QA/QC and Factory Calibration of Backscattering Data

Ian Walsh
Director of Science, Sea-Bird Scientific

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Topics

- Variance Structure and Measurements
- QA/QC: QARTOD
- Calibration Structure
- Calibration and Field Variance Scales

Separating Variance

G Model: $$Signal = e^{-kt} = A_1 e^{-k_1 t} + B_2 e^{-k_2 t} + C_3 e^{-k_3 t}$$

$$I_0 = 1 = A_1 + B_2 + C_3$$

$$Signal_{inst} = e^{-k_{inst} t} \qquad Signal_{tgt} = e^{-k_{tgt} t} \qquad Signal_{fix} = e^{-k_{fix} t}$$

A G Model expands a reaction into components.

For the calibration, we can divide the sources of change into the Instrument, Target, Fixture.

We can then estimate the factors upon each source.

Instrument: Temperature, pressure, Elapsed time, pressure and temperature, time and pressure, time and temperature, time and temperature and pressure. Others?

Target: Same as instrument, chemical changes with time: oxidation, UV breakdown,

Fixture: Mixing rate, flow past instrument

We can then sum up the relative changes and apportion the total change into the fractional change functions.

Separating Variance: Physical

$$Signal_{inst} = e^{-k_{inst}t}$$

$$Signal_{tgt} = e^{-k_{tgt}t}$$

$$Signal_{fix} = e^{-k_{fix}t}$$

Instrument Design Engineering:

1. Temperature
2. Pressure
3. Elapsed time (age)
4. Pressure and temperature
5. dTime and pressure
6. dTime and temperature
7. dTime and temperature and pressure.

Separating Variance: Optics

$$Signal_{inst} = e^{-k_{inst}t}$$

$$Signal_{tgt} = e^{-k_{tgt}t}$$

$$Signal_{fix} = e^{-k_{fix}t}$$

Instrument Operational Parameters:

1. Signal to Noise
2. Signal Range
    1. Resolution
3. Signal Variance
    1. < 2 counts StDev @ 60 seconds dark counts

New Operational Parameter:

4. Noise Range
    1. Defined as Max – Min over time
        1. Dark Counts
        2. No Load (clean water)

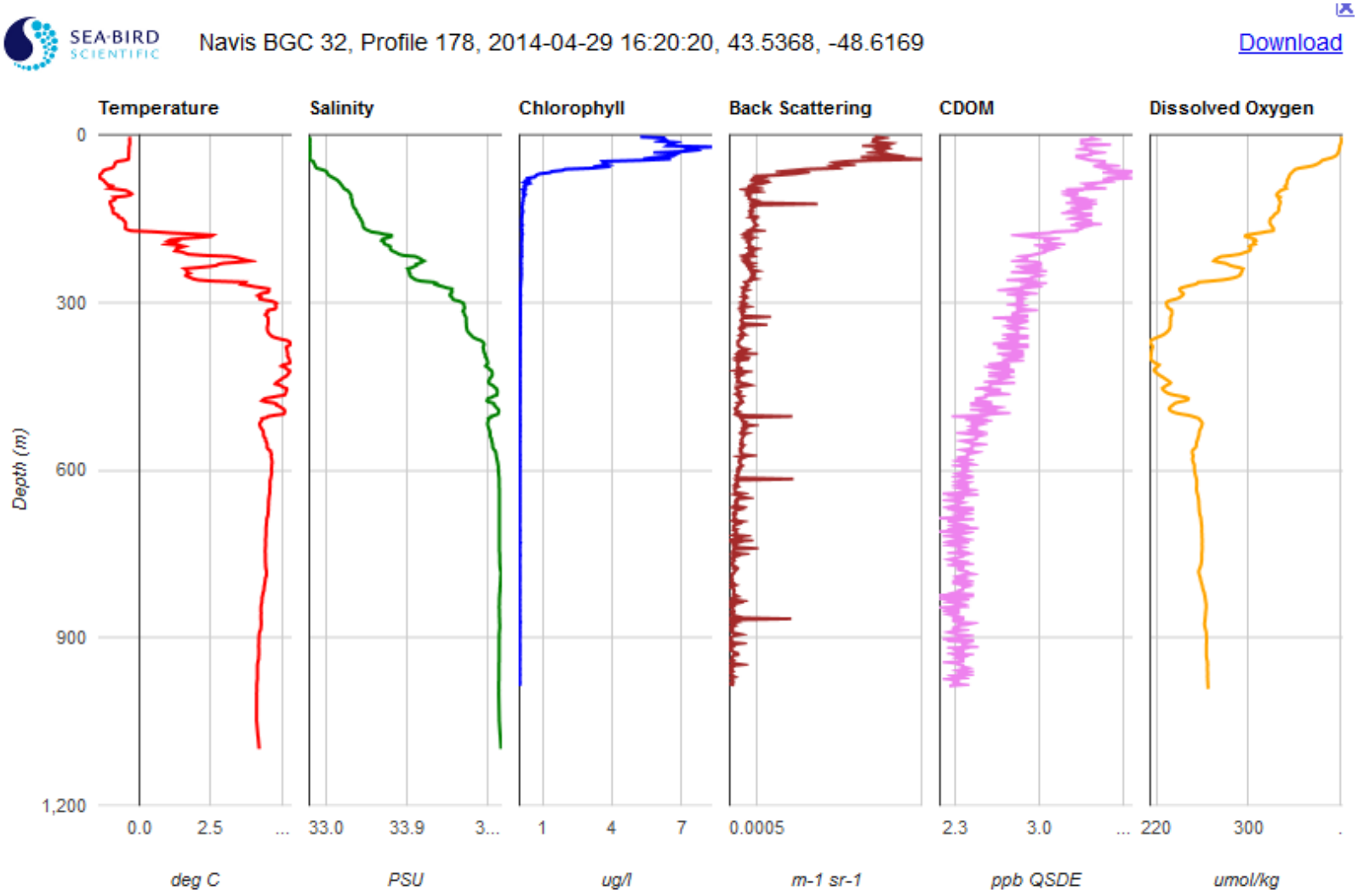
QARTOD Tests: Optical

Table 3-2. QC Tests in order of implementation and hierarchy.

