



OWNER'S MANUAL

BTM3000 PAR SENSOR



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DECLARATION OF CONFORMITY

CE and ROHS Certificate of Compliance

We Apogee Instruments, Inc.
721 W 1800 N
Logan, Utah 84321
USA

Declare under our sole responsibility that the product:

Model: BTM-3000
Type: Quantum (PAR) Sensor

are in conformity with the following standards and relevant EC directives:

Emissions: EN 61326-1:2013
Immunity: EN 61326-1:2013

EU directive 2004/108/EC, EMC
EU directive 2006/95/EC, Low Voltage Directive – Annex 1: Safety Objectives
EU directive 2002/95/EC, RoHS (Restriction of Hazardous Substances)
EU directive 2011/65/EU, RoHS2

Please be advised that based on the information available to us from our raw material suppliers, the products manufactured by us do not contain, as intentional additives, any of the restricted materials, including cadmium, hexavalent chromium, lead, mercury, polybrominated biphenyls (PBB), polybrominated diphenyls (PBDE).

Further note that Apogee Instruments does not specifically run any analysis on our raw materials or end products for the presence of these substances, but rely on the information provided to us by our material suppliers.

Dr. Bruce Bugbee
President
Apogee Instruments, Inc.
February 2015

INTRODUCTION

Radiation that drives photosynthesis is called photosynthetically active radiation (PAR) and is typically defined as total radiation across a range of 400 to 700 nm. PAR is often expressed as photosynthetic photon flux density (PPFD): photon flux in units of micromoles per square meter per second ($\mu\text{mol m}^{-2} \text{s}^{-1}$, equal to microEinsteins per square meter per second) summed from 400 to 700 nm (total number of photons from 400 to 700 nm). While Einsteins and micromoles are equal (one Einstein = one mole of photons), the Einstein is not an SI unit, so expressing PPF as $\mu\text{mol m}^{-2} \text{s}^{-1}$ is preferred.

Sensors that measure PAR (PPFD) are often called quantum sensors due to the quantized nature of radiation. A quantum refers to the minimum quantity of radiation, one photon, involved in physical interactions (e.g., absorption by photosynthetic pigments). In other words, one photon is a single quantum of radiation.

BioTek Marine's BTM3000 PAR Sensor consists of a cast acrylic diffuser (filter), photodiode, and signal processing circuitry mounted in an anodized aluminum housing, and a cable to connect the sensor to a measurement device. Sensors are potted solid with no internal air space, and are designed for continuous PAR (PPFD) measurement in indoor, outdoor and underwater environments. The BTM 3000 series sensors output is directly proportional to PAR (PPFD) under sunlight (natural setting) or electric lights (electric setting). The signal from the sensor is directly proportional to radiation incident on a planar surface (does not have to be horizontal), where the radiation emanates from all angles of a hemisphere.

SPECIFICATIONS

Resolution: 0.1 $\mu\text{mol m}^{-2} \text{s}^{-1}$

Calibration Factor: custom for each sensor and stored in the firmware

Calibration Uncertainty: $\pm 5 \%$ (see Calibration Traceability below)

Measurement Repeatability: less than 1 %

Non-stability (Long-term Drift): less than 2 % per year

Non-linearity: less than 1 % (up to 4000 $\mu\text{mol m}^{-2} \text{s}^{-1}$)

Response Time: less than 1 ms

Field of View: 180°

Spectral Range: 410 nm to 655 nm (wavelengths where response is greater than 50 % of maximum; see Spectral Response below)

Directional (Cosine) Response: $\pm 5 \%$ at 75° zenith angle (see Cosine Response below)

Temperature Response: 0.06 \pm 0.06 % per C (see Temperature Response below)

Operating Environment: -40 to 70 C, 0 to 100 % relative humidity
can be submerged in water up to depths of 30 m

Dimensions: 2.4 cm diameter and 2.8 cm height

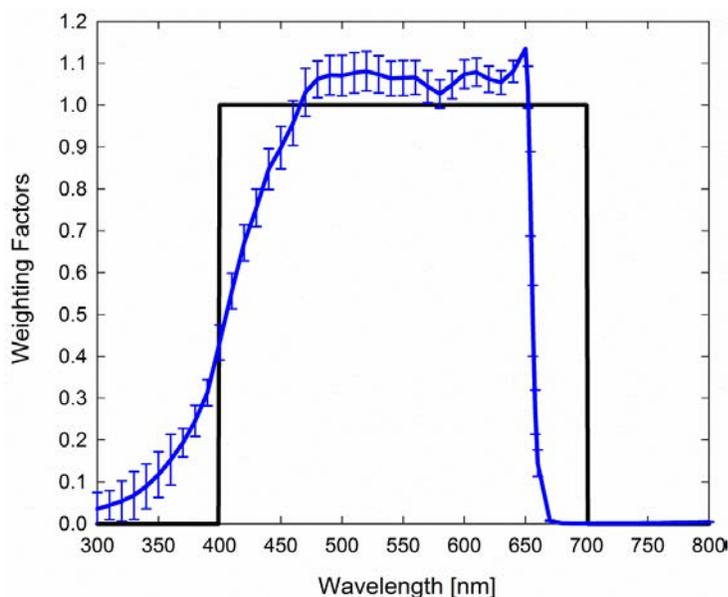
Mass: sensor head weighs 90 g

USB Cable: 4.6 m (15 ft)

Calibration Traceability:

