APPENDIX

Underway CO_2 Measurements aboard the RVIB Palmer and Data Management of the Global VOS Program

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1. INTRODUCTION:

This report describes the progress made during the period September 1, 2005, through October 1, 2006 under the NOAA grant NA03OAR4320179 which is entitled "CICAR-Underway CO_2 measurements aboard the RVIB Palmer and data management of the global VOS program".

2. PROJECT OBJECTIVES:

The sea-air net flux of CO_2 is governed by the difference between pCO_2 in surface ocean water and that in the overlying atmosphere and by the gas transfer rate across the sea-air interface. The former depends primarily on the physical, chemical and biological processes occurring within the sea (such as seawater temperature, biological productivity and upwelling of deep waters), and the latter is controlled mainly by ocean-atmosphere interactions including wind-induced turbulence above and below the interface. The primary objective of this proposed investigation is to determine the space-time distribution of the sea-air pCO_2 difference. In conjunction with CO_2 gas transfer coefficients which are being improved by other scientific groups, a reliable net sea-air flux of CO_2 estimate over regional to global scales can be obtained using improved sea-air pCO_2 difference data. The results will give us an improved understanding of geographical and interannual variability of the sea-air CO_2 transfer flux.

We have operated successfully a semi-automated surface water pCO_2 system aboard the RVIB Nathaniel Palmer with vital operational assistance from the Raytheon Polar Support group. Since RVIB Palmer, an ice-breaking research vessel, is one of the few research ships which are operated in high latitude areas of the Southern Ocean even during winter months, our CO_2 program aboard this vessel allows us to make observations in hostile environments of the high latitude oceans, where deep and intermediate water masses are formed in winter. Although the Palmer spends a large fraction of year in the Weddell and Ross Seas, Antarctica, she has taken a few long trans-oceanic cruises over warmer oceans during the past three years. Therefore, in addition to seasonal and interannual observations over the high latitude Southern Oceans, we have been able to make measurements along long transects over other parts of global oceans. (see Fig. 1). We continue to acquire the surface ocean pCO_2 and associated SST and salinity data aboard the RVIB Palmer during this coming investigation period.

Our proposed work is a part of a consortium of investigators who operate their respective pCO_2 systems aboard other research and commercial vessels. The consortium includes the following groups: Richard Feely and his PMEL/NOAA group investigate mainly the equatorial Pacific aboard the NOAA ships; Rik Wanninkhof and his group at AOML/NOAA are primarily responsible for measurements over the Atlantic Ocean; Nick

Bates of Bermuda Institute of Ocean Sciences (BIOS), Bermuda, makes measurements in the western North Atlantic between Bermuda and N. America; Frank Millero and his group at the University of Miami investigates coastal waters and Caribbean. Pooling of the data among the participants will allow us to cover a large part of the global oceans. The data produced by the NOAA-supported groups as well as those from international collaborators from Japan, Iceland, Germany and France, are being processed into a single format at the Lamont-Doherty Observatory, and are made accessible to the participants via our web site (www.ldeo.columbia.edu/CO2). In addition, we have assembled a global surface water pCO_2 data from national and international investigators, and transferred it to the Carbon Dioxide Information and Analysis Center (CDIAC) at the Oak Ridge National Laboratory, for the permanent archive and ready access to the public. Research papers on the interpretation of the data are being written with collaborating researchers.

3. PROGRESS TO DATE:

3-a) Field Program aboard the RVIB Palmer:

The Lamont group is primarily responsible for the acquisition of the surface water pCO_2 data aboard the RVIB Palmer.

The locations of our data obtained aboard the RVIB Palmer since the beginning of this project in 2001 are shown in Figure 1. The dates, location and number of measurements, which have been added to the web site during the present funding period, are listed in Table 1. A total of about 425,000 surface water pCO_2 measurements were processed during the first 4.5 years of this project (January, 2001 – April, 2005), and additional 85,000 have been processed and added to our database during this 2005-06 funding period. The expeditions of the Palmer during 2005-06 were mostly in the high-latitude Pacific Sector of the Southern Ocean between latitudes 40°S and 75°S.

