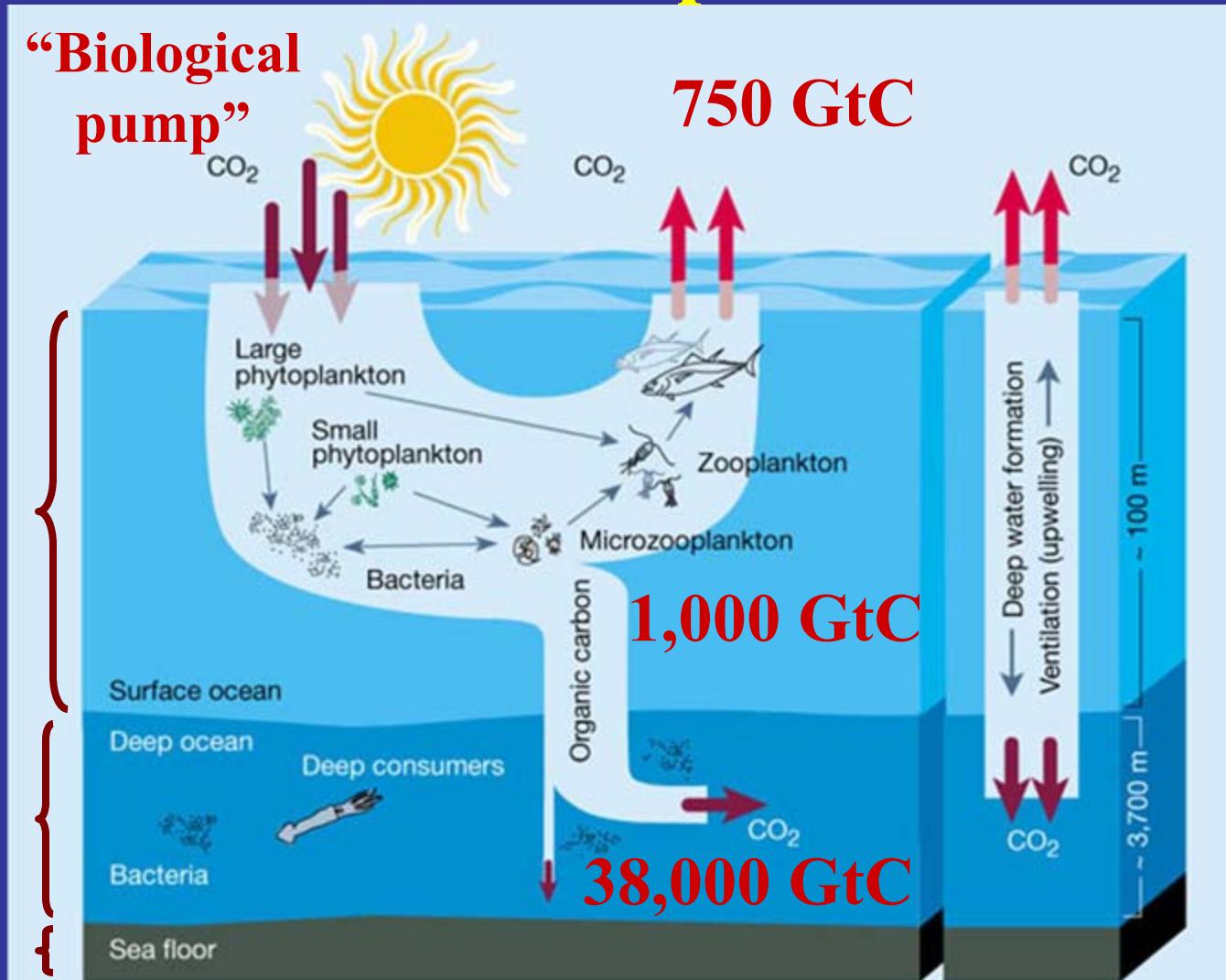


Injection of CO₂ into subseabed formation



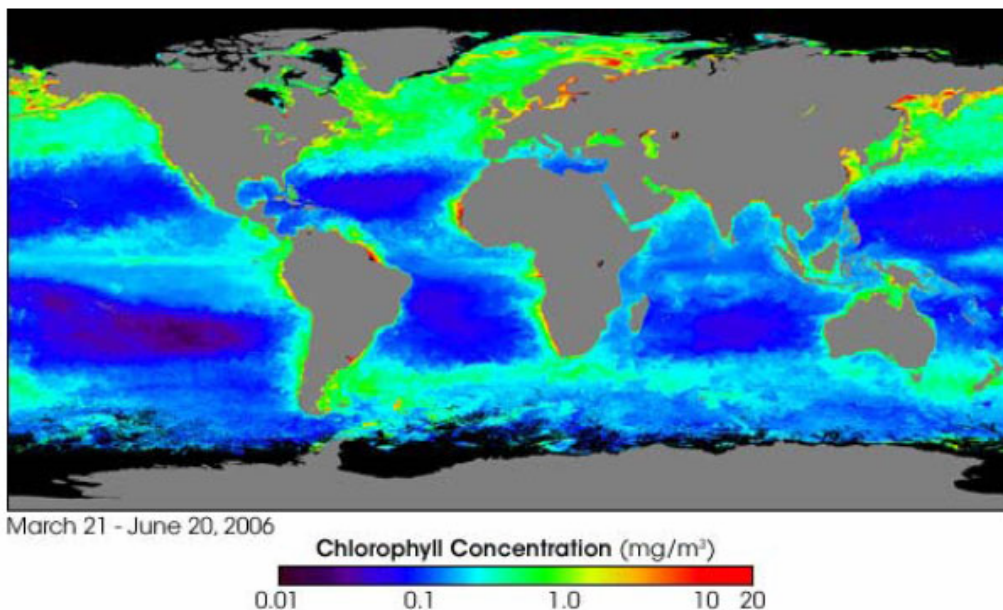
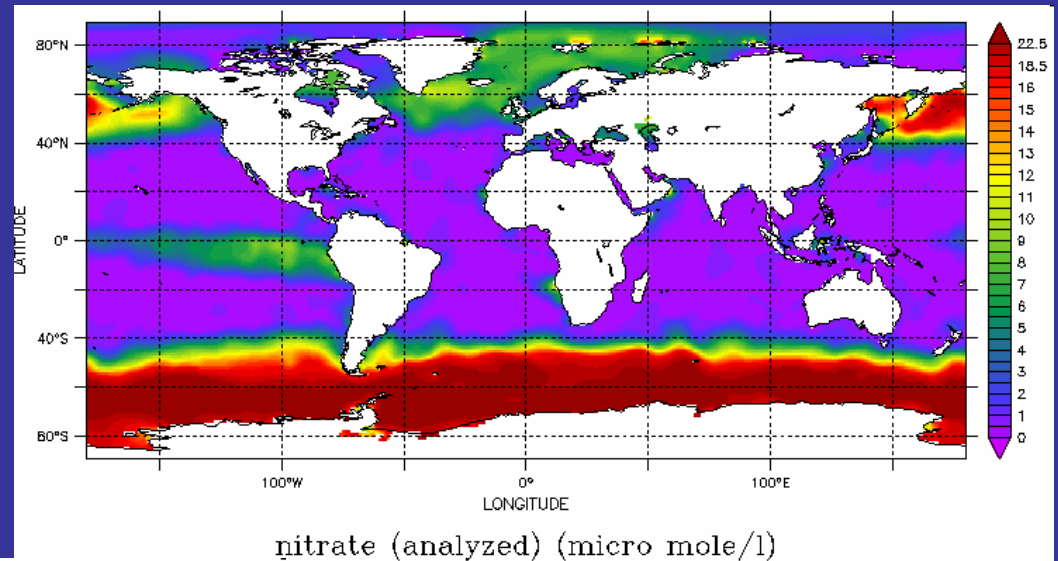
1 million tons of CO₂ per year = 0.27 million tons carbon = 39,000 A.E.

