

# Global Repeat Hydrographic/CO<sub>2</sub>/Tracer Surveys in Support of CLIVAR and Global Cycle Objectives: Carbon Inventories and Fluxes

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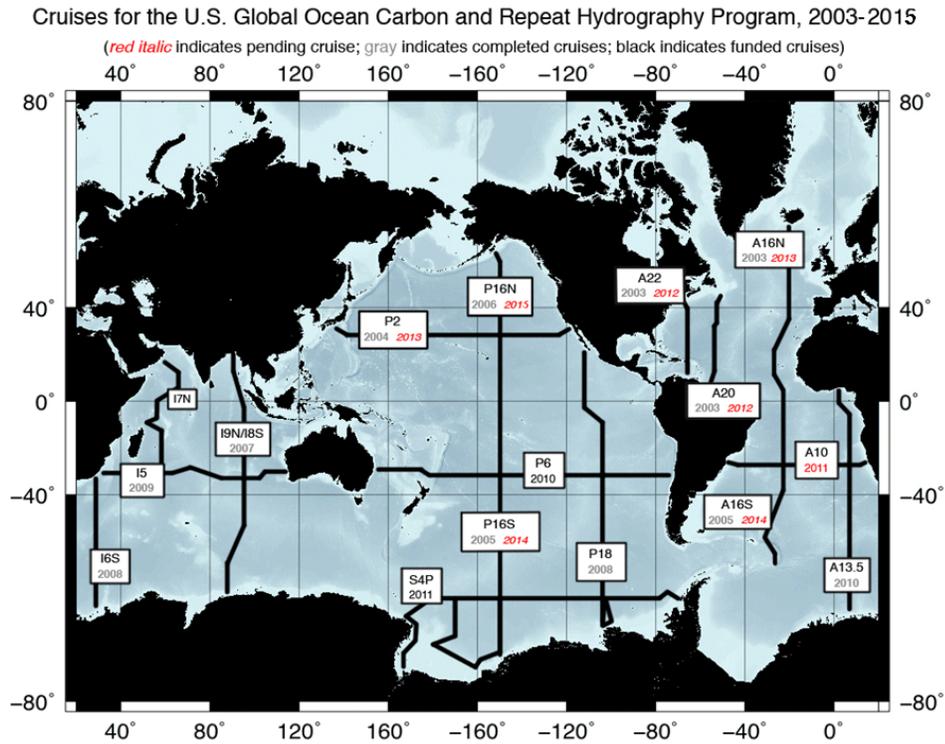
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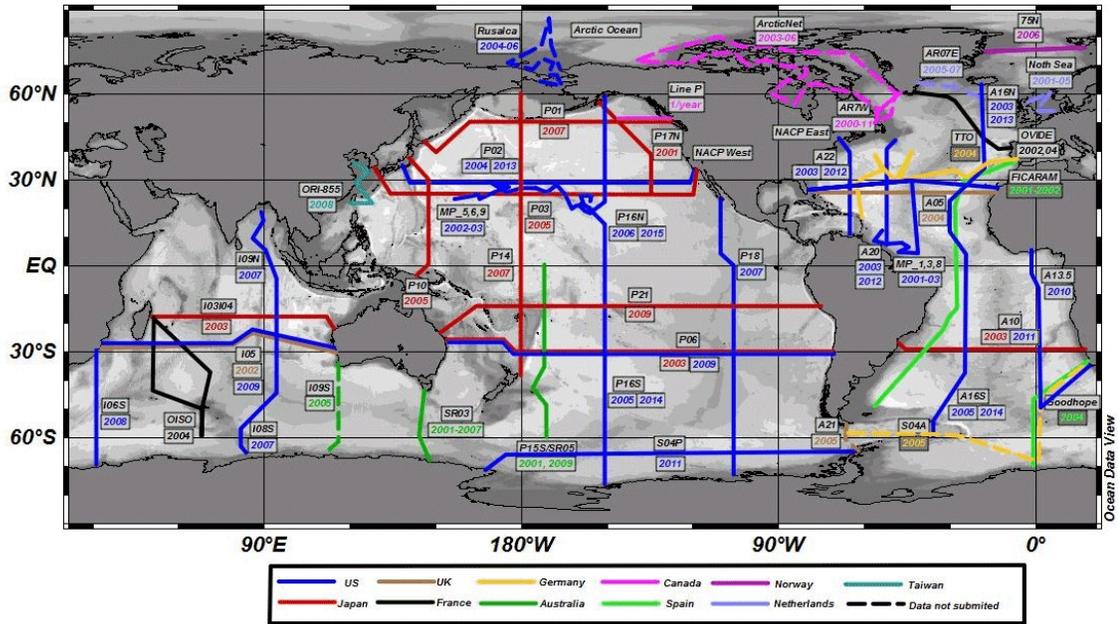
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## Project Summary

