



DATA PRODUCT SPECIFICATION FOR FLUOROMETRIC CDOM CONCENTRATION

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Document Control Sheet

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This document has been reviewed and approved for release to Configuration Management.

OOI Chief Systems Engineer: _____



Date: 2012-05-16

This document has been reviewed and meets the needs of the OOI Cyberinfrastructure for the purpose of coding and implementation.

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1 Abstract

This document describes the computation used to calculate the OOI Level1 Fluorometric Colored Dissolved Organic Matter (CDOM) Concentration core data product, which is calculated using data from the WetLabs three wavelength instrument (FLORT). This document is intended to be used by OOI programmers to construct appropriate processes to create the OOI Level1 Fluorometric CDOM Concentration core data product.

2 Introduction

2.1 Author Contact Information

Please contact Merrie Beth Neely (mneely@oceanleadership.org) for more information concerning the computation and other items in the main document. Contact Oscar Schofield (oscar@rutgers.edu) for more information concerning the sample code and data set appendices, or the Data Product Specification lead (DPS@lists.oceanobservatories.org).

2.2 Metadata Information

2.2.1 Data Product Name

The OOI Core Data Product Name for this product is

- CDOMFLO

The OOI Core Data Product Descriptive Name for this product is

- Fluorometric CDOM Concentration

2.2.2 Data Product Abstract (for Metadata)

The OOI Level 1 Fluorometric CDOM concentration core data product is a measure of how much light has been re-emitted from refractory colored organic compounds found in the colored dissolved organic matter (CDOM) in seawater. This data product describes as a measure of the amount of tannins (polyphenols that bind to proteins and other large molecules) or lignins (polymers of phenolic acids) from decaying plant material or byproducts from the decomposition of animals. It accounts for the tea-like color of some water masses. CDOM is not particulate, but water masses can contain both CDOM and turbidity. CDOM absorbs ultraviolet light and fluoresces visible blue light. The fluorescence of CDOM is used in many applications such as continuous monitoring of wastewater discharge, natural tracer of specific water bodies, ocean color research and the effect of CDOM on satellite imagery, and investigations of CDOM concentrations impacting light availability used for primary production.

2.2.3 Computation Name

Not required for data products.

2.2.4 Computation Abstract (for Metadata)

This computation computes the OOI Level 1 Fluorometric CDOM Concentration core data product using a simple linear scaling of the Level 0 Fluorometric CDOM Concentration from the WetLabs three channel fluorometer (FLORT).

2.2.5 Instrument-Specific Metadata

See Section 4.4 for instrument-specific metadata fields that must be part of the output data.

2.2.6 Data Product Synonyms

Synonyms for this data product are

- CDOM fluorescence

- CDOM concentration

2.2.7 Similar Data Products

A similar product that this data product may be confused with is CHLAFLO, which yields the same measurement (but at different excitation and emission wavelengths), uses a similar calibration and zeroing principle, and essentially the same equation, but processes the Chlorophyll *a* fluorescence data stream from the instrument instead of the CDOM fluorescence.

2.3 Instruments

The WETLabs ECO triplet was selected by the OOI to make this measurement on both mobile and fixed platforms. The fixed platform instrument will have a wiper to actively limit biofouling, while those installed on mobile assets (profilers, gliders, and AUVs) will have only passive mitigation of biofouling (coating and copper faceplates). For more information on the instruments from which the inputs to OOI Level1 Fluorometric CDOM concentration core data product are obtained, see the FLORT Processing Flow document (DCN 1342-00530). This document contains information on the FLORT instrument class make/model; it also describes the flow of data from the FLORT instrument through all of the relevant QC, calibration, and data product computations and procedures.

Note that the raw CDOM data from the fluorimeters on board the gliders and autonomous underwater vehicles (AUVs) are processed onboard the vehicles with proprietary software from the vehicle vendors. These data are presented already in decimal format in appropriate units therefore processing raw hexadecimal data from the FLORT is not included in the algorithm described in this document.

Please see the Instrument Application in the SAF for specifics of instrument locations and platforms.

