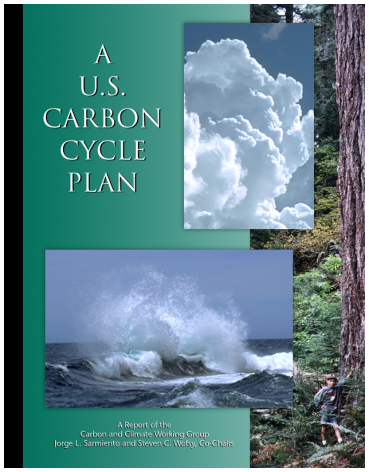
Surprises in the anthropogenic carbon budget

Why OCB is so important!

Jorge Sarmiento
Princeton University

Co-lead author of the US Carbon Cycle Science Plan

The U. S. Carbon Cycle Plan (published in 1999)



Jorge L. Sarmiento,Co-Chair	Princeton University
Steven C.Wofsy, Co-Chair	Harvard University
Eileen Shea,Coordinator	Adjunct Fellow, East-West Center
A. Scott Denning	Colorado State University
William Easterling	Pennsylvania State University
Chris Field	Carnegie Institution
Inez Fung	University of California,Berkeley
Ralph Keeling	Scripps Institution of Oceanography
James McCarthy	Harvard University
Stephen Pacala	Princeton University
W. M. Post	Oak Ridge National Laboratory
David Schimel	National Center for Atmospheric Research
Eric Sundquist	United States Geological Survey
Pieter Tans	NOAA,CMDL
Ray Weiss	Scripps Institution of Oceanography
James Yoder	University of Rhode Island

Scientific questions

In the very broadest terms,the plan addresses two fundamental scientific questions:

- What has happened to the carbon dioxide that has already been emitted by human activities?
- What will be the future atmospheric CO_2 concentration trajectory resulting from both past and future emissions?

A question that should probably be added to the plan

- How will CO_2 impact oceanic and terrestrial systems (e.g., ocean acidification)?

SPECIFIC ISSUES AND NEEDS THAT WE IDENTIFIED

I. SCIENTIFIC ISSUES

A. Consensus that there is a large Northern Hemisphere terrestrial sink, but we do not know where it is or what its mechanisms are (GOAL 1)

B. Recognition that the oceans are a major carbon sink that may change in the future (GOAL 2)

C. Recognition that we need to understand land use history to determine the present and future carbon budget (GOAL 3)

II. SOCIETAL NEEDS

A. Improved Future Predictions (GOAL 4)

B. Evaluation of Management Strategies (GOAL 5)

Goal 2: Understanding the Ocean Carbon Sink

- To establish accurate estimates of the oceanic carbon sink, including interannual variability, spatial distribution, sensitivity to climate change, and underlying mechanisms.
- In the near-term, focus should be given to the North Atlantic and North Pacific.

WHAT THE US CARBON CYCLE SCIENCE PLAN PROPOSED

(1) **Sustained observations** over the important space and time scales of variability.

(2) **Manipulative experiments** to probe key mechanisms and their interactions.

(3) **Model development** aimed at understanding and predicting the critical processes.

Major Program Elements and Activities for Goal 2

(a) Required new technology

(b) Air-sea carbon fluxes

(c) Oceanic inventory measurements

(d) Process studies, models, and synthesis

Initial Goal 2 funding priorities

Rough cost estimate: $25M startup, ~$50M/year operations for Goal 2 only

- Both facility and technology development for automated and streamlined ocean sampling for long time-series and underway measurements
- Analysis of World Ocean Circulation Experiment/Joint Global Ocean Flux Study (WOCE/JGOFS) data for CO_2 uptake by the oceans
- New ongoing program of air-sea carbon flux and ocean inventory measurements
- Continued ocean process studies and enhanced manipulation experiments
- Enhanced development of Earth system modeling to include interactive carbon and climate dynamics.

AN UPDATE ON ISSUES AND NEEDS

I. SCIENTIFIC ISSUES

A. Consensus that there is a large Northern Hemisphere terrestrial sink, but we do not know where it is or what its mechanisms are. New evidence that there is a large terrestrial sink in the tropics and a suggestion that the terrestrial sink may be responding non-linearly to climate change (GOAL 1)

B. Recognition that the oceans are a major carbon sink that may already be responding to environmental change [*change in the future*] (GOAL 2)

C. Recognition that we need to understand land use history to determine the present and future carbon budget (GOAL 3)

II. SOCIETAL NEEDS

A. Improved Future Predictions including assessments of direct CO_2 impacts on ecosystems (GOAL 4)

B. Evaluation of Management Strategies (GOAL 5)

On the importance of taking a long term view (E. Sarachik)

(1) The importance of carbon dioxide is through its indirect effect on temperature, the water cycle, and ecosystems.

(2) The carbon problem will be with us essentially forever.

(3) There will be a permanent observing system for climate because society will demand it. Carbon will be part of it

(4) The "forever" aspect presents new challenges and opportunities to researchers.

- Example: weather forecasting and the upper air observing system exists because US Weather Service issues products ("forecasts") of continuing value to society.
- The State of the Carbon Cycle Report (SOCCR) is the first of what will likely be a long series of carbon system updates.

Deliverables for Goal 2

- Better understand ocean processes in critical regions such as the Southern Ocean.
- Determine the existence, magnitude, and interannual variability of oceanic carbon sinks and sources on regional scales.
- Attribute observed changes in the ocean carbon sink to variations in circulation, biology, and chemistry.
- Incorporate improved oceanic CO_2 flux estimates for better constraints on inverse models in estimating terrestrial sinks.