What other mechanism could transfer CO₂ into the deep ocean?



Why consider the biological pump?

Phytoplankton
require light and
nutrients to grow



But some regions
appear to have
plenty of nutrients
but very little
phytoplankton
biomass

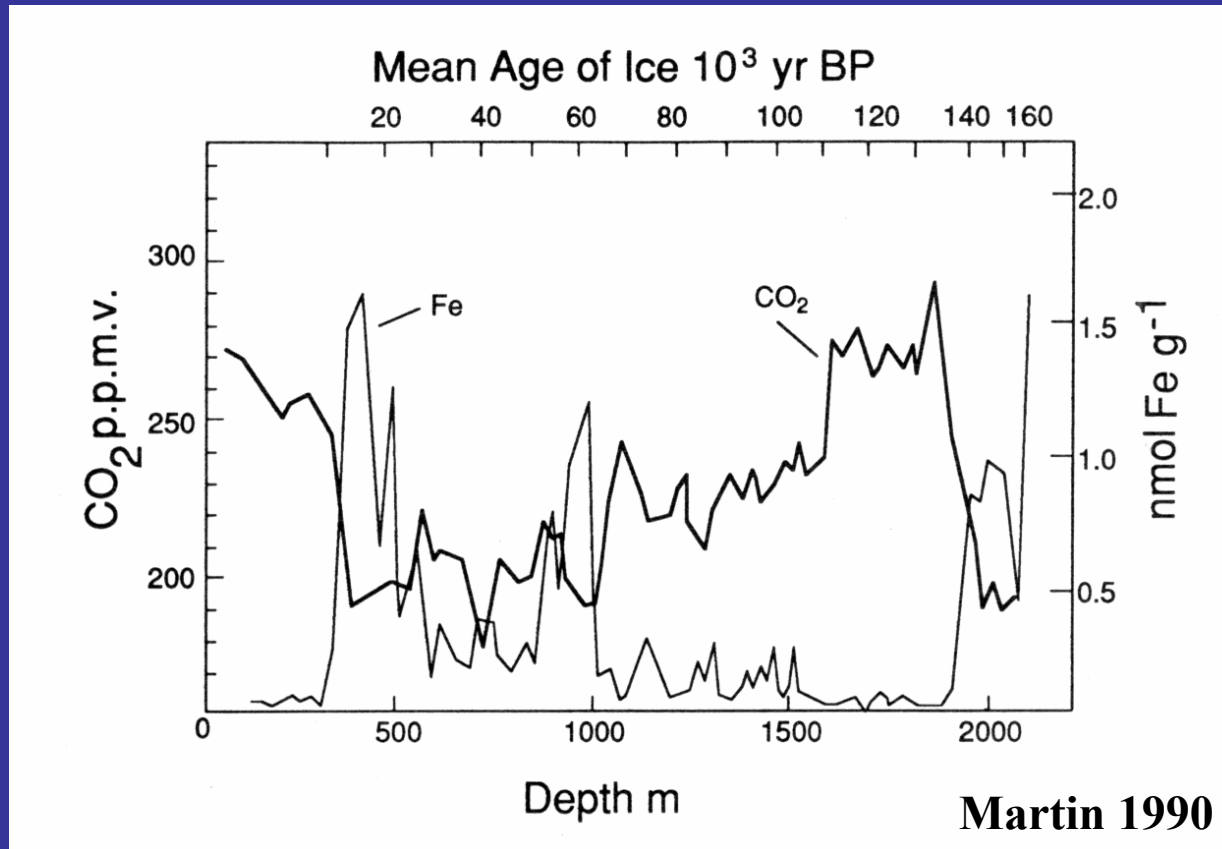


The iron hypothesis

Dr T. J. Hart, 1925-1927 *Discovery* Expedition to the Southern Ocean:

