Combination Fluorometer-Scattering-CDOM Sensor

ECO FLbbCD2k

User's Guide

The user's guide is an evolving document. If you find sections that are unclear, or missing information, please let us know. Please check our website periodically for updates.

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ECO Sensor Warranty

This unit is guaranteed against defects in materials and workmanship for one year from the original date of purchase. Warranty is void if the factory determines the unit was subjected to abuse or neglect beyond the normal wear and tear of field deployment, or in the event the pressure housing has been opened by the customer.

To return the instrument, contact WET Labs for a Return Merchandise Authorization (RMA) and ship in the original container. WET Labs is not responsible for damage to instruments during the return shipment to the factory. WET Labs will supply all replacement parts and labor and pay for return via 3rd day air shipping in honoring this warranty.

Return Policy for Instruments with Anti-fouling Treatment

WET Labs cannot accept instruments for servicing or repair that are treated with anti-fouling compound(s). This includes but is not limited to tri-butyl tin (TBT), marine anti-fouling paint, ablative coatings, etc.

Please ensure any anti-fouling treatment has been removed prior to returning instruments to WET Labs for service or repair.

Shipping Requirements

1. Please retain the original ruggedized shipping case. It meets stringent shipping and insurance requirements, and protects your meter.

2. Service and repair work cannot be guaranteed unless the meter is shipped in its original case.

3. Clearly mark the RMA number on the outside of your case and on all packing lists.

4. Return instruments using 3rd day air shipping or better: do **not** ship via ground.

Electrical equipment marked with this symbol may not be disposed of in European public disposal systems. In conformity with EU Directive 2002/96/EC (as amended by 2003/108/EC), European users of electrical equipment must return old or end-of-life equipment to the manufacturer for disposal at no charge to the user.

1. Specifications

Optical

Backscattering wavelength	700 nm
Backscattering sensitivity[1]	0.0015 m^{-1}
Backscattering range[1]	0–3 m^{-1}
Fluorometer EX/EM	470/695 nm
Chlorophyll sensitivity	0.015 µg/l
Fluorescence range	0 –30 µg/l
CDOM EX/EM	370/460 nm
CDOM Sensitivity	0.28 ppb
CDOM Range	0–375 ppb
Linearity (all)	99% R^2

Environmental

Temperature range	0 to 30 deg C
Depth rating	2000 m

Mechanical

Diameter	6.3 cm
Length	14.9 cm
Weight in air	0.605 kg
Weight in water	0.312 kg
Pressure housing	ABS, epoxy, HDPE, 6061 aluminum (hard anodized)

Electrical

Digital output resolution	12 bit
RS-232 output	19200 baud
Data output rate	1 Hz (settable to 4 Hz)
Connector	MCBH-6-MP
Input	7–15 VDC
Current	50 mA

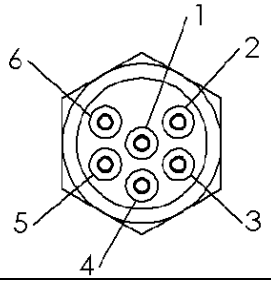
[1]*Backscattering specifications are given in beam c_p (m^{-1}) based on the regression of the response of the instrument relative to the beam c_p measured at the coincident wavelength using an ac-9 spectrophotometer. Scale factors for backscattering incorporate the target weighting function and the solid angle subtended.*

2. ECO FLbbCD Meter Components

The following subsections describe the bulkhead connectors and items delivered with the ECO sensor.

2.1 FLbbCD Connector

ECO FLbbCD sensors use an MCBH-6-MP bulkhead connector. The pin functions for this connector are shown below.



Pin	Function
1	Ground
2	RS-232 (RX)
3	Reserved
4	V in
5	RS-232 (TX)
6	Reserved

2.2 Delivered Items

The standard ECO delivery consists of the following:

- the instrument itself
- CD with ECOView, device file
- protective cover for optics
- this user's guide
- instrument-specific calibration sheet
- fluorescent stick for bench testing.

3. Theory of Operation

The FlbbCD combines the Flbb optical design with a CDOM fluorometer. The FlbbCD measures proxies of phytoplankton abundance (chlorophyll fluorescence), total particle concentration (backscattering), and dissolved organic matter (CDOM fluorescence) in a single data stream. The sensor is tuned for resolution of temporal and spatial gradients in the blue ocean while still providing a range that covers shelf and slope environments. The backscattering sensor is calibrated with NIST traceable beads for comparison with remote sensing data sets.

The ECO line uses a 1.4 KHz modulated LED excitation rate to generate the ON/OFF cycles for measurements and removal of background light. Scattered and fluoresced light is synchronously detected by a silicon photodiode. The LED wavelength and interference filters on the detector side are engineered to measure the parameter chosen while minimizing interference from extraneous signals. Specifications are given on the instruments specification sheet.

The acceptance angle for the chlorophyll fluorescence and 700 nm backscattering in the Flbb configuration is 140 degrees.