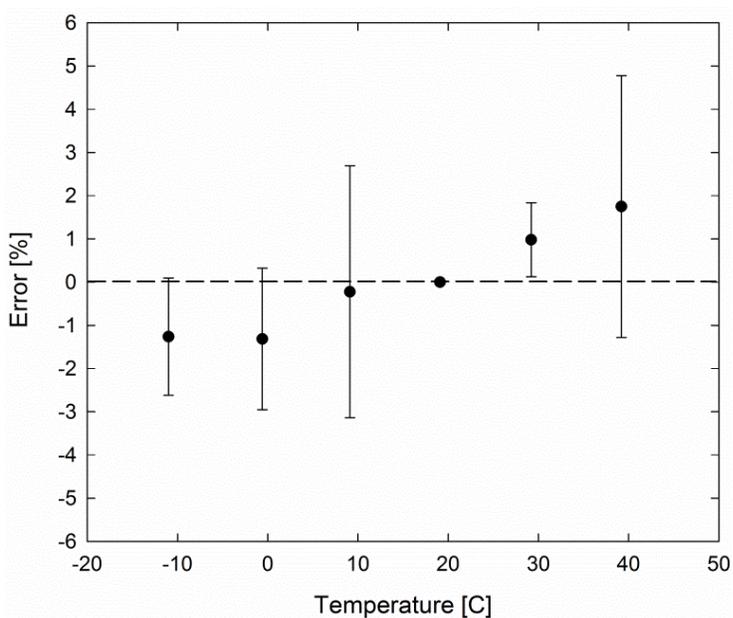
BioTek Marine's BTM3000 sensors are calibrated through side-by-side comparison to the mean of four Apogee model SQ-110 or SQ-120 transfer standard quantum sensors under high output T5 cool white fluorescent lamps. The transfer standard quantum sensors are calibrated through side-by-side comparison to the mean of at least three LI-COR model LI-190R reference quantum sensors under high output T5 cool white fluorescent lamps. The reference quantum sensors are recalibrated on a biannual schedule with a LI-COR model 1800-02 Optical Radiation Calibrator using a 200 W quartz halogen lamp. The 1800-02 and quartz halogen lamp are traceable to the National Institute of Standards and Technology (NIST).

Spectral Response:



Mean spectral response of six sensors (**error bars represent two standard deviations above and below mean**) compared to PAR (PPFD) weighting function. Spectral response measurements were made at 10 nm increments across a wavelength range of 300 to 800 nm in a monochromator with an attached electric light source. Measured spectral data from each quantum sensor were normalized by the measured spectral response of the monochromator/electric light combination, which was measured with a spectroradiometer.

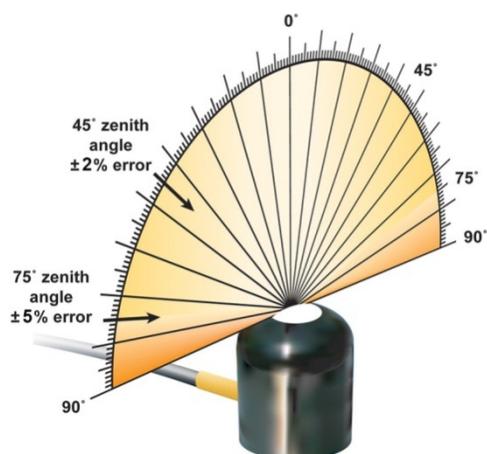
Temperature Response:



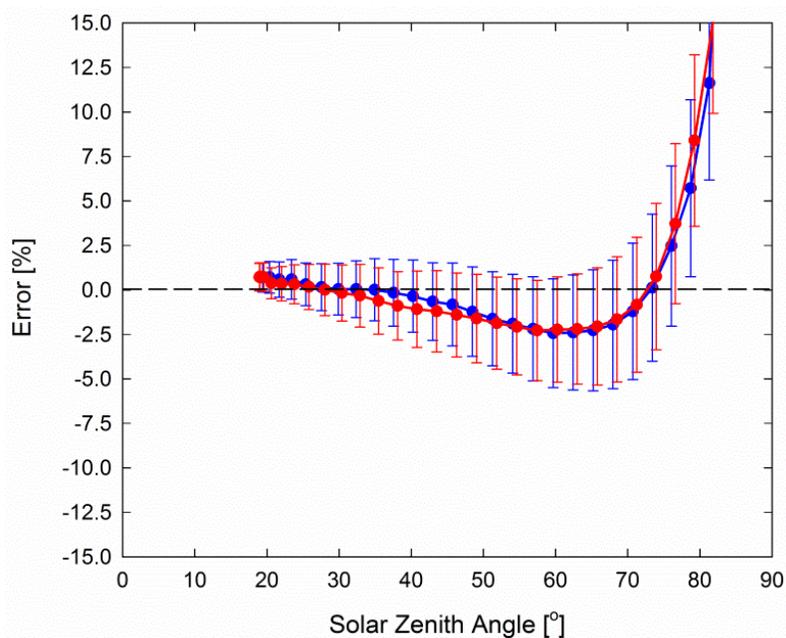
Mean temperature response of eight sensors (**errors bars represent two standard deviations above and below mean**). Temperature response measurements were made at 10 C intervals across a temperature range of -10 to 40 C in a temperature controlled chamber under a fixed, broad spectrum, electric lamp. At each temperature set point, a spectroradiometer was used to measure light intensity from the lamp and all quantum sensors were compared to the spectroradiometer. The spectroradiometer was mounted external to the temperature control chamber and remained at room temperature during the experiment.