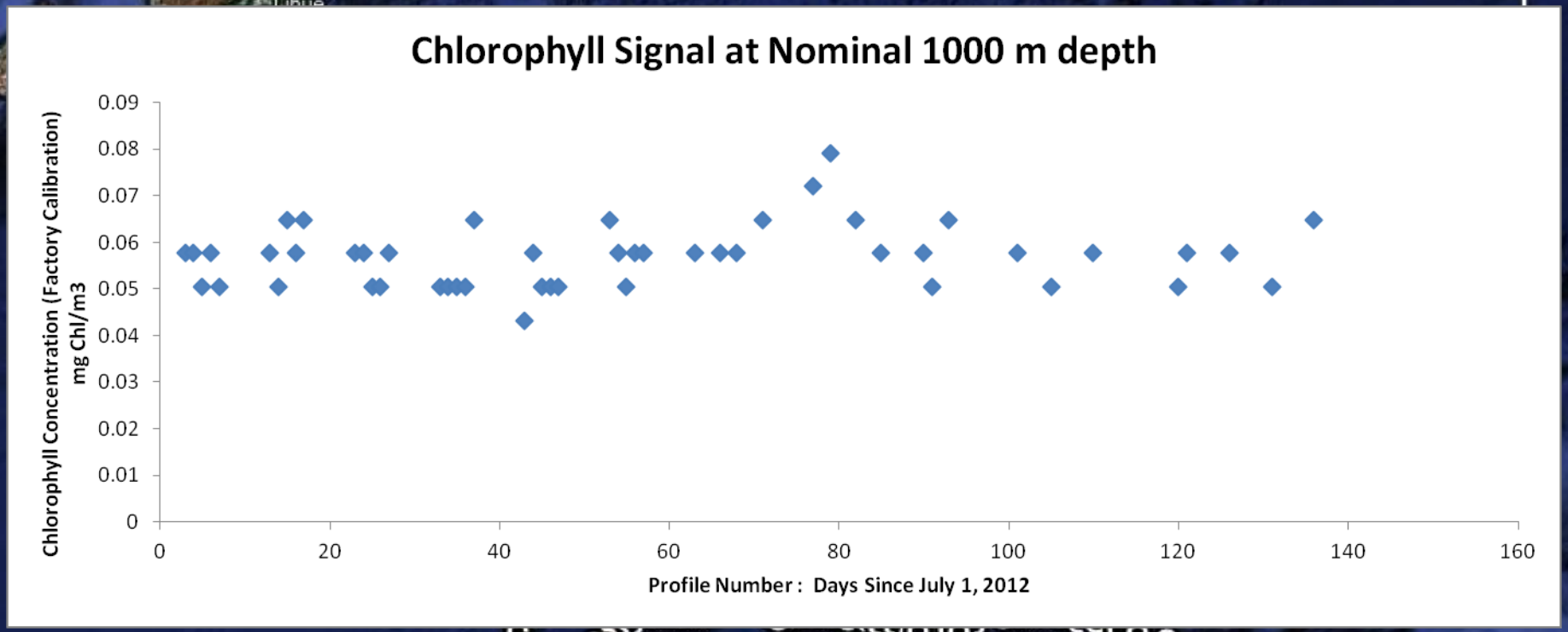
Group 1 *Required*	Test 1	Timing/Gap Test
	Test 2	Syntax Test
	Test 3	Location Test
	Test 4	Gross Range Test
	Test 5	Decreasing Radiance, Irradiance, and PAR Test
Group 2 *Strongly Recommended*	Test 6	Photic Zone Limit for Radiance, Irradiance, and PAR Test
	Test 7	Climatology Test
	Test 8	Spike Test
	Test 9	Rate of Change Test
	Test 10	Flat Line Test
Group 3 *Suggested*	Test 11	Multi-Variate Test
	Test 12	Attenuated Signal Test
	Test 13	Neighbor Test

