updated 18 June 2021

Cruise Report for GEOTRACES GApr13-Leg 4 (BAIT-IV, AE 1930, BATS 365)

R/V *Atlantic Explorer*, Bermuda Atlantic Time-series Study Region, 15-21 November 2019

Overview of BAIT Project (GEOTRACES Process Study GApr13):

Jointly funded by the US National Science Foundation and the UK Natural Environment Research Council, the Bermuda Atlantic Iron Time-series (BAIT) project aims to combine field data from the Bermuda Atlantic Time-series Study (BATS) region with an established, state-of-the-art ocean biogeochemical model in order to constrain the pools, fluxes and physicochemical transformations that control the oceanic distribution of dissolved iron (DFe), thereby advancing our ability to model the ocean iron cycle and project its sensitivity to future change. Specifically, seasonally resolved data on the vertical (upper 2,000 m) and lateral (tens of km) distributions of particulate, dissolved, colloidal, soluble and ligand-bound iron species will be obtained from the chemical analysis of water column samples collected during five cruises, spanning a full annual cycles, shared with the monthly BATS program cruises. These data, along with ancillary data from then BATS program, will be used to test and inform numerical modeling experiments, and thus derive an improved understanding of the mechanisms that control the distribution and dynamics of DFe in the oceanic water column.

BAIT-IV Cruise Synopsis:

GEOTRACES cruise GApr13-Leg 4 (BAIT-IV) was piggybacked on BATS cruise 365, with an extra two sea days added to the BATS program cruise to accommodate the BAIT program activities and another ancillary project (PIs Curry, Grundle and Lomas). Participants on GApr13-Leg 4 were were Peter Sedwick (Old Dominion University, BAIT PI), Rod Johnson (Bermuda Institute of Ocean Sciences, Chief Scientist, BATS PI, BAIT co-PI), Salvatore Caprara (University of South Florida, postdoctoral fellow), Lauren Chaco (Northeastern University, graduate student), Dan Ohnemus (Skidaway Institute of Oceanography, BAIT co-PI), and Bettina Sohst (Old Dominion University, research specialist).

Sailing was delayed by one day to allow for repair of the MASH2k winch by an engineer who was dispatched from the UNOLS winch pool. Weather at departure on 15 November was a mix of sun and showers with moderate northeast winds and seas; sea conditions improved on 16 November and then began deteriorating with increasing winds and seas through 17-18 November, with no work possible due to rough weather during the early portion of 18 November. Winds and seas continued moderate to rough for the remainder of the cruise. The BAIT project sampling followed a similar sampling strategy to that used on BAIT-I through BAIT-III, with no need for near-surface sampling using the small boat given the deeper mixed layer (~50-80 m depth). The rough weather pushed our sampling at the BATS Spatial Stations to the latter part of the cruise. Sampling was generally successful, despite minor damage to the trace metal CTD carousel due to a line becoming snagged (the damage was repaired at sea). The crew and marine technicians aboard R/V *Atlantic Explorer*, and the BATS program team, provided invaluable assistance.

During the cruise period, the Mercator Ocean model forecasts suggested that the BATS area was located between a large anticyclonic eddy centered northeast of Bermuda and a small cyclonic

feature centered to the southeast of the BATS region (Fig. 1), driving a surface circulation from northeast to west within the BATS region. This Mercator analysis was generally consistent with shipboard ADCP and hydrographic observations, as well as sediment-trap drift during the cruise, which indicated surface flow shifting towards an east-to-west direction.

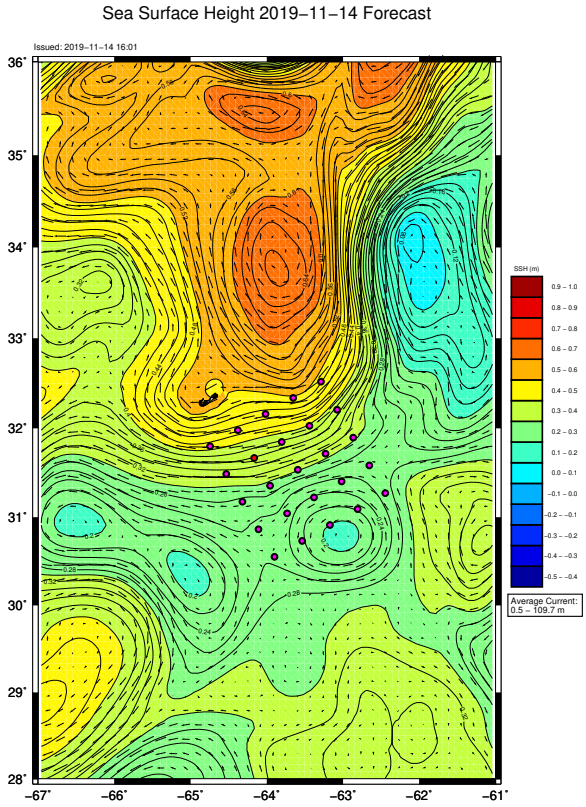

Figure 1. *Mercator Ocean model sea surface height forecast for BATS region, 14 November 2019.*

A test/bottle soak cast of the trace-metal CTD (TMCTD) rosette was performed at Hydrostation S, with 0.2-µm filtered seawater samples taken from bottles closed at nominal depths in the range of 146-168 m for use as matrix water by S. Caprara. The BAIT water column sampling (TMCTD casts and McLane pump deployments) were then undertaken at BATS and at BATS Spatial Stations #13 and #1 to provide information on mesoscale lateral gradients. Due to time constraints, the TMCTD sampling at BATS Spatial Station #1 was limited to a maximum target depth of 1000 m (which was not achieved, due to the wire angle in the rough sea conditions), and the McLane pumps were not able to be deployed at that station.

