Photosynthetically Active Radiation Sensor

ECO PAR

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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Attention!

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.

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.

Shipping Requirements

1. Please retain the original rugged 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.

Table of Contents

1. Overview

Photosynthetically Active Radiation (PAR) at 400–700 nm is an important parameter used in energy balance models, ecosystem characterization, and productivity analyses for agronomic, oceanic and climatological studies. PAR measurements are routinely used in laboratory studies focusing on plant physiology and photosynthesis.

Phytoplankton and higher plants use electromagnetic energy in the PAR region for photosynthesis. The radiation in this range, usually measured as Photosynthetic Photon Flux Density, has units of quanta (photons) per unit time per unit surface area. The units most commonly used are micromoles of quanta per square meter per second (µmol photons • m^{-2} • s^{-1}).

1.1 Specifications

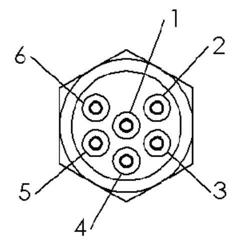
Mechanical	
Diameter	6.3 cm
Length	12.7 cm (std)
Weight (in air)	0.4 kg (std)
Weight (in water)	0.02 kg (std)
Pressure housing	Acetal copolymer
Temperature range	0–30 deg C
Depth rating	200 m
Electrical	
Digital output resolution	14 bit
RS-232 output	19200 baud
Analog output signal	0–5 V
Internal data logging	optional
Data memory	90,000 samples
Internal batteries	optional
Connector	MCBH-6-MP
Current, typical	50 mA
Current, sleep	140 µA
Bio-wiper™ cycle	140 mA
Sample rate	To 8 Hz
Input voltage	7–15 VDC
Optical	
Field of view	Cosine response (spectrally corrected)
Collector area	86 mm^2
Detectors	Custom 17 mm^2 silicon photodiode
Cosine response	Within 3% @ 0–60 deg C
Range	0–6500 µmol photons • m^{-2} • s^{-1}

1.2 Connectors

ECO-series PAR sensors use a six-pin bulkhead connector. Table 1 summarizes pin functions for the bulkhead connectors.

Table 1. Pinout summary for *ECO* connector

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



WARNING!

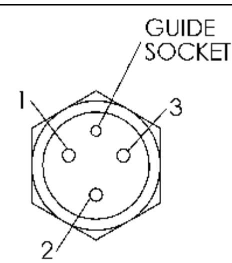
If you are going to build or use a non-WET Labs-built cable, do not use the wire from pin 3 or the *ECO* meter will be damaged.

Input power of 7–15 VDC is applied to pin 4. 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.

1.2.1 Battery Connector

Units with internal batteries have a second bulkhead connector that comes with a jumper plug to supply power to the unit. The pin functions for this connector are summarized below.

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



1.3 Delivered Items

The standard ECO delivery consists of the following:

- ECO meter
- dummy plug w/lock collar
- protective cover for optics
- Stainless steel mounting bracket and hardware (Appendix A)
- this user's guide (on CD)
- ECOView host program user's guide (on CD)
- ECOView host program and device files (on CD)
- instrument-specific calibration sheet

Spare Parts

- One 3/32-in. hex key for *bio-wiper*™ removal
- Three 4-40 x 3/8 in. 316 stainless steel replacement screws for *bio-wiper*™

- Internal battery units: Additional spare parts
  - Two end flange O-rings (size 224) and two vent plug O-rings (size 010)
  - Two jacking screws for connector flange removal
  - One 3/32-in. hex key for jacking screws
  - Power plug for autonomous operation
  - Three pre-cut segments (7 inches) of 0.036-inch diameter monofilament for end flange
  - Three pre-cut segments (0.25 inches) of 0.094-inch diameter white nylon bar stock for replacing the white plastic dowel pin.

1.4 Optional Equipment

1.4.1 Test Cable

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

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

1.4.2 Bio-wiper™ and Copper Faceplate

The PAR sensor is equipped with an integrated non-contact anti-fouling *bio-wiper*™ and copper faceplate for use in extended deployments. This wiper performs autonomously as part of a pre-programmed sampling sequence upon instrument power-up. The rate of closure and opening is dependent on both temperature and depth. See Section 2.5.1 for important details on maintenance and cleaning.

WARNING!

Do **NOT** rotate the *bio-wiper*™ by hand. This can damage the wiper motor and will void the warranty.

1.4.3 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.

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

2. Instrument Operation

Please note that certain aspects of instrument operation are configuration-dependent. These are noted where applicable within the manual.

2.1 Operating the Sensor for Data Output

1. Connect the test cable's 6-socket connector to the instrument.

2. Connect the DB-9 connector to a PC with ECOView software installed on it. (Or insert the factory-supplied CD with ECOView).

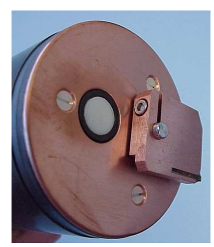
WARNING!
Always use a regulated power supply to provide power to ECO sensors if not using a 9V battery with the test cable: power spikes may damage the meter.

