Report to the Ocean Carbon and Biogeochemistry Scientific Steering Committee

submitted by

The Ocean Time-Series Advisory Committee
composed of Craig Carlson, Steve Emerson, Ken Johnson, Dennis McGillicuddy, Chris Sabine and Deborah Bronk (chair)

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Purpose:

- To review the parameters currently measured at three U.S. ocean time-series sites - HOT, BATS, and CARIACO.
- To determine whether core parameters, as defined by the August 1996 report of the U.S. JGOFS Time-Series Oversight Committee, are currently measured using comparable methods at the three sites under review.

At the end of August 2007, the Ocean Time-Series Advisory Committee (OTSAC) distributed a three-part questionnaire to contacts at the three ocean time-series under review: Mike Lomas (BATS), Matt Church (HOT), and Frank Muller-Karger (CARIACO). Parts I and II were designed to collect information on a wide array of chemical, physical, and biological parameters that were measured currently (Part I) as well as what was proposed in the 2007 resubmission (Part II). Part III included a number of general questions regarding the time-series sites and their needs.

Responses were received in October and reviewed by the committee. There is a great deal of useful information and suggestions for improvement in the responses that the committee will take under advisement. Here, as a first step in that evaluation, we provide an overview of where the three sites currently stand with respect to the suite of core measurements as defined by the 1996 report. That report listed the following 20 parameters as core measurements:

Temperature	Silicate
Depth	Dissolved organic carbon (DOC)
Conductivity (salinity)	Total dissolved nitrogen (TDN)
Dissolved oxygen	Particulate carbon (PC)
Dissolved inorganic carbon	Particulate nitrogen (PN)
Total alkalinity	Chlorophyll a, b, and c
pH	Bacteria and cyanobacteria abundance
Nitrite	Primary production
Nitrate	Bacterial production
Soluble reactive phosphorus (SRP)	Carbon and nitrogen flux

A summary of the responses to Part I and II is presented in Table 1. The core parameters listed above are highlighted in green in the table.

Based on the questionnaire responses, we found that, in general, HOT, BATS, and CARIACO are in good agreement with the 1996 core measurements. The following issues were identified for future consideration:

1. Overall, the programs share similar depth coverage with one exception, in the case of BATS, DIC and total alkalinity measurements are only made in the upper 500 m.

2. Carbonate system: CARIACO does not measure DIC directly, but calculates it from pH and total alkalinity. BATS does not measure pH directly, but could calculate it from total alkalinity and DIC.

3. Nitrite: All sites measure combined nitrate plus nitrite. In addition, BATS and CARIACO also measure nitrite; HOT does not measure nitrite independently.

4. Terminology: One issue that came up repeatedly was differences in terminology between the sites with respect to dissolved and particulate pools. For example, referring to a measurement as dissolved when it had not been filtered.

5. Particulate C (and PN): BATS measures particulate organic carbon (POC) after acidifying samples to remove particulate inorganic carbon (PIC). HOT and CARIACO do not.

6. Bacterial production: BATS uses the thymidine method (a measure of bacterial DNA production) and CARIACO uses the leucine method (a measure of protein/biomass production). HOT does not currently measure bacterial production.

7. Carbon and nitrogen flux: CARIACO uses deep traps. Both BATS and HOT use PIT traps but process them differently with respect to the removal of swimmers: BATS picks out swimmers while HOT uses a screen to remove them. This difference was highlighted as a concern in the 1996 report, which recommended that it was essential to "compare directly the methods used by the two programs [HOT and BATS] for 'swimmer' removal."

In conclusion we acknowledge the researchers who coordinated the site information presented here – Mike Lomas (BATS), Frank Muller-Karger (CARIACO), and Matt Church, Dave Karl, and Roger Lukas (HOT). We are grateful for their attention to detail and timely response to questions. They are clearly committed to maintaining excellence in these valuable research programs. As the oceanographic community continues to wrestle with questions of global scale change the value of these time-series will only increase.

Table 1. Final Time-Series Measurement Summary

Core parameters, as defined by the 1996 US JGOFS Time-Series Oversight Committee, are highlighted in green. Each site was asked to identify those variables they considered core variables (Considered core?) and whether the variable was currently being measured. A "1" indicates that the variable was considered core and/or was measured. A core score of 3 indicates that all three time-series sites considered the variable a core measurement. A measured score of 3 indicates that all three sites currently measure the variable. See the comment column for details on substantive differences between the sites.

