ECO 3-Measurement Sensor with Wiper

(Triplet-w)

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. 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 will not service instruments 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 plastic 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.

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1. Overview

WET Labs offers the custom *ECO* Triplet-w as a three-sensor instrument that can be configured for a variety of measurement options:

- Three scattering
- Three fluorescence
- Two scattering, one fluorescence
- Two fluorescence, one scattering

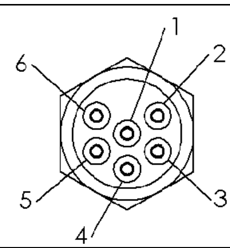
Scattering

- Blue
- Green
- Red

Fluorescence

- Chlorophyll
- CDOM (limited to one CDOM channel)
- Uranine (fluorescein)
- Phycoerythrin, phycocyanin
- Rhodamine

1.1 Connectors

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

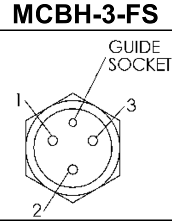
WARNING

If you are going to build or use a non-WET Labs-built cable, do not use the wire from pin 3 or the *ECO* meter will be damaged.

The power supply current returns through the common ground pin. The input power signal has a bi-directional filter. This prevents external power supply noise from entering into *ECO*, and also prevents internally generated noise from coupling out on to the external power supply wire.

1.1.1 Connectors for Units with Internal Batteries

Units equipped with internal batteries have a second bulkhead connector that comes with a blue-tipped power plug to supply power to the unit.

Socket	Function	MCBH-3-FS
1	V in	
2	N/C	
3	Battery out	

1.2 Optional Equipment

Triplet-w meters are available with the following optional equipment:

- test cable
- internal batteries
- external thermistor
- pressure sensor

1.2.1 Test Cable

A test cable is optionally available with each unit. This cable includes three legs:

1. A connector for providing power to the instrument from a user-supplied 9V battery.
2. A DB-9 serial interface connector.
3. A six-socket in-line connector for providing power and signal to the instrument.

1.2.2 Internal Batteries

ECO units with internal batteries are supplied with six 9-volt Lithium batteries as their power source. They can use either standard alkaline cells for a total capacity of approximately 1000 mA-hrs, or for longer deployments, $LiMnO_2$ cells to achieve more than 2000 mA-hrs of operational capacity. Actual total usage time of the internal batteries is a function of several parameters. These include nominal water temperature, sequence timing, sample periods, and total deployment duration.

WARNING!

Certain pins are always "hot." Be sure to keep the dummy plugs on internal battery units when a connector is not in use.

For even greater deployment capability contact WET Labs for information on external battery packs.

1.2.3 External Thermistor

ECO meters are optionally equipped with an external thermistor. The thermistor is calibrated at WET Labs and the calibration coefficients are supplied on the instrument's calibration sheets. Thermistor output is in counts and can be converted into engineering units using the instrument's device file and ECOView software or the raw data can be converted in the user's software (e.g. MATLAB or Excel) using the calibration equation:

Temperature (deg C) = (Output * Slope) + Intercept

1.2.4 Pressure Sensor

ECO meters are optionally equipped with a strain gauge pressure sensor. The pressure sensor is calibrated at WET Labs and the calibration coefficients are supplied on the instrument's calibration sheets. Pressure sensor output is in counts and can be converted into engineering units using the instruments device file and ECOview software or the raw data can be converted in the user's software (e.g. MATLAB or Excel) using the calibration equation:

Relative Pressure (dbar) = (Output * Slope) + Intercept

Note that strain gauge pressure sensors are susceptible to atmospheric pressure changes and should be "zeroed" on each deployment or profile. The calibration equation for pressure above should be used first to get the relative pressure and the cast offset should then be subtracted to get the absolute pressure:

Absolute Pressure (dbar) = Relative Pressure (dbar) - Relative Pressure at Atmospheric/Water interface (dbar)

WARNING!

Do not exceed the pressure sensor's depth rating (see calibration sheet).

A plastic fitting filled with silicone oil provides a buffer between the pressure transducer and seawater. The transducer is both sensitive and delicate. Following the procedures below will ensure the best results and longest life from your pressure sensor.

Pressure is transmitted from the water to the stainless steel transducer diaphragm via a plastic fitting filled with silicone oil. The inert silicone oil protects the pressure sensor from corrosion, which would occur after long exposure to salt water. The fitting will generally prevent the oil from escaping from the reservoir into the water. However, you may occasionally wish to ensure that oil remains in the reservoir on top of the transducer.

WARNING!

Never touch or push on the transducer.

1. Thoroughly clean the top of the instrument.
2. Completely remove the white nylon Swagelock fitting using a 9/16-in. wrench.
3. Check for obstructions in the tiny hole. Blow clear with compressed air or use a small piece of wire.
4. Wipe clean the O-ring at the base of the Swagelock fitting.
5. Screw the Swagelock fitting into the end flange until finger tight.
6. Tighten it an additional 1/8 turn using a wrench only if necessary.
7. Wipe up any excess oil.