3-b) Upgrading of the underway pCO_2 system aboard the RVIB Palmer;

Upgrading of our pCO_2 system was started two years ago with the support from NOAA. It has been completed successfully for the past two years. More automation has been added, and the at-sea performance of the upgraded system has been excellent.

Figure 1- The locations of surface water pCO_2 measurements made aboard the RVIB Palmer since 2001. Colors indicate the years when the measurements were made. The 2005-06 observations are mostly in the New Zealand-Ross Sea and Drake Passage areas.

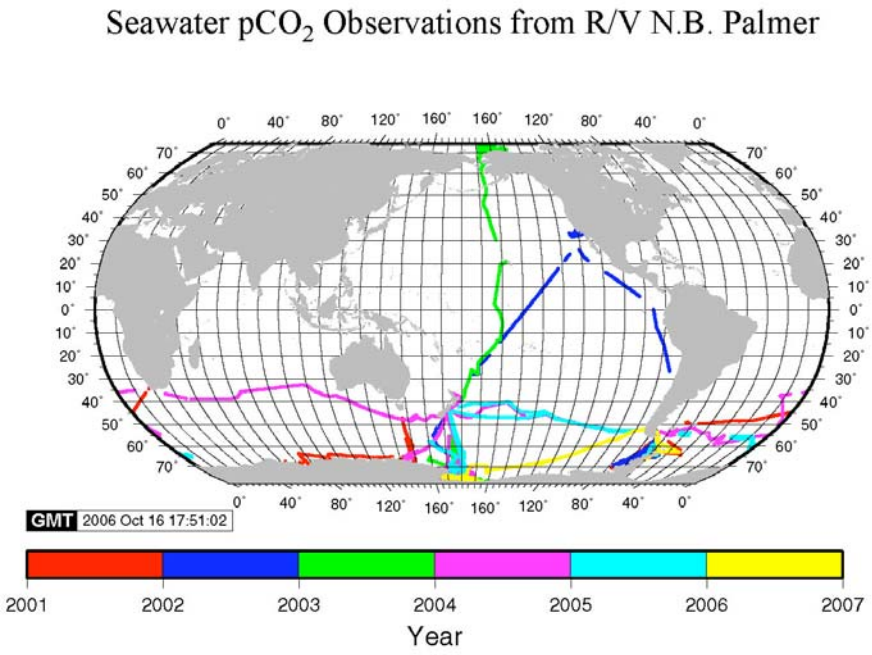

Table 1 – List of the RVIB N. B. Palmer expeditions and the number of surface water pCO_2 measurements obtained since the inception of this project in 2001 through May, 2005.

CRUISE DESIGNATION	PROJECT NAMES	DATES	NO. OF PCO_2 OBS.
NBP 01/1	East Antarctic Margin	30 Jan - 20 Mar 2001	12,300
NBP 01/2	South West Pacific	01-19 Apr 2001	6,541
NBP 01/3	SO-GLOBEC	23 Apr - 06 Jun 2001	20,446
NBP 01/4	SO-GLOBEC	21 Jul - 01 Sep 2001	14,960
NBP 01/5	Antarctic Peninsula	07 Sep - 26 Oct 2001	27,312
NBP 01/6	SO-GLOBEC	09 Nov- 01 Dec 2001	10,317
NBP 01/7	Antarctic Peninsula	05 Dec 01 - 12 Jan 02	22,627
NBP 02/1	Antarctic Peninsula	18 Jan - 04 Mar 02	24,542
NBP 02/2	GLOBEC III	09 Apr - 21 May 2002	25,327
NBP 02/4	GLOBEC IV	31 Jul - 09 Sep 2002	29,640
NBP 02/5	Transit along W. South America	23 Sep - 19 Oct 2002	8,317
NBP 02/6	USCG Inspection	30 Oct - 08 Nov 2002	6,732
NBP 02/7	Reconst. of Paleo S. Pac.	10 Nov - 06 Dec 2002	5,702
NBP 02/9	ANSLOPE, from Lyttleton to McMurdo	11 Dec 2002 - 03 Jan 2003	6,925
NBP 03/1	Ross Ice Shelf Survey	5 - 30 Jan 2003	8,062
NBP 03/1A	Ross Sea Research	2-20 Feb 2003	7,227

Table 1 – continued

CRUISE DESIGNATION	PROJECT NAMES	DATES	NO. OF PCO_2 OBS.