Cosine Response:

BTM3000 Cosine Response



Directional, or cosine, response is defined as the measurement error at a specific angle of radiation incidence. Error for BioTek Marine's PAR sensors is approximately $\pm 2\%$ and $\pm 5\%$ at solar zenith angles of 45° and 75° respectively.



Mean cosine response of twenty-three sensors (**error bars represent two standard deviations above and below mean**). Cosine response measurements were made by direct side-by-side comparison to the mean of four reference thermopile pyranometers, with solar zenith angle-dependent factors applied to convert total shortwave radiation to PAR (PPFD). Blue points represent the AM response and red points represent the PM response.

Spectral Errors for PAR Measurements with BioTek Marine PAR Sensors:

BioTek Marine PAR Sensors are calibrated to measure PAR for either sunlight (natural setting) or electric light. The difference between the calibrations is 12 %. A sensor calibrated for electric lights (calibration source is T5 cool white fluorescent lamps) will read approximately 12 % low in sunlight (natural setting).

Radiation Source (Error Calculated Relative to Sun, Clear Sky)	PAR Error [%]
Sun (Clear Sky)	0.0
Sun (Cloudy Sky)	1.4
Reflected from Grass Canopy	5.7
Reflected from Deciduous Canopy	4.9
Reflected from Conifer Canopy	5.5
Transmitted below Grass Canopy	6.4
Transmitted below Deciduous Canopy	6.8
Transmitted below Conifer Canopy	5.3
Radiation Source (Error Calculated Relative to Cool White Fluorescent, T5)	
Cool White Fluorescent (T5)	0.0
Cool White Fluorescent (T8)	-0.3
Cool White Fluorescent (T12)	-1.4
Compact Fluorescent	-0.5
Metal Halide	-3.7
Ceramic Metal Halide	-6.0
High Pressure Sodium	0.8
Blue LED (448 nm peak, 20 nm full-width half-maximum)	-12.7
Green LED (524 nm peak, 30 nm full-width half-maximum)	8.0
Red LED (635 nm peak, 20 nm full-width half-maximum)	4.8
Red, Blue LED Mixture (85 % Red, 15 % Blue)	2.4
Red, Green, Blue LED Mixture (72 % Red, 16 % Green, 12 % Blue)	3.4
Cool White Fluorescent LED	-4.6
Neutral White Fluorescent LED	-6.7
Warm White Fluorescent LED	-10.9

Quantum sensors can be a very practical means of measuring PAR from multiple radiation sources, but spectral errors must be considered. The spectral errors in the table above can be used as correction factors for individual radiation sources.

INSTALLATION

Installing the software on PC:

1. Double click on the installer package:



2. On the 'Welcome' screen, please click 'Next' to continue.
3. Select the radio button next to "I Agree" to the UELA... and click 'Next' to continue.
4. On the 'Ready to Install the Program' screen, click 'Install' to continue.
5. Click 'Finish' to complete the installation. There are shortcuts on your desktop and in your start bar.

Installing the software on Mac:

Mac software downloads automatically.

Installing the sensor:

The sensor can be mounted to a solid surface with the 10/32 nylon mounting screw provided. To accurately measure PAR incident on a horizontal surface, the sensor must be level. A BioTek Marine Saltwater Submersible Sensor Wand provides the ideal mounting platform to properly level your sensor in your tank.

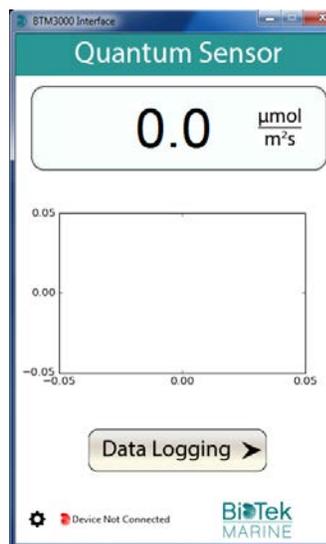
Once mounted (or prior to use), the green cap should be removed from the sensor. The green cap can be used as a protective covering for the sensor when it is not in use.

In order to prevent tank water from entering your computer, form a drip loop outside of the tank. Plug the USB jack into an open USB port on your computer, the device driver will install automatically.

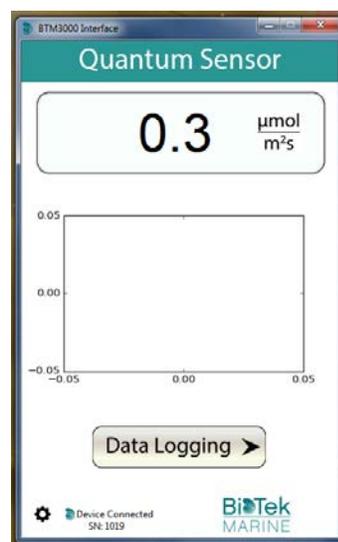
OPERATION AND MEASUREMENT

WINDOWS SOFTWARE

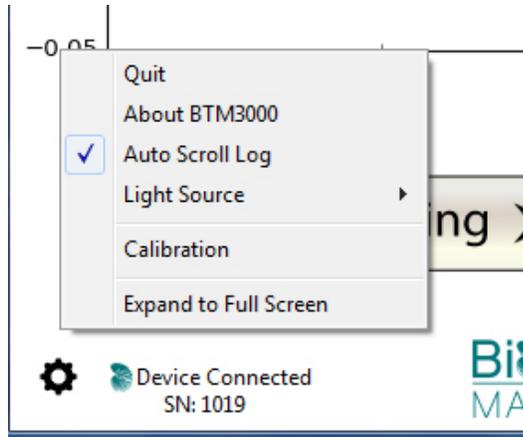
When the BTM3000 sensor is not plugged into the USB port, the software will display a message in the lower left corner, "Device Not Connected," indicating it cannot establish communication with the sensor.