Multivariate test needs further work

Profile Display



SEA-BIRD SCIENTIFIC

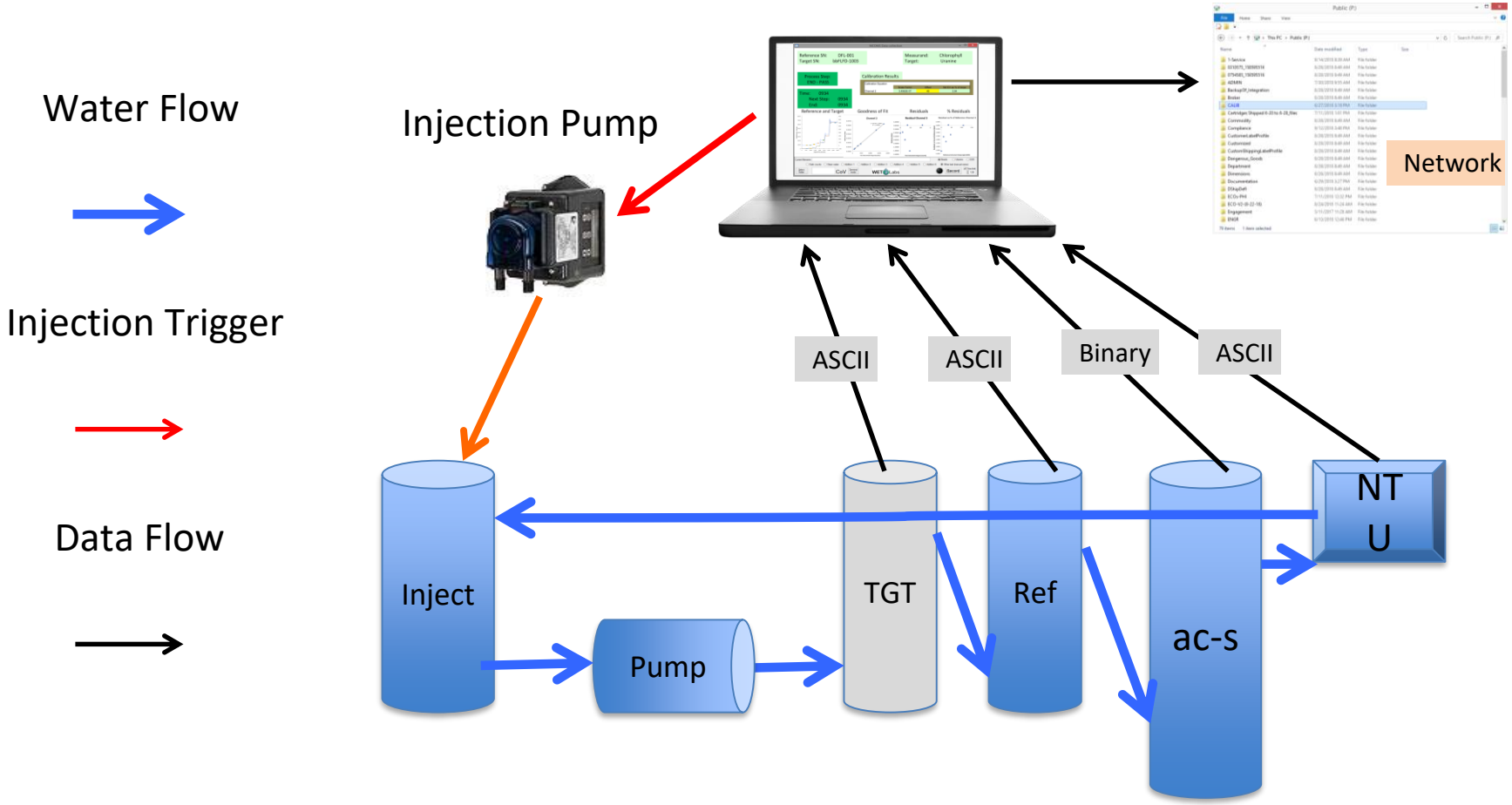


There is no discernible trend in the deep chlorophyll data over the first five months.
This suggests that there is no significant biofouling interference with the ECO signals.