NBP 3/4A	Alaska North Slope	06 Jul - 18 Aug 2003	17,136
NBP 03/5	Southern Ocean near 175E	26 Oct - 13 Dec 2003	7,427
NBP 3/5A	Ross Sea Research	18 Dec 2003 - 02 Jan 2004	4,501
NBP 04/1	Western Ross Sea	20 Jan - 19 Feb 2004	12,299
NBP 04/2	ANSLOPE III	26 Feb - 11 Apr 2004	17,708
NBP 04/3	Transit New Zealand to Chile	16 Apr - 12 May 2004	9,463
NBP 04/4	Transit Chile to South Africa	18 May - 19 Jul 2004	22,755
NBP 04/6	Transit South Africa to New Zealand	27 Jul - 20 Aug 2004	14,227
NBP 04/8	ANSLOPE IV	06 Oct - 10 Dec 2004	21,958
NBP 04/9	Antarctic Research	15 Dec 2004 - 23 Jan 2005	14,443
NBP 05/1	Transit McMurdo to Chile	17 Jan - 16 Feb 2005	5,736
NBP 05/1B	Transit New Zealand to Chile	03 Mar - 24 Mar 2005	7,494
NBP 05/2	Tidewater Glaciers	31 Mar - 24 Apr 2005	8,235
TOTAL 2001-2005 (Previous Reporting Periods)			***424,170***
NBP 05/5	Antarctic Research	23 Jun - 14 Jul 2005	3,983
NBP 05/6	Maud Rise	20 Jul - 18 Sep 2005	19,066
NBP 05/7	Transit Chile to New Zealand	23 Sep - 21 Oct 2005	9,554
NBP 05/8	Biology Effects	26 Oct - 12 Dec 2005	18,387
NBP 06/1	Ecology of Phytoplankton	17 Dec 2005 - 30 Jan 2006	16,174
NBP 06/2	Paleo History of S. Pacific	02 Feb - 21 Feb 2006	7,740
NBP 06/3	Paleo History of Larsen Ice Shelf	12 Apr - 05 May 2006	10,005
TOTAL 2005-2006 (Current Reporting Period)			***84,909***

3-c) pCO_2 Data Processing and Management:

The Lamont group is responsible for quality control (QC) and management of the surface water pCO_2 data acquired by the members of the VOS consortium, so that the participants of the VOS program are able to access the data which are listed in an uniform format. For this purpose, we have established an open web site at the following URL: http://www.ldeo.columbia.edu/CO2. The site provides not only the numerical data, but also maps showing the ship's tracks for each data file. The new data will be accessible only to the VOS participants for a set period agreed on by the PIs, and will be sent to the Carbon Dioxide Information and Analysis Center (CDIAC), Oak Ridge, TN, for the permanent archiving and distribution to the public.

3-d) Data from the NSF's LTRE Program in the Drake Passage Area:

As a part of the VOS program, we processed and added to our database the measurements made during cruises of the R/V Laurence M. Gould, which is supported by NSF as a part of the Long-Term Research in Environmental Biology (LTRE) program. For the 2005-06 period, the Gould transited across the Drake Passage every month (Fig. 2), and these observations are ideally suited to document seasonal variability in the area. During the present reporting period of 2005-06, about 100,000 new surface water pCO_2 data have been added to our database (Table 2). A total of 284,000 surface water pCO_2 data have been obtained since the beginning of the program in 2002 (Table 2).

Figure 2 – The locations of the surface water pCO_2 measurements obtained aboard the

RV Gould during this project, March, 2002 through August, 2006. The years of the measurements are color coded.

