Calibration and data processing of bb9-274 used on the deployment cruise:
CLIVEC 7

Scott Freeman
NASA GSFC, Greenbelt, MD
Scott.freeman@nasa.gov

Document Version 1.0, July 11, 2013

NAME: WET Labs bb-9
S/N: 274

1) Introduction and Summary

The Environmental Characterization Optics, or ECO scattering meter measures scattering at nine wavelengths at 124 degrees. The bb-9 uses nine LEDs modulated at 1 kHz for source light. The source light enters the water volume and scattered material is detected by a detector positioned such that the acceptance angle forms a 124° intersection with the source beam.

2) Calibration/Maintenance

2.1) Manufacturer calibrations/coefficients

The calibration applied to these data was performed on July 19, 2012 at WET Labs, Inc. in Narragansett, RI. 0.1 μm NIST-traceable polystyrene microspheres were used, and dark offsets were obtained by covering the detectors with electrical tape. Details for the calibration of ECO scattering sensors are provided in Sullivan, et al (2013). The sensitivity of each channel was provided in the bb-9 user's manual, and the wavelengths were reported in the build document.

Table 1: Results of calibration 7/19/2012

Wavelength (nm)	Scaling Factor	Sensitivity	Dark Offset
409	1.89807E-05	2.4E-05	33.9
441	1.44723E-05	2.5E-05	56.0

488	1.89866E-05	2.1E-05	57.3
508	1.10866E-05	1.8E-05	58.5
526	9.73822E-06	7.7E-06	52.8
594	6.39727E-06	1.0E-05	49.8
652	5.30434E-06	3.8E-06	56.8
679	3.84661E-06	3.6E-06	53.9
715	3.58917E-06	3.2E-06	54.4

2.2) Self calibration methods and results

WET Labs ECO sensors do not require field calibrations. Dark offsets were not obtained in the field, as the deployment schedule did not allow for multiple casts.

3) Deployment

3.1) Measurement methods

Profiles were made at each station, except when bottom depth was greater than 150 meters, due to limitations in the battery housing. The sequence was one downcast from approximately 3 meters after soaking at 10 meters to degas, then an upcast with periodic time series at depths where bottles were being fired. These have not been separated in the files submitted to SeaBass. Only the ends of the files, when the rosette was out of the water, have been eliminated. The instrument was configured to provide raw digital counts for later processing, instead of using a device file and standard processing.

3.2) Package design

The bb-9 was mounted to the CTD rosette on an auxiliary ring, facing downward and positioned so that the ring reflected none of the light. Other instruments used were: a Seabird SBE-49 CTD, a Wetlabs acs, a Wetlabs DH4 data handler, a Satlantic OCR 7-

wavelength irradiance sensor. It was powered through the DH4 by a Li-ion 12VDC battery pack, and the archived data were uploaded after each cast.

4) Data processing

4.1) Data analysis

Processing the VSF data requires the corresponding temperature and salinity values from the CTD and the absorption and scattering coefficients from the ac-s. As these instruments have a higher sampling rate, they were binned to one-second intervals to match the bb-9. The ac-s was processed first to account for salinity, temperature, and instrument drift (see CLIVEC7_CalReport_acs.docx for details).

First, the scaling factor and dark offset from the instrument calibration were applied to the raw counts to obtain the total volume scattering function, β_{tot} at each wavelength (λ).

$$\beta(124^{\circ},\lambda)_{tot} = SF(124^{\circ},\lambda) * (V(124^{\circ},\lambda) - DO(124^{\circ},\lambda)) \tag{1}$$

where SF = scaling factor, V is raw digital counts (voltage proxy), and DO is the dark offset (table 1).

Next, the $\beta(124°,\lambda)_{tot}$ was corrected for absorption using the corresponding absorption coefficient from the acs and the specific path length of the bb-9, 0.0391 meters.

$$\beta(124^{\circ},\lambda) = \beta(124^{\circ},\lambda)_{tot} * e^{(\ell * a_{gp})} \tag{2}$$

The volume scattering function of seawater ($\beta_{seawater}$) was found using Zhang, et al's (2009) model, with salinity and temperature input from the Seabird SBE-49 CTD. This value was subtracted from β(λ) to obtain the volume scattering function of the particle field only.

$$\beta(124^{\circ},\lambda)_{p} = \beta(124^{\circ},\lambda) - \beta(124^{\circ},\lambda)_{seawater} \tag{3}$$

The particulate backscattering coefficient $b(\lambda)_p$ was estimated using the chi factor, χ. For 124°, χ is 1.0772.

$$b(\lambda)_{bp} = 2\pi * \beta(\lambda)_p * \chi \quad (4)$$

The backscattering coefficient of seawater b_{bw} (Zhang, et al, 2009) was added to the particulate backscattering coefficient to obtain the total backscattering coefficient.

$$b_{bt} = b_{bp} + b_{bw} \quad (5)$$

The particulate backscattering ratio, b_{bp}/b_p, was not calculated, but can be easily done by using values from the bb-9 and the corresponding wavelengths from the acs. Some averaging could be useful to these data, as the two instruments are not necessarily sampling the same particle field at the same time due to particle patchiness.

4.2) Quality control

Processed data was reviewed by eye for any evidence of contamination by bubbles or potential interference from the instrument package. No such contamination was found to be present.

5) References

bb9 user's manual. Retrieved from http://www.wetlabs.com/sites/default/files/documents/bb9k.pdf

Sullivan, J., M. Twardowski, J.R.V. Zaneveld, and C. Moore. 2013. Measuring optical backscattering in water, *In*: A. Kokhanovsky (Ed), *Light Scattering Reviews 7: Radiative Transfer and Optical Properties of Atmosphere and Underlying Surface*, Springer Praxis Books, DOI 10.1007/978-3-642-21907-8_6, pp. 189-224.

Zhang, X., L. Hu, and M. He, "Scattering by pure seawater: Effect of salinity," 2009. *Optics Express 17*, 5698-5710.