1.3 Delivered Items

The standard ECO delivery consists of the following:

- the instrument itself
- this user's guide
- ECOView user's guide
- ECOView host program on CD
- instrument-specific calibration sheet
- protective cover for optics

Spare Parts

- Fluorescent sticks for bench testing
- Extra set screw for wiper
- 1/16-in. hex key for removing set screw

Spare Parts for units with batteries:

- Two end flange O-rings (size 144) and two vent plug O-rings (size 010)
- Two jacking screws for connector flange removal
- One 3/32-in. hex key for jacking screws
- Jumper plug for autonomous operation
- Three pre-cut 8.5 in. segments of 0.036-in. diameter monofilament for end flange
- Three pre-cut 0.250 in. segments of 0.094-in. diameter white nylon bar stock for replacing the white plastic dowel pin.

2. Specifications

Specifications include all optical parameters. Depending on the configuration ordered, not all scattering and fluorometer specifications will apply.

	Triplet-w	Triplet-wB
Mechanical		
Diameter	8.08 cm	
Length	22.1 cm	35.86 cm
Weight in air	1.28 kg	2.1 kg
Weight in water	0.29 kg	0.43 kg
Material	Acetal co-polymer	
Environmental		
Temperature range	0–30 deg C	
Depth rating	600 m	
Electrical		
Digital output resolution	12 bit	
Internal data logging	Yes	
Internal batteries	No	Yes
Connector	MCBH6MP	MCBH6MP and MCBH3FS
Input	7–15 VDC	
Current, typical	60 mA	
Current, sleep	140 µA	
Data memory	67,000 samples	
Sample rate	User selectable to 4 Hz	
RS-232 output	19200 baud	
Optical		
Scattering wavelengths	470, 532, 650, or 700 nm	
Range, typical	0–5 m^{-1}	
Sensitivity, all	0.003 m^{-1}	
Chlorophyll EX/EM	470/695 nm	
Sensitivity	0.025 µg/l	
Range, typical	0–50 µg/l	
CDOM EX/EM	370/460 nm	
Sensitivity	0.28 ppb	
Range, typical	0–375 ppb	
Uranine EX/EM	470/530 nm	
Sensitivity	0.15 ppb	
Range, typical	0-300 ppb	
Rhodamine EX/EM	540/570 nm	
Phycocyanin EX/EM	630/680 nm	
Phycoerythrin EX/EM	540/570 nm	
Sensitivity	0.09 ppb	
Range	0–175 ppb	
Linearity	99% R2	

Specifications are subject to change without notice.

3. Operation

Please note that certain aspects of instrument operation are configuration-dependent. These are noted where applicable within the manual. *ECO* sensors can be used in a moored or profiling mode, with or without a host computer/data logger. The *ECO*s are versatile instruments, capable of operating under a variety of user-selected settings.

UV LED Safety Note: Units with CDOM measurement

- 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.

3.1 Initial Checkout

*ECO*s are factory-configured to begin continuously sampling upon power-on. Electrical checkout of *ECO* is straightforward.

Connect the 6-socket connector on the optional test cable to the instrument to provide power to the LEDs and electronics (see Section 1 for a diagram of the pinouts of the *ECO*). Connect the battery leads on the test cable to a 9V battery. Light should emanate from the meter.

3.2 Operating the Sensor for Data Output

Note

ECO meters are sensitive to AC light. Before making measurement, turn AC lighting off.

1. Connect the 6-socket connector to the instrument to provide power to the LEDs and electronics. Connect the DB-9 connector to a computer with the ECOView host program installed on it.

WARNING!

Always use a regulated power supply to provide power to ECO sensors if not using a 9V battery with the test cable as power spikes may damage the meter.

2. Start ECOView. Select the appropriate COM port.
3. Supply power to the meter, then click on the Start Data button. Output will appear in the Raw Data window. Remove the protective cover.

4. Test the instrument's signal using the fluorescent stick. Hold the stick 1–4 cm above the optical paths in an orientation that maximizes exposure of the stick. (Parallel with the beams, not intersecting them). The signal will increase toward saturation (maximum value on characterization sheet). The sensor will operate until you select Stop Data in ECOView, or until it completes the requested samples.

5. Check the settings for the ECO and change if necessary. ECOView factory settings for continuous operation:
   - Set Number of Samples = 0
   - Set Number of Cycles = 0.

6. If the meter does not light after performing step 3, check the power source. Perform steps 2 and 3 to verify communication. If it still does not light, contact WET Labs.

Note

ECO meters with internal batteries can be powered in several ways:
1. From the six-pin bulkhead connector using the optional test cable and a regulated power supply **or** 9 V battery.
2. Using the jumper plug in the three-socket bulkhead connector. This is particularly useful for moored applications. The meter will run according to its stored settings.

If the jumper plug is in place on the meter and supplying power and the test cable is connected, power will be supplied by the equipment supplying the highest voltage. To conserve the internal batteries, use the test cable and an external power source set to 10–15 volts.

Refer to the ECOView User's Guide for details about using the software.

3.3 Deployment

Once power is supplied, the unit is ready for submersion and subsequent measurements. Some consideration should be given to the package orientation. Do not face the sensor directly into the sun or other bright lights. For best output signal integrity, locate the instrument away from significant EMI sources.

Caution

The *ECO* should be mounted so that the LED source will not "see" any part of a cage or deployment hardware. This will affect the sensor's output.

Other than these basic considerations, one only needs to make sure that the unit is securely mounted to whatever lowering frame is used and that the mounting brackets are not damaging the unit casing. The instrument can be used in a moored or profiling mode. WET Labs recommends that if the meter is used in moored mode, grab samples should be obtained on some regular basis as a validity check.