	BATS	CARIACO	HOT
Cruises/ yr	15	12	10
Depth range (m)	4200	1310	4750
DATA Storage/ Access	http://bats.bios.edu/	http://www.imars.usf.edu/CAR/index.html	http://hahana.soest.hawaii.edu

Variable	JGOFS 1996 list of Core	BATS Considered Core? (1=yes)	BATS Measured (1=yes)	BATS Depths (m)	CARIACO Considered Core? (1=yes)	CARIACO Measured (1=yes)	CARIACO Depths (m)	HOT Considered Core? (1=yes)	HOT Measured (1=yes)	HOT Depths (m)	Did PIs list as core? Core Score	Do they measure it? Measured Score	Method Differences	Comments
1. Continuous Measurements														
Depth (Pressure)	yes	1	1	0-4200	1	1	0-1310	1	1	0-4700	3	3		
Temperature	yes	1	1	0-4200	1	1	0-1310	1	1	0-4700	3	3		
Conductivity (Salinity)	yes	1	1	0-4200	1	1	0-1310	1	1	0-4700	3	3		
Dissolved Oxygen	yes	1	1	0-4200	1	1	0-1310	1	1	0-4700	3	3		
Fluorescence (Chloropigment)		1	1	0-4200	1	1	0-1310	1	1	0-4700	3	3		
Beam Transmission		1	1	0-4200	1	1	0-1310	1	1	0-1000	3	3	yes	HOT uses AC-9 spectral absorption, rather than transmissometer
2. Optical Measurements														Optical measurement for BATS provided collected by the Bermuda Bio-Optics program (BBOP) coordinated by Norm Nelson and Dave Siegel.
Incident Irradiance (PAR)			1	surface		1	surface	1	1	surface	1	3		
Surface Downwelling Irradiance			1	5-120m		1	surface	1	1	surface	1	3	yes	
Upwelling Radiance and Downwelling Irradiance			1	5-120m		1	0-70	1	1	0-175	1	3		
Fast Repetition Rate Fluorometry								1	1	0-250	1	1		
AC-9 Spectral absorption								1	1	0-250	1	1		
3. Water Column Chemical Measurements														
Oxygen		1	1	0-4200	1	1	0-400	1	1	0-4750				
Salinity		1	1	0-4200	1	1	0-1310	1	1	0-4750				
DIC	yes	1	1	0-500			0-1310	1	1	0-4750	2	2	yes	CARIACO does not measure DIC directly, but calculates from pH and TA.
Total Alkalinity (TA)	yes	1	1	0-500	1	1	0-1310	1	1	0-4750	3	3		
pH	yes	0	0		1	1	0-1310	1	1	0-4750	2	2	yes	BATS does not measure pH directly, but could calculate it from DIC and TA.
Nitrite	yes	1	1	0-4200	1	1	0-1310	0	0		2	2		
Nitrate Plus Nitrite	yes	1	1	0-4200	1	1	0-1310	1	1	0-4750	3	3		
Ammonium					1	1	0-1310				1	1		
Soluble Reactive Phosphorus (SRP)	yes	1	1	0-4200	1	1	0-1310	1	1	0-4750	3	3		
Silicate	yes	1	1	0-4200	1	1	0-1310	1	1	0-4750	3	3		
Low Level Nitrate Plus Nitrite								1	1	0-200	1	1		
Low-Level SRP		1	1	0-250				1	1	0-200	2	2		
Fe								1	1	surface	1	1	yes	HOT collects TFe (not filtered) samples for Ed Boyle on each cruise as an ancillary investigator measurement.