2.4 Literature and Reference Documents

WETlabs ECO FL User's Guide (FL) Revision AM 14 Sept. 2011

WETlabs ECO Triplet-w User's Guide (triplet w) Revision C 28 Sept. 2011

Ivona Cetinić, Gerardo Toro-Farmer, Matthew Ragan, Carl Oberg, and Burton H. Jones, 2009. Calibration procedure for Slocum glider deployed optical instruments. *Optics Express*, 17(18):15420-15430

Paula G. Coble, C. A. Schultz, and K. Mopper, 1993. Fluorescence contouring analysis of DOC intercalibration experiment samples: a comparison of techniques. *Mar. Chem*, 41: 173-178

Paula G. Coble, 1996. Characterization of marine and terrestrial DOM in seawater using excitation-emission matrix spectroscopy. *Mar. Chem*, 51: 325-346

Jorge A. Herrera-Silveira and J. Ramirez-Ramirez, 1996. Effects of natural phenolic material (tannin) on phytoplankton growth. *Limnol. Oceanogr.*, 41: 1018-1023

Anthony Vodacek, N. V. Blough, M. D. DeGrandpre, E. T. Peltzer, and R. K. Nelson, 1997. Seasonal variation of CDOM and DOC in the middle Atlantic bight: terrestrial inputs and photooxidation. *Limnol. Oceanogr.*, 42: 674-686

P. L. Smart, B. L. Finlayson, W. D. Rylands and C. M. Ball, 1976. The relation of fluorescence to dissolved organic carbon in surface waters. *Water Research*, 10: 805-811

D. A. Skoog, D. M. West, F. J. Holler and S. R. Crouch, *Analytical Chemistry: An Introduction*, 7th ed., Chapter 23, pp. 594-631. Revised January 24, 2005.

See also anything posted:

<https://confluence.oceanobservatories.org/display/science/Common+Instrument+ICD>

Or

<https://confluence.oceanobservatories.org/display/Presentations/OOI+FLOR+Collaboration>

2.5 Terminology

2.5.1 Definitions

The following terms are defined here for use throughout this document. Definitions of general OOI terminology are contained in the Level 2 Reference Module in the OOI requirements database (DOORS).

CDOM – Colored Dissolved Organic Matter, or Chromophoric Dissolved Organic Matter, either is appropriate.

CDOM fluorescence – is light that has been re-emitted from refractory colored organic compounds found in CDOM. By measuring the intensity and nature of this fluorescence, CDOM can be estimated. The FLORT instrument delivers the raw counts from CDOM contained in a water sample based on excitation and emission at a single wavelength.

concentration - is a measure of the amount of something, in this case CDOM in parts per billion.

scale factor – is used to scale the output counts of the instrument to CDOM concentration in ppb. This factor is calculated at the factory for each instrument and provided on the instrument calibration sheet – it is an instrument-specific constant that will change with each factory calibration. The scale factor is then applied to the output signal to provide the direct conversion of the output to CDOM concentration. For CDOM, WET Labs uses a solution where XX is the meter output in counts of the concentration of the solution used during the factory instrument characterization as shown here.

$$\text{Scale Factor [ppb/counts]} = 308 \div (\text{XX} - \text{dark counts})$$

$$\text{Example: } 308 \div (4148 - 56) = 0.0753$$

While this constant can be used to obtain approximate values, field calibration is highly recommended (see Cetinic et al for procedures). See appendix D for an example of the factory characterization sheet.

dark counts - The instrument's baseline reading in the absence of source light is the dark count value. A dark count value is determined at the factory for each instrument and provided on the instrument calibration sheet. The *factory* dark count is used to calculate the *factory* scale factor. While this constant can be used to obtain approximate values, field calibration is highly recommended. This is determined by measuring the signal output in clean, de-ionized water with black tape over the detector.

2.6 Acronyms, Abbreviations and Notations

General OOI acronyms, abbreviations and notations are contained in the Level 2 Reference Module in the OOI requirements database (DOORS). The following acronyms and abbreviations are defined here for use throughout this document.

