Bermuda Biological Station For Research, Inc.
Bermuda Atlantic Time-series Study

Chapter 2. Shipboard Sampling Procedures

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1.0 Introduction

The BATS cruises consist of a single four–five day cruise at monthly intervals. The core set of measurements (see table 1 for complete set of measurements) are collected on two hydrocasts with a 24 place rosette, one dawn - dusk *in situ* measurement of integrated primary production and a sediment trap deployment of three days duration. These cruises usually follow a regular schedule for the sequence and timing of events. This schedule is described below. Weather, equipment problems and other activities occasionally cause this schedule to be interrupted or rearranged. In the data report for each cruise, the exact schedule actually used is reported, including the timing and nature of all additional activities. The schedule described below represents a summary of all the core activities on each cruise in the order that they would be performed barring any other factors.

The transit time to the BATS station (31° 40' N, 64° 10' W) is approximately 6 hours. First the sediment traps are deployed at a site 5 nautical miles S of BATS to avoid entanglement with moored arrays in the vicinity of the OFP site (31° 50' N, 64° 10' W). The trap is free-floating and equipped with a strobe, radio beacon and an ARGOS satellite transmitter. Once deployed, the ship returns to the nominal BATS station to commence the sampling. In the first six years of the BATS program (until September 1994, BATS 72) the ship remained near the traps for the sampling period resulting in a quasi-Lagrangian sampling plan. In this time the maximum deviation from the nominal site was approximately 100 km, however, for approximately 75 % of cruises the deviation was less than 25 km.

2.0 Hydrocasts

The core measurements require 2 hydrocasts using a 24 place rosette system. The deeper of the two casts is usually done first. 24 discrete water samples are taken on each cast with 12 liter Ocean Test Equipment® (OTE) bottles.

The cast order is as follows:

Cast 1: 0–4200 m. Bottle samples (24) are collected at 100 m intervals from 300 - 1400 m, at 200 m intervals from 1400 - 2600 m, then at 3000 (duplicates), 3400, 3800, 4000 and 4200 m.

Cast 2: 0–250 m. Two bottles are closed at each of the following depths: the surface, 10, 20, 40, 60, 80, 100, 120, 140, 160, 200, 250 m.

3.0 Water Sampling

Sampling begins immediately after the rosette is brought on board and secured in the CTD garage. Care is taken to protect the rosette sampling operation from rain, wind, smoke or other variables which may effect the samples.

Cast 1: Oxygen samples are drawn first from all depths. After all the oxygen samples are drawn, samples for dissolved organic matter are taken (DOC and DON), followed by salinity and nutrient samples. Samples for particulate organic carbon and nitrogen (POC/ PON) and particulate silicate (PSi) are taken from the top 8 depths. Finally, samples for bacterial enumeration are drawn at 3000 and 4000 m.

Cast 2: Oxygen samples are drawn from all depths, from one set of OTE bottles. Samples for total CO_2 (C_T) and alkalinity, dissolved organic matter (DOC and DON), salinity and nutrients are also taken from this one set of bottles.

The replicate depths are used for POC/ PON and PSi samples, followed by samples for fluorometric chlorophyll, HPLC determination of pigments, and bacterial enumeration.

Deckboard water-processing activities are usually divided into specific tasks. Two or three people draw the water, while one person keeps track of the sampling operation. Bottle numbers for each sample at each depth are determined before the cast. All of the people sampling are informed of the sampling scheme and the oversight person ensures that it is carried out accurately.

4.0 Primary Production

The primary production cast is generally performed on the second day, depending on the weather, time of arrival at station, etc. The dawn to dusk *in situ* production measurement involves the pre-dawn collection of water samples at the BATS site at 8 depths using trace-metal clean sampling techniques. The bottles are 12 liter Go-Flos with Viton O-rings. These Go-Flos are acid cleaned with 10 % HCl between cruises. The bottles are mounted on the Kevlar line and depths are measured with a metered block, or premeasured before the cast, and marked. These samples are brought back on deck, transferred in the dark to 250 ml incubation flasks, the ^{14}C spike added and the flasks attached to a length of polypropylene line at each depth of collection.This array is deployed at the BATS site with

surface flotation which includes a radio beacon and a flasher. The ship follows this production array during the 12–15 hour period that it is deployed, occasionally shuttling back to the sediment trap location. This array is recovered at sunset and processed immediately.

