Sea-Bird Electronics, Inc.
13431 NE 20th Street
Bellevue, WA 98005
USA

Phone: (425) 643-9866
Fax: (425) 643-9954
E-mail: seabird@seabird.com
Web: www.seabird.com

APPLICATION NOTE NO. 87 **Revised March 2010**

Calculating Calibration Coefficients for the WET Labs ECO-BB Scattering/Turbidity Meter

This Application Note applies to the use of the WET Labs ECO-BB series of scattering/turbidity meters with Sea-Bird CTDs. The ECO-BB has a response that is linear over the measurement range provided. The ECO-BB is not directly supported in Sea-Bird software. However, you can set up the ECO-BB channel as a User Polynomial in the configuration (.con or .xmlcon) file, allowing you to define an equation relating sensor output voltage to calculated engineering units:

$$\text{Value} = a0 + (a1 * V) + (a2 * V^2) + (a3 * V^3)$$

Select the User Polynomial for the ECO-BB channel when setting up the configuration (.con or .xmlcon) file in Sea-Bird software (SBE Data Processing or Seasave). The software prompts for a0, a1, a2, and a3. These values can be calculated from the calibration sheet provided by WET Labs.

WET Labs has changed the type of output available from the ECO-BB:

- For products **currently** sold by WET Labs:
  - ECO-BB with 0 – 5 $m^{-1}\ sr^{-1}$ range: WET Labs provides a calibration sheet for calculation of output in $m^{-1}\ sr^{-1}$.
- For products **previously** sold by WET Labs:
  - ECO-BB with 0 – 25 NTU range: WET Labs provided **two** calibration sheets, for calculation of output in NTU **or** $m^{-1}\ sr^{-1}$, as desired by the user.
  - ECO-BB with 0 – 100 NTU range: WET Labs provided a calibration sheet for calculation of output in NTU only.

Note: If you require NTU output in a currently manufactured product, WET Labs ECO-NTU or ECO-FLNTU are calibrated for calculation of output in NTU. See *Application Note 62*.

Each calibration sheet provides a *Dark Counts* and *Scale Factor* consistent with the output units. Derivation of a0, a1, a2, and a3 for the user polynomial follows for $m^{-1}\ sr^{-1}$ and NTU (NTU output available only for older ECO-BB meters).
Note: The WET Labs calibration sheet actually lists Dark *Counts*, and then provides the value for Dark *Counts* in both counts and in volts. For clarity, we refer to it below as Dark *Output*, since we are dealing with voltage output.

Calibration Coefficients in $m^{-1}\ sr^{-1}$

The WET Labs calibration sheet defines ECO-BB output as:

$$\beta(\theta c) = (\text{Output} - \text{Dark Output}) * \text{Scale Factor} \qquad (\beta(\theta c) \text{ in units of } m^{-1}\ sr^{-1})$$

where:

Output (volts) = *in-situ* output of the ECO-BB
Dark Output (volts) = measured output obtained by covering detector with black tape and submersing in water.
Scale factor (β(θc)/volts) = multiplier

Setting the WET Labs equation equal to the user polynomial equation and calculating a0, a1, a2, and a3:

$$(\text{Output} - \text{Dark Output}) * \text{Scale Factor} = a0 + (a1 * V) + (a2 * V^2) + (a3 * V^3)$$

Expanding the left side of the equation and using consistent notation (Output = V):

$$\text{scale factor} * V - \text{scale factor} * \text{Dark Output} = a0 + (a1 * V) + (a2 * V^2) + (a3 * V^3)$$

Rearranging:

$$(-\text{scale factor} * \text{Dark Output}) + (\text{scale factor} * V) = a0 + (a1 * V) + (a2 * V^2) + (a3 * V^3)$$

Solving for a0, a1, a2, and a3:

a0 = - scale factor * Dark Output **a1 = scale factor** **a2 = a3 = 0**

Calibration Coefficients in ***NTU*** (only for older ECO-BB meters; purchase ECO-NTU or ECO-FLNTU for sensors currently sold by WET Labs that provide NTU output)

The WET Labs calibration sheet defines ECO-BB output as:
turbidity = (Output – Dark Output) * Scale Factor (turbidity in units of *NTU*)
where:
Output (volts) = *in-situ* output of the ECO-BB
Dark Output (volts) = measured output obtained by covering detector with black tape and submersing in water.
Scale factor (NTU/volts) = multiplier

Setting the WET Labs equation equal to the user polynomial equation and calculating a0, a1, a2, and a3:

$$(Output - Dark\ Output) * Scale\ Factor = a0 + (a1 * V) + (a2 * V^2) + (a3 * V^3)$$

Expanding the left side of the equation and using consistent notation (Output = V):

$$scale\ factor * V - scale\ factor * Dark\ Output = a0 + (a1 * V) + (a2 * V^2) + (a3 * V^3)$$

Rearranging:

$$(- scale\ factor * Dark\ Output) + (scale\ factor * V) = a0 + (a1 * V) + (a2 * V^2) + (a3 * V^3)$$

Solving for a0, a1, a2, and a3:
a0 = - scale factor * Dark Output   a1 = scale factor   a2 = a3 = 0

Field Calibrations

While the factory-supplied Scale Factor can be used to obtain approximate values, field calibration is highly recommended. The relationship between ECO-BB output and β(θc) or turbidity is somewhat variable, and is not easy to determine in the laboratory. Particle shape and size are some of the factors that affect the relationship. To accurately measure with the ECO-BB, perform calibrations on seawater samples with distributions of particles that are similar to what is expected *in-situ*. Determine β(θc) or turbidity independently, and use those values, as well as readings from the ECO-BB, to determine the correct Scale Factor. **The Scale Factor is correct as long as the distribution of particle sizes and shapes does not change; the condition does change with season and geographic location.**