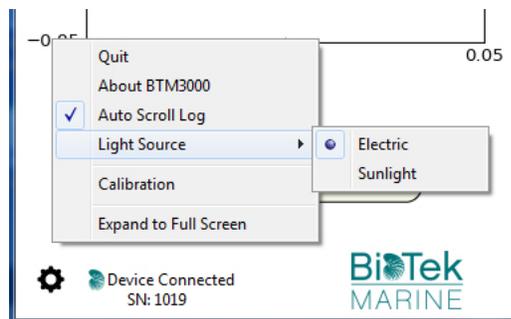
Plug the sensor into a USB port and allow some time for the sensor to automatically establish communication with the software. Once established, the message in the lower left corner will display "Device Connected SN: ####" and real-time PAR readings will update on the screen. Moving the sensor closer to a light source should increase the readings, while blocking all light from the sensor should drop the reading to zero.



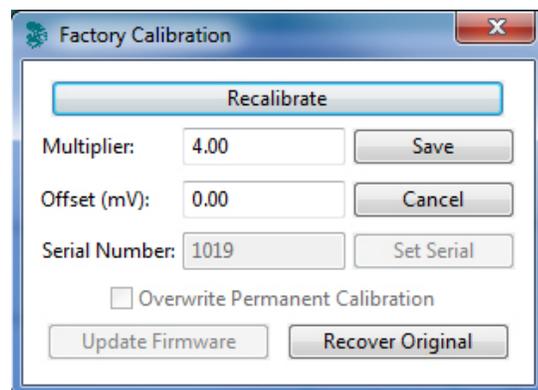
Click the **'Settings'** icon to display the software options.



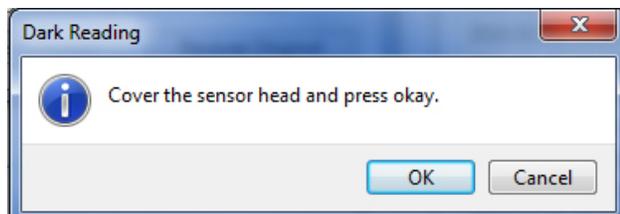
Clicking **'Light Source'** will allow the user to change the sensor's default calibration reference from Electric to Sunlight. Electric should be selected when measuring most indoor artificial light sources, while Sunlight should be selected when measuring sunlight (such as when evaluating the need for recalibration).



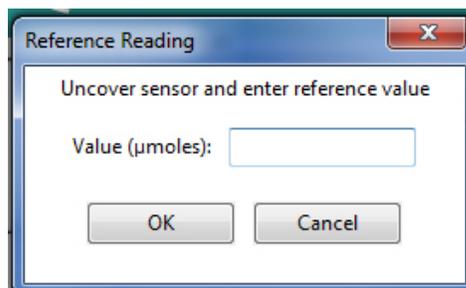
Clicking **'Calibration'** will display the factory calibrated multiplier and offset values. These values are saved in firmware and can be recovered by clicking the 'Recover Original' button. Deriving a new calibration multiplier and offset is accomplished by clicking the 'Recalibrate' button. This is applicable if users want to calibrate the sensor to their own specific light source. Note that a reference PAR value of the light source is required to complete a recalibration.



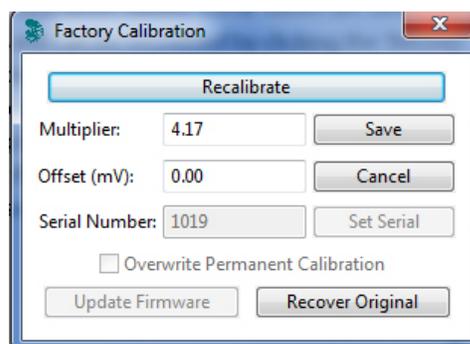
After clicking the 'Recalibrate' button the user will be prompted to cover the sensor. Place a dark cap over the sensor and wait for the real-time PAR reading to settle at zero. Click OK.



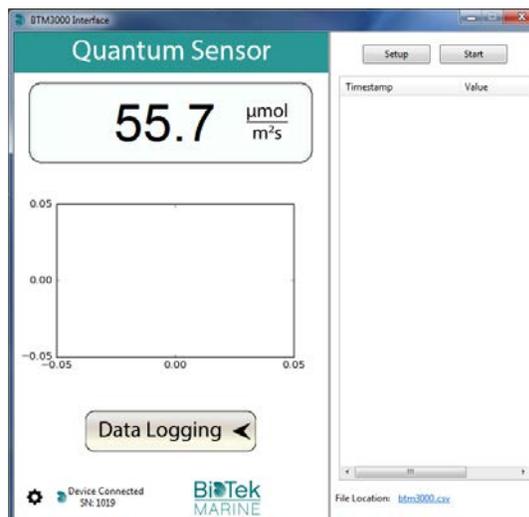
Uncover the sensor and wait for the PAR reading to settle **before** entering the reference value. Click OK.



The multiplier and offset values will automatically calculate and update in the appropriate field. Be sure to click 'Save' to retain the new multiplier and offset.