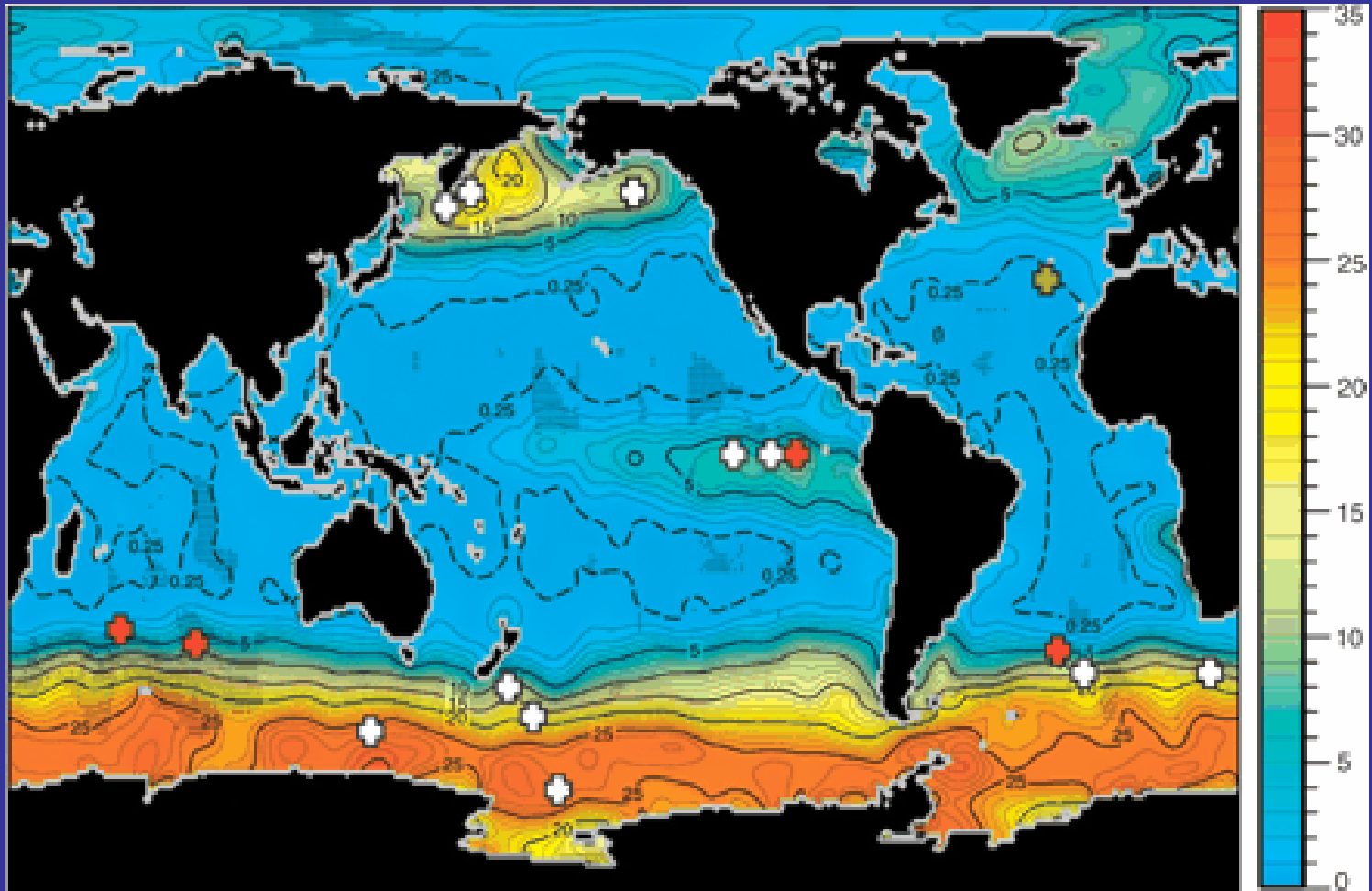
“The greater richness of the neritic seas remains inexplicable unless we assume that minute quantities of inorganic compounds, as iron and manganese, or of organic compounds derived from the land, exert a strongly favorable influence on diatom growth.”

The iron hypothesis: “Fe supplies may be limiting phytoplankton growth” - Martin and Gordon, 1988



**Paleoclimate: CO₂ has positive correlation with temperature, negative correlation with dust.
Link = efficiency of biological pump(?)**

Field testing the iron hypothesis.

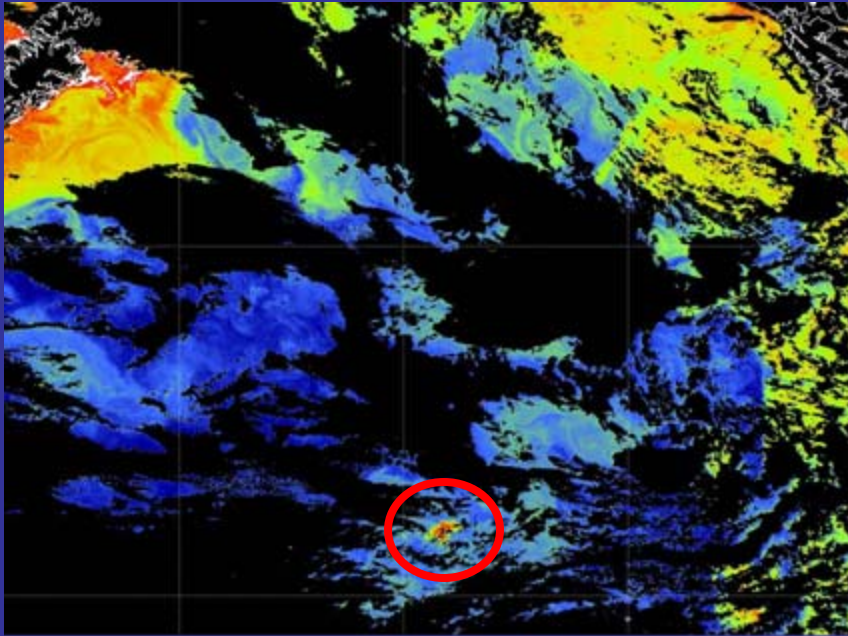


White crosses: iron addition experiments since 1993.

Red crosses: natural iron enrichment investigated.