4. Upkeep and Maintenance

We highly recommend that *ECO* meters be returned to the factory annually for cleaning, calibration and standard maintenance. Contact WET Labs or visit our website for details on returning meters and shipping.

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

After each cast or exposure of the instrument to natural water, flush the instrument 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.

At the end of an experiment, the instrument should be rinsed thoroughly, air-dried and stored in a cool, dry place.

4.1 Replacing the Wiper Motor

1. Loosen wiper set screw.
2. Slide wiper from motor shaft.
3. Remove and retain the three faceplate screws, then remove faceplate from head
4. Grip motor shaft and pull straight up. You may need to GENTLY use pliers to get a grip on the shaft. Retain the alignment dowel.
5. Once the motor assembly is removed, rinse with fresh water 2–3 times.
6. Dry the motor assembly bore with dry, or canned, air.
7. Flush bore with isopropyl alcohol (IPA) to remove any remaining water.
8. Dry the wiper motor assembly bore with dry, canned, air.
9. Insert new motor assembly into bore.
10. Align dowel holes as your re-insert the alignment dowel.
11. Re-attach faceplate to optics head with the faceplate screws.
12. Slide wiper onto motor shaft.
13. Set the gap between the wiper and the instrument face to 0.085 in. An improperly set gap will either fail to clean the face or cause the motor to draw excessive current.
14. Re-secure the wiper set screw.

4.2 Removing End Flange and Batteries

WARNING!

Changing the batteries will require opening the pressure housing of the ECO sensor. Only people qualified to service underwater oceanographic instrumentation should perform this procedure. If this procedure is performed improperly, it could result in catastrophic instrument failure due to flooding or in personal injury or death due to abnormal internal pressure as a result of flooding.

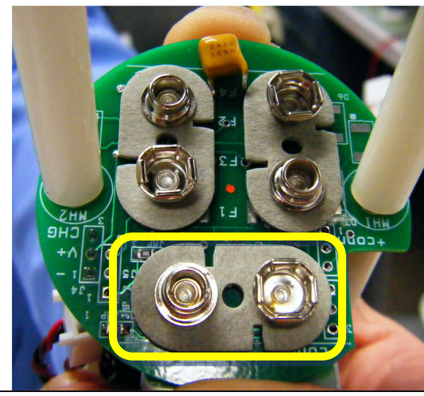
WET Labs Inc. disclaims all product liability from the use or servicing of this equipment. WET Labs Inc. has no way of controlling the use of this equipment or of choosing qualified personnel to operate it, and therefore cannot take steps to comply with laws pertaining to product liability, including laws that impose a duty to warn the user of any dangers involved with the operation and maintenance of this equipment. Therefore, acceptance of this equipment by the customer shall be conclusively deemed to include a covenant by the customer to defend and hold WET Labs Inc. harmless from all product liability claims arising from the use and servicing of this equipment. Flooded instruments will be covered by WET Labs Inc. warranties at the discretion of WET Labs, Inc.

1. Make sure the instrument is thoroughly dry.
2. Remove the dummy plugs.
3. With connector end flange pointed downwards away from face, release seal from vent plug.
4. Remove moisture from vent plug area. Inspect the two 010 O-rings and replace if necessary.
5. Using needle nose pliers, remove filament from end flange.
6. Lift flange from pressure housing until seal is broken. The jacking screws supplied as spare parts can be used to “push” the flange from the pressure housing, then removed.
7. Remove any excess moisture from flange–can seal area.
8. Work end flange out of pressure housing. Gently disconnect each Molex connector.
9. Gently pull the white cord at the loop to remove the battery pack from the pressure housing.
10. Remove the black plastic protectors from the ends of the long screws securing the batteries.

11. Loosen the retaining screws (1/4 in. slotted driver). Though previously recommended, removing both screws yields a pile of parts and complicates the replacement process.

4.3 Replacing Batteries

1. Tilt the battery board enough to secure the first battery in the set of contacts perpendicular to the other two (outlined in yellow).

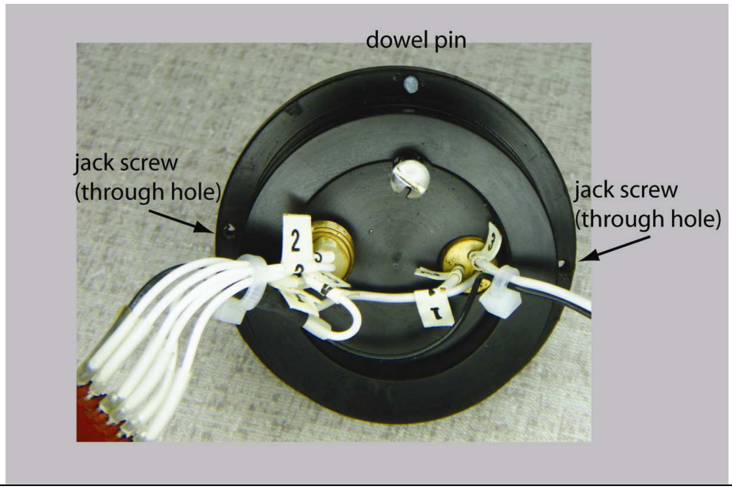


2. Pivot the boards in the opposite direction to secure the remaining two batteries. Repeat steps 1 and 2 for the second set of batteries.