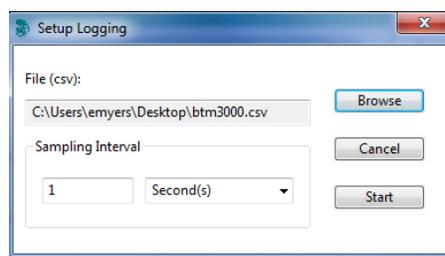


Clicking '**Data Logging**' will allow the user to log interval measurements in a csv file while the software is open and communicating with the sensor.



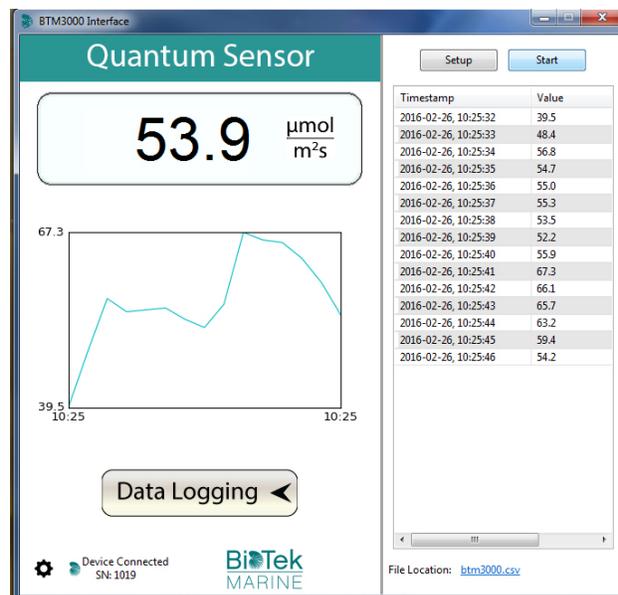
Click 'Setup' and the Setup Logging window appears. Click the 'Browse' button to create or select a csv file.

Select the desired sampling interval. Note that 1 second is the minimum interval allowed. Click 'Start'.



The data logging window will start to update at the specified sampling interval and display the Timestamp, Light Source, and Data Value. At the same time, data will be written to the csv file. Note that if the csv file is open in another program new data will not be saved to it.

The data logging window can be closed without affecting logged data by clicking the 'Exit' button. The 'Stop' button must be clicked to end data logging.



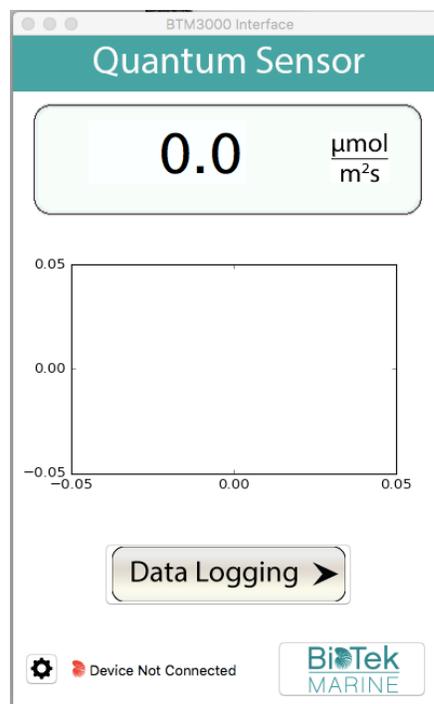
The about screen tells you the software and firmware versions. These can be used to troubleshoot if problems arise.



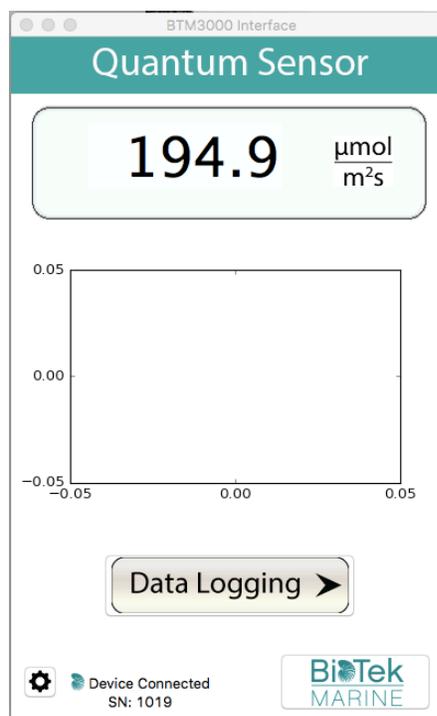
To use additional BTM3000 devices, open additional BTM3000 software windows. The device serial number will display in the lower left hand corner of the corresponding software window. Devices may be selected by serial number in the tool bar.

MAC OS SOFTWARE

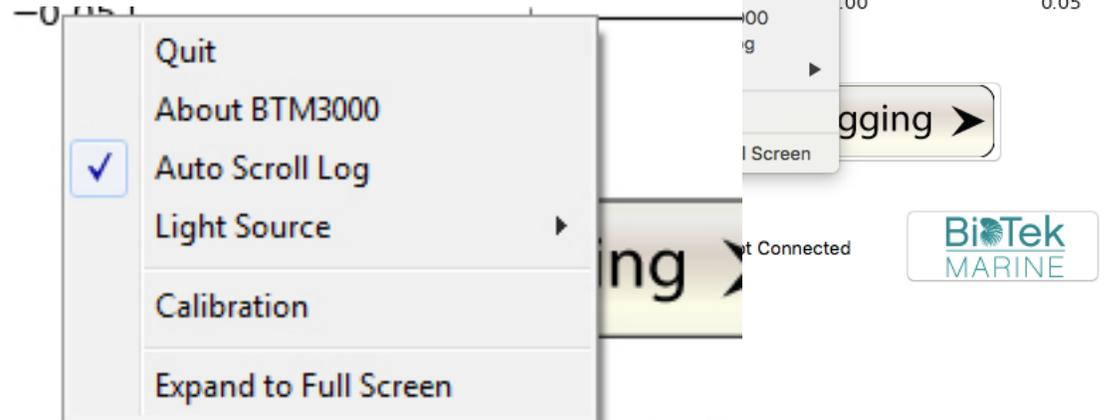
When the BTM3000 sensor is not plugged into the USB port, the software will flash a message in the lower left corner, "Device Not Connected," indicating it cannot establish communication with the sensor.