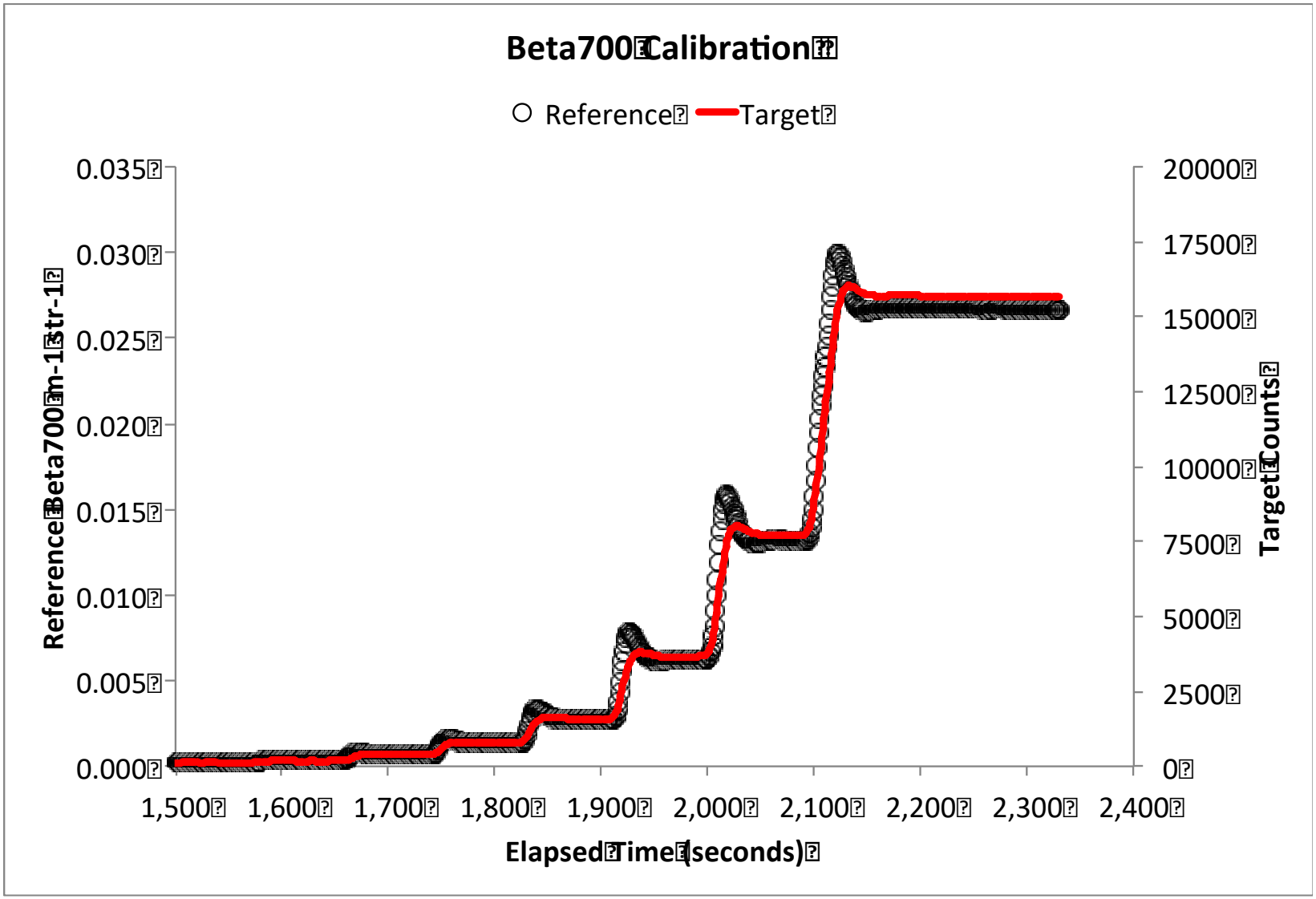
Kapaa

Kailua Kona

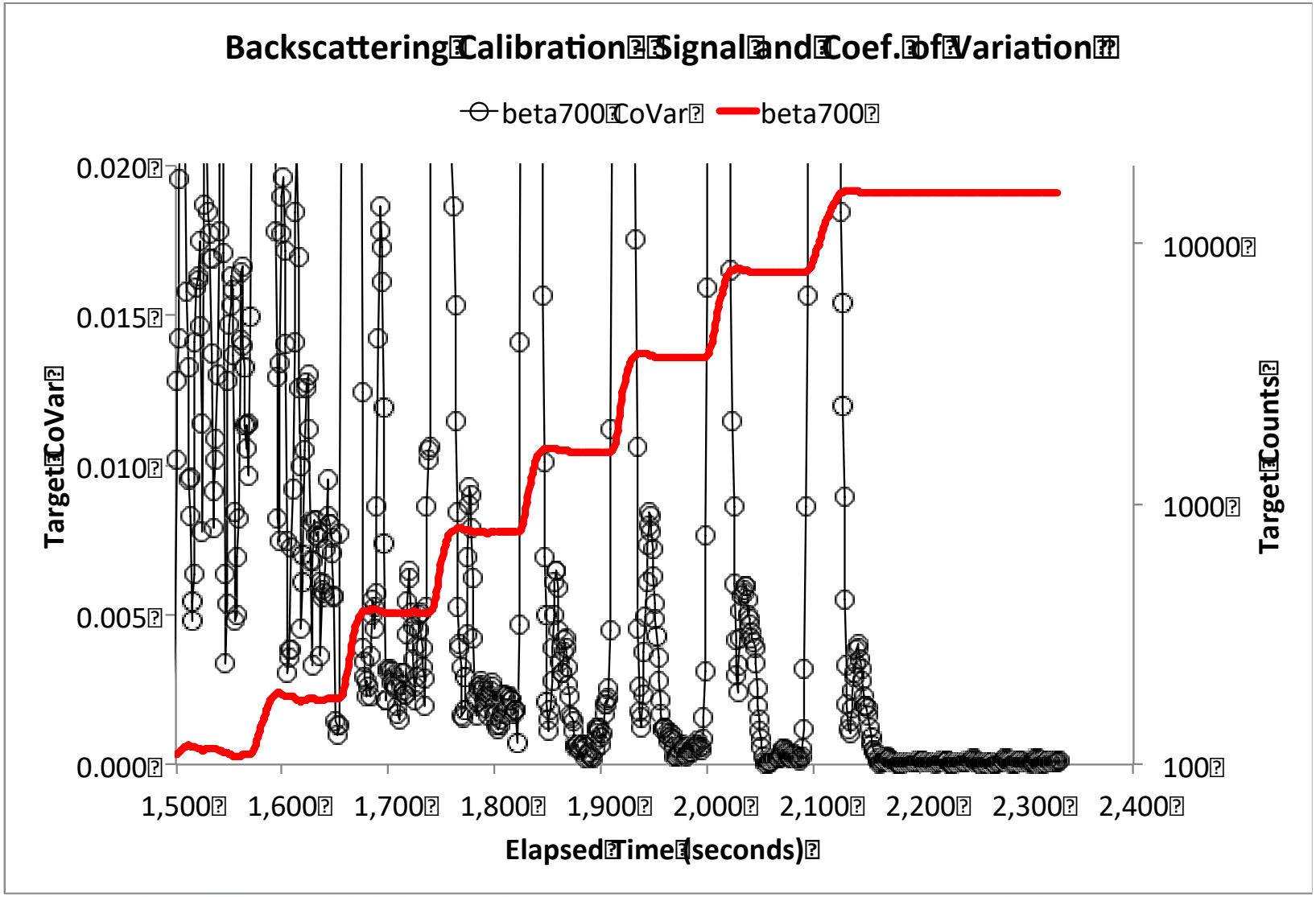
Automated Continuous Flow Optical Calibration System Block Diagram



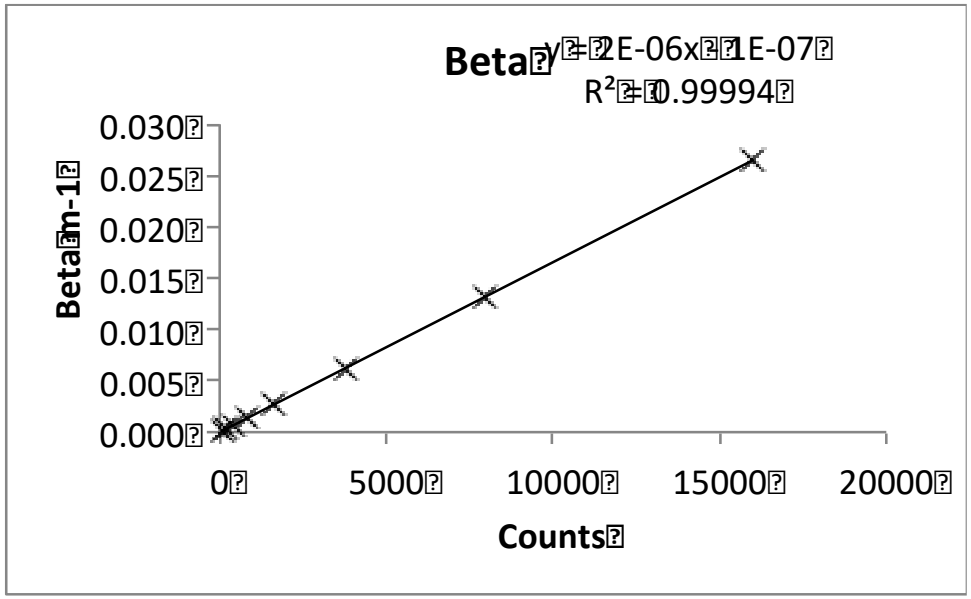
Automated Continuous Flow Optical Calibration System