3. Hold the assembly plates on top and bottom securely while re-tightening the screws. The bottoms of the batteries tend to splay out, so as you snug the assembly, make sure the batteries do not protrude beyond the boards. If they do, the pressure housing O-ring will be compromised when the assembly is re-inserted.
4. Re-install the bottom neoprene pad and the black plastic protective covers on the ends of the screws.
5. Remove and check the pressure housing O-ring for nicks or tears. Replace if necessary. Before re-installing, apply a light coat of vacuum grease (e.g. Dow Corning high vacuum grease) on the O-ring.
6. Carefully insert the battery pack in the pressure housing.

7. Re-connect the Molex connectors. Slowly rotate the end flange into the housing so the wires are pushed down and the dowel pin is aligned with the dowel hole in the end flange (NOT the jack screw holes, which go through the end flange).

   Note that the dowel pin may be in the end flange or the pressure housing.



8. Ensure no wires are pinched between the end flange and the pressure housing.

9. Push the end flange all the way on to the pressure housing, making sure no wires are pinched.

10. Re-insert the monofilament.

4.4 Checking Vent Plug

If there is fouling on the vent plug, it should be cleaned and the two 010 O-rings replaced. Otherwise, this mechanism should be maintenance-free.

WARNING!
The pressure housing is made of plastic material that scratches easily. Do not let the screwdriver slip and scratch the can when removing or replacing the vent plug. Use a toothpick (something softer than the plastic) to remove the O-rings from the vent plug.

1. Pull vent plug out about half way; hold plug while unscrewing the truss screw. When screw is removed, pull vent plug from end flange.

2. “Pinch” bottom O-ring around vent plug to form a small gap you can work a toothpick into. Use the toothpick to help roll the bottom O-ring off the plug.

3. Perform the same procedure with the top O-ring.

4. Clean the vent plug and vent plug hole using a dry lint-free tissue or cotton swab.

5. Lightly coat two undamaged or new O-rings with silicon grease (e.g. Dow Corning high vacuum grease). Install the top O-ring (nearest to large end of plug) first, then the bottom one.

6. Insert vent plug into its hole in the end flange and hold it while inserting the truss screw. Rotate the vent plug to begin tightening the screw. Finish tightening using a screwdriver, being careful not to over-tighten truss screw.

5. Data Analysis

Raw data from the *ECO* meter is output in counts from the sensor, ranging from 0 to 4120 +/- 5. The ECOView host program will automatically perform the necessary calculations for both scattering and fluorescence.

- Calibration yields scattering data in the form of volume scattering coefficients, $\beta(\theta,\lambda)$ with units of m^{-1} sr^{-1}, where θ is angle and λ is wavelength.
- Characterization yields fluorescence data in the form of µg/l (chlorophyll), or ppb (other fluorescence measurements).

5.1 Scattering 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 *ECO* 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(117°, a=0):

beta_corr(117°, a=0) = beta_meas(117°, a) exp(0.0391a)

Absorption can be measured with an ac-9 meter. For each scattering wavelength, the matching absorption coefficient must be used from the ac-9. Because the *ECO* C3 scattering component 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}.

Temperature correction—Output from an LED reference detector is provided, which gives an indication of relative LED intensity during operation. Work is presently under way to incorporate this signal as an ongoing correction for measurements. Largest expected deviations in the calibration coefficients are about 10 percent in the temperature range 0–28 degrees C. Note that these errors become more pronounced for very clear waters. If the instrument is planned for use in clear water environments at the ends of this temperature range, it is recommended that a request be made for calibration data to be collected as close to the expected environmental temperature as possible.

5.2 Derived Parameters

5.2.1 Volume Scattering of Particles

The corrected volume scattering of particles, $\beta(117°,\lambda)$ values represent total volume scattering, i.e., scattering from particles and molecular scattering from water. To obtain the volume scattering of particles only, subtract the volume scattering of water, $\beta_w(117°,\lambda)$:

$$\beta_p(117°,\lambda) = \beta(117°,\lambda) - \beta_w(117°,\lambda)$$

where $\beta_w(117°,\lambda)$ is obtained from the relationship (from Morel 1974):

$$\beta_w(\theta,\lambda)=1.38(\lambda/500nm)^{-4.32}(1+0.3S/37)10^{-4}\ (1+\cos^2\theta(1-\delta)/(1+\delta))m^{-1}sr^{-1},\ \delta=0.09$$

where S is salinity.

For total scattering of pure water,

$b_w(\lambda) = 0.0022533\ (\lambda/500nm)^{-4.23}$.

For total scattering of seawater (35–39 ppt),

$b_{sw}(\lambda) = 0.0029308\ (\lambda/500nm)^{-4.24}$.

For backscattering by water, divide b_w or b_{sw} by 2. The units for the b coefficients are $(10^{-4}\ m^{-1})$.

5.2.2 Backscattering Coefficients

Particulate backscattering coefficients, $b_{bp}(\lambda)$ with units of m^{-1}, can be determined through estimation from the single measurement of $\beta_p(117°,\lambda)$ using an X factor:

$$b_{bp} = 2\pi\ X\ \beta_p(117°)$$

From measurements of the volume scattering function with high angular resolution in a diversity of water types, Boss and Pegau (2001) have determined X to be **1.1** (Boss, E., and S. Pegau, 2001. The relationship of scattering in an angle in the back direction to the backscattering coefficient, *Applied Optics*). This factor estimates b_{bp} with an estimated uncertainty of 4 percent. The conversion can be used for $\beta(117°)$ measurements made at any visible wavelength.