3. Start ECOView. Select the appropriate COM port and device file.

4. Supply power to the meter, then click on the Start Data button. Output will scroll in the Raw Data window.

   Connecting the auxiliary leg of the test cable to a digital multimeter will display analog output. The center of the RCA connector provides analog out signal and the outside provides ground.

5. Remove the meter's protective cover. Apply power. the *bio-wiper*™ will open and depending on the settings, operate until you select Stop Data. Place your thumb on the circular window. Output counts will decrease to about 50. Select Stop Data. The *bio-wiper*™ will close and the instrument will await the next command.



6. 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.

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

2.2 *Bio-wiper*™ Operation

The anti-fouling *bio-wiper*™ and faceplate extend the possible deployment duration by retarding biological growth on the instrument's optical surface. The *bio-wiper*™ covers the optical surface while the instrument is in "sleep" mode, when it has completed the number of samples requested, and when you select Stop Data in ECOView. When the meter wakes up, the optical surface is exposed by the *bio-wiper's*™ counter-clockwise rotation.

If power is shut off in mid cycle, the *bio-wiper*™ will reinitialize to the beginning of the user-selected settings when power is applied again.

WARNING!
Do NOT rotate the *bio-wiper*™ by hand. This will void the warranty.

2.3 Deployment

Once power is supplied to the meter, the unit is ready for submersion and subsequent measurements. Some consideration should be given to the meter's orientation. For best output signal integrity, locate the instrument away from significant EMI sources.

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.

2.4 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.

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 acrylic and can easily be damaged or scratched.

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

2.4.1 *Bio-wiper*™ and Faceplate Cleaning and Maintenance

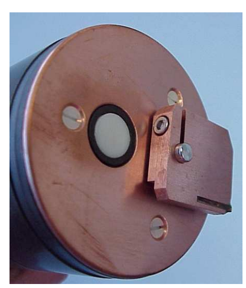
The *bio-wiper*™ and the copper faceplate need to be removed from the meter for thorough cleaning to maximize anti-fouling capability.

1. Be sure the meter is **NOT** powered or connected to a power source prior to removing the *bio-wiper*™ and faceplate.

WARNING!
Manually turning the motor shaft can damage the wiper motor and will void the warranty.

Make sure the *bio-wiper*™ is loosened from the shaft before attempting to rotate it.

2. Remove *bio-wiper*™: Use the factory-supplied 3/32-in. hex key to loosen the screw that secures the wiper to the shaft on the instrument.
3. Remove faceplate: Use a small Phillips screwdriver to remove the screws that attach the plate to the optics head.



4. Wash *bio-wiper*™ and/or copper faceplate with soapy water. Rinse and dry thoroughly. Note the condition of the copper on the instrument side of the wiper. It is normal for copper to corrode and turn green, especially after the

instrument has been removed from the water. This corrosion will slightly reduce the wiper’s anti-fouling ability the next time it is deployed.

5. Buff each with a pad of green Scotch Brite® (or similar) until shiny.

6. Clean the *bio-wiper*™ shaft and the shaft hole using an isopropyl alcohol-saturated cotton swab. Allow to dry.

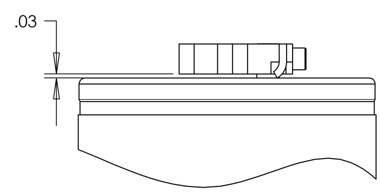
7. Re-install faceplate.

8. Check the screw used to secure the bio-wiper to the shaft: a hex key must fit snugly into the screw socket. If the socket is in any way compromised, use a new screw (4-40 x 3/8 in. 316 stainless steel treated with anti-seize. These are shipped as part of the meter’s spare parts kit.)

9. Slide the *bio-wiper*™ over the shaft. Be careful not to twist it on, thus rotating the shaft.

10. Rotate the *bio-wiper*™ into the closed position.

11. Set the gap between the *bio-wiper*™ and the instrument face to 0.03 in. (0.8 mm). An improperly set gap will either fail to clean the face or cause the motor to draw excessive current.



✓ *Three business cards are approximately 0.03 in. thick.*

12. Use the 3/32-in. hex key to tighten the screw to “finger-tight,” then snug an additional quarter-turn.

13. Run the instrument to verify operation. The *bio-wiper*™ must rotate 180 degrees to clear the optics before sampling, and 180 degrees to cover the optics after sampling.

14. If the wiper needs adjusting, loosen the screw, make any necessary adjustments, and repeat steps 9 through 13 to ensure the wiper is performing properly.

2.4.2 Internal Batteries

ECO sensors powered with internal batteries can either run directly from the internal batteries or can operate from power supplied by an external DC power supply (7–15 volts). Internal-to-external source conversion is facilitated by a jumper plug that plugs into the unit’s bulkhead connector. When inserted, the plug forms a connection from the battery to the electronics power supply. By removing the plug, the instrument can be powered and communicate via a test or deployment cable.