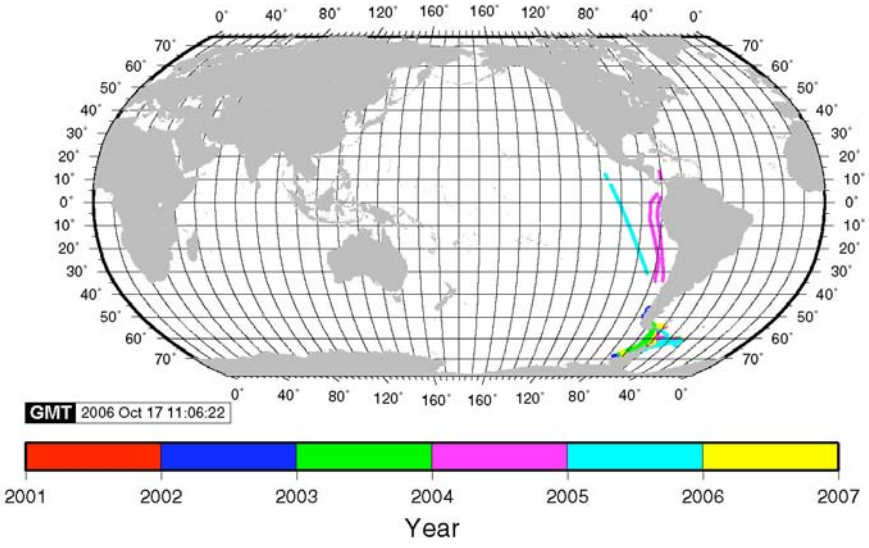

Table 2 – List of the R/V Laurence M. Gould expeditions and the number of surface water pCO_2 observations added to the VOS database since the inception of this project in 2002.

Cruise No.	Project Name	Dates	No. Obs.	Annual Total
2002				
02/1	Antarctic Penninsula	07 - 18 Mar 02	2731	
02/2	Palmer Shuttle	22 Mar - 02 Apr 02	1879	
02/3	GLOBEC III	07 Apr - 20 May 2002	8659	
02/4	Palmer Shuttle	21 Jun - 22 Jul 2002	4815	
02/5	GLOBEC IV	29 Jul - 18 Sep 2002	6787	
02/6	Palmer Shuttle	23 Sep - 07 Oct 2002	2332	
02/8	Open Cape Shirreff	03 Nov - 17 Nov 2002	3137	
02/9	Scotia Arc GPS Project	23 Nov - 23 Dec 2002	8209	**38,549**
2003				
03/1	LTER	31 Dec 2002 - 08 Feb 2003	13831	
03/2	GLOBEC	13 Feb - 07 Mar 2003	4167	
03/2	Palmer Shuttle	12 Mar - 29 Mar 2003	5721	
03/4	Biological Research	05 Apr - 07 May 2003	9334	
03/4A	Biological Research	10 May - 05 Jun 2003	4629	
03/5	Palmer Shuttle	15 Jun - 29 Jun 2003	2618	
03/5A	Palmer Shuttle	15 Aug - 04 Sep 2003	5774	
03/6	Palmer Shuttle	23 Sep - 06 Oct 2003	2495	
03/7	Palmer Shuttle	10 - 22 Oct 2003	3450	
03/8	Palmer Shuttle	07 - 18 Nov 2003	3758	
03/9	Antarctic Penn Research	23 Nov - 29 Dec 2003	12288	**68,065**

Table 2 (Continued)