5.0 Sediment Trap Deployment and Recovery

Upon arrival at the BATS station, the sediment trap array is deployed and allowed to drift free for a 72 hour period. The trap array has Multi-traps at 150, 200, and 300m depths.The array's location is monitored via the ARGOS transponder and by regular relocation by the ship. Twice daily, the trap position is radioed to the ship by BBSR personnel. The traps recovery is generally the last operation carried out before returning to the dock.

6.0 Sample Processing

Most of the actual sample analysis for the short BATS cruises is done ashore at the Bermuda Biological Station for Research. Oxygen samples are analyzed at sea because of concerns regarding the storage of these samples for periods of two to three days. Oxygen samples collected on the last day are sometimes returned to shore for analysis. All of the other measurements have preservation techniques that enable the analysis to be postponed. See the individual chapters for details.

The analysis of particulate silicate (PSi) is carried out by Dr. Mark Brzezinski at the University of California at Santa Barbara (UCSB). Analysis of dissolved organic nitrogen (DON) is undertaken by Dr. Dennis Hansell, and measurement of alkalinity by Dr. Nicholas Bates, both at Bermuda Biological Station for Research. The methods used are not detailed in individual chapters here but can be obtained from the references listed below.

7.0 References

Hansell, D.A. and T. Y. Waterhouse.(1997). Controls on the distribution of organiccarbon and nitrogen in the eastern Pacific Ocean. *Deep-Sea Research* 44: No.5: 843-857.

Brzezinski, M. A. and D. M. Nelson (1995). The annual silica cycle in the SargassoSea near Bermuda. *Deep-Sea Research.* I 42: 1215-1237.

D.O.E. (1994). *Handbook of methods for the analysis of the various parameters of the carbon dioxide system in seawater*; version 1.0, edited by A.G. Dickson and C. Goyet.

Table 1. Core measurements made at the BATS site

Continuous Electronic Measurements:

Parameter	Depth Range (m)	Technique/Instrument
Temperature	0-4200	Thermister on Seabird SBE-911 plus CTD
Salinity	0-4200	Conductivity sensor on SeaBird SBE-911*plus* CTD
Depth	0-4200	Digiquartz pressure sensor on SeaBird SBE-911*plus* CTD
Dissolved Oxygen	0-4200	SeaBird Polarographic Oxygen Electrode
Beam Attenuation	0-4200	SeaTech, 25 cm Transmissometer
Fluorescence	0-500	SeaTech Fluorometer

Discrete Measurements from OTE Bottles on CTD:

Parameter	Depth Range (m)	Technique/Instrument
Salinity	0-4200	Conductivity on Guildline Autosal 8400A
Oxygen	0-4200	Winkler Titration, automated endpoint detection
Total CO_2	0-250	Automated coulometric analysis
Alkalinity	0-250	High precision titration
Nitrate	0-4200	CFA colorometric with Technicon AA
Nitrite	0-4200	CFA colorometric with Technicon AA
Phosphate	0-4200	CFA colorometric with Technicon AA
Silicate	0-4200	CFA colorometric with Technicon AA
Dissolved organic carbon	0-4200	High-temperature, catalytic oxidation
Dissolved organic nitrogen	0-4200	UV oxidation
Particulate organic carbon	0-4200	High-temperature combustion, CHN analyzer
Particulate organic nitrogen	0-4200	High-temperature combustion, CHN analyzer
Particulate silica	0-4200	Chemical digestion, colorometric analysis
Fluorometric chlorophyll a	0-250	Acetone extraction, Turner fluorometer
Phytoplankton pigments	0-250	HPLC, resolves 19 pigments
Bacteria	0-3000	DAPI stained, fluorescence microscopy

Rate Measurements:

Parameter	Depth Range (m)	Technique/Instrument
Primary production	0-140	Trace-metal clean, *in situ* incubation, ^{14}C uptake
Bacterial activity	0-140	Thymidine incorporation
Particle fluxes	150, 200, 300	Free-drifting cylindrical trap (MultiPITs)
Mass flux		Gravimetric analysis
Total carbon flux		Manual swimmer removal, CHN analysis
Organic carbon flux		Manual swimmer removal, acidification, CHN analysis
Organic nitrogen flux		Manual swimmer removal, CHN analysis