CDOM – Colored Dissolved Organic Matter

ppb – parts per billion

QSDE – Quinine Sulfate Dihydrate Equivalent

VDC – volts of DC current

2.6.1 Variables and Symbols

The following variables and symbols are defined here for use throughout this document.

XX = concentration of a sample of interest (ppb)

Coutput = raw counts “calibrated” digital data output when measuring a sample of interest

Cdc = dark counts, the measured signal “calibrated” digital data output of meter in clean water with black tape over the detector

scale_factor = multiplier in ppb per volts

3 Theory

3.1 Description

The WET labs Environmental Characterization Optics (ECO) miniature fluorometer allows the user to measure relative chlorophyll, CDOM, uranine, phycocyanin, or phycoerythrin (the latter three are not currently included as OOI core data product) concentrations by directly measuring the amount of fluorescence emission in a sample volume of water. The ECO miniature fluorometer uses an LED to provide the excitation source. An interference filter is used to reject the small amount of out-of-band light emitted by the LED. The light from the source enters the water volume at an angle of approximately 55–60 degrees with respect to the end face of the unit. Fluoresced light is received by a detector positioned where the acceptance angle forms a 140-degree intersection with the source beam. An interference filter is used to discriminate against the scattered excitation light.

Raw data from the FLORT instrument is output in counts from the sensor, ranging from 0 to approximately 16000. The scale factor is factory-calculated by obtaining a consistent output in a solution with a known concentration, then subtracting the meter’s dark counts. The scale factor, dark counts, and other characterization values are given on the instrument’s characterization sheet shipped by the vendor with each meter. The scale factor is then applied to the output signal to provide the direct conversion of the output to CDOM concentration. While scale factor can be used to obtain approximate values, field/shipboard calibration is highly recommended prior to deployment. It is important to perform calibrations using a quinine sulfate standard and blanking with CDOM free seawater (or suitable replacements for both – see Cetinic et al) as you expect to encounter *in situ*. This will provide a refined dark count for refining the scale factor, thereby providing an accurate and meaningful field/shipboard calibration prior to deployment. The instrument response is linear over the measurement range provided (0 to 16000 counts, or 0-5 Volts). Once a zero point has been determined and a refined scale factor established from the field/shipboard calibration prior to deployment, the conversion of dark count volts to CDOM concentration is straightforward using the equation:

$$XX = (Coutput - Cdc) * scale_factor$$

Where:

XX = concentration of a sample of interest (ppb)

Coutput = calibrated voltage output when measuring a sample of interest

Cdc = dark counts, the calibrated measured signal output (in VDC) of meter in clean water with black tape over the detector

scale_factor = multiplier in ppb per volts`

Note, that the nature of CDOM probed by fluorometer is a function of both the excitation and emission wavelength that is chosen. As the OOI FLORT instrument has a single channel to measure excitation and emission wavelengths, the systems cannot provide information on the composition of the CDOM present.

Optical Specifications for Fluorescence Meters

Specifications given below are typical. Linearity for all is 99% R2. Other ranges are available on Request from WETlabs.

Parameter	EX/EM	Sensitivity	Range
Chlorophyll-a (Chl)	470/695 nm	0.02 µg/l	0–125 µg/l
Colored Dissolved Organic Matter (CDOM)	370/460 nm	0.09 ppb	0–500 ppb

3.2 OOI pre-deployment field or laboratory calibration and post-recovery data QC considerations:

Scale factor: WET Labs supplies a scale factor that can be found on the instrument-specific calibration sheet that ships with each meter. In the field the Scale factor is refined by obtaining a consistent output in a solution with a known CDOM concentration (XX), then subtracting the meter's dark counts. Land-based or shipboard laboratory determination of CDOM fluorescence (both **pre-and post-deployment**) should be made to further refine the scale factor calculation for data QC use when processing real-time L1b data. This measurement should be repeated multiple times, using replicates of serial dilution cultures. Field proxy measurements from *in situ* instruments and filtered water samples for CDOM extraction (see Coble et al, 1993 and 1996) are necessary for comparison at the time of deployment and recovery of both fixed instruments and instruments on mobile platforms. This is especially important for instruments deployed in the hulls of gliders and AUVs. Instrument-specific drift attributable to biofouling vs. inherent drift can be determined **post-recovery** by taking replicate CDOM measurements in fluorescence free water both before and after the biofouling has been thoroughly chemically and mechanically removed from the optical window (see Cetinic et al). The latter measurement represents inherent drift and the difference between the initial measurements and the inherent drift measurements represents that from biofouling that affect the scale factor calculation applied (see also dark counts below). These post-recovery measurements require minimal human in the loop time and effort and are used to determine the linear application of automated QC for both types of drift in L1c data.