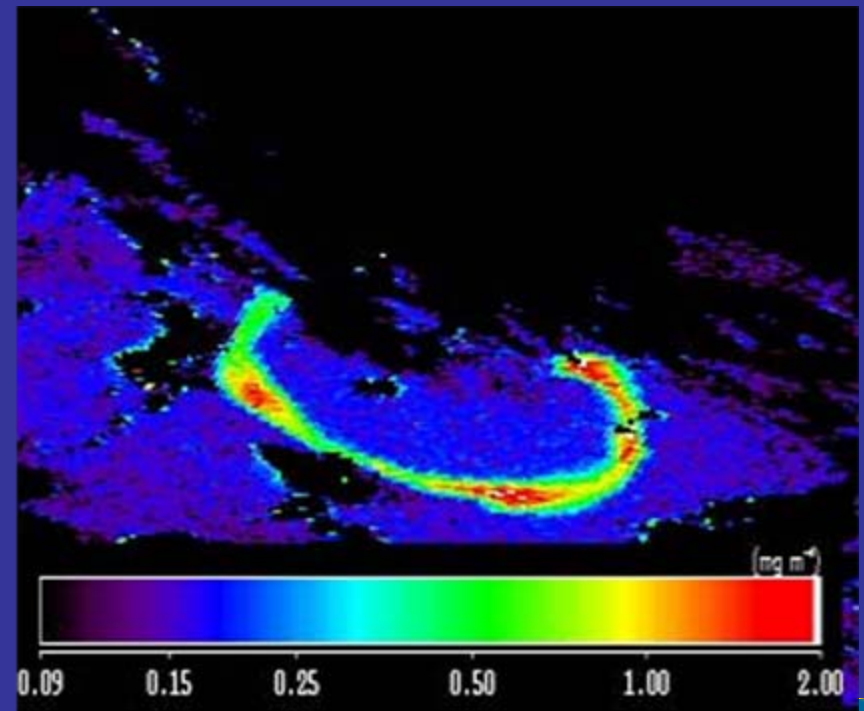
Source: Boyd *et al.*, 2007, *Science* 315: 612

All experiments resulted in blooms.



**SOIREE: Southern
Ocean Iron Release
Experiment, 1999**

**SERIES: Subarctic
Ecosystem Response to Iron
Enrichment Study, 2002**



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But carbon export not obvious...

Property	IronEX I (6)	IronEX II (30)	SOIREE (49)	EisenEx (56)	SEEDS I (57)	SOFEX-S (54, 58)	SOFEX-N (58)	EIFEX (46)	SERIES (17)	SEEDS II (59)	SAGE (59)	FeeP (59)
Fe added (kg)	450	450	1750	2350	350	1300	1700	2820	490	480	1100	1840
Temperature (°C)	23	25	2	3 to 4	11	-1	5	4 to 5	13	9 to 12	11.8	21
Season	Fall	Summer	Summer	Spring	Summer	Summer	Summer	Summer	Summer	Summer	Fall	Spring
Light climate ($\mu\text{mol quanta m}^{-2} \text{ s}^{-1}$)	254 (max) to 230 (min)	216 to 108	59 to 33	82 to 40	178 to 39	103 to 62	125 to 74		173 to 73		59 to 52	
Dilution rate (day^{-1})	0.27	0.18	0.07	0.04 to 0.43	0.05	0.08	0.1		0.07 to 0.16			0.4
Chlorophyll, $t = 0$ (mg m^{-3})	0.2	0.2	0.2	0.5	0.9	0.2	0.3	0.6	0.4	0.8	0.6	0.04
Chlorophyll, maximum (mg m^{-3})	0.6	3.3	2.3	2.8	23.0	2.5	2.4	3.0	5.5	2.4	1.3	0.07
MLD (m)	35	40*	65*	80*	13	35	45	100	30*	30	70*	30*
Bloom phase (duration, days)	Evolving (5) subducted	Decline (17)	Evolving (13)	Evolving (21)	Evolving (10)	Evolving (28)	Evolving (27) subducted	Partial decline, evolving (37)	Decline (25)	Evolving (25)	No bloom (17)	No bloom (7)
δDIC (mmol m^{-3})	6	26	17	14	58	21	13		36		nc	<1
δDMS ($\mu\text{mol m}^{-3}$)	0.8	1.8	2.9	1.3, then to 0†	nc	nc	Increased		8.5, then to -5.7†	nc	nc	nc
Dominant phytoplankton	Mixed	Diatom	Diatom	Diatom	Diatom	Diatom	Mixed	Diatom	Diatom	Mixed	Mixed	<i>Cyanobacteria</i> <i>Prochlorococcus</i>
Export	nc	increase	nc	nc	nc	Increase	Increase§	Increase	Increase	nc	nc	
Mesozooplankton stocks	Increase‡	Increase	nc	nc	nc	nc	nc	Increase	Increase	Increase	nc	nc
Primary production (max/min ratio)	4	6	9	4	4	6	10	2	10		2	1.7

*Changes in MLD were observed during the study; the maximum MLD is shown (for initial MLD, see table S1). †An initial increase in DMS concentration followed by a decline by the end of the study. ‡Based on anecdotal evidence. §Increased export was mainly associated with a subduction event.