Cruise No.	Project Name	Dates	No. Obs.	Annual Total
2004				
04/1	Antarctic Penn Research	01 Jan - 07 Feb 2004	12556	
04/2	Antarctic Penn Research	12 Feb - 24 Mar 2004	14222	
04/3	Antarctic Penn Research	28 Mar - 12 Apr 2004	2100	
04/4	Antarctic Penn Research	16 Apr - 10 May 2004	5510	
04/5	Antarctic Penn Research	14 - 24 May 2004	3797	
04/6	Palmer Shuttle	30 May - 09 Jun 2004	2609	
04/7	Palmer Shuttle	13 - 27 Jun 2004	2835	
04/8	Transit Chile to Louisiana	06-16 Jul 2004	3849	
04/10	Transit Louisiana to Chile	25 Aug - 12 Sep 2004	4539	(Inside EEZ)
04/11	Palmer Shuttle	25 Sep - 12 Oct 2004	3165	
04/12	Palmer Shuttle	17 - 30 Oct 2004	2091	
04/13	Palmer Shuttle	08 - 18 Nov 2004	4014	
04/14	Palmer Shuttle	24 Nov - 31 Dec 2004	10916	**72,203**
2005				
05/1	LTER Palmer Penn.	31 Dec 2004 - 05 Feb 2005	14091	
05/2	Paleohistory of Larsen Shelf	11 Feb - 12 Mar 2005	11411	
05/3	Palmer Shuttle	15 Mar - 28 Mar 2005	2398	
05/4	Acoustic Census in W Antarc.	02 Apr - 15 Apr 2005	1377	
05/5	Evolution of Antarctic Fishes	20 Apr - 12 May 2005	3674	
05/6	Evolution of Antarctic Fishes	18 May - 09 Jun 2005	3126	
05/7	Tracers, Bio and Gas Exch.	13 Jun - 28 Jun 2005	2837	
05/8	Hazardous Waste Pickup	03 Jul - 31 Jul 2005	4440	
05/9	Palmer Shuttle	16 Aug - 02 Sep 2005	3876	
05/11	Support of Palmer Station	17 Sep - 29 Sep 2005	2436	
05/12	Support of Palmer Station	23 Oct - 03 Nov 2005	3032	
05/14	Support of Palmer Station	08 Nov - 22 Nov 2005	3900	
05/15	Support of Palmer Station	27 Nov - 26 Dec 2005	6462	
				63,060
2006				
06/1	Support of Palmer Station	02 Jan - 08 Feb 2006	10538	
06/2	Support of Palmer Station	14 Feb - 16 Mar 2006	8137	
06/3	Support of Palmer Station	21 Mar - 04 Apr 20006	3072	
06/4	Support of Palmer Station	26 Apr - 07 May 2006	2601	
06/5	Support of Palmer Station	14 May - 15 Jun 2006	11145	
06/6	Support of Palmer Station	20 Jun - 02 Jul 2006	3840	
06/8	Support of Palmer Station	06 Aug - 16 Aug 2006	2932	
				42,265
	Grand Total			**284,142**

3-e) Data from the NOAA's AOML and PMEL:

During the current funding period, we have received a large number of surface water pCO_2 data from the AOML group of NOAA. These data have been examined at Lamont and added to our database. The cruise designations, dates and the number of pCO_2 measurements obtained are listed in Table 3. Since the location map for these NOAA data are shown in the AOML and PMEL CO_2 websites, they are not duplicated here. For the current funding period, we have received from the AOML/NOAA (R.

Wanninkhof PI), about 33,000 pCO_2 observations made aboard the R/V Ron Brown and 112,000 made during the Explorers of Seas program. These have been quality-controlled and added to the database of about 275,000 pCO_2 observations obtained during previous funding periods.

No new data for the PMEL program (R. A. Feely and C. Cosca) aboard the Ka'imimoana and for the Bermuda program (N. Bates) have been received for the 2005-06 period.

Table 3 - Surface water pCO_2 data received from the AOML/NOAA and PMEL/NOAA groups for quality control and archiving.

Previous Reporting Periods (2002-2004) :

SHIP	CRUISE NO.	PROJECT NAME	DATES	pCO_2 Obs.
AOML/NOAA				
Ron Brown	RB-04-01	NTAS Mooring	12-24 Feb 2004	2,301
Ron Brown	RB-04-02A	Saharan Dust Leg A	29 Feb-15 Mar 2004	2,539
Ron Brown	RB-04-02B	Saharan Dust Leg B	17-26 Mar 2004	1,776
Ron Brown	RB-04-03	Windward Passage	29 Mar-12 Apr 2004	2,668
Ron Brown	RB-04-04A	Ocean Expl. Transit	29 Apr-03 May 2004	612
Ron Brown	RB-04-04B	Ocean Expl. Mount.	08-24 May 2004	2,818
Ron Brown	RB-04-05	Ocean Expl. Titanic	27 May-10 Jun 2004	2,486
Ron Brown	RB-04-06	NURP Deep Sea Corals	17-28 Jun 2004	2,032
Ron Brown	RB-04-07A	New England Air Qual	05-23 Jul 2004	3,347
Ron Brown	RB-04-07B	New England Air Qual	26 Jul - 12 Aug 2004	2,920
Ron Brown	RB-05-01A	CLIVAR A16S Trans.	20 Dec 04 - 05 Jan 05	1,332
Ron Brown	RB-05-1B	Clivar A16S	11 Jan - 22 Feb 2005	7.829
Subtotal				**32,363**
Expl. Seas*	EX0401	Weekly Cruises in Caribbean Sea and Western Trop. Atlantic	From 02 March 2002 through 03 April 2005	
		2002: 30 Files		39,262
		2003: 39 Files		76,322
		2004: 50 Files		82,025
Expl. Seas	EX0517	2005: 28 Files		44,834
Subtotal				**242,443**
PMEL/NOAA				
Ka'imimoana	KA2004_1	TAO-TOGA Array	27 Mar-24 Apr 2004	3,696
Ka'imimoana	KA2004_2	TAO-TOGA Array	28 Apr-31 May 2004	3,589
Ka'imimoana	KA2004_3	TAO-TOGA Array	18 Jun-14 Jul 2004	2,999
Ka'imimoana	KA2004_4	TAO-TOGA Array	12 Jul-15 Aug 2004	3,466
Subtotal				**13,742**