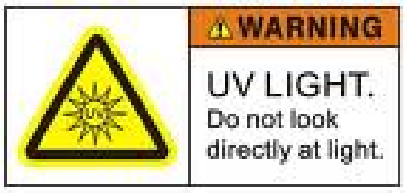
4. Instrument Operation

Operating environment notice

ECO sensors are precision instruments. Data transfers should be performed away from harsh environments such as strong electric fields or electrostatic discharge sources. If used in a such an environment, there is a chance that the sensor may experience disturbances that will temporarily stop data transfers. In that event, move the sensor to a location further from the electric field or ESD source. Reset the sensor by momentarily turning its power supply off, then on.

Units with CDOM measurement: UV LED Safety Note

- UV LEDs emit intense UV light during operation.
- Do not look directly into a UV LED while it is in operation, as it can be harmful to the eyes, even for brief periods.
- If it is necessary to view a UV LED, use suitable UV-filtered glasses or goggles to avoid damage to the eyes.
- Keep UV LEDs and products containing them out of the reach of children.
- Take appropriate precautions, including those above, with pets or other living organisms that might suffer injury or damage from exposure to UV emissions.



This label is affixed to all products containing UV LEDs.

4.1 Initial Checkout

Supplied from the factory, *ECO*s are configured to begin continuously sampling upon power-on.

Connect the instrument to a power supply using a WET Labs test cable. The LEDs should light up when the battery is connected. If the instrument is equipped with a CDOM fluorometer you will not see a light on that channel. Put a piece of white paper an inch off the face of the instrument and you should see a blue light on the paper when the UV light is emitted.

4.2 Upkeep and Maintenance

After each cast or exposure of the instrument to natural water, flush with clean fresh water, paying careful attention to the sensor face. Use soapy water to cut any grease or oil accumulation. Gently wipe clean with a soft cloth. The sensor face is composed of ABS plastic and optical epoxy and can easily be damaged or scratched.

WARNING!
Do not use acetone or other solvents to clean the sensor.

5. Data Analysis

Data from the *ECO* fluorometer and scattering sensor represents raw output. Applying linear scaling constants, this data can be expressed in meaningful forms of chlorophyll fluorescence and backscattering.

5.1 Chlorophyll Scale Factor

The scale factor is factory-calculated by obtaining a consistent output of a solution with a known concentration, then subtracting the meter's dark counts. The scale factor, dark counts, and other characterization values are given on the instrument's characterization sheet.

For chlorophyll, WET Labs uses the chlorophyll equivalent concentration (CEC) as the signal output using a fluorescent proxy.

Scale Factor = xx µg/l ÷ (Chl Equivalent Concentration – dark counts)

For example, where a target has a known concentration of 25 mg Chl m^{-3}:

Scale Factor (SF) = 25 mg Chl m^{-3} ÷ (3198 counts – 71 counts)

= 0.0080 mg Chl m^{-3} $count^{-1}$

The scale factor is then applied to the output signal to provide the direct conversion of the output signal to chlorophyll concentration. WET Labs supplies a scale factor on the instrument-specific calibration sheet that ships with each meter. While this constant can be used to obtain approximate values, field calibration is highly recommended.

5.2 Data Offset or Dark Counts

The instrument's dark counts, or offset, are the instrument's output in the absence of signal, e.g. perfectly clear water.

Offsets or dark counts are a function of the impedance of the system that the instrument is installed in. The factory offset or dark counts supplied on the calibration sheet should only be used as a general guidance for the instrument's actual use environment. The dark count value for the instrument should be measured as the instrument will be used.

This must be done by installing the instrument in the system. Use black electrical tape to block the detectors and turn the system on. Record ninety samples and average the last sixty samples.

Use the average as the system offset.

5.3 Chlorophyll Response

Digital chlorophyll data is processed using linear scaling. Obtaining a "calibrated" output simply involves subtracting a digital offset value from output when measuring a sample of interest and multiplying the difference by the instrument scaling factor.

$[Chl]_{sample} = (C_{output} - C_{dc}) * Scale\ Factor$

where
$[Chl]_{sample}$ = concentration of a chlorophyll sample of interest (µg/l)
C_{output} = output when measuring a sample of interest (counts)
C_{dc} = dark counts, the measured signal output of meter in clean water with black tape over the detector
Scale factor = multiplier in mg/l/count

Similar calculations are done for the backscattering and CDOM channels, see the instruments' calibration sheet for scale factors and factory offsets.

5.4 Data Corrections

Attenuation coupling—For the population of photons scattered within the remote sample volume in front of the sensor face, there is attenuation along the path from the light source to the sample volume to the detector. This results in the scattering measurements being underestimates of the true volume scattering in the hydrosol. Corrected volume scattering coefficients can be obtained by accounting for the effect of attenuation along an average pathlength. This average pathlength was numerically solved in the weighting function determinations developed by Dr. Ron Zaneveld that are used in the calibration procedures.