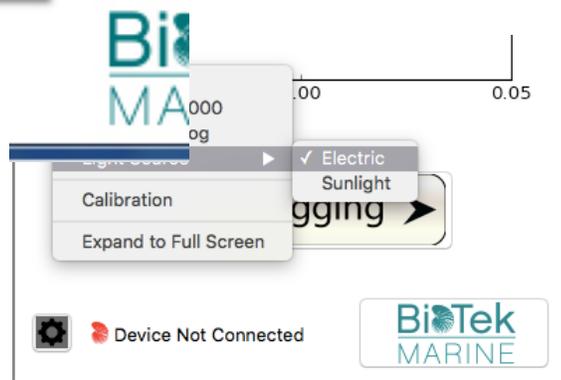
Plug the sensor into a USB port and allow some time for the sensor to automatically establish communication with the software. Once established, the message in the lower left corner will display "Device connected SN: ####" and real-time PAR readings will update on the screen. Moving the sensor closer to a light source should increase the readings, while blocking all light from the sensor should drop the reading to zero.



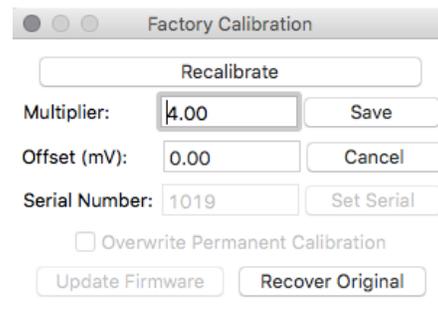
Clicking the **'Settings'** icon to display the software options.



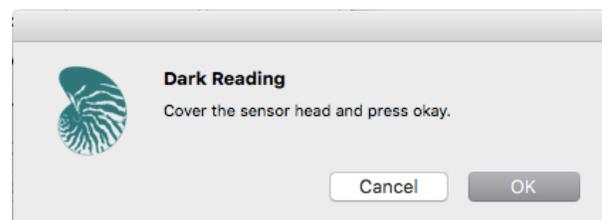
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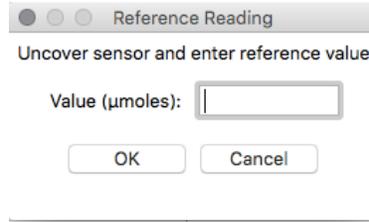
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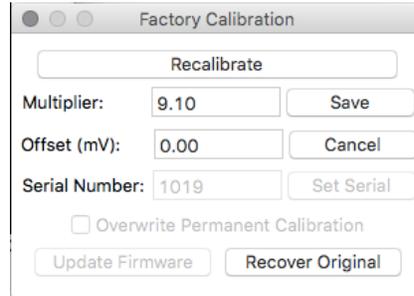
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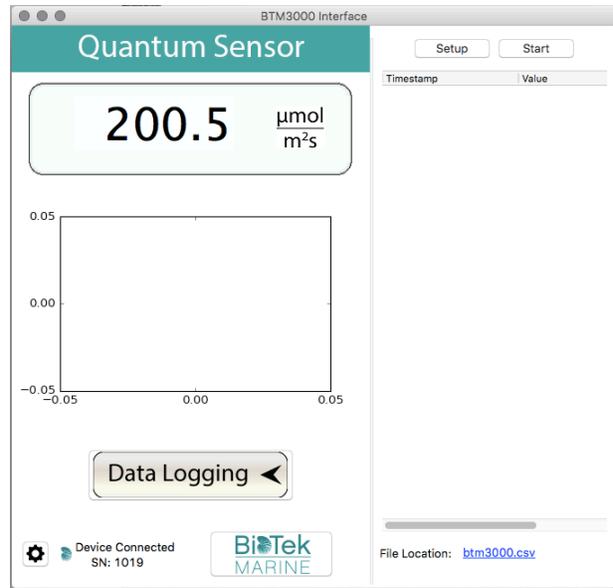
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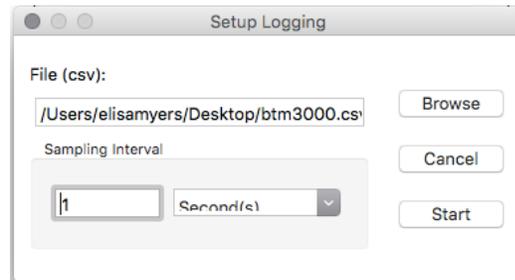