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.
5. Using needle nose pliers, remove filament from end flange.
6. Lift flange from pressure housing until seal is broken. The jacking screws can be used to "push" the flange from the pressure housing and then can be removed or left in the end flange.
7. Remove any excess moisture from flange–can seal area.
8. The battery pack is connected to the processor boards by a six-pin Molex connector: do NOT pull too hard or far on the battery pack or it will come unplugged and the unit returned to WET Labs.
9. Remove the black plastic protectors from the ends of the long screws securing the batteries.
10. Loosen and remove the screws (3/16-in slotted driver).

Replacing End Flange and Batteries

1. Replace the batteries.

2. Re-install the screws:
   - Align the groove in each of the plates so the six-wire extension bundle will fit in it along its length.
   - Be careful not to cross-thread into the bottom end plate nor to over-tighten the screws.
   - If they are too tight, the fiber washers that act as separators between the batteries will flex.
   - Make sure there are equal amounts of screw threads protruding from the bottom end plate when they are secure. This will ensure the pack is straight and will fit into the pressure housing with no difficulty.

3. Re-install the black plastic protective covers on the ends of the screws.

4. 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 on the O-ring.

5. Carefully replace the battery pack in the pressure housing.

6. Plug in the three-pin, then the six-pin Molex connectors. Sensor operation can now be tested if desired.

7. Align the hole in the end flange (NOT the jack screw holes) with the white dowel pin. While coiling the six wire bundle and making sure none are pinched between the end flange and the pressure housing, position the flange on the housing. Leave space to re-insert the gray foam spacer, making sure the cut-out accommodates the vent plug screw.

8. Push the end flange all the way on to the pressure housing, making sure no wires are pinched. Be sure the vent plug does not pop up. If it does, you'll need to re-position the foam spacer.

9. Re-insert the monofilament.

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. 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.

Note

A portion of the truss screw head has been removed to allow for venting in case of pressure buildup.

3. Data Output

Raw data from the *ECO* meter is output in counts from the sensor, ranging from 0 to a logarithmic maximum of approximately 16000 counts. The ECOView host program will automatically perform the necessary calculations for data in units of µmol photons.

The ECO PAR sensor uses a logarithmic fitting function to convert between output voltage and PAR. The relationship between PAR and voltage is described by:

$$PAR = Im \times 10^{\frac{x-a_0}{a_1}}$$

in water

$$PAR = 1.0 \times 10^{\frac{x-a_0}{a_1}}$$

in air

Where
Im is the immersion coefficient,
a_1 is the scaling factor,
a_0 is the voltage offset (typically 0),
x is the voltage.

This information is on the meter-specific calibration sheet and is used to calculate PAR in units of µmol photons • m^{-2} • s^{-1}.

4. Characterization and Testing

Each meter's optical component is manufactured and calibrated at Satlantic.

4.1 Testing

When the instrument is completely assembled, it goes through the tests below to ensure performance.

4.1.1 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.

4.1.2 Pressure

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

4.1.3 Mechanical Stability

Before final testing, 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.

4.1.4 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 2.0 counts/hour.

4.1.5 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.

4.1.6 Voltage and Current Range Verification

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

5. Terminal Communications

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

5.1 Interface Specifications

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

5.2 Command List

Command	Parameters passed	Description
!!!!!	none	Stops data collection; allows user to input setup parameters
$ave	single number, 1 to 65535	Number of measurements for each reported value
$clk	24hr format time, hhmmss	Sets the time in the Real Time Clock
$dat	date, format mmddyy	Sets the date in the Real Time Clock
$emc	none	Erases the Atmel memory chip, displays menu when done
$get	none	Reads data out of Atmel memory chip. Prints "etx" when completed.
$int	24hr format time, hhmmss	Time interval between packets in a set
$mnu	none	Prints the menu, including time and date
$pkt	single number, 0 to 65535	Number of individual measurements in each packet
$rec	1 (on) or 0 (off)	Enables or disables recording data to Atmel memory chip
$rls	none	Reloads settings from flash
$run	none	Executes the current settings
$set	single number, 0 to 65535	Number of packets in a set
$sto	none	Stores current settings to internal flash

6. Device and Output Files

Each meter ships with a CD containing the meter-specific device file, a sample output file, characterization information, ECOView host program, and the applicable user's guides. 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.

6.1 Plot Header

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

6.2 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.

6.3 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 first column
sc = scale
dc = dark counts—meter output in clean water with optics head taped
v = measured volts dc

Date=x	MM/DD/YY
Time=x	HH:MM:SS
N/U=x	Column is Not Used

6.4 Sample Device File

```
ECO PAR-xxx
Created on: 10/06/08

COLUMNS=3
DATE=1
TIME=2
PAR=3
im=1.3589
a1=3036.7296
a0=3602.6580
```

6.5 PAR Sample Output File

Date (MM/DD/YY)	Time (HH:MM:SS)	PAR sig (counts)
6/14/2005	7:57:55	5912
6/14/2005	7:57:56	5911
6/14/2005	7:57:57	5911

Revision History

Revision	Date	Revision Description	Originator
A	1/9/09	Draft document (DCR 637)	H. Van Zee, C. Wetzel
B	3/9/09	Update to ECOView 1.20 (DCR 631)	J. Bell, H. Van Zee
C	2/15/11	Add internal battery option (DCR 736)	M. Johnson, H. Van Zee