Automated Continuous Flow Optical Calibration System



Automated Continuous Flow Optical Calibration System: Goodness of Fit

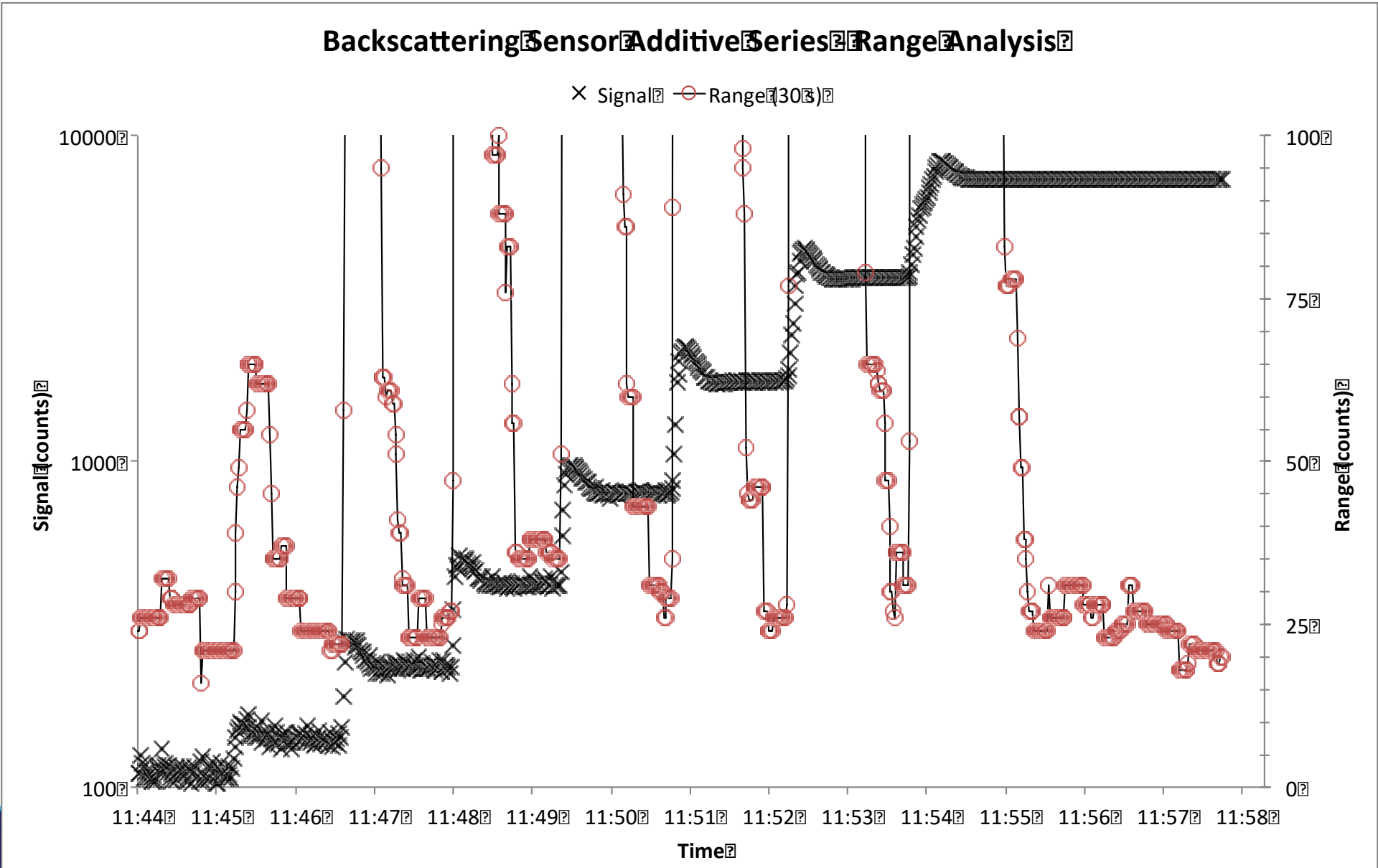


Beta

Calibration Equation	Scale Factor	Offset	Std Err as % of slope
Channel 1	0.002885364	0	14.34
Channel 2	1.65598E-06	0	0.31
Channel 3	0.037095476	0	47.15

MCOMS uses Standard Error as % of Slope

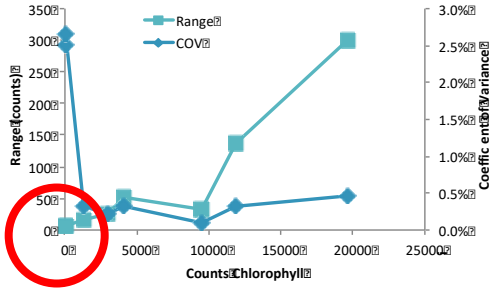
Automated Continuous Flow Optical Calibration System

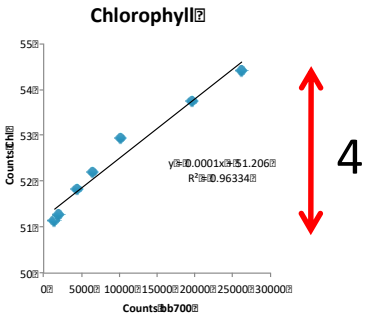


Calibration & Field Variance Scales: Quality Assurance

Is variance a real measure of the environment or instrument noise?

Calibration Data



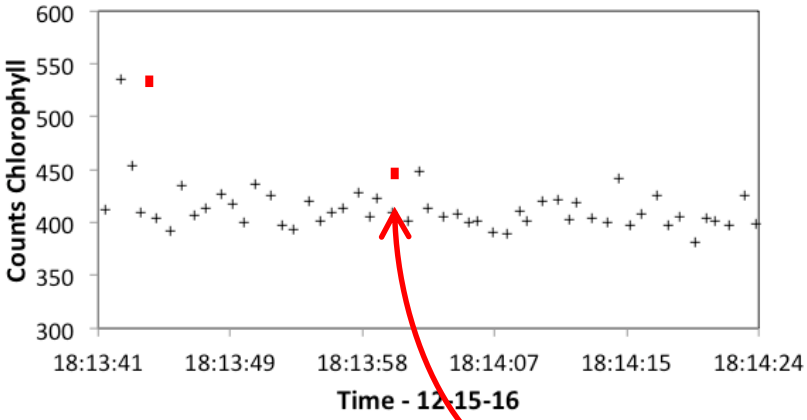


4

Dark Counts: 7
Clean Water: 6

Blank Range

Field Data



Calibration Blank Range + Backscattering Maximum Interference =

7 counts + 4 counts = 11 counts

Mary Oliver

to the ocean which, even if we think we have measured it,
has no final measure.

