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PAR Light Sensors

Background Information

Sea-Bird Scientific has several application notes about PAR sensors from various manufacturers. This application note provides an overview of PAR measurements and units, and is applicable to all PAR sensors.

PAR is an abbreviation for **P**hotosynthetically **A**vailable **R**adiation (also called **P**hotosynthetically **A**ctive **R**adiation). Solar radiation reaching Earth's surface is a mixture of ultraviolet light, visible light, and near-visible infrared radiation. All of this radiation conveys heat; the portion between approximately 400 and 700 nm wavelength can be captured and used by photo-autotrophs (organisms capable of obtaining energy directly from sunlight), and is called PAR.

Irradiance is the flux of solar radiation incident on a surface per unit time per unit area and is reported in units of energy content (Watts/m^2) or photon content (quanta/m^2 sec, µEinsteins/m^2 sec, or µmol photons/m^2 sec). Conversion from energy to photon content can be made with Planck's equation, provided that the light wavelength is known. The energy of a photon is related to its wavelength as follows:

$E = hc / \lambda$

where

h = Planck's constant (6.626×10^{-34} Joules sec); c = speed of light (2.998×10^{8} m/sec); λ = wavelength (m)

This equation provides the energy for a single wavelength. For a broad spectrum PAR sensor, a wavelength of approximately 550 nm (550×10^{-9} m) is typically used for the conversion.

> "For marine atmospheres with sun altitudes above 22 degrees, the quanta/watt ratio for the region 400 to 700 nm is 2.77×10^{18} quanta/sec/Watt to an accuracy of plus or minus a few percent." This quote and further discussion of the relationship of quanta to Watts in the water column is found in Smith and Morel (1974) Limnol. Oceanogr. 19(4):591-600.

E (at 550 nm) = hc / λ = (6.626×10^{-34} Joules sec) * (2.998×10^{8} m/sec) / (550×10^{-9} m) = 3.61×10^{-19} Joules
(Note: 1 / 3.61×10^{-19} = 2.77×10^{18} quanta/sec/Watt, the value quoted in the above reference.)

Application Notes for PAR Sensors

Application notes describe how to enter coefficients from the manufacturer's calibration in the CTD configuration (.con or .xmlcon) file to provide Seasoft output in µEinsteins/m^2·sec (=µmol/m^2·sec).

- Application Notes **11Chelsea, 11Licor, and 11QSP-L and 11QSP-PD** (Biospherical) for **underwater** PAR sensors by those manufacturers
- Application Notes **11S and 47** for **Surface** PAR sensors by **Biospherical**
- Application Note **96** for **underwater** and **Surface** PAR sensors by **Satlantic**

Selecting Output Units

Seasoft V2 allows for the user-selection of PAR output units, with a pull-down list of units. The selected units appear in the data file header; **the unit selection does not actually modify the calculated data values**.

To modify the calculated data values to correspond to the selected units, modify the Multiplier (for underwater sensors) and Conversion factor (for surface sensors) as described in the table below for your sensor(s):

To convert to:	***All Underwater* PAR - set Multiplier to:** ***Biospherical Surface* PAR - multiply calculated Conversion factor by:** ***Satlantic Surface* PAR - set Conversion factor to:**
μmol photons/m^2·sec or μEinsteins/m^2·sec	**1.0**
μmol photons/cm^2·sec or μEinsteins/cm^2·sec	(1.0) / (100 cm/m)^2 = **1×10^{-4}**
mol photons/m^2·sec or Einsteins/m^2·sec	(1.0) / (1×10^{6} μEinsteins/Einstein) = **1×10^{-6}**
mol photons/cm^2·sec or Einsteins/cm^2·sec	(1×10^{-6}) / (100 cm/m)^2 = **1×10^{-10}**
quanta/m^2·sec	(1×10^{-6}) * (6.022×10^{23} quanta/Einstein) = **6.022×10^{17}**
quanta/cm^2·sec	(6.022×10^{17}) / (100 cm/m)^2 = **6.022×10^{13}**
Watts/m^2	(6.022×10^{17}) / (2.77×10^{18} quanta/sec/Watt) = **0.2174**
Watts/cm^2	(0.2174) / (100 cm/m)^2 = **2.174×10^{-5}**
μWatts/m^2	(0.2174) * (1×10^{6} μWatts/Watt) = **2.174×10^{5}**

Notes:

- *1 Einstein = 1 mol (6.022×10^{23}) of photons; 1 Watt = 2.77×10^{18} quanta/sec*
- In Seasoft V2, 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).
- Multiplier can also be used to scale output for comparing 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.