Following the sampling strategy used on the previous BAIT cruises, nominal TMCTD sampling depths were selected between 20 m and 1700 m (limited by available line on winch and wire angle), and included the subsurface chlorophyll maximum (SCM), the dissolved oxygen minimum, and density surfaces of 26.1, 26.3 and 26.6 sigma, as estimated from immediately preceding BATS CTD casts. Nominal McLane pump deployment depths included those used by

Mak Saito's ongoing sampling program (30 m, SCM, 150 m, 200 m), and other depths of interest where possible. Surface mixed layers were generally in the 50-80 m thickness range (defined as the depth at which temperature changes by 0.2°C relative to a 10 m reference depth, after de Boyer Montegut et al. 2004). The depth of the SCM typically varied between ~70-100 m.

Reference:

de Boyer Montégut, C., Madec, G., Fischer, A.S., Lazar, A. and Iudicone, D., 2004. Mixed layer depth over the global ocean: An examination of profile data and a profile-based climatology. *Journal of Geophysical Research: Oceans*, 109(C12).

Summary of BAIT-IV Sampling Operations:
(all sampling depths are nominal)

1). Test/bottle soak TMCTD cast, TM-000
Recovered 00:22 GMT, 16 Nov 2019, near 32°11.482'N, 64°29.186'W (Hydrostation S)
Deployed to ~1700 m depth, bottles closed sequentially at 168-146 m depth; 0.2-µm filtered composite sample taken for matrix water for USF group

2). TMCTD cast for particles, TMP-001
Recovered 01:16 GMT, 17 Nov 2019, at 31°39.483'N, 64°10.150'W (near BATS)
Samples collected at 20, 30, 50, 75, 90, 150, 200, 294, 538, 840, 1000, 1700 m depth
All bottles filtered through 0.4 µm membranes for particles

3). TMCTD cast for dissolved species, TM-001
Recovered 05:25 GMT, 17 Nov 2019, at 31°39.579'N, 64°11.205'W (near BATS)
Samples collected at 20, 30, 50, 75, 90, 150, 200, 294, 538, 840, 1000, 1700 m depth
Subsamples taken for dissolved Fe, soluble Fe, dissolved Co, dissolved Al, dissolved Fe isotopes, dissolved Fe ligands, soluble Fe ligands (20, 90, 200 m), cellular metals (20, 90 m), and dissolved macronutrients

4). Shallow McLane pump cast for particles, MCL-001
Recovered 11:00 GMT, 17 Nov 2019, at 31°40.749'N, 64°10.833'W (near BATS)
Pumps deployed at nominal depths of 30, 90, 150, 200 m

5). TMCTD cast for particles, TMP-002
Recovered 08:41 GMT, 20 Nov 2019, at 31°31.866'N, 63°33.813'W (near Spatial Station #13)
Samples collected at 20, 30, 50, 70, 100, 126, 200, 256*, 515, 740, 1000, 1700 m depth
*Niskin-X bottle position #8 = 256 m nominal depth (26.3 sigma) failed to close due to damaged lanyard release mechanism (subsequently repaired)
All bottles filtered through 0.4 µm membranes for particles

6). TMCTD cast for dissolved species, TM-002
Recovered 09:46 GMT, 20 Nov 2019, at 31°31.038'N, 63°34.751°'W (near Spatial Station #13)
Samples collected at 20, 30, 50, 70, 100, 126, 200, 256*, 515, 740, 1000, 1700 m depth

*Niskin-X bottle position #8 = 256 m nominal depth (26.3 sigma) failed to close due to damaged lanyard release mechanism (subsequently repaired)
Subsamples taken for dissolved Fe, soluble Fe, dissolved Al, dissolved Fe isotopes, dissolved Fe ligands, cellular metals (20, 70 m), dissolved Pb (20 m), and dissolved macronutrients

7). Shallow McLane pump cast for particles, MCL-002
Recovered 17:00 GMT, 20 Nov 2019, at 31°27.736'N, 63°29.599'W (near Spatial Station #13)
Pumps deployed at nominal depths of 30, 70, 126, 200 m

8). Deep McLane pump cast for particles, MCL-003
Recovered 03:30 GMT, 21 Nov 2019, at 31°38.266'N, 64°13.466'W (near BATS)
Pumps deployed at nominal depths of 256, 545, 810, 1000 m

9). TMCTD cast for particles, TMP-003
Recovered 12:23 GMT, 21 Nov 2019, at 31°46.274'N, 64°49.404'W (near Spatial Station #1)
Samples collected at 20, 30, 50, 75, 100, 172, 200, 250, 284, 560, 820, 1000 m
All bottles filtered through 0.4 μm membranes for particles

10). TMCTD cast for dissolved species, TM-003
Recovered 15:03 GMT, 21 Nov 2019, at 31°45.062'N, 64°48.855'W (near Spatial Station #1)
Samples collected at 20, 30, 50, 75, 100, 172, 200, 250, 284, 560, 820, 1000 m depth
Subsamples taken for dissolved Fe, soluble Fe, dissolved Al, dissolved Fe isotopes, dissolved Fe ligands, cellular metals (30, 100 m), and dissolved macronutrients
Note: Niskin-X bottle #1 had leaked due to mis-cocking
This was last operation on cruise; time did not allow sampling to 1700 m nor shallow pump cast