- There you were, and it was like spring

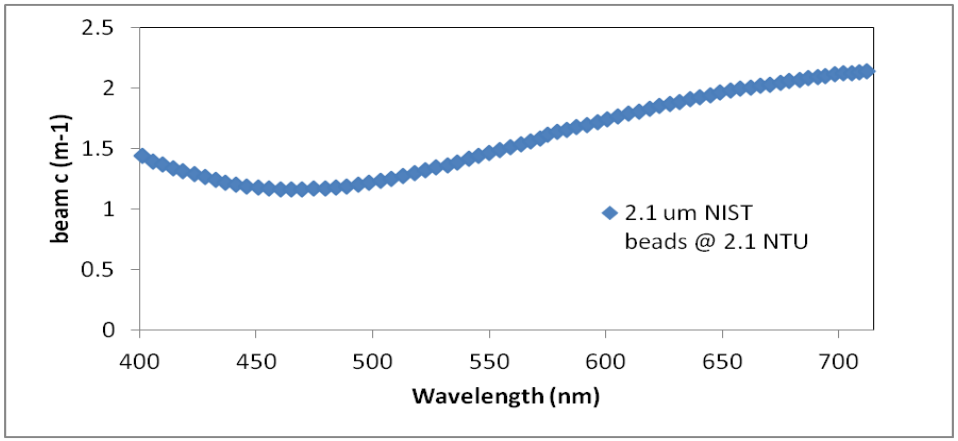
Factory Calibration Methods

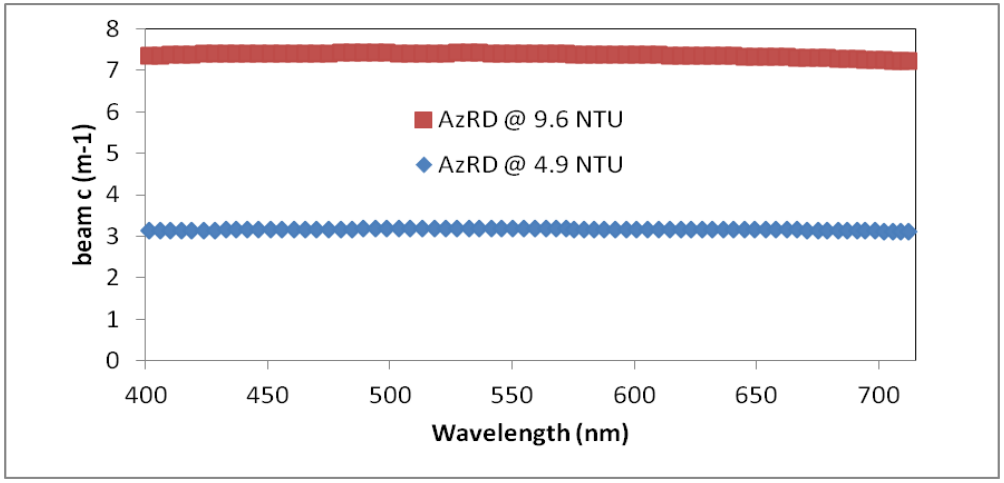
- Backscattering and Turbidity
  - Turbidity is operationally defined
    - It is not a scientific unit (i.e. expressed in mass, time, volume)
  - Backscattering is dependent on target population:
    - Size distribution
    - Index of refraction
    - Shape: we treat all things as spheres
  - Spectrally Dependent

Factory Calibration Methods

Backscattering - Spectrally Dependent

2.0 um beads





New method uses 0.1 um beads

Field Calibration Methods

Grab samples from

Niskin bottles

Particulate organic carbon and inherent optical properties during 2008 North Atlantic Bloom Experiment
Ivona Cetinić, Mary Jane Perry, Nathan T. Briggs, Emily Kallin, Eric A. D'Asaro, and Craig M. Lee
JGR, VOL. 117, C06028

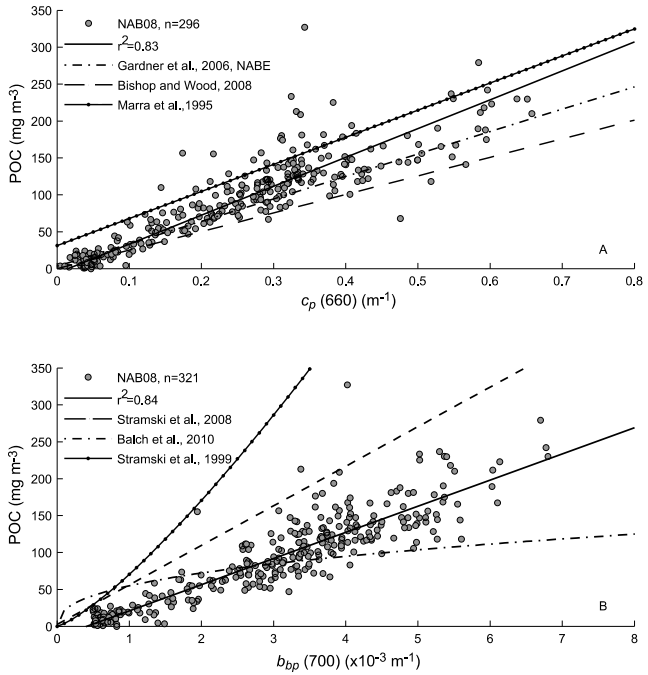
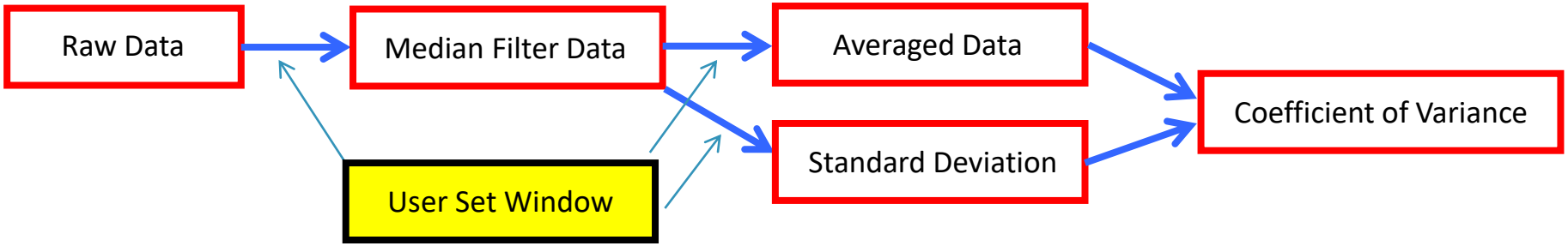


Figure 6. Basis of the optical proxies relationship for POC. Solid line is linear fit to NAB08 data. (a) POC versus c_p data set is overlain with regression of *Gardner et al.* [2006] for NABE (dash-dotted line), global data of *Bishop and Wood* [2008] (dashed line), and *Marra et al.* [1995] (dots on solid line). (b) POC versus b_{bp} (700 nm) data set is overlain with regression of *Stramski et al.* [2008] (555 nm, dashed line), data from Atlantic Meridional Transect cruises [*Balch et al.*, 2010] (532 nm, dash-dotted line), and Ross Sea data set [*Stramski et al.*, 1999] (510 nm, dots on solid line). See Tables 1 and 2 for regression coefficients.