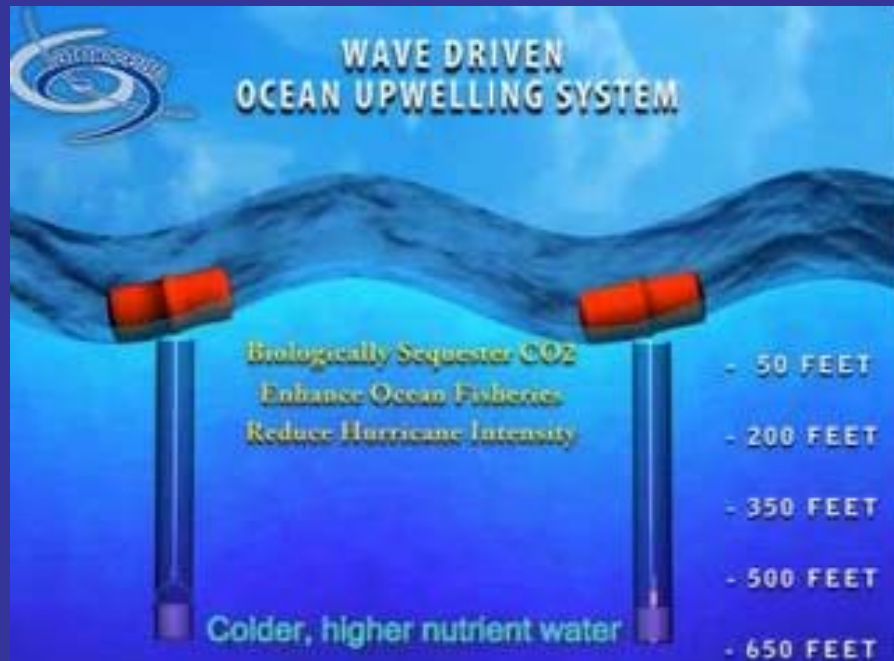
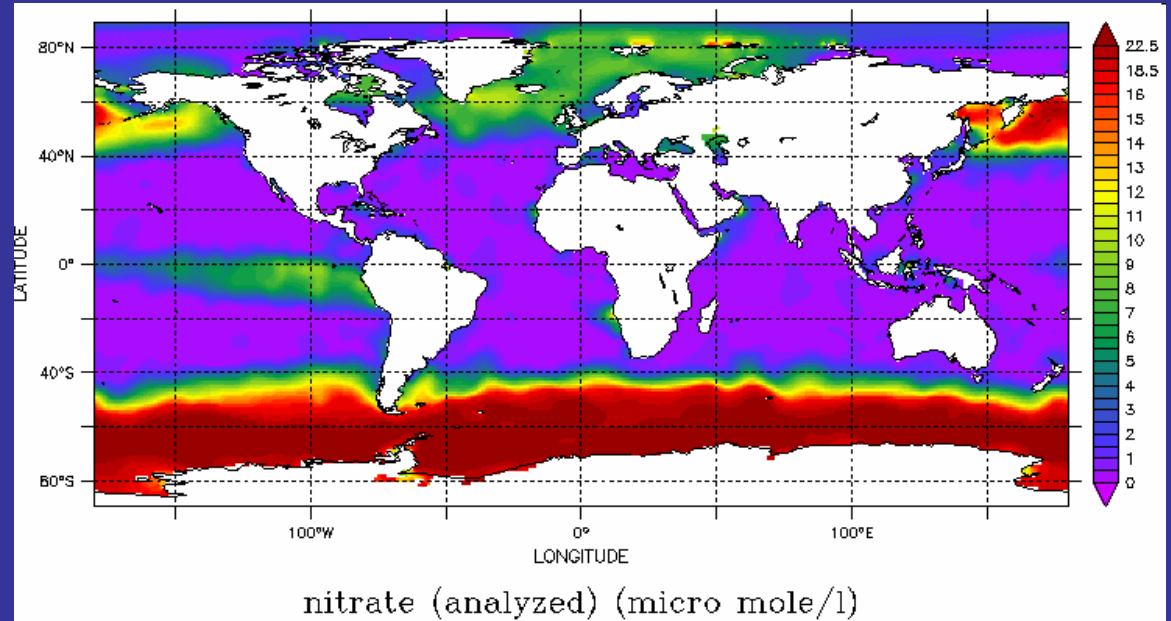
But carbon export ambiguous...

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Dominant	Mixed	Diatom	Diatom	Diatom	Diatom	Diatom	Mixed	Diatom	Diatom	Mixed	Mixed	Cyanobacteria
nc	increase	nc	nc	nc	Increase	Increase‡	Increase	Increase	Increase	nc	nc	nc
increase	increase	increase	increase	nc	nc	nc	nc	nc	nc	nc	nc	nc
Primary production (max/min ratio)		4	6	9	4	4	6	10	2	10	2	1.7

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Other ideas include adding urea to low nitrogen regions: attempt to perform experiment in Sulu Sea was blocked in 2007



Or pumping nutrient-rich deep waters to the surface in low nutrient regions: field test May 2008

Is there a financial incentive?





United Nations Framework Convention on climate change. *U.S. ratified in 1992*

ARTICLE 2: The ultimate objective... is to achieve... stabilization of greenhouse gas concentrations in the atmosphere at a level that would prevent dangerous anthropogenic interference with the climate system.





Kyoto Protocol (1997): commits Annex I (developed) countries to caps on total emissions. Calls for national GHG source and sink accounting and includes “flexible mechanisms” for achieving targets.





The
World
Bank

State and trends of the carbon market, 2008

Karan Capoor and Philippe Ambrosi

	2006		2007	
	Volume (MtCO ₂ e)	Value (MUS\$)	Volume (MtCO ₂ e)	Value (MUS\$)
Allowances				
EU ETS	1,104	24,436	2,061	50,097
New South Wales	20	225	25	224
Chicago Climate Exchange	10	38	23	72
UK ETS	na	na		
Sub total	1,134	24,699	2,109	50,394
Project-based transactions				
Primary CDM*	537	5,804	551	7,426
Secondary CDM	25	445	240	5,451
JIT†	16	141	41	499
Other Compliance & Voluntary Transactions	33	146	42	265
Sub total	611	6,536	874	13,641
TOTAL	1,745	31,235	2,983	64,035

*: Clean Development Mechanism; †: Joint Implementation

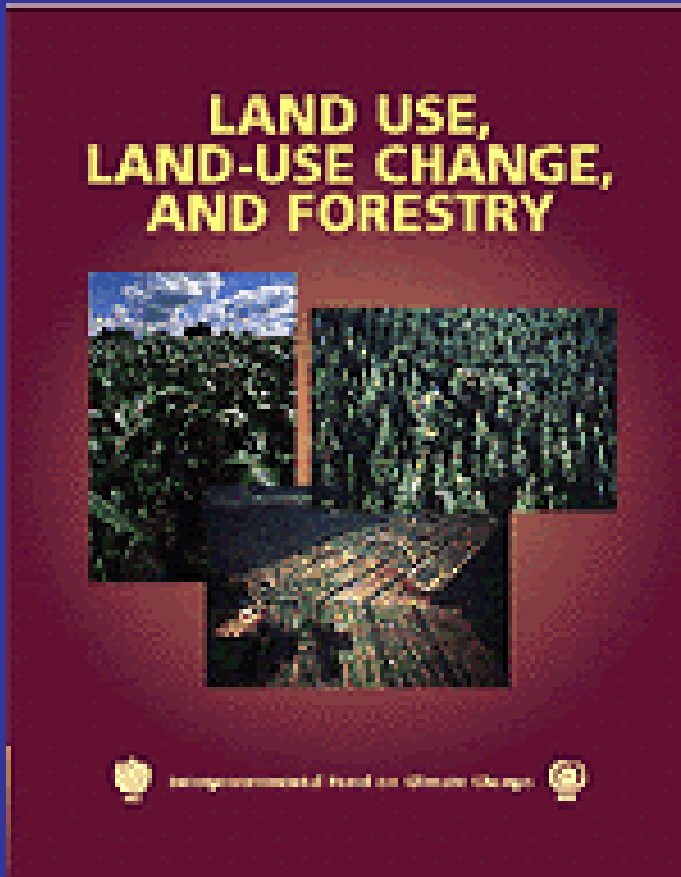
82 M.
A.E.