To compute total backscattering coefficients, $b_b(\lambda)$ with units of m^{-1}, the backscattering from pure water, $b_{bw}(\lambda)$ (see above), needs to be added to $b_{bp}(\lambda)$:

$$b_b(\lambda) = b_{bp}(\lambda) + b_{bw}(\lambda).$$

5.2.3 Fluorescence Response

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 on the instrument's characterization sheet.

For chlorophyll, WET Labs uses the chlorophyll equivalent concentration (CEC) as the signal output using a fluorescent proxy approximately equal to 25 µg/l of a *Thalassiosira weissflogii* phytoplankton culture.

Scale Factor = 25 µg/l ÷ (CEC – dark counts)
Example: 25 ÷ (3198 – 71) = 0.0080.

For CDOM, uranine (fluorescein), and phycoerythrin, WET Labs uses a solution where *x* is the meter output in counts of the concentration of the solution used during instrument characterization.

Scale Factor = 308 ppb ÷ (*x* – dark counts)
Example: 308 ÷ (4148 - 56) = 0.0753.

The scale factor is then applied to the output signal to provide the direct conversion of the output counts to chlorophyll concentration. WET Labs supplies a scale factor that can be found 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.

Because of the varied environments in which each user will work, it is important to perform characterizations using similar seawater as you expect to encounter *in situ.* This will provide an accurate dark count value, equivalent phytoplankton types and similar physiological conditions for calculating the scale factor, thereby providing an accurate and meaningful calibration. Once a zero point has been determined and a scale factor established, obtaining a "calibrated" output simply involves subtracting the digital dark counts value from output when measuring a sample of interest and multiplying the difference by the instrument scaling factor:

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

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

6. Calibration/Characterization and Testing

Prior to shipment, each *ECO* is calibrated/characterized and tested to ensure it meets the instrument's stated specifications. Scattering channel(s)s are typically configured for a measurement range of 0–5 m^{-1}. Fluorescence channel(s) are characterized using a specific concentration of a fluorescing material that yields a scaled µg/l or ppb output range:
Chlorophyll: 0–50 µg/l
CDOM: 0–375 ppb
Phycocyanin, Phycoerythrin, and rhodamine: 0–175 ppb
Uranine (fluorescein): 0–300 ppb

6.1 Scattering Calibration

Definition of Terms

β: phase function	**b**: total scattering coefficient
θ: angle	**θc**: centroid angle
W: weighting function	**λ**: wavelength
Cp: particulate attenuation coefficient	**SF**: Scaling Factor
m^{-1}: per meter	**sr^{-1}:** per steradian

Each meter ships with a calibration sheet that provides instrument-specific calibration information, derived from the steps below.

1. For a given scattering centroid angle (θc), compute the weighting function W(θ,θc), by numerical integration of sample volume elements according to the sensor geometry.

2. Determine scattering phase functions, β(θ, λ)/b(λ), for the polystyrene bead microsphere calibration particles by weighting volume scattering functions computed from Mie theory according to the known size distribution of the polystyrene bead microsphere polydispersion and normalizing to total scattering.

3. By convolving W(θ,θ c) with β(θ, λ)/b(λ), compute the normalized volume scattering coefficient for each measurement angle, β(θ, λ)/b(λ), with units of sr^{-1} β(θc)/b for 2.00-micron diameter polystyrene bead microspheres.

4. Experimentally obtain raw scattering counts simultaneously with attenuation coefficients (C_p, using an ac-9) for a concentration series of the polystyrene bead microsphere polydispersion. Absorption by the calibration particles is assumed negligible.

5. Obtain b/counts from the slope of a linear regression between Cp (equivalent to b for the beads) and counts.

6. Multiplying the experimental b/counts by the theoretical β(θc)/b yields the calibration scaling factor, SF.

7. To obtain β(θc), subtract the dark counts from measured raw counts, then multiply by SF.

8. This test also provides a measure of the inherent opto-electronic noise level of the instrument. A standard deviation from the average number of counts on a 1 minute data file is taken. This is translated into the resolution of β(θc) (minimum detectable signal change) in units of m^{-1} sr^{-1}.

6.2 Fluorometer Characterization

Gain selection is performed at WET Labs by setting several gain settings in the instrument and running a chlorophyll (or proxy) dilution series to determine the zero voltage offset and to ensure that the dynamic range covers the measurement range of interest. The dilution series also establishes the linearity of the instrument's response. As is the case with other fluorometers, you must characterize your meter to determine the actual zero point and scale factor for your application.

6.3 Testing

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.

Pressure: To ensure the integrity of the housing and seals, *ECO* meters are subjected to a wet hyperbaric test before final testing. The testing chamber applies a water pressure of at least 50 PSI.

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.

Electronic Stability: This value is computed by collecting a sample once every 5 seconds 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 2.0 counts/hour.

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 (3 counts for CDOM).

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

As an alternative to ECOView Host software, *ECO* sensors can be controlled from a terminal emulator or customer-supplied interface software. This section lists the low-level interface commands for this type of operation.