*/ Cruise Ship "Explorer of the Seas"

Table 3 – continued
2005-2006 Period:

SHIP	CRUISE NO.	PROJECT NAME	DATES	pCO_2 Obs.
AOML/NOAA				
Ron Brown	RB-05-01C	Clivar A16S Transit Leg C	01-03 Mar 2005	766
Ron Brown	RB-05-02	Plueddermann Moorings	10-18 Mar 2005	1,560
Ron Brown	RB-05-03A	Ocean Explorations Lost City	18 Jul-03 Aug 2005	1,406
Ron Brown	RB-05-03B	Ocean Explorations Stepping Stone	10 Aug-03 Sep 2005	2,926
Ron Brown	RB-05-03SB	SeaBeam Patch Test	12-15 Jul 2005	612
Ron Brown	RB-05-03T	Ocean Explorations Transit	06-09 Sep 2005	in prep.
Ron Brown	RB-05-04	Western Boundary Time Series	11-24 Sep 2005	2,332
Ron Brown	RB-05-05	Stratus Mooring	04-20 Oct 2005	2,805
Ron Brown	RB-05-06	TAO Cruise	27 Oct-25 Nov 2005	5,169
Subtotal				**17,576**
Ron Brown	RB-06-01	Plueddermann Moorings	16 Feb- 03 Mar 2006	2,697
Ron Brown	RB-06-02	Western Boundary Time Series	12-28 Mar 2006	3,056
Ron Brown	RB-06-03	Ocean Explorations	11-30 Apr 2006	3,461
Ron Brown	RB-06-04	Tsunami Source Potential in the Caribbean	03-19 May 2006	3,035
Ron Brown	RB-06-05a	AMMA African Monsoon Sahara Dust	27 May - 17 Jun 2006	3,993
Subtotal				**16,224**
Expl. Seas*	Ex0501-Ex0548	Weekly Cruises in Caribbean Sea and Western Trop. Atlantic 44 Files	From24 Jan 2005 through 11 Dec 2005	67,231
Expl. Seas*	Ex0549-EX0636	Weekly Cruises in Caribbean Sea and Western Trop. Atlantic 31 Files	From 12 Dec 2005 through 11 Aug 2006	45,037
Subtotal				**112,268**
PMEL/NOAA				
No Additional Files				
Subtotal				**0**

*/ Cruise Ship “Explorer of the Seas” in 2005 15 files were added for total of 44 files.

4. DATA DISTRIBUTION, ANALYSIS AND SYNTHESIS:

During this funding period, we completed two major data sets for public release. First, we have assembled a surface water pCO_2 database for the global oceans, and submitted it to the CDIAC, Oak Ridge, TN, for archiving and distribution to the public. This data set is about 450 megabytes long and contains about 3 million surface water pCO_2 measurements and related observations (such as temperature, salinity and pressure) made by a large number of national and international investigators. This is the most extensive and complete surface water pCO_2 dataset that has ever been assembled. It covers the period 1968-2006, and includes open ocean data as well as coastal water data. The data assembled are only those measured using equilibrator-CO_2 analyzer systems, and have been quality controlled based upon the stability of the system performance, reliability of calibrations for CO_2 analysis and internal consistency of data. The overall uncertainty of the pCO_2 values listed are estimated to be ± 2.5 μatm on the average.