The Repeat Hydrography CO<sub>2</sub>/Tracer Program is a systematic and global re-occupation of select hydrographic sections to quantify changes in storage and transport of heat, fresh water, carbon dioxide (CO<sub>2</sub>), chlorofluorocarbon (CFC) tracers and related parameters. It builds upon earlier programs (e.g., World Ocean Circulation Experiment (WOCE)/Joint Global Ocean Flux Study (JGOFS) during the 1990s) that have provided full depth data sets against which to measure future changes, and have shown where atmospheric constituents are getting into the oceans. The Repeat Hydrography CO<sub>2</sub>/Tracer Program reveals much about internal pathways and changing patterns that will impact ocean carbon sinks on decadal time scales. The program is designed to assess changes in the ocean's biogeochemical cycle in response to natural and/or human-induced activity. Changes in the ocean's transport of heat and freshwater caused by climate change, which could affect the circulation by decreasing the thermohaline overturning, can also be documented using long-term observations throughout the water column. Below the 2000-m depth of Argo float observations, Repeat Hydrography provides the only global measurements for observing long-term trends in the ocean (Figure 1). The program also provides data for Argo sensor calibration (e.g., [www.argo.ucsd.edu](http://www.argo.ucsd.edu)), and support for continuing model development that will lead to improved forecasting skill for oceans and global climate. By integrating the scientific needs of the carbon and hydrography/tracer communities, major synergies and cost savings have been achieved. The philosophy is that in addition to efficiency, a coordinated approach will produce scientific advances that exceed those of having individual carbon and hydrographic/tracer programs. These advances will contribute to the following overlapping scientific objectives: 1) data for model calibration and validation; 2) carbon inventory and transport estimates; 3) heat and freshwater storage and flux studies; 4) deep and shallow water mass and ventilation studies; and 5) calibration of existing and new autonomous sensors. The data products are posted on the CLIVAR and Carbon Hydrographic Data Office (<http://cchdo.ucsd.edu/>) and the Carbon dioxide Information Analysis Center (<http://cdiac.ornl.gov/oceans/>) within six months of cruise completion for all parameters, and the results are used for research publications, atlases, and outreach materials. The end products are used by scientists to develop and validate models of ocean circulation changes, and models of the uptake of carbon dioxide and other anthropogenic trace gases. They are also used to assess and validate models of future impacts to ocean biological ecosystems resulting from acidification, stratification, and circulation changes.

The program is co-sponsored by NOAA and the National Science Foundation and is being implemented to maintain decadal time-scale sampling of ocean transports and inventories of climatically significant parameters in support of the Ocean Carbon Monitoring Network of the Program Plan for Building a Sustained Observing Network for Climate. The sequence and timing for the sections (Figure 1; Table 1) takes into consideration the program objectives, providing global coverage, and anticipated resources. Also considered is the timing of national and international research programs, including the focus of CLIVAR in the 2011-2014 timeframe; the SOLAS Program that emphasizes constraining the carbon uptake in the surface oceans, in part, in support of the North American Carbon Program (NACP); and the international Integrated Marine Biogeochemistry and Ecosystem Research (IMBER) program. Emphasis during 2013 is on the Northern Hemisphere. In addition, the proposed sections are selected so that there is roughly a decade between them and the WOCE/JGOFS occupations. The Repeat Hydrography CO<sub>2</sub>/Tracer Program is managed in accordance with the COSP Ten Climate Monitoring Principles.





**Figure 1.** Global map of U.S (top) and international (bottom) Repeat Hydrography CO<sub>2</sub>/Tracer Program hydrographic sections with carbon system measurements. In the bottom panel, solid lines indicate funded lines. Dashed lines indicate planned lines that are not fully funded at this time. The U.S. cruises are designated with blue lines. Section lines S4P and A10 were occupied in FY 2011.

*Table 1. Sequence of Repeat Hydrography CO<sub>2</sub>/Tracer cruises for 2013–2015 and their previous occupations in 2003–2006.*

**Schedule of US CO<sub>2</sub>/CLIVAR Hydrography Lines** (as of 10/29/2012)

Dates	Cruise (for updated schedule, see <a href="#">cruise schedule</a> web page)	Days	Ports	Contact/Chief Scientist (overall coordinator: Jim Swift, SIO)	Ship
06/19/03-07/10/03	A16N, leg 1	22	Reykjavik-Madeira	Bullister, PMEL	Ron Brown
07/15/03-08/11/03	A16N, leg 2	28	Madeira - Natal, Brazil	Bullister, PMEL	Ron Brown
06/15/04-07/25/04	P2, leg 1	41	Yokohama-Honolulu	Robbins, SIO	Melville
07/28/04-08/27/04	P2, leg 2	32	Honolulu - San Diego	Swift, SIO	Melville
01/09/05-02/22/05	P16S	45	Wellington-Tahiti	Sloyan/Swift, WHOI/SIO	Revelle
01/11/05-02/26/05	A16S	48	Punta Arenas - Fortaleza	Wanninkhof, Doney; NOAA/AOML, WHOI	Ron Brown
02/13/06-03/03/06	P16N, leg 1	18	Tahiti-Honolulu	Sabine, NOAA/PMEL	Thompson
03/10/06-03/30/06	P16N, leg 2	21	Honolulu-Kodiak	Feely, NOAA/PMEL	Thompson
2013	A16N	60	Reykjavik-Madeira-Natal	Wanninkhof, NOAA/PMEL	Ron Brown

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<b>Dates</b>	<b>Cruise</b> (for updated schedule, see <a href="#">cruise schedule</a> web page)	<b>Days</b>	<b>Ports</b>	<b>Contact/Chief Scientist</b> (overall coordinator: Jim Swift, SIO)	<b>Ship</b>
2014	A16S	~45	Brazil-Argentina	In NOAA program	Ron Brown
2013	P02	62	Yokohama-San Diego	Pending	Revelle
2014	P16S	42		Pending	UNOLS
2015	P16N	68		In NOAA program	NOAA