116 M.
A.E.

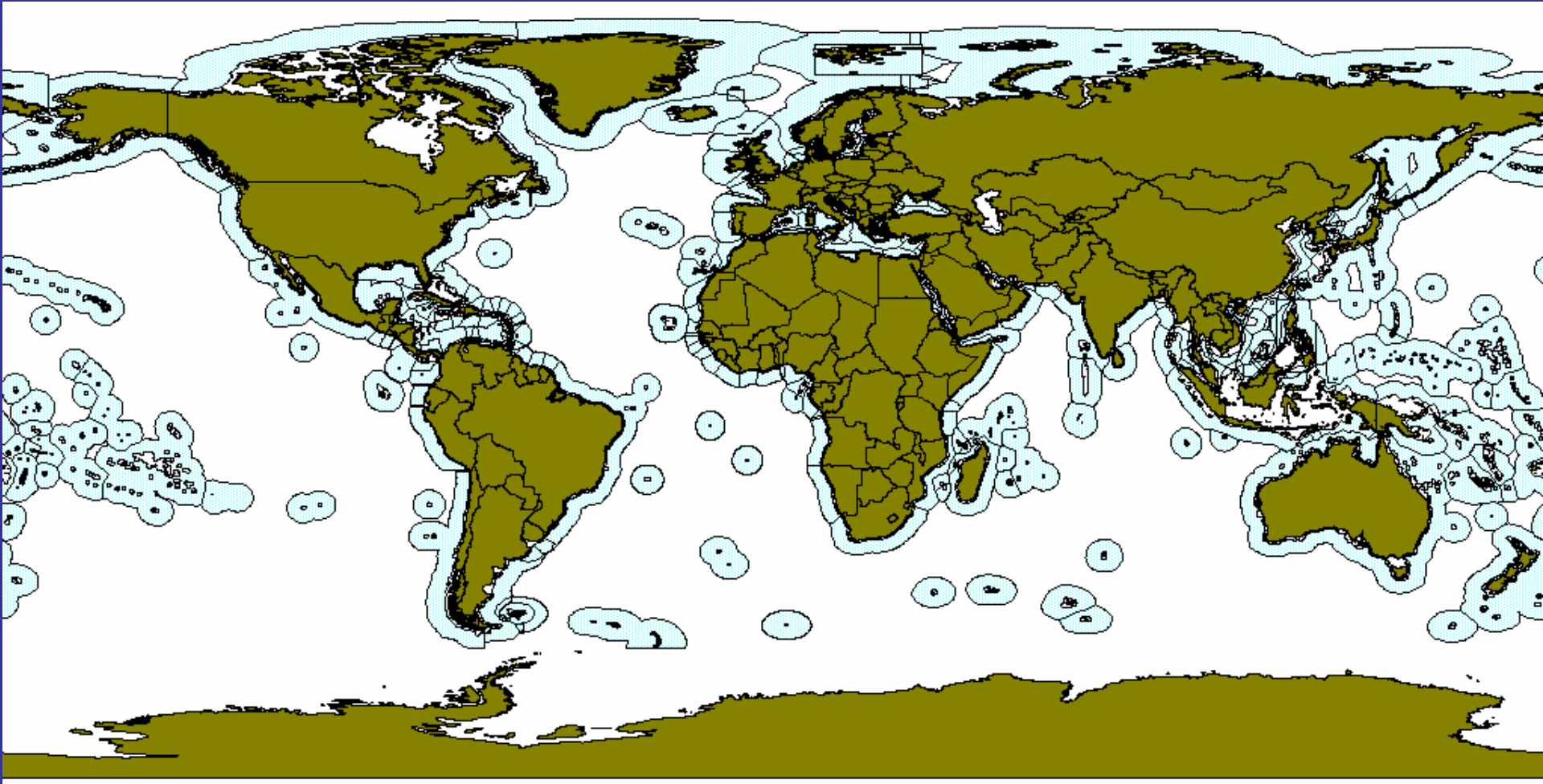
Kyoto Protocol Article 3 and the terrestrial carbon cycle

Article 3.3: net changes in GHG emissions from *afforestation*, *reforestation* and *deforestation* that occurred since 1990, can be used to meet Parties' emission reduction commitments.

Article 3.4: Parties may include forest, cropland and grazing land management and revegetation in their GHG accounting for the first commitment period.