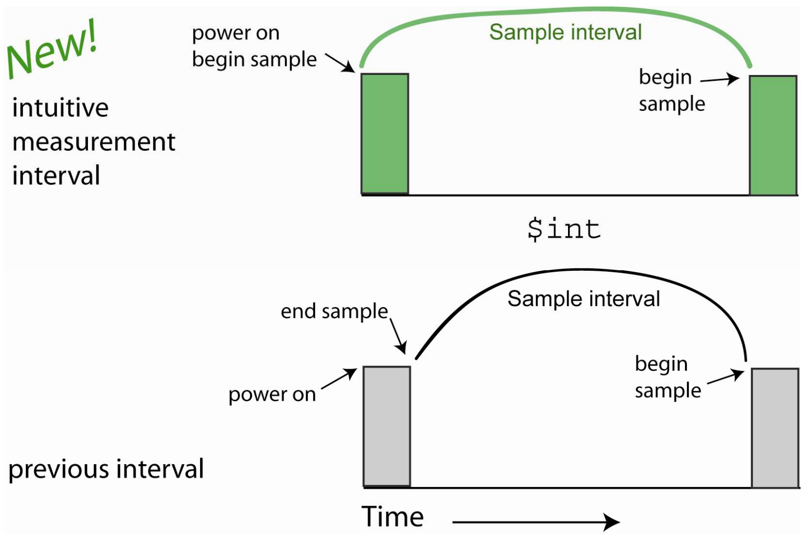
7.1 Command List

Command	Parameters passed	Description
!!!!!!!	none	Interrupt instrument operation. Do not append a carriage return at the end of the string of exclamation points or it will not work correctly.
$asv	1,2 or 4	Analog scaling value for single channel instruments. A value of 1 will cause the analog output to cover only the bottom ¼ of the digital output on a 14 bit instrument. A value of 2 will cause the analog output to cover the bottom ½ of the digital output on a 14 bit instrument. A value of 4 will cause the analog output to cover the full digital range of a 14 bit instrument.
$ave	1 to 255	Number of measurements for each reported value.
$m1d	0 to 65535	Measurement 1 dark count value for calculating engineering unit output.
$m1s	float	Measurement 1 slope value used for calculating engineering unit output.
$m2d	0 to 65535	Measurement 2 dark count value for calculating engineering unit output.
$m2s	float	Measurement 2 slope value used for calculating engineering unit output.
$m3d	0 to 65535	Measurement 3 dark count value for calculating engineering unit output.
$m3s	float	Measurement 3 slope value used for calculating engineering unit output.
$met	none	Prints out meta data describing the output being produced by the instrument. The first field is the output column, second is a field tag, third is a field name, fourth is used for units where appropriate. More values follow for data columns, including scale and offset values for that channel. Implementation is usable, but not complete as of 9/19/11.
$mnu	none	Prints the menu appropriate for the instrument. More fields are displayed for instruments with memory and a shutter or wiper.
$pkt	0 to 65535	Number of individual measurements in each packet. 0 (factory default) is continuous operation.
$rat	2400 to 230400	Baud rate for instrument communications. It must be a valid baud rate, and will default to 19200 if not. In this case the baud rate will be displayed as 19201 to indicate it defaulted to this value, but the operational baud rate is 19200. Fastest rates will only work over a short distance.
$rfd	none	Reloads original factory settings.
$rls	none	Reloads settings from flash.
$run	none	executes the current settings
$seq	0 to 3	Selects which of the pre-defined output sequences to use when outputting data.
$sto	none	stores current settings to internal flash.
$clk	24hr format time, hhmmss	Sets the time in the Real Time Clock.
$dat	date, format ddmmyy	Sets the date in the Real Time Clock.
$emc	none	Erases the memory chip, displays menu when done. There is no way to undo this operation. Use it with caution.
$get	none	Reads data out of Atmel memory chip. Prints "etx" when completed.

Note

Read carefully! The `$int` operation has changed.

Command	Parameters passed	Description
$int	24hr format time, hhmmss	Time from the start of one packet to the start of the next packet in a set. This change will produce more consistent packet timing. Older firmware versions counted from the end of one to the start of the next. To sample every 30 minutes, simply set the interval to 003000. It is no longer necessary to account for the time spent making the measurement or moving the wiper. See example below.



$man	1 (enable) or 0 (disable)	Enables or disables manual start time. Will start sampling at programmed wake time when enabled. This is automatically enabled if a manual start time is entered.

Note

Manual start time (`$mst`) is a new function that allows you to synchronize the sampling start time of multiple instruments in a single deployment.

$mst	24 hr format time, hhmmss	Manual start time. If enabled, instrument will wait until this time to start sampling when powered. This allows all instruments in a deployment to be synchronized in their sampling or for sampling to begin at some predetermined time after deployment.
$rec	1 (on) or 0 (off)	Enables or disables recording data
$set	0 to 65535	Number of packets in a set. 0 (factory default) results in the stored configuration repeating continuously.

7.2 Interface Specifications

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

8. Device and Output Files

The ECOView host program requires a device file to provide engineering unit outputs for any of its measurements. Except for the first line in the device file, all lines of information in the device file that do not conform to one of the descriptor headers will be ignored. Every ECOView device file has three required elements: Plot Header, Column Count Specification, and Column Description.

8.1 Plot Header

The first line in the device file is used as the plot header for the ECOView plots.

8.2 Column Count Specification

The Column Count Specification identifies how many columns of data to expect. It follows the format "Column=n." The Column Count Specification must be present before any of the Column Descriptions are listed.

