This application note applies to the following Biospherical Instruments PAR light sensors, which all have a built-in log amplifier:
- QSP-200L and QCP-200L - no longer in production
- QSP-2300L, QSP-2350L, QCP-2300L, QCP-2300L-HP, QCP-2350L-HP, and MCP-2300 - current production

These PAR sensors are compatible with the following Sea-Bird CTDs:
- SBE 9*plus*
- SBE 16 or 19 – These PAR sensors may not be compatible with 6-cell housing version of these CTDs; consult Sea-Bird.
- SBE 16*plus*, 16*plus*-IM, or 19*plus* – CTD's optional PAR connector **not** required when using one of these PAR sensors. The PAR sensor interfaces with an A/D voltage channel on the CTD.
- SBE 16*plus* V2, 16*plus*-IM V2, 19*plus* V2, or 25*plus* –The PAR sensor interfaces with an A/D voltage channel on the CTD.
- SBE 25 – CTD's PAR connector (optional on older versions) **not** used with these PAR sensors. The PAR sensor interfaces with an A/D voltage channel on the CTD.

Note: The CTD voltage channel for use with the PAR sensor can be single-ended or differential.

Seasoft computes PAR using the following equation:

$$\textbf{PAR} = [\textbf{multiplier} * (10^9 * 10^{(V-B)/M}) / \textbf{calibration constant}] + \textbf{offset}$$

Make the following entries/selections in the CTD configuration (.con or .xmlcon) file:

M = 1.0   and   **B** = 0.0   (Notes 2 and 3)
calibration constant = 10^5 / Cw   (Notes 2 and 4)
conversion units = appears in data file header; does not modify calculated values, which are controlled by multiplier entry
multiplier = 1.0 for output units of µEinsteins/m^2·sec   (Note 5)
offset = - (10^4 * Cw * 10^V)   (Note 6)

Notes:
1. In our Seasoft V2 suite of programs, edit the CTD configuration (.con or .xmlcon) file using the Configure Inputs menu in Seasave V7 (real-time data acquisition software) or the Configure menu in SBE Data Processing (data processing software).
2. Sea-Bird provides two calibration sheets for the PAR sensor in the CTD manual:
   - Calibration sheet generated by Biospherical, which contains Biospherical's calibration data.
   - Calibration sheet generated by Sea-Bird, which incorporates the Biospherical data and generates M, B, and calibration constant needed for entry in Sea-Bird software (saving the user from doing the math).
3. For all SBE 911*plus*, 16, 16*plus*, 16*plus*-IM, 16*plus* V2, 16*plus*-IM V2, 19, 19*plus*, 19*plus* V2, 25, and 25*plus* CTDs, M = 1.0. For SBE 9/11 systems built before 1993 that have differential input amplifiers, M = 2; consult your SBE 9 manual or contact factory for further information. B should always be set to 0.0.
4. Cw is the *wet* µEinsteins/cm^2·sec coefficient from the Biospherical calibration sheet. A typical value is on the order of 9.0 x 10^{-6}; values have varied over the years.
5. The multiplier can be used to calculate irradiance in units other than µEinsteins/m^2 sec. See Application Note 11General for multiplier values for other units.
   The multiplier can also be used to *scale* the data, to compare the *shape* of data sets taken at disparate light levels. For example, a multiplier of 10 would make a 10 µEinsteins/m^2·sec light level plot as 100 µEinsteins/m^2·sec.
6. Offset (µEinsteins/m^2·sec) = - (10^4 * Cw * 10^V), where V is the *dark voltage*.

   The dark voltage may be obtained from:
   - Biospherical calibration certificate for your sensor (*Average Dark* volts on calibration sheet), or
   - CTD PAR channel with the sensor covered (dark) -- in Seasave V7, display the *voltage output* of the PAR sensor channel.

   Example:
   If Cw = 9.0 x 10^{-6} and Dark Voltage = 0.0021, offset = - (10^4 * 9.0 x 10^{-6} * $10^{0.0021}$) = -0.0904.

   Instead of using the dark voltage to calculate the offset, you can also directly obtain the offset using the following method:
   Enter M, B, and Calibration constant, and set offset = 0.0 in the configuration (.con or .xmlcon) file. In Seasave V7, display the *calculated PAR output* with the sensor dark; then enter the negative of this reading as the offset in the configuration file.

Mathematical Derivation

1. Using the sensor output in volts (V), Biospherical calculates:
   light (μEinsteins/$\mathbf{cm^2}$·sec) = Cw * (10$^{\text{Light Signal Voltage}}$ - 10$^{\text{Dark Voltage}}$).

2. Seasoft calculates: light (μEinsteins/$\mathbf{m^2}$·sec) = [multiplier * 10^9 * $10^{(V - B)/M}$ / Calibration constant] + offset
   where M, B, Calibration constant, multiplier, and offset are the Seasoft coefficients entered in the CTD configuration file.

3. To determine Calibration constant, let B = 0.0, M = 1.0, and multiplier = 1.0. Equating the Biospherical and Seasoft relationships:
   10^4 ($\mathbf{cm^2}$/$\mathbf{m^2}$)* Cw * (10$^{\text{Light Signal Voltage}}$ - 10$^{\text{Dark Voltage}}$) = (10^9 * 10^V) / Calibration constant + offset

   Since offset = - (10^4 * Cw * 10$^{\text{Dark Voltage}}$), and V = Light Signal Voltage:
   Calibration constant = 10^9 / (10^4 * Cw) = 10^5 / Cw

   Example:
   If Wet calibration factor = 9.0 x 10^{-6} μEinsteins/cm^2·sec, then C = 1.1111 x 10^{10} (for entry into configuration file).

Notes:

- See Application Note 11S for integrating a Biospherical Surface PAR sensor with the SBE 11*plus* Deck Unit (used with the SBE 9*plus* CTD).

- See Application Note 47 for integrating a Biospherical Surface PAR sensor with the SBE 33 or 36 Deck Unit (used with the SBE 16, 16*plus*, 16*plus* V2, 19, 19*plus*, 19*plus* V2, 25, or 25*plus* CTD).

Application Note Revision History

Date	Description
	Initial release.
July 2001	Add information about offset term, and clarify units.
October 2004	• Update with new (2003) Biospherical PAR sensor part numbers. • Expand / rewrite / reorganize.
June 2005	Provide output in microEinsteins/m^2 sec, and refer to Application Note 11General for conversion to other units.
May 2007	Incorporate Seasave V7, and eliminate discussion of Seasoft-DOS.
March 2008	• Update to include V2 SeaCATs (16*plus* V2, 16*plus*-IM V2, 19*plus* V2). • Remove 'amps' in description of calibration coefficients and units on Biospherical's calibration sheet, because Biospherical changed their calibration sheet.
February 2010	• Add information on QSP-2350L (same functioning as QSP-2300L, just different connector) and QCP-2300L-HP (same functioning as QCP-2300L, just higher depth range), which are on current price list • Change Seasoft-Win32 to Seasoft V2. • Add information on .xmlcon files. • Update address.
October 2012	Update to include SBE 25*plus*.
August 2016	Update example / typical values of Cw and dark voltage to better reflect current Biospherical calibration sheets.
May 2017	Update example to correct typo in value for C.
June 2017	Add information on QCP-2350L-HP (same functioning as QCP-2300L, just different connector).
July 2017	• Update for Seasave and SBE Data Processing versions 7.26.7 and later: - Add selection of Conversion units in PAR calibration coefficients dialog. • New template.