dark counts: Land-based or shipboard laboratory determination of dark counts (pre-deployment) should be made to further refine the scale factor calculation for data QC use when processing real-time L1b data. This is determined by measuring the signal output in clean, de-ionized water with black tape over the detector in a darkened room or chamber devoid of ambient light. This measurement should be repeated multiple times, using different placements of tape to maximize detector coverage. This is especially important for instruments deployed in the hulls of gliders and AUVs. Instrument-specific drift attributable to biofouling vs. inherent drift can be determined **post-recovery** by taking repeating the pre-deployment dark count procedures – making repeated measurements in fluorescence free water both before and after the biofouling has been thoroughly chemically and mechanically removed from the optical window (see Cetinic et al). The latter measurement represents inherent drift and the difference between the initial measurements and the inherent drift measurements represents that from biofouling that affect the dark count value applied to determine the corrected post-recovery scale factor. These post-recovery measurements require minimal human in the loop time and effort and are used to determine the linear application of automated QC for both types of drift in L1c data.

3.3 Mathematical Theory

It is possible that the instrument may be set up to operate in either analog or digital format and both are in volts, but the OOI will only use digital format. The driver and transforms do not need to support analog output. The equations are essentially the same, and the OOI will use the digital version provided below.

Digital data:

Scaling is linear. Once a zero or blank has been determined and a refined scale factor established from field/shipboard calibration prior to deployment, the conversion of volts to CDOM concentration is straightforward using the equation below. Obtaining the concentration (XX) simply involves subtracting a digital dark counts value and multiplying the difference by the instrument scaling factor. Use the equation:

$$XX = (C_{\text{output}} - C_{\text{dc}}) * \text{scale_factor}$$

3.4 Known Theoretical Limitations

No known theoretical limitations to date.

3.5 Revision History

No revisions to date.

4 Implementation

4.1 Overview

Level 0 (raw data) from the FLORT instrument is output in counts from the sensor, ranging from 0 to approximately 16000. The conversion from L0 to the L1 Fluorometric CDOM Concentration data product is implemented using a linear scaling equation.

4.2 Inputs

Inputs are:

- L0 counts ranging from 0 to 16000 (corresponds to a direct current volt range of 0 to 5).
- Scale factor from factory calibration and refined through at-sea, pre-deployment calibration (or just factory-supplied instrument calibration sheet in the absence of a field calibration), saved as part of the instrument metadata
- Cdc from pre-deployment benchtest, saved as part of the instrument metadata
- Preset emission (370nm) and excitation wavelengths (460nm) for CDOM

Input Data Format

- The L0 Fluorometric CDOM Concentration data product is a 6 digit floating decimal string.

Range checks on the inputs are applied as part of the global range check (GLBLRNG, DCN 1341-10004) specified in the FLORT Processing Flow document (DCN 1342-00530). A separate range check on the inputs does not need to be applied.

4.3 Processing Flow

Pre-processing and Product-specific calibration: *The instrument-specific information (such as the scale factor and factory calibration method) must be captured from the most-recent factory calibration sheet, the instrument must be appropriately field/shipboard calibrated using in situ water and also 'zeroed' or a blank determined using water free of fluorescent matter. The dark count and scale factor values from the factory documentation can be used as a default setup for the concentration calculation, but the refined values for both obtained during field/shipboard calibration pre-deployment must be transmitted to CI to 'update' the automated pre-deployment (L1b) data QC equations applied to the real-time data.*

Product-specific quality control: *As described above under OOI pre-deployment field or laboratory calibration and post-recovery data QC considerations, a linear*

or curvilinear optical biofouling correction to account for both biofouling and inherent drift can be applied to the data based upon at-recovery on-board testing or post-deployment/pre-recovery ship of opportunity comparisons that are available. This too must be transmitted to CI to 'update' the automated post-recovery (L1c) data QC equations that will be applied to the data.