8.3 Column Description

Every column in the ECO meter's output must have a corresponding Column Description in the device file. The following notation is used in identifying the elements of each Column Description.

x = the column number, starting with 1 as the 1st column
sc = scale
dc = dark count, same as offset
off = offset, same as dark count
mw = measurement wavelength—wavelength used by the sensor for its measurement
dw = display wavelength—wavelength/color range (380–780 nm)
v = measured volts dc

Fluorescence Measurements

Order of output, left to right:

Chl=	x	sc	off
IENGR=	x	sc	off
Phycoerythrin=x		sc	off
Phycocyanin=x		sc	off
Rhodamine=	x	sc	off
Cdom=	x	sc	off

Scattering Measurements

Lambda=x	sc	off	mw	dw

Miscellaneous

Date=x	DD/MM/YY
Time=x	HH:MM:SS
N/U=x	Not Used
sig=x	signal output, in counts

There are several default parameters that ECOView uses in the scatter calculations for scattering. These parameters are (a) salinity; (b) water type, fresh or sea water; (c) Chi ; and (d) theta, the measurement angle. The user may change these using the following device file elements (the values shown are the defaults).

Salinity=32	32 PSU
Water=Sea	Meter is assumed to be in salt water (Use "Pure" for fresh water)
XFactor=1.1	X Factor Correction Value
Theta=117	Back scattering angle

8.4 Output and Device File Formats

Because of the variety of configurations available for this custom instrument, each Triplet ships with its instrument-specific sample output file and device file on the accompanying CD.

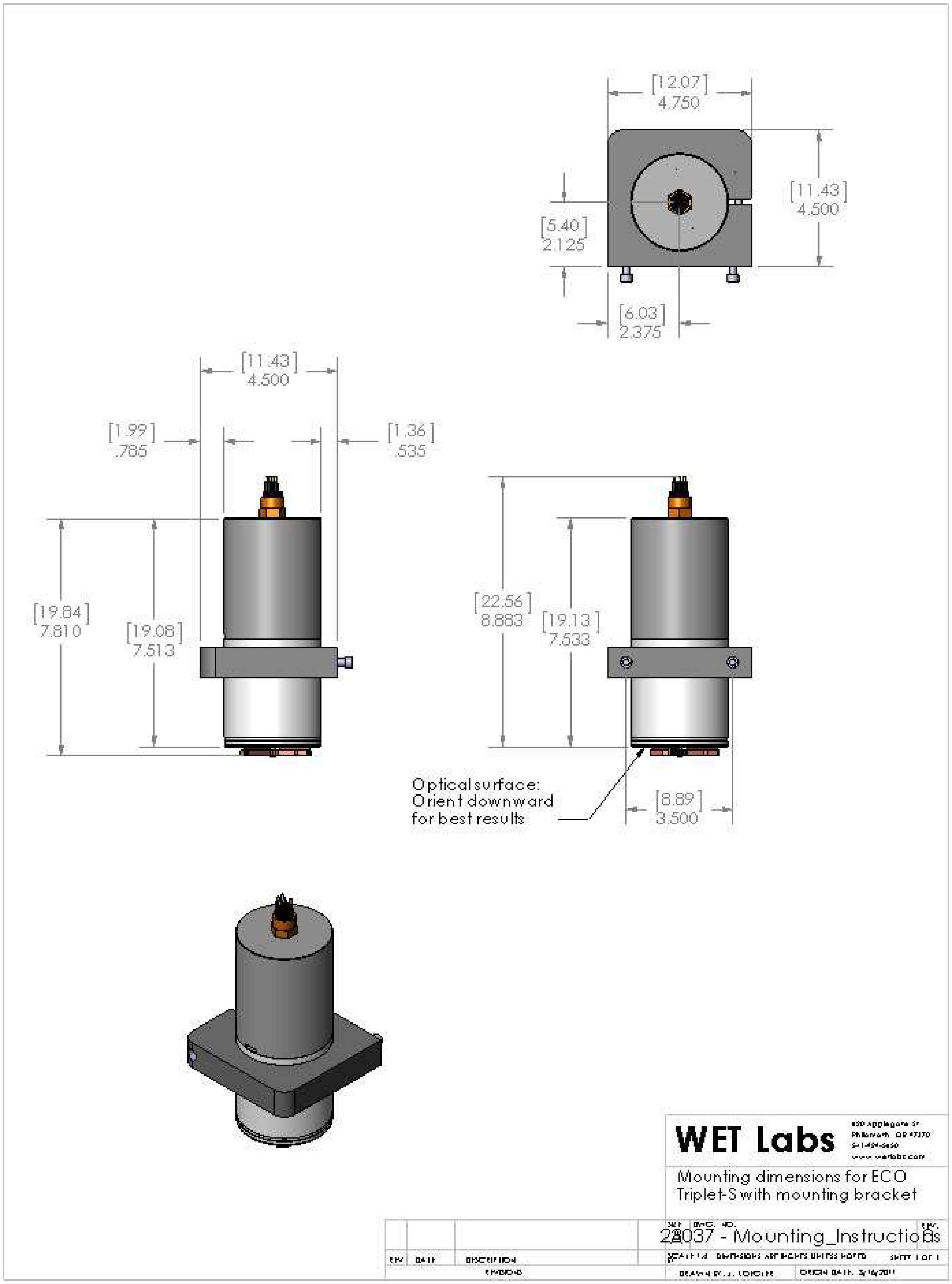
```
ECO TripletW-5000
Created on: 12/17/10

Columns=9
N/U=1
N/U=2
N/U=3
lambda=4        0.00001043  50    470   470
N/U=5
lambda=6        0.000006822 61    532   532
N/U=7
cdom=8          0.0918      47
N/U=9
```