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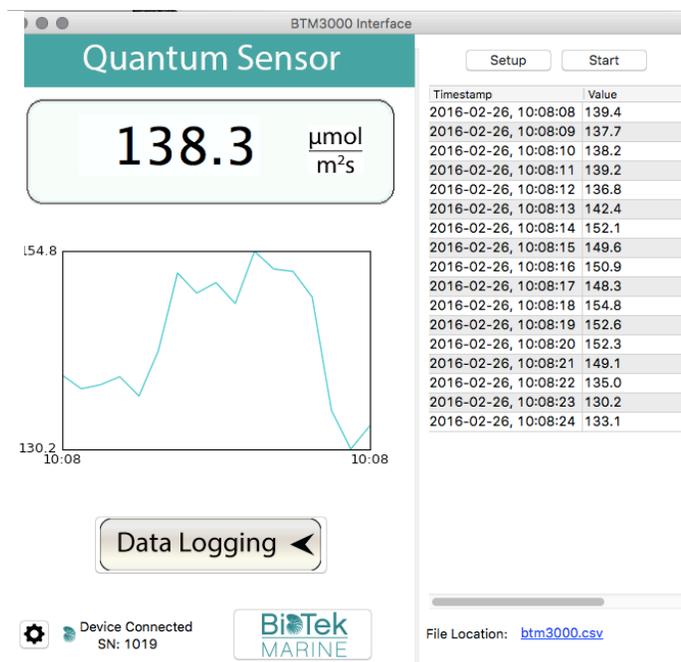
Click 'Setup' and the Setup Logging window appears. Click the 'Browse' button to create or select a csv file.

Select the desired sampling interval. Note that 1 second is the minimum interval allowed. Click 'Start'



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The data logging window can be closed without affecting logged data by clicking the 'Exit' button. The 'Stop' button must be clicked to end data logging.



The about screen tells you the software and firmware versions. These can be used to help troubleshoot if problems arise.



To use additional BTM3000 devices, open additional BTM3000 software windows. The device serial number will display in the lower left hand corner of the corresponding software window. Devices may be selected by serial number in the tool bar.

MAINTENANCE AND RECALIBRATION

Debris on the diffuser is a common cause of low readings. The sensor has a domed diffuser and housing for improved self-cleaning but materials can accumulate on the diffuser (e.g., fish food, excrement, and algal growth) and partially block the optical path. Organic deposits are best removed using water, or window cleaner and a soft cloth or cotton swab. Salt deposits should be dissolved with vinegar and removed with a soft cloth or cotton swab. **Never use an abrasive material or cleaner on the diffuser.**

The Clear Sky Calculator (www.clearskycalculator.com) can be used to determine the need for quantum sensor recalibration. It determines PAR (PPFD) incident on a horizontal surface at any time of day at any location in the world. It is most accurate when used near solar noon in spring and summer months, where accuracy over multiple clear and unpolluted days is estimated to be $\pm 4\%$ in all climates and locations around the world. For best accuracy, the sky must be completely clear, as reflected radiation from clouds causes incoming radiation to increase above the value predicted by the clear sky calculator. Measured values of PPFD can exceed values predicted by the Clear Sky Calculator due to reflection from the sides and edges of clouds. This reflection increases the incoming radiation. The influence of high clouds typically shows up as spikes above clear sky values, not a constant offset greater than clear sky values.

To determine recalibration need, input site conditions into the calculator and compare PAR (PPFD) measurements (made with a clean sensor) to calculated PAR (PPFD) values for a clear sky. If sensor PAR (PPFD) measurements over multiple days near solar noon are consistently different than calculated values (by more than 6%), the sensor should be cleaned and re-leveled. If the PAR (PPFD) measurements are different please contact support@biotekmarine.com to discuss your results and the return of your sensor(s) for recalibration.


HOME

1 For best accuracy, comparison should be made on clear, non-polluted, summer days within one hour of solar noon.

2 Enter input parameters in the blue cells at right. Definitions are shown below.

3 Sensor must be level and perfectly clean. Enter your measured solar radiation in the blue "Measured PPF" cell at far right.

4 Difference between the model and your sensor is shown in the yellow "DIFFERENCE FROM MODEL" cell at right.

5 Run the model on replicate days. Contact Apogee for recalibration if the measured value is more than 5% different than the estimated value. You will be contacted within two business days.

For a discussion on model accuracy and sensitivity of input parameters, [CLICK HERE](#).

+ INPUT AND OUTPUT DEFINITIONS

Latitude = latitude of the measurement site [degrees]; for southern hemisphere, insert as a negative number; info may be obtained from <http://touchmap.com/latlong.html>

Longitude = longitude of the measurement site [degrees], expressed as positive degrees west of the standard meridian in Greenwich, England (e.g. 74° for New York, 260° for Bangkok, Thailand, and 358° for Paris, France).

Input Parameters for Estimating Photosynthetic Photon Flux (PPF):

Latitude = °

Longitude = °

Longitude_{tz} = °

Elevation = m

Day of Year =

Time of Day = (h min = 0.1 hr)

Daylight Savings = hr

Air Temperature = C

Relative Humidity = %

Output from Model:

Model Estimated PPF = 2037 $\mu\text{mol m}^{-2} \text{s}^{-1}$

Measured PPF = $\mu\text{mol m}^{-2} \text{s}^{-1}$

DIFFERENCE FROM MODEL = -2.3 %

+ CONTACT APOGEE FOR RECALIBRATION

Name:

E-mail:

Phone:

Serial #:

Comments:

Please include all requested information.

This site is developed and maintained by:



calibration@apogee-inst.com

Clear Sky Calculator for **quantum (PAR) sensors**. Site data are input in blue cells in middle of page and an estimate of PAR (PPFD) is returned on right-hand side of page.

CUSTOMER SUPPORT TOPICS



Sensor model number, serial number, and production date are located near the USB jack on the sensor cable.