Variable	JGOFS 1996 list of Core	BATS Considered Core? (1=yes)	Measured (1=yes)	Depths (m)	CARIACO Considered Core? (1=yes)	Measured (1=yes)	Depths (m)	HOT Considered Core? (1=yes)	Measured (1=yes)	Depths (m)	Did PIs list as core? Core Score	Do they measure it? Measured Score	Method Differences	Comments
Dissovled organic carbon (DOC)	yes	1	1	0-4200	1	1	0-1310	1	1	0-4750	3	3		
Total dissolved nitrogen (TDN)	yes	1	1	0-4200		1	0-1310	1	1	0-1000	2	3	yes	BATS - HTC, HOT - UV oxidatation, CARIACO - persulfate oxidation. HOT does not filter.
TDP			1	0-500		1	0-1310	1	1	0-1000	1	3		HOT does not filter.
Particulate carbon (PC)	yes	1	1	0-1000		1	0-1310	1	1	0-350	2	3	yes	BATS measures POC after removing PIC with acid fuming. CARIACO and HOT do not.
Particulate nitrogen (PN)	yes	1	1	0-1000		1	0-1310	1	1	0-350	2	3	yes	PN samples are run with the same method as PC.
PP			1	0-500		1	0-1310	1	1	0-350	1	3	yes	
Particulate Biogenic Silica		1	1	0-1000			0-1310	1	1	0-175	2	2		
N_2O						1	0-1310	1	1	0-1000	1	2		HOT has proposed CH_4 and N_2O measurements in the renewal. It is not currently a core measurement.
CH_4						1	0-1310	1	1	0-1000	1	2		HOT has proposed CH_4 and N_2O measurements in the renewal. It is not currently a core measurement.
4. Biomass Measurements														
Fluorimetric Chlorophyll a & Pheopigments		1	1	0-250	1	1	0-100	1	1	0-175	3	3		
Chlorophyll a, b & c	yes	1	1	0-250		1	0-100		1	0-175	1	3		HOT measures pigments by HPLC and chlorophyll by fluoresence (Turner 10-AU; note TD700 not a core measurement). BATS and CARIACO use HPLC.
HPLC Pigments		1	1	0-250		1	0-100	1	1	0-175	2	3		
Phycoerythrin						1	0-100		1	0-175	0	2		
Adenosine 5'-Triphosphate									1	0-350	0	1		
Bacteria and Cyanobacteria	yes	1	1	0-800		1	0-1310	1	1	0-175	2	3	yes	HOT - flow cytometry, CARIACO and BATS - epifluorescence microscopy
Mesozooplankton		1	1	0-200		0		1	1	0-175	2	2		

Variable	JGOFS 1996 list of Core	BATS Considered Core? (1=yes)	Measured (1=yes)	Depths (m)	CARIACO Considered Core? (1=yes)	Measured (1=yes)	Depths (m)	HOT Considered Core? (1=yes)	Measured (1=yes)	Depths (m)	Did PIs list as core? Core Score	Do they measure it? Measured Score	Method Differences	Comments
5. C Assimilation and Particle Flux														
Primary Production	yes	1	1	0-140	1	1	0-100	1	1	5-125	3	3		
Bacterial Production	yes	1	1	0-1000	1	1	0-1310				2	2	yes	Thymidine incorporation used at BATS, Leucine at CARIACO, nothing listed at HOT.
C and N Flux	yes	1	1	150,200,300	1	1	125 , 1310	1	1	150	3	3	yes	BATS (picked) and HOT (screened) use PIT traps but proces them slightly differently; CARIACO uses deep traps. HOT measures isotopes (^{15}N and ^{13}C) on trap material.
P Flux			1	150,200,300	1	1	125 , 1310	1	1	150	2	3		
Si Flux					1	1	125 , 1310	1	1	150	2	2		
N_2 fixation								1	1	5-125				In the renewal proposal, HOT has proposed to measure $^{15}N_2$ fixation on an *in situ* array
6. Currents														
Shipboard ADCP			1					1	1	0-300	1	2		
Moored ADCP					1	1	30-400				1	1		
Lowered Acoustic Doppler Current Profiler					1	1	10-1310				1	1		
7. Instrument Towfish														
Pressure (Depth)											0	0		
Temperature											0	0		
Conductivity (Salinity)											0	0		
Fluorescence											0	0		
8. Bow Intake System														
Temperature			1					1	1		1	2		
Conductivity (Salinity)			1					1	1		1	2		
pCO2			1					1	1		1	2		
Fluorescence (Chloropigment)			1					1	1		1	2		
9. Moored Instruments														
Inverted Echo Sounder Network (Dynamic height)											0	0		
Sequencing Sediment Traps (Particle Flux)			1	500; 1500; 3000	1	1	125 , 1310	1	1	2800, 4000	2	3		BATS deep traps maintained by Maureen Conte as part of OFP.
Physical-Biogeochemical Mooring											0	0		
10. Autonomous Vehicles														
Sea Gliders									1	0-1000	0	1		Proposed in renewal