Error handling: none.

Post-processing: *The appropriate automated QC tests are Global range, spike, stuck value, and with some future local knowledge applied a local range and temporal spatial gradient tests may be applied. However, the nature of phytoplankton abundance (and thus fulvic CDOM) is patchy and blooms can be both transient and dynamic – characteristics which make it difficult to set the parameters for all these tests with certainty. CDOM from riverine origin (humic) will be easier to quantify on a seasonal and local basis. See also **OOI pre-deployment field or laboratory calibration and post-recovery data QC considerations** above.*

The specific steps necessary to create all calibrated and quality controlled data products for each OOI core instrument are described in the instrument-specific Processing Flow documents (DCN 1342-00530). These processing flow documents contain flow diagrams detailing all of the specific procedures (data product and QC) necessary to compute all levels of data products from the instrument and the order in which these procedures are to be applied.

The processing flow for the Fluorometric CDOM Concentration computation is as follows:

Step 1:

The marine operator must perform the field/shipboard determination of dark counts to serve as a zero or blank procedure using fluorescent free water such as Barnstead MilliQ, etc. The dark count from field/shipboard calibration is saved as instrument metadata to be provided to CI immediately post-deployment as an update from the factory provided dark count used as a default.

Step 2:

The marine operator must perform a field/shipboard calibration using a quinine sulfate standard (or appropriate substitute solution) and similar seawater as you expect to encounter *in situ*. This provides an accurate blank for calculating the scale factor, thereby providing an accurate and meaningful calibration. The scale factor from field calibration is saved as instrument metadata to be provided to CI immediately post-deployment as an update from the factory provided scale factor used as a default. The instrument can then be deployed.

Step 3 (digital mode):

For digital mode, the conversion of counts from the instrument to CDOM concentration is straightforward using the equation:

$$XX = (\text{Coutput} - \text{Cdc}) * \text{scale_factor}$$

Where:

XX = CDOM concentration of a sample of interest (ppb)

Coutput = output in counts when measuring a sample of interest

Cdc = dark counts, the measured signal output of the fluorometer in clean water with black tape over the detector

scale_factor = multiplier in ppb per volts

4.4 Outputs

The output of the CDOM concentration computation is

- CDOM concentration in parts per billion (ppb) as a 6 digit floating decimal string.

There is no OOI Level 2 science program requirement for accuracy, precision or drift of CDOM estimates.

The metadata that must be included with the output are

- factory or field/shipboard refined scale factor used in this calculation
- factory or field/shipboard refined dark counts (in volts or counts) used in this calculation
- zero or blank (in volts or counts) set on the instrument during field/shipboard calibration
- Any corresponding post-deployment or at-recovery field CDOM extractions, *in situ* measurements, or post-recovery drift measurements used to refine the above field calibration factor for L1b or L1c data.

4.5 Computational and Numerical Considerations

4.5.1 Numerical Programming Considerations

There are no numerical programming considerations for this computation. No special numerical methods are used.

4.5.2 Computational Requirements

- Assuming we are reprocessing the data upon recovery of the various assets, and that one sample is a single data point from any FLORT, and example number of samples are as follows.
- For an RSN or global mooring riser or global flanking mooring: 1 FLORs each mooring * 12 samples/hour * 24 hours *365 days= 105120 samples.
- For an endurance or Pioneer mooring: 3 FLORs each mooring * 12 samples/hour*24 hours*365 days = 315360 samples
- For a coastal glider: 1 sample/second * 6 months = $1.6 * 10^7$ samples.
- For an AUV: 1 sample/second * 6 months = $1.6 * 10^7$ samples.
- For a deep profiler on RSN: 1 sample/second for a 1000m profile with a profiler moving at 0.5 m/s operating 48 times per day (assumes that a CTD profile is taken on both down and up casts and profiler is operating continuously) for 365 days = $3.5 * 10^7$ samples. NOTE these instruments are also located on global, endurance, pioneer and RSN surface piercing profilers, deep profilers, and wire following profilers.