Data Processing

Date	Water Temperature (F)	Water Conductivity (S/m)	Water Salinity	Dissolved Oxygen (mg/l)	Chlorophyll A (ug Chl/l)	Turbidity (NTU)
11/1/2016 1:00	58.694	1.84	13.86	9.23	5.5	1.89
11/1/2016 2:00	58.406	1.81	13.63	9.2	4.39	1.87
11/1/2016 3:00	58.478	1.82	13.74	9.05	3.97	1.93
11/1/2016 4:00	58.442	1.82	13.73	9.01	4.12	2.02
11/1/2016 5:00	58.46	1.83	13.76	8.97	4.17	2.04
11/1/2016 6:00	58.514	1.84	13.84	8.86	4.18	2.16



$$\text{Value } (t_{n-3}) < \text{Value } (t = n) < \text{Value } (t_{n+3})$$

Median Filter

Spikes are removed using a Median Filter

The user sets the filter window. There should be some feedback between the user selection and the results to help set the best window, e.g.:

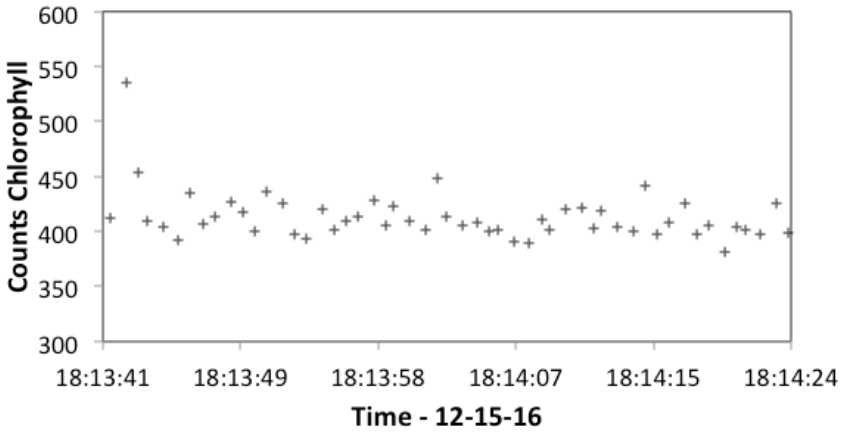
1) Number of spikes removed
2) Number of spikes remaining (will happen if a window includes more than one spike)
3) Coefficient of variance of original and filtered data

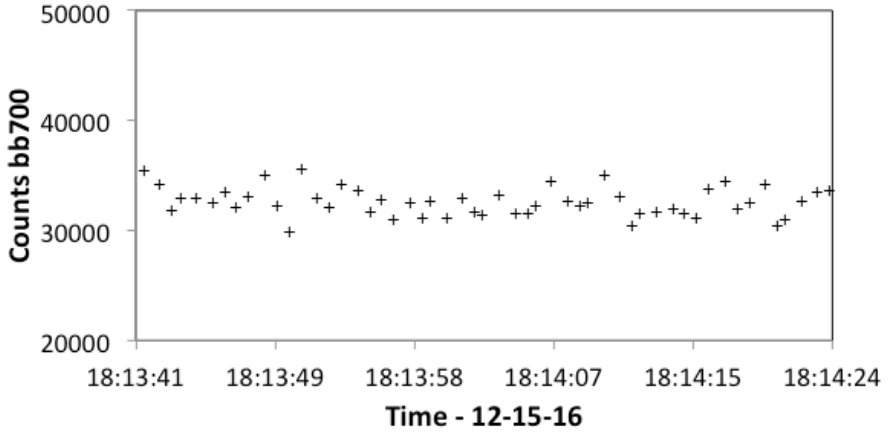
Date	Water Tempe	Water Condu	Water Salinit	Dissolved Ox	Chlorophyll A	Turbidity		Temp Med3	Cond Med3	Sal Med3	DO Med3	Chl Med3	Turb Med3
11/7/2016 8:00	56.642	1.4	10.56	9.12	4.97	1.99		56.678	1.40	10.56	9.24	5.50	1.91
11/7/2016 9:00	56.534	1.36	10.28	9.17	5.77	1.91		56.678	1.36	10.28	9.26	5.50	1.95
11/7/2016 10:00	56.678	1.35	10.14	9.26	6	2.06		56.678	1.36	10.22	9.26	5.77	1.99
11/7/2016 11:00	56.84	1.36	10.22	9.4	5.5	1.95		56.786	1.35	10.14	9.40	5.77	1.99
11/7/2016 12:00	56.786	1.31	9.82	9.51	6.34	2.19		56.840	1.35	10.04	9.51	5.77	1.95
11/7/2016 13:00	57.128	1.33	9.98	9.67	6.48	2.08		57.128	1.35	10.04	9.67	6.00	1.95
11/7/2016 14:00	57.488	1.34	10	9.84	5.29	1.82		57.434	1.36	10.04	9.84	6.34	1.82

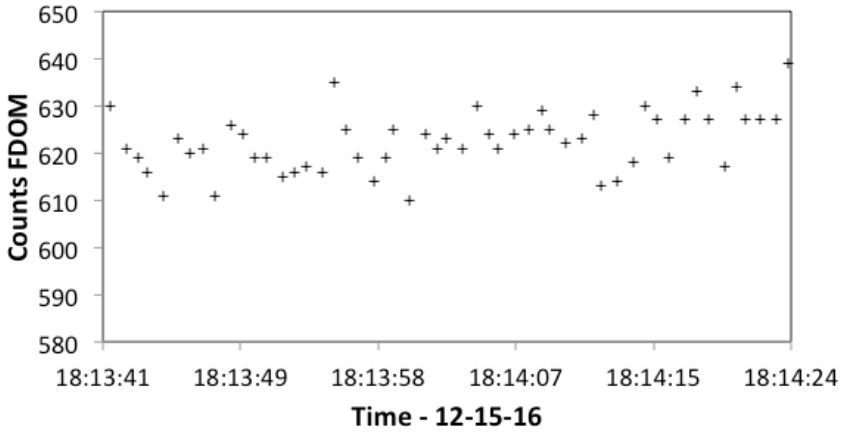
Original Data → Median Filtered Data

Calibration & Field Variance Scales

Is variance a real measure of the environment or instrument noise?