Since the calibration of the BB uses microspherical scatterers, the component of attenuation that can be attributed to scattering is incorporated into the scaling factor, i.e., the calibration itself. Thus, only absorption of the incident beam needs to be included in the correction.

The dependence on absorption, a, is determined as follows, where the measured scattering function at a given value of a, beta_meas(angle, a), is corrected to the value for a = 0 m^{-1}, beta_corr(140°, a=0):

beta_corr(140°, a=0) = beta_meas(140°, a) exp(0.0391a)

Absorption can be measured with an ac-9 device. For each ECO-BB wavelength, the matching absorption coefficient must be used from the ac-9. Because the *ECO*-BB incorporates short pathlengths and relatively small scattering volumes in its measurements, this attenuation error is typically small, about 4 percent at a = 1 m^{-1}.

6. Characterization and Testing

ECO FLbbCD is configured for a chlorophyll measurement range of 0–30 µg/l. The scattering sensor's measurement range is 0–3 m^{-1}. The CDOM sensor's measurement range is 0-375 ppb. As is the case with other fluorometers, a detailed characterization must be performed to determine the actual zero point and scale factor for your particular use.

The tests below were performed at WET Labs to ensure the meter's performance.

1. **Dark counts**: The meter's baseline reading in the absence of source light is the dark count value. This is determined by measuring the signal output of the meter in clean, de-ionized water with black tape over the detector.

2. **Pressure**: To ensure the integrity of the housing and seals, *ECO*s are subjected to a wet hyperbaric test before final testing. The testing chamber applies a water pressure of at least 40 PSI.

3. **Mechanical Stability**: Before final testing, the *ECO* meters are subjected to a mechanical stability test. This involves subjecting the unit to mild vibration and shock. Proper instrument functionality is verified afterwards.

4. **Electronic Stability**: This value is computed by collecting a sample once every second for twelve hours or more. After the data is collected, the standard deviation of this set is calculated and divided by the number of hours the test ran. The stability value must be less than 2 counts/hour.

5. **Noise**: Noise is computed from a standard deviation over 60 samples. These samples are collected at one-second intervals for one minute. A standard deviation is then performed on the 60 samples, and the result is the published noise on the calibration form. The calculated noise must be below 2 counts for Chl and bb channels while CDOM must be below 3 counts.

6. **Voltage and Current Range Verification**: To verify the *ECO* operates over the entire specified voltage range (7–15 V), a voltage test is performed at 7 and 15V, and the current draw and operation is observed. The current must remain constant at both 7 and 15V.

7. Terminal Communications

ECO sensors can be controlled using WET Labs' ECOView software, a terminal emulator or customer-supplied interface software. This section outlines hardware requirements and low-level interface commands for this type of operation.

7.1 Interface Specifications

- baud rate: 19200
- data bits: 8
- parity: none
- stop bits: 1
- flow control: none

7.2 Command List

Command	Parameters passed	Description
!!!!!	none	Stops data collection; allows user to input setup parameters. Note that if the meter is in a sleep state, the power must be turned off for a minute, then powered on while the "!" key is held down for several seconds.
$ave	single number, 1 to 65535	Number of measurements for each reported value
$mnu	none	Prints the menu
$pkt	single number, 0 to 65535	Number of individual measurements in each packet
$rls	none	Reloads settings from flash
$run	none	Executes the current settings

8. Sample Output File

N/U	Chl Sig	N/U	bb Sig	N/U	CDOM Sig	Therm
695	54	700	51	460	58	550
695	53	700	51	460	57	549
695	54	700	52	460	57	550
695	54	700	52	460	58	550
695	55	700	52	460	57	550
695	53	700	51	460	57	550

WET Labs WEEE Policy

In accordance with Directive 2002/96/EC and the Council of 27 January 2003, WET Labs policy regarding the collection and management of Waste Electrical and Electronic Equipment (WEEE) is published here and is available at www.wetlabs.com.

A core component of our corporate vision is to accept responsibility for preserving our environment and we embrace the opportunity to work with our customers and the EU to reduce the environmental impact resulting from the continuous improvement of our products.

WEEE Return Process

To meet the requirements of the WEEE Directive, WET Labs has instituted a product end-of-life take back program. To arrange return for an end-of-life WEEE product:

1. Contact WET Labs Customer Service
   - By phone: 1-541-929-5650
   - By email: support@ wetlabs.com

   WET Labs will provide:
   WEEE RMA number
   Shipping account number, method, and address

2. Package and ship the WEEE back to WET Labs

WEEE will be processed in accordance with WET Labs' equipment end-of-life recycling plan.

Revision History

Revision	Date	Revision Description	Originator
draft	4/4/12	Per conversation with J. Koegler	
A	6/4/12	Add ESD operating notice (DCN 798)	J. Pearson, H. Van Zee