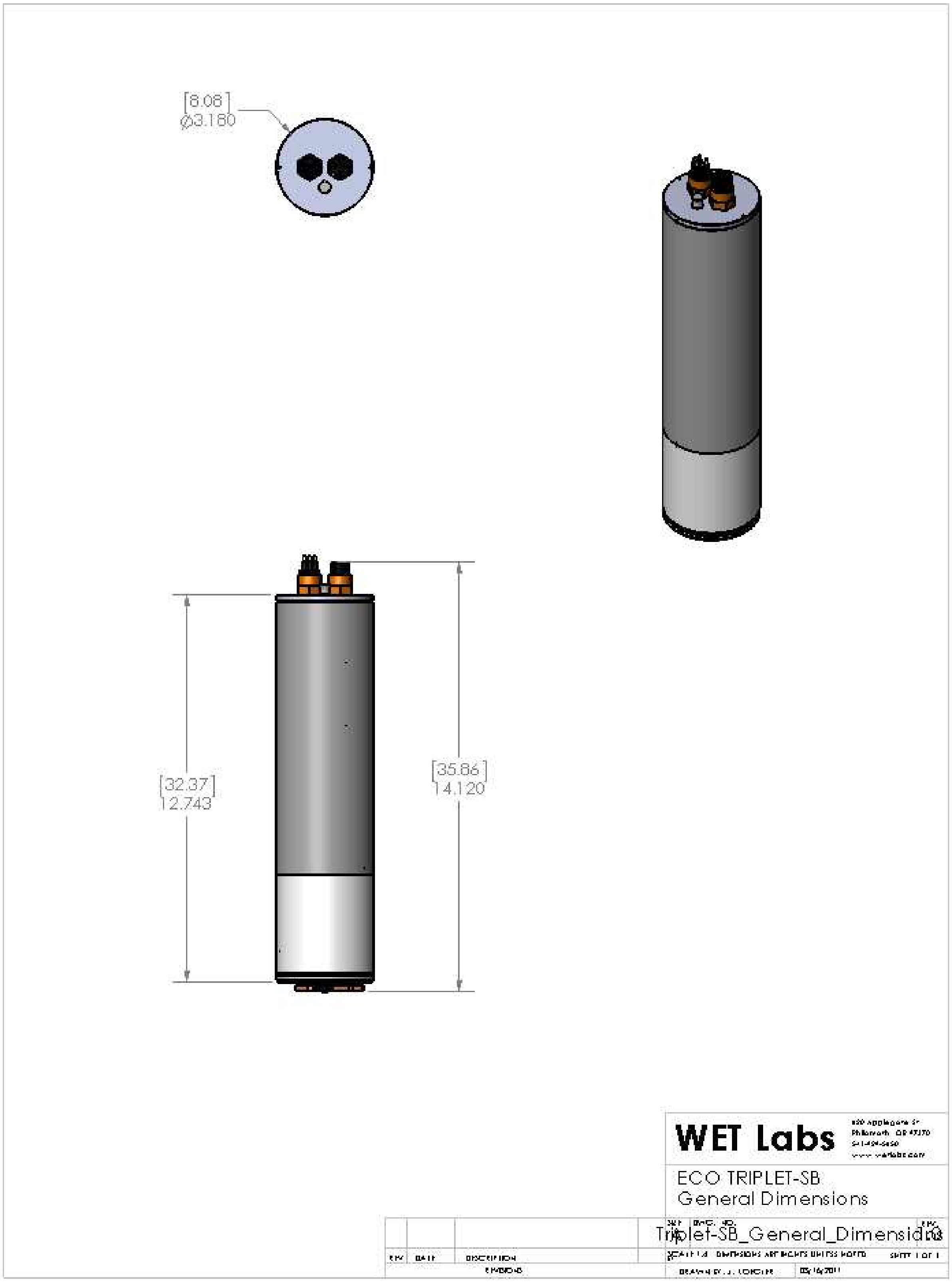
Output Format

Date	Time	N/U	sig	N/U	sig	N/U	sig	Therm
3/24/2011	17:30:02	470	51	532	68	460	51	--
3/24/2011	17:30:03	470	52	532	69	460	53	--
3/24/2011	17:30:04	470	52	532	69	460	52	--
3/24/2011	17:30:05	470	51	532	72	460	51	--
3/24/2011	17:30:06	470	52	532	70	460	52	--
3/24/2011	17:30:07	470	51	532	68	460	52	--

Appendix A: Mounting Details, Standard Triplet-w



Appendix B: General Dimensions, Triplet-w with Internal Batteries



Revision History

Revision	Date	Revision Description	Originator
A	3/30/11	New document (DCR 752)	J. Koegler, W. Strubhar
B	5/9/11	Update phycocyanin specs (DCN 762)	M. Johnson, H. Van Zee
C	9/28/11	Update specs, operational capabilities (DCN 770)	J. Koegler, W. Strubhar, H. Van Zee