Second, we have compiled a dataset for pCO_2 measurements made within 800 km around North America and used the results for the preparation of the SOCCR report (Chavez and Takahashi, in press). The database thus assembled has been distributed to all the participants of the Coastal Ocean Carbon Cycle Workshop convened at PMEL in Seattle, WA, October, 2006. Our analysis shows that the coastal waters within 80 km for the shore of North America emits CO_2 at a mean rate of 19 (± 22) Tera grams of carbon per year (Tera grams = 10^{12} grams = million metric tons). This is about 1% of the mean annual ocean uptake rate of 2 Peta grams of carbon per year (Peta grams = 10^{15} grams = billion metric tons).

In collaboration with other researchers, we have analyzed the data and the results have been published in scientific journals. A list of 2005-06 publications that are based upon the surface water observations made during this and previous grants is provided below.

Published in 2005-06:

Rangama, Y., Boutin, J., Etcheto, J., Merlivat, L., Takahashi, T., Delille, B., Frankingnoulle, M. and Bakker, D. C. E. (2005). Variability of the air-sea CO_2 flux inferred from shipboard and satellite measurements in the Southern Ocean south of Tasmania and New Zealand. Jour. Geophys. Res., 110, C09005, doi:10.1029/2004JC002619, 2005.

Li, Z., Adamec, D., Takahashi, T. and Sutherland, S. C. (2005). Global autocorrelation scales of the partial pressure of oceanic CO_2. Jour. Geophys. Res., 110, C08002, doi:10.1029/2004/C002723.

Patra, P. K., Maksyutov, S., Ishizawa, M., Nakazawa, T., Takahashi, T. and Ukita, J. (2005). Interannual and decadal changes in the sea-air CO_2 flux from atmospheric CO_2 inverse modeling. Glob. Biogeochem. Cycles, 19, GB4013, doi:10.1029/2004GB002257, 2005

Takahashi, T., S. C. Sutherland, R. A. Feely, and R. Wanninkhof (2006), Decadal change of the surface water pCO_2 in the North Pacific: A synthesis of 35 years of observations, J. Geophys. Res., 111, C07S05, doi:10.1029/2005JC003074.

Feely, R. A., T. Takahashi, R. Wanninkhof, M. J. McPhaden, C. E. Cosca, S. C. Sutherland, and M. Carr (2006), Decadal variability of the air-sea CO_2 fluxes in the equatorial Pacific Ocean, J. Geophys. Res., 111, C08S90, doi:10.1029/2005JC003129.

McKinley, G. A., Takahashi, T., Butenhuis, E., Chai, F., Christian, J. R., Doney, S. C., Le Quere, C., Lima, I., Murtugudde, R., Shi, L. and Wetzel, P. (2006). North Pacific carbon cycle response to climate variability on seasonal to decadal time scales. Jour. Geophys. Res., 111, C07S06, doi:.10.1029/2005JC003173.

Chavez, F. and Takahashi, T. (in press). Coastal oceans, Chapter 15, in the State of Carbon Cycle Report (SOCCR), 2004-2006, Inter Government Agencies.

5. FUTURE WORK:

Two at-sea projects are being planned: a) R/V Marcus Langseth of LDEO and b) Icebreaker Healy of USCG.

a) Program aboard the R/V M. Langseth:

Lamont-Doherty Earth Observatory has acquired a new research vessel named R/V Marcus Langseth (about 2000 tons) with supporting funds from the NSF, and she will start her research cruises in early 2007. We are planning to put together an underway pCO_2 system using available spare parts supplemented with some new purchases. The pCO_2 system will be operational in early 2007, and will be added to the VOS program. R/V Langseth is operated primarily as a marine geophysics ship in various parts of the global oceans. Often, she will stay in a small area over deep oceans as well as over coastal areas for a month for detailed geophysical survey. This will give us an opportunity to observe local time-variability in surface water pCO_2 over different parts of the oceans.

b) Program aboard the Icebreaker Healy of USCG:

In spite of the fact that the oceanographic conditions in the Arctic have been changing rapidly, CO_2 observations are extremely scarce especially during winter months. We do not know whether the Arctic Sea is a sink or source for atmospheric CO2 on the annual average. We have started asking the USCG the availability of space aboard the Icebreaker Healy for our pCO2 system. New funding will be sought for such a project if the USCG responds favorably to our request.