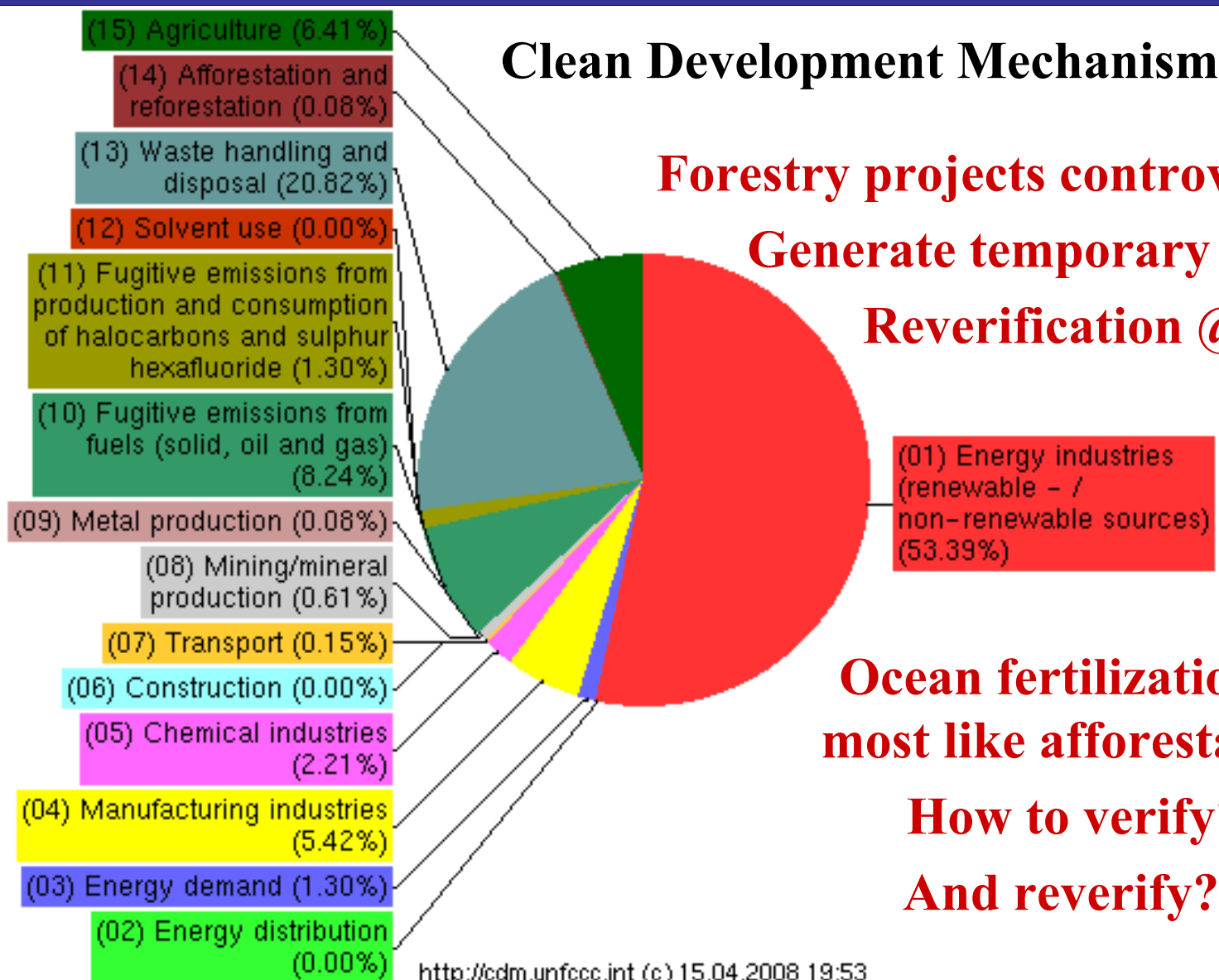


No equivalent for ocean carbon sinks

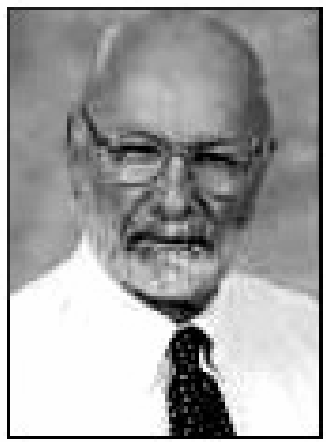


Ocean carbon sinks and international climate policy,
Rehdanz, Tol and Wetzel, *Energy Policy* 2006

What projects generate carbon credits?



Commercial interest in ocean fertilization.



1999: Michael Markels, Jr, files U.S. patent # 6,056,919 for method of sequestering CO₂ in the ocean using iron and other fertilizers: anticipates CO₂ regulation

2002: Russ George founds Planktos to tackle global warming and the global collapse of phytoplankton(?). Anticipates voluntary market



Commercial interest in ocean fertilization.



2006: Margaret Leinen becomes Chief Scientific Officer for son's company, Climos. Following Kyoto-like procedures but anticipating voluntary market

May 2008: Dave Karl and Atmocean attempt to pump deep water to the surface using wave driven pumps attached to long tubes. Pump breaks.