Cable Length:

Fifteen feet is the maximum cable length that can be built into the sensor.

Modifying Cable Length:

If you required a longer cable length an “active” USB extension cable is required. Please note, the connection between the cables must be made water tight prior to submersion.

Unit Conversion Charts:

BioTek Marine BTM3000 quantum sensors are calibrated to measure PAR in units of $\mu\text{mol m}^{-2} \text{s}^{-1}$. It is possible to convert the PAR value to units of light quantity (e.g., footcandles or lux), but it requires conversion factors that are specific to the radiation source of interest. These conversion factors can be found in the Knowledge Base on Apogee Instruments website (<http://www.apogeeinstruments.com/knowledge-base/>; scroll down to Quantum Sensors section).

RETURN AND WARRANTY POLICIES

RETURN POLICY

To avoid returns, we suggest you ask about any product you are unsure of and their warranties before you order.

For Unopened Packages:

BioTek Marine cannot accept returns of products once they have been opened and used. Before opening each product, please check its packaging and label carefully to be sure you received the correct product. If the supplier's original packaging and seal is still intact, you may return the product to us within 30 days from purchase for an exchange, merchandise credit or refund (excluding shipping and handling charges), subject to a 10% restocking fee. Return shipping charges incurred are the responsibility of the customer.

BioTek Marine RMA Process (Returned Merchandise Authorization)

All products returned must be accompanied by a valid Return Authorization (RA) number issued by us within 30 days of your original invoice date. After 30 days from purchase, we can no longer issue an RA and will refer you to the manufacturer for warranty service. All returned products must be 100% complete in original packaging and in resalable condition, with all packaging, software (where applicable), manuals, cables, components, blank warranty cards and other accessories and documentation included. A valid RA number must be written clearly and conspicuously on the outside of the shipping box.

Shipping and handling charges are not refundable. On items where shipping and handling is not billed or is free, shipping and handling charges will be approximated to 10% of the regular retail price of merchandise. BioTek Marine is not responsible for shipping charges and insurance on all return shipments including defective items.

WARRANTY POLICY

What is Covered

The BTM3000 is warranted to be free from defects in materials and craftsmanship for a period of one (1) year from the date of shipment from our warehouse. To be considered for warranty coverage an item must be evaluated either at our warehouse or at the manufacturer.

What is Not Covered

The customer is responsible for all costs associated with the removal, reinstallation, and shipping of suspected warranty items to our warehouse.

The warranty does not cover equipment that has been damaged due to the following conditions:

1. Improper installation or abuse.
2. Operation of the instrument outside of its specified operating range.
3. Natural occurrences such as lightning, fire, etc.
4. Unauthorized modification.
5. Improper or unauthorized repair.

Please note that nominal accuracy drift is normal over time. Routine recalibration of sensors/meters is considered part of proper maintenance and is not covered under warranty.

Who is Covered

This warranty covers the original purchaser of the product or other party who may own it during the warranty period.

What We Will Do

At no charge we will:

1. Either repair or replace (at our discretion) the item under warranty.
2. Ship the item back to the customer by the carrier of our choice.

Different or expedited shipping methods will be at the customer's expense.

How To Return An Item

1. Please do not send any products back to BioTek Marine until you have received a Return Authorization (RA) number from our technical support department by calling (803) 788-4445. We will use your RA number for tracking of the service item.
2. Send all RMA sensors and meters back in the following condition: Clean the sensor's exterior and cord. Do not modify the sensors or wires, including splicing, cutting wire leads, etc. If a connector has been attached to the cable end, please include the mating connector – otherwise the sensor connector will be removed in order to complete the repair/recalibration.
3. Please write the RMA number on the outside of the shipping container.
4. Return the item with freight pre-paid and fully insured to our factory address shown below. We are not responsible for any costs associated with the transportation of products across international borders.

BIOTEK MARINE

535 CLEMSON RD #D
COLUMBIA, SC 29229, USA

5. Upon receipt, BioTek Marine will determine the cause of failure. If the product is found to be defective in terms of operation to the published specifications due to a failure of product materials or craftsmanship, BioTek Marine will repair or replace the items free of charge. If it is determined that your product is not covered under warranty, you will be informed and given an estimated repair/replacement cost.

OTHER TERMS

The available remedy of defects under this warranty is for the repair or replacement of the original product, and BioTek Marine is not responsible for any direct, indirect, incidental, or consequential damages, including but not limited to loss of income, loss of revenue, loss of profit, loss of wages, loss of time, loss of sales, accrument of debts or expenses, injury to personal property, or injury to any person or any other type of damage or loss.

This limited warranty and any disputes arising out of or in connection with this limited warranty ("Disputes") shall be governed by the laws of the State of South Carolina, USA, excluding conflicts of law principles and excluding the Convention for the International Sale of Goods. The courts located in the State of South Carolina, USA, shall have exclusive jurisdiction over any Disputes.

This limited warranty gives you specific legal rights, and you may also have other rights, which vary from state to state and jurisdiction to jurisdiction, and which shall not be affected by this limited warranty. This warranty extends only to you and cannot be transferred or assigned. If any provision of this limited warranty is unlawful, void or unenforceable, that provision shall be deemed severable and shall not affect any remaining provisions. In case of any inconsistency between the English and other versions of this limited warranty, the English version shall prevail.

This warranty cannot be changed, assumed, or amended by any other person or agreement.

BIOTEK MARINE 535 CLEMSON RD #D , COLUMBIA, SC 29229, USA
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