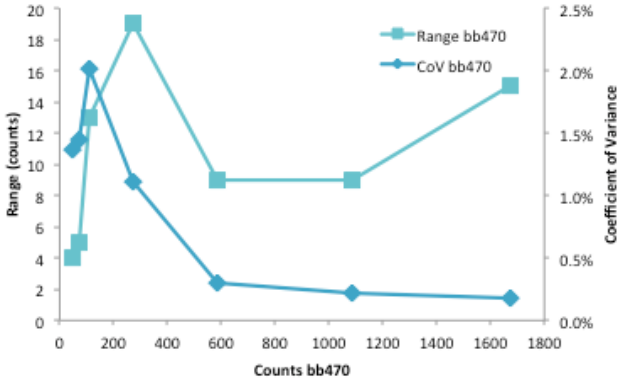




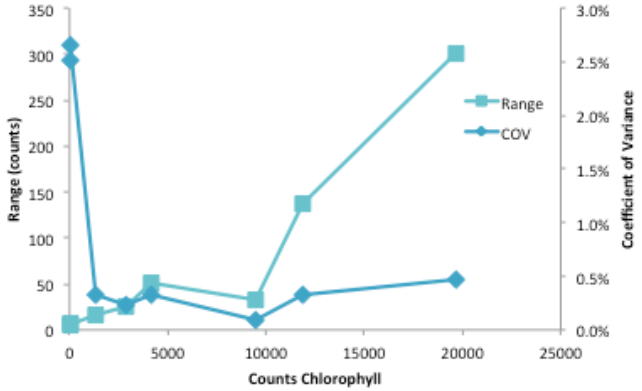
Calibration & Field Variance Scales: Uncertainty Scales from Calibration

The Noise Range is defined as the difference between the maximum and minimum values recorded in the last sixty samples from the noise specification data set.

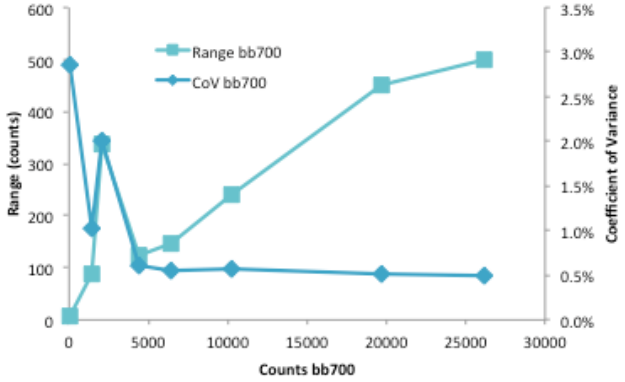
ECO backscattering



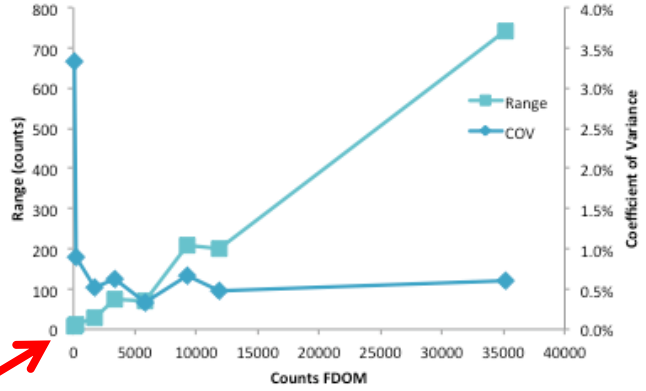
SeaOWL Chlorophyll



SeaOWL backscattering



SeaOWL FDOM



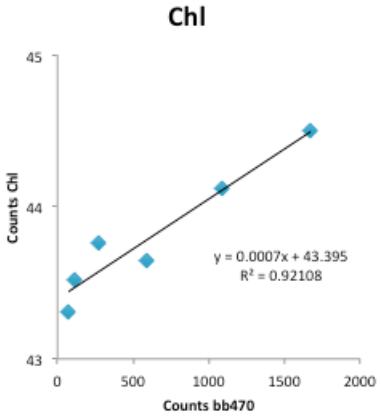
The first two points are the dark and clean water values

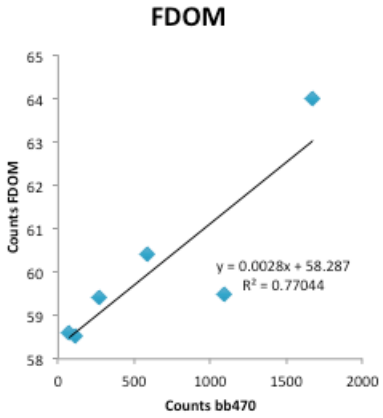
Calibration & Field Variance Scales: Backscattering Interference

During the bead calibration addition series calibration procedure the instruments record the signal on the fluorescence channels. This data represents the potential impact of backscattering interference on the chlorophyll and FDOM data in the field.

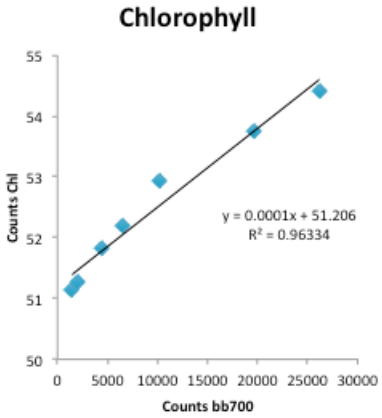
While there is generally positive correlation between the bead loading and the fluorescence signals the absolute magnitude is small relative to field data.

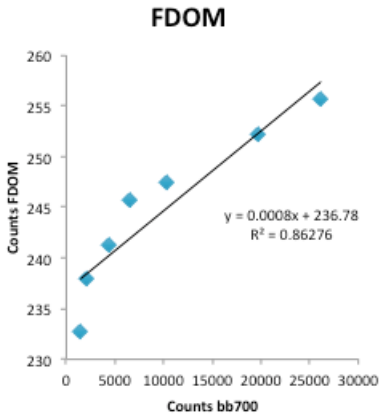
ECO





SeaOWL





Calibration & Field Variance Scales: Sample Averaging

Increasing the sample averaging decreases the noise range.

All calibrations are done with instruments set to output at approximately 1 Hz.

Instruments are shipped with the Average set to 1 Hz.