Scientists



Entrepreneurs



Lawyers

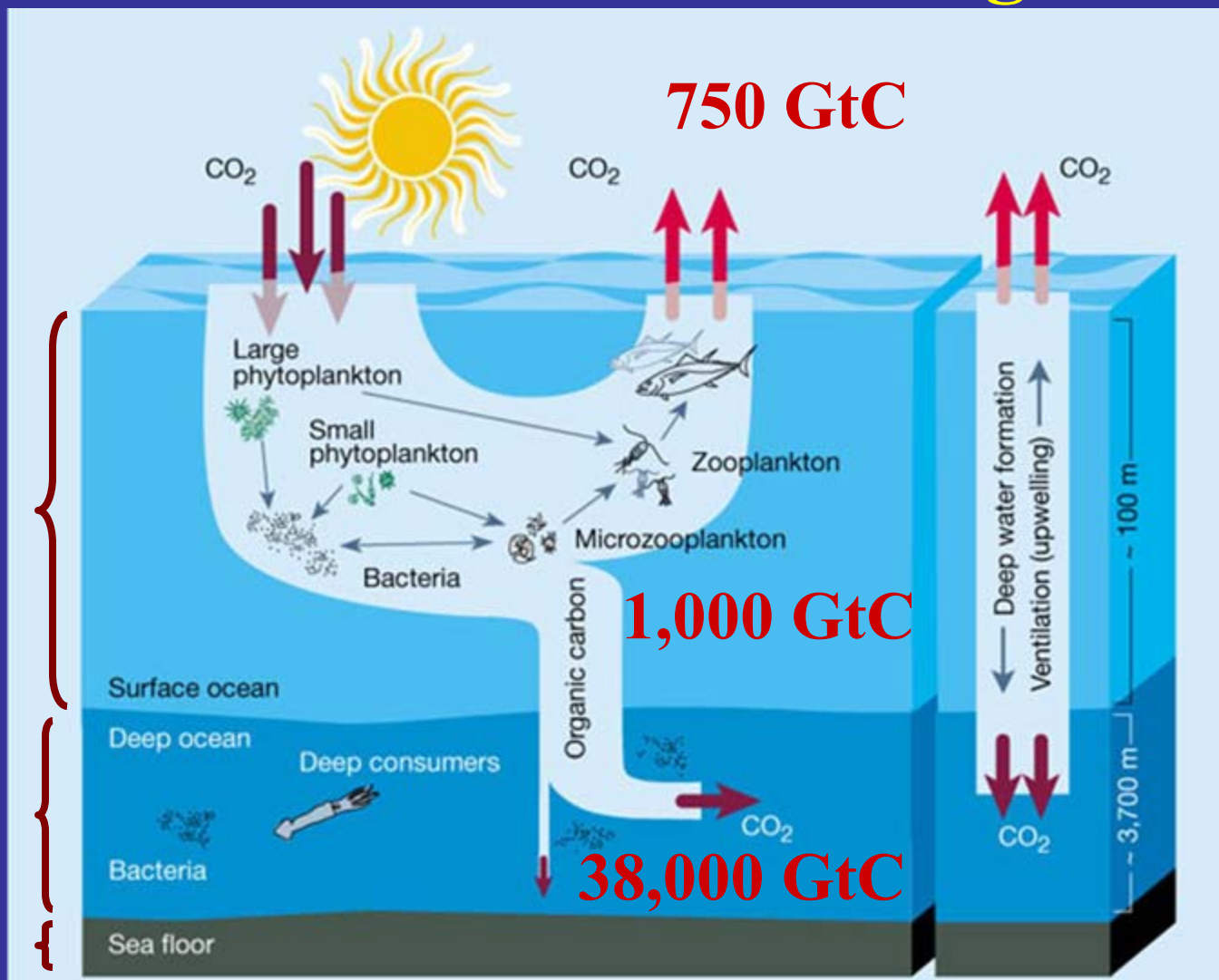


Carbon traders



Can we measure export? How well and over what time scale? Are we being honest?

%?
→ ?
%?
%?



Source: Chisholm, S.W. 2000. *Nature* 407, 685-687



Already concerns about fraud in US

MASSACHUSETTS
OREGON
WASHINGTON
CONNECTICUT
CALIFORNIA
SOUTH DAKOTA
MISSOURI
NEW YORK
CALIFORNIA



Select Committee on Energy Independence and Global Warming U.S. House of Representatives

July 18, 2007

Ms. Deborah Platt Majoras
Chairman
Federal Trade Commission
600 Pennsylvania Avenue, N.W.
Washington, D.C. 20580

Dear Chairman Platt Majoras:

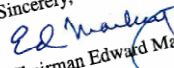
As you may be aware, environmentally-conscious consumers and businesses purchasing "offsets" to their carbon-emitting activities have helped support a boom in marketing a wide array of carbon offset products. This business is still largely unregulated. As the opportunity to profit in this sector attracts more players, the potential for marketing claims misleadingly portray the offset products in question also grows.

As the agency charged with preventing misleading or deceptive trade practices, the Federal Trade Commission has already developed a set of guidelines that businesses using claims of environmental benefits to market their products can follow to stay clear of allegations of consumer fraud. However, the examples provided in these guidelines are not directly applicable to the carbon offsets market.

Accordingly, I urge you to undertake a public process designed to update the Commission's Guides for the Use of Environmental Marketing Claims (15 C.F.R. Part 260) so that consumer confidence in the offset market can be assured. Some in the industry are working on standards that will be relevant to such an update, and I urge you to take those into account as you analyze this area. This market is developing rapidly, and promises to provide important benefits to this country and to consumers. But it is certainly not immune to the potential for unfair or deceptive trade practices.

I would appreciate hearing from you at your earliest convenience about this request. Please contact me directly or Mr. Joel Beauvais of the Select Committee staff (202-225-4012). Thank you for taking steps to keep this market vibrant and fair.

Sincerely,


Chairman Edward Markey

F. James Sensenbrenner, Jr., Ranking Member

F. JAMES SENSENBRENNER, JR., WISCONSIN
RANKING MEMBER
JOHN W. SHADDOCK, ARIZONA
GREG WALDEN, OREGON
CANDICE S. MILLER, MICHIGAN
JOHN SULLIVAN, OLAHOMA
MARBHA BLACKBURN, TENNESSEE

26.02.08 Senator calls on traders to
avoid "fraud" in emerging US carbon
market
California Senator Dianne Feinstein
today called on the North American
carbon trading community to endorse
measures designed to prevent fraud in
a growing market for greenhouse gas
reductions.



What other impacts could be important?

- **Iron limitation = inefficient use of macronutrients**
- **Successful iron addition means macronutrients used and exported to deep ocean so not available downstream**
- **In Kyoto terms, this would have to be accounted for as “leakage”**
- **O₂, N₂O and CH₄ impacts may also happen later and far away—these would have to be subtracted from carbon credits**
- **Adding nutrients likely to cause ecosystem shifts**



And what about those lawyers?



UNCLOS Article 192:

States have the obligation to protect and preserve the marine environment.

1972 London Dumping Convention (1996 Protocol)
... to prevent the pollution of the sea by the dumping of waste and other matter



United States Marine Protection, Research and Sanctuaries act

...prohibits dumping from US flagged ship or of material from US port

Iron fertilization gets on the agenda at the London Convention/London Protocol



SCIENTIFIC GROUP OF THE LONDON
PROTOCOL – 1st Meeting
18 – 22 June 2007
Agenda item 12

3 Initial press reports indicated that the planned iron addition by Planktos, Inc. off the Galapagos Islands would be done using a vessel flagged in the United States, the *Weatherbird II*. Such a project potentially would be subject to permitting requirements under the United States' Ocean Dumping Act, which implements the London Convention on ocean dumping.

4 The United States Environmental Protection Agency (EPA) contacted Planktos, Inc. on 21 May 2007, to get additional information about the iron addition projects.

5 Planktos, Inc. contacted the EPA on Wednesday, 23 May 2007, to state that the company will not use the *Weatherbird II*, a United States' flagged vessel, for releasing the iron. Instead, the EPA understood the representative of Planktos, Inc., to say that the company will use a non-United States flagged vessel for releasing the iron so as not to be subject to regulation under the United States' Ocean Dumping Act. Planktos, Inc. was not able to say at the time under which country the vessel(s) used for the iron additions would be flagged. Planktos, Inc. also was unable to identify from which country the vessel(s) used in the iron releases would be leaving, although the EPA understands that the vessel(s) would not leave from the United States.



“...given the present state of knowledge, ocean fertilization activities other than legitimate scientific research should not be allowed.” London, October 31 2008



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Ocean fertilization, carbon credits and the Kyoto Protocol

- Excellent science on iron limitation and primary production
- Commercial interest excited by the Kyoto Protocol
- Not clear that Kyoto Protocol credits could be generated
- In the meantime, it looks like ocean fertilization will be restricted by law



Questions?



MAUNA LOA FACILITY



of the
**NETWORK FOR THE DETECTION OF
STRATOSPHERIC CHANGE**

**LAT : 19.539° , LONG: 155.578°
ELEVATION: 3396 m (11,141 ft)**

Dedicated November 1997



marian.westley@noaa.gov