4.6 Code Verification and Test Data Set

The code will be verified using the test data set provided, which contains inputs and their associated correct outputs. CI will verify that the code is correct by checking that the output, generated using the test data inputs, is identical to the test data density output.

Input: factory dark count 48, factory scale factor 0.0848 ppb/count, factory temp at time of characterization 21.5°C. Red highlighting of CDOM raw indicates L0 data input.

date (RT)	time (RT)	CDOM (em)	CDOM raw
99/99/99	99:99:99	460	51
99/99/99	99:99:99	460	50
99/99/99	99:99:99	460	50
99/99/99	99:99:99	460	52
99/99/99	99:99:99	460	50
99/99/99	99:99:99	460	51
99/99/99	99:99:99	460	51
99/99/99	99:99:99	460	51

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99/99/99	99:99:99	460	51
99/99/99	99:99:99	460	51
99/99/99	99:99:99	460	49
99/99/99	99:99:99	460	52
99/99/99	99:99:99	460	52
99/99/99	99:99:99	460	53
99/99/99	99:99:99	460	52
99/99/99	99:99:99	460	51

Output:

Count	Date	Time	CDOM-ppb
1	999999	999999	0.2544
2	999999	999999	0.1696
3	999999	999999	0.1696
4	999999	999999	0.3392
5	999999	999999	0.1696
6	999999	999999	0.2544
7	999999	999999	0.2544
8	999999	999999	0.2544
9	999999	999999	0.2544
10	999999	999999	0.2544
11	999999	999999	0.0848
12	999999	999999	0.3392
13	999999	999999	0.3392
14	999999	999999	0.424
15	999999	999999	0.3392
16	999999	999999	0.2544

Appendix A Example Code

Example code from Murray State University's Matt Williamson.

```
'Description: Creates CDOM table with PPB from Digital output
'Author: Ron Hooks
'Date Created: 8-26-2010

'Declarations
Public CDOM_ppb
Dim strRawdata As String * 100
Dim strParsRaw As String *100
Dim intParsRaw As Float
Dim intNbytes
Dim strStart As String * 100
Dim strStop As String * 100
Dim fltScaleFactor As Float

' Force the datalogger into sequential mode
SequentialMode

'CDOM Table
DataTable (CDOM,1,-1)
    DataInterval (0,1,Min,10)
    Sample(1,CDOM_ppb,IEEE4)
EndTable

'Main Program
BeginProg
strStart = "$run" & CHR(13) & CHR(10)
strStop = "!!!!!" 'stop
fltScaleFactor = 0.0311

    Scan (30,Sec,0,0)
        SW12 (1) 'temporary, make sure to connect to cont. power
        SerialOpen (Com3,19200,0,0,10000)

        'send start command
        SerialOut (Com3,strStart,"",0,100)

        'give time for sensor to take readings
        Delay (1,10,Sec)

        'record CDOM output
        SerialInRecord (Com3,strRawdata,58,0,13,intNbytes,01) 'start on
last ":" in time stamp, end on CR

        'Parse output
        Select Case intNbytes 'the number of bytes returned can determine
the size of the ppb value (0 to 16355)
            Case = 12
                strParsRaw = Mid (strRawdata,8,1) 'grab one digit
            Case = 13
                strParsRaw = Mid (strRawdata,8,2) 'two
            Case = 14
```

```
    strParsRaw = Mid (strRawdata,8,3) 'three
Case = 15
    strParsRaw = Mid (strRawdata,8,4) 'four
Case = 16
    strParsRaw = Mid (strRawdata,8,5) 'five
EndSelect

'convert to integer for calculation
intParsRaw = strParsRaw

    ' Convert CDOM data to ppb
    ' Coefficients from Characterization Sheet:
    ' CDOM (QSDE), ppb = Scale Factor * (Output - Dark
Counts)
    ' Scale Factor = 0.0311 ppb/count
    ' Dark Counts = 44
CDOM_ppb = fltScaleFactor*(intParsRaw - 44)

'place into table
CallTable CDOM

'clear string
strRawdata=""

'send stop command
SerialOut (Com3,strStop,"",3,100) 'stop measuring, close wiper

NextScan
EndProg
```

Appendix B Output Accuracy

There is no accuracy requirement for CDOM fluorescence in The OOI requirements database (DOORS). There is no statement of accuracy by the manufacturer.

