ECO Sensor Centroid Angles and χ for Backscatter Measurements

ECO and MCOMS/SeaOWL UV-A backscattering meters from Sea-Bird Scientific (formerly WET Labs) allow the estimation of the optical backscattering at one wavelength. Configurations of the instrument exist with different wavelengths, centroid angles, and χ values. (Sullivan et al., 2013). These properties are summarized in Table 1.

Single-Channel Sensors:

Single-channel ECO backscatter sensors have an in-water centroid angle of 124°. These include the ECO BB and ECO NTU sensors along with OEM variants of these sensors (AP2, 2K, SLC, etc.).

Dual-Channel Sensors:

Dual-channel ECO backscatter sensors (backscatter at 700 nm paired with chlorophyll fluorescence) have an in-water centroid angle of 142°. These include the FLNTU and FLBB versions, along with OEM variants of these sensors (AP2, 2K, SLC, RTD, SB variants).

Three-Channel Sensors:

Three-channel ECO backscatter sensors (individually paired LED source with detector) have an in-water centroid angle of 124°. These include the following ECO models: bb3, BBFL2, BB2FL and Triplet-w family.

Combined Three-Channel Sensors:

Combined three-channel ECO backscatter sensors (backscatter at 700 nm paired with chlorophyll fluorescence, along with either another backscatter or fDOM channel) have an in-water centroid angle of 124°. These include the following ECO models: FLBB-CD, FLBB-BB along with OEM variants of these sensors (2K, AP2, SLC, REM, BOSS, 6K).

MCOMS and SeaOWL UV-A:

MCOMS and SeaOWL UV-A backscatter sensors (backscatter at 700 nm paired with chlorophyll fluorescence, along with either another backscatter or FDOM channel) have an in-water centroid angle of 150°.

Summary:

Table 1: Summary of all Sea-Bird Scientific ECO and MCOMS sensor characteristics for backscattering meters.

Sea-Bird Scientific Sensor	In-water centroid angle $\bar{\theta}$	Full Width at Half Maximum (FWHM)	Optical Bandwidth	$\chi(\bar{\theta})$
MCOMS and SeaOWL UV-A	150°	20°	20nm	1.142*
Single-Channel Sensors	124°	20°	20nm	1.076**
Dual-Channel Sensors	142°	30°	20nm	1.097*
Three-Channel Sensors	124°	20°	20nm	1.076**
Combined Three Channel Sensors	124°	20°	20nm	1.076**

Angular sensitivity

The angular sensitivity of each sensor was used by WET Labs to derive the in-water centroid angles $\bar{\theta}$ in Table 1.

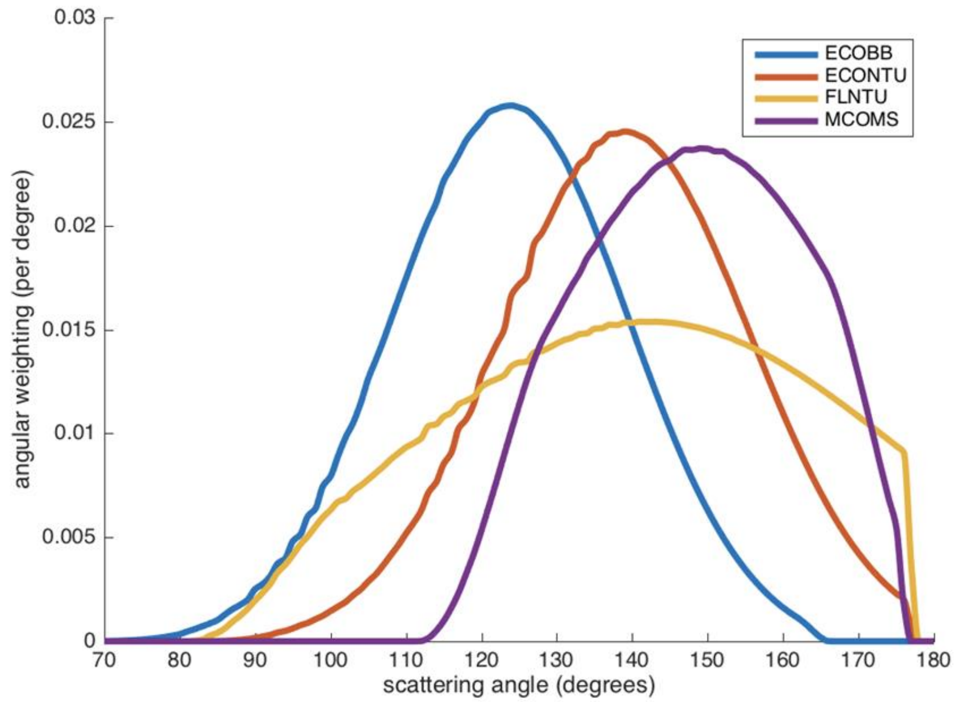

Fig. 1. Angular sensitivity for Sea-Bird Scientific backscattering meters

χ Factor:

The backscattering coefficient $b_b(\lambda)$ is estimated from the measurement $\beta(\bar{\theta},\lambda)$ using $\chi(\bar{\theta})$ factor as follows: if $\beta(\theta,\lambda)$ is the volume scattering function (VSF; [m^{-1} sr^{-1}], the angular distribution of scattering relative to the direction of light propagation, θ, at wavelength λ), then backscatter $b_b(\lambda)$ [m^{-1}] is defined as:

$$b_b(\lambda) = 2\pi \int_{\pi/2}^{\pi} \beta(\theta,\lambda) \sin(\theta)\, d\theta \qquad (1)$$

To obtain the particulate backscatter coefficient $b_{bp}(\lambda)$ from a single angle measurement of the VSF in the backward direction, the contribution of pure seawater, β_{sw}, first must be removed (Equation (2)). The values of $\beta_{sw}(\theta,\lambda)$ with dependencies on temperature *T*, practical salinity *S*, and a depolarization ratio of δ = 0.039 are derived from the study of Zhang et al. (2009).

$$\beta_p(\theta,\lambda) = \beta(\theta,\lambda) - \beta_{sw}(\theta,\lambda,T,S,\delta) \qquad (2)$$

Using $\chi(\bar{\theta})$ as a conversion factor, which relates $b_b(\lambda)$ to $\beta_p(\bar{\theta},\lambda)$ and allows us to extrapolate the measurement at a single angle to the total coefficient (Boss and Pegau, 2001), it follows that:

$$b_{bp}(\lambda) = 2\pi\chi(\bar{\theta})[\beta(\bar{\theta},\lambda) - \beta_{sw}(\bar{\theta},\lambda,T,S,\delta)] \qquad (3)$$

References

* (Mike Twardowski, Com. Pers)

** Sullivan, J. M.; Twardowski, Michael S. and Zaneveld, J. R. V. & Moore, C. C. Kokhanovsky, A. (Ed.), 2013. Light Scattering Reviews Volume 7: Radiative transfer and optical properties of atmosphere and underlying surface, Measuring optical backscattering in water. Praxis Publishing Ltd, 189-224

E. Boss and W. S. Pegau, 2001. Relationship of light scattering at an angle in the backward direction to the backscattering coefficient, Applied Optics. 40(3):5503-5507.

Zhang, X., L. Hu, and M.-X. He, 2009. Scattering by pure seawater: effect of salinity, Optics Express, 17, 5698-5710. For a MATLAB implementation of $\beta_{sw}(\bar{\theta},\lambda,T,S,\delta)$, see https://github.com/ooici/ion-functions/blob/master/ion_functions/data/matlab_scripts/flort/betasw_ZHH2009.m (Accessed 2024-05-16).