Appendix C Sensor Calibration Effects

Failure to account for fluorescence from degraded chlorophyll *a*, phaeopigments and other refractory pigments found in CDOM during the predeployment calibration process can lead to overestimates of the chlorophyll *a* concentration in a discrete water sample, and consequently the phytoplankton biomass and primary productivity in an ecosystem. If both chlorophyll *a* and CDOM concentration are measured coincidentally (i.e. three channel fluorometry is enabled, vs. only two channels) then a correction factor can be applied to the chlorophyll *a* data stream. This is not possible unless CDOM is coincidentally measured, so the inherent error in chlorophyll *a* must be reported where CDOM is not coincidentally measured.

Because optical surfaces can be colonized by phytoplankton, and the chlorophyll *a* in such colonial phytoplankton would be measured as a consequence of being within the optical path of the instrument and likely to contribute to the fluorescence signal, biofouling must be corrected for in the post-deployment signal. Such colonization is likely to be nil at the time of deployment, but rapidly colonize the optical surfaces to quickly reach a carrying capacity, and can be corrected with a linear or logarithmic curve applied to the data. However, unless a reliable estimate of the period of time when the carrying capacity is reached *in situ* can be determined, it is more reasonable to assume a linear or logarithmic correction applied across the entire deployment time period that assumes no biofouling at deployment and maximum biofouling at recovery.

The post-recovery handling and testing procedures for all optical instruments should be well documented in the field procedures because even slight adjustments to the biofouling community will result in dramatic changes to the optical properties reported by the instruments. Thus care should be taken to not disturb, desiccate, or alter the temperature and salinity under which the instruments were held *in situ*. The post-recovery handling methodology shall be informed by the oceanographic community and the vendor's recommendations – as collected and adopted by the OOI program through QC workshops, whitepapers, webinars, and other outreach and community validation efforts.

Also chlorophyll *a* concentration is a proxy for phytoplankton biomass and is not a direct measure of it. The same chlorophyll *a* concentration can be reported for a water mass with low abundance of large phytoplankton or high abundance of small phytoplankton. Using algorithms and ancillary measurements some passes at particle size can be obtained through intense human in the loop post-processing – which is entirely beyond the scope of the OOI program. In addition, only the light harvesting pigment of chlorophyll *a* fluorescence is measured by this method, and no estimate of the presence or abundance of accessory pigments is included, which can be diagnostic of phytoplankton community groups; and the photosystem 'health' of the phytoplankton assemblage is also not assessed with this method, as may be possible with other types of fluorometry.

Appendix D Sample Factory Characterization Sheet

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ECO CDOM Fluorometer Characterization Sheet

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S/N: FLBBCDSLK-2110

CDOM concentration expressed in ppb can be derived using the equation:

$$\text{CDOM (ppb)} = \text{Scale Factor} * (\text{Output} - \text{Dark Counts})$$

Dark Counts	Digital
Scale Factor (SF)	48 counts
Maximum Output	0.0848 ppb/count
Resolution	4130 counts
	1.0 counts
Ambient temperature during characterization	21.5 °C

Dark Counts: Signal output of the meter in clean water with black tape over detector.

SF: Determined using the following equation: $SF = x \div (\text{output} - \text{dark counts})$, where x is the concentration of the solution used during instrument characterization. SF is used to derive instrument output concentration from the raw signal output of the fluorometer.

Maximum Output: Maximum signal output the fluorometer is capable of.

Resolution: Standard deviation of 1 minute of collected data.

FLBBCDSLK-2110.xls

Revision S

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