### COMPARISON OF ECO AND SEAPOINT FLUOROMETERS DURING MULTIPLE 2024 CRUISES

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**INTRODUCTION**

***During 2024 pairs of fluorometers were deployed together on many cruises to determine the impact of switching from using SeaPoint fluorometers to ECO fluorometers. The data used to produce the plots in this document may be found in “SeaPoint\_ECO\_Data\_for\_Comparisons.xlsx”.***

***A combined report with comments about each cruise is saved as ““SeaPoint\_ECO\_Comparisons.docx”.***

***The cruises were studied in order of processing, as follows:***

***2024-002***

***2024-001***

***2024-006***

## 2024-002

**For this cruise there was a change in sensors after cast # 32.**

**Events 1-31 SeaPoint 3950 and ECO 2216 (On CTD #1515)**

**Events 47-140 SeaPoint 3949 and ECO 2215 (On CTD #0506)**

**One limitation on this cruise was the low range of extracted chlorophyll.**

In the regular processing of CTD data from 2024-002, the 2 SeaPoint fluorometers and ECO 2216 all produced similar results, while ECO 2215 stood out as having a much larger dark value.

In this study the pairs will be compared for each CTD that was used.

The dark value was subtracted from all fluorescence data and then the fit of ECO versus SeaPoint was done for each CTD.

Dark Values: SeaPoint 3950 0.09

SeaPoint 3949 0.04

ECO 2216 0.055

ECO 2215 0.26

Plots were made for each CTD as follows:

1. ECO vs SP

2. ECO-dark value vs SP-dark value

3. SP/ECO vs CHL

4. SP and ECO vs CHL

5. SP and ECO vs CHL – limited range of CHL so the 2 different CTD pairs could be compared.

6. SP/ECO vs ECO

7. SP/ECO vs Pressure full range

8. SP/ECO vs Pressure 0-200db

For CTD 1515: Comparison between SP 3970 and ECO 2216

Plots 1 & 2: There is little difference between the SeaPoint and ECO fluorometers. Subtracting dark values made an insignificant change; the slope of the fit is unchanged but goes through the origin.

Plot. 3 showed SeaPoint being higher than ECO when CHL was <0.2ug/L but they were very close above that level.

Plot 4. The fits of the SP and ECO sensors versus CHL shows good agreement.

Plot 5. This is the same as plot 3 (only differs for CTD 0506).

Plot 6. SeaPoint is mostly much higher than ECO until ECO=0.2 and just slightly higher for ECO > 0.2.

Plot 7. Shows the Seapoint has some areas where it is much higher than ECO but those are in deep water where values are very low.

Plot 8. This shows the same material but expanded to display the more significant depths for CHL. The two sensors are close down to 40db but beyond that the SeaPoint is often much higher, up to 3 times the ECO.

CONCLUSIONS:

* Before correction when the SeaPoint read 0.09ug/L, the ECO read 0.04ug/L, and after subtracting dark values, when SeaPoint=0 then ECO = -0.02.
* So we can get good correspondence by subtracting the dark values from each set, but the absolute difference is not significant, ~0.4%.
* These two sensors are in good agreement, but subtracting the dark value appears to improve that somewhat. It will be more interesting to repeat these tests on data with higher chlorophyll values.
* The one oddity was seeing SeaPoint fluorescence much larger than ECO fluorescence at depths where chlorophyll was very low. This is a feature often seen in fluorometers, and is normal in SeaPoint sensors and to a lesser extent in ECO sensors. This is not an area of great interest given low chlorophyll. This is presumably due to its sensitivity to sinking material.

CTD 0506: Next the same sort of corrections were applied SeaPoint 3949 vs ECO 2215 data.

Plot 1. The ECO reads almost 9% higher than the SeaPoint.

Plot 2 shows a better correspondence at the origin after dark values were subtracted, though the difference remains large.

Plot 3 is of little interest since there was very little very low CHL. SeaPoint values were about 70% of ECO values for CHL range of 0.2 to 1.2ug/L.

Plot 4 shows the very different fits of ECO and SP versus CHL.

Plot 5 has a limited CHL range comparable to the one for CTD #1515 and that hints that the differences between the sensors may be higher at higher CHL. These are uncorrected data and there are insufficient data to reach any conclusions about this.

Plot 6 shows that the SeaPoint is much lower than the ECO, especially so for ECO<0.6.

Plot 7 shows SeaPoint much lower than ECO in deep water. This is using uncorrected fluorescence.

Plot 8 shows considerable variations with SeaPoint lower than ECO in the top 100db and much lower below that.

Conclusions

* ECO 2215 has an unusually large dark value and should be monitored. It is out of step with ECO 3949 and also with SeaPoint 3950 and SeaPoint 3949.
* Before correction when SeaPoint 3949 read 0.12ug/L, ECO 2215 read 0.33ug/L, and after subtracting dark values, when SeaPoint=0.08 then ECO = 0.03ug/L.
* So we can get good correspondence by subtracting the dark values from each set. Unlike the case for CTD #1515 this is a significant change to the ECO reading. The correction looks like a simple offset, but until tested against high CHL this is not a secure conclusion.
* Uranine testing of all sensors is recommended. Tests can be done to see if those results generally agrees with dark values when used at sea, but it appears to be the case. For inshore work, those tests are the only way to get reliable dark values.

The comparison of ECO and SeaPoint fluorometers will continue through the year. For 2024-002, I would recommend archiving the SeaPoint channels because of concerns about the ECO #2215. If it is used in higher chlorophyll conditions, there may be clearer evidence of whether it is a matter of adjusting values appropriately, or getting the sensor serviced.

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## 2024-001

**The CTD was switched after cast #10. SeaPoint #4186 was used for casts 1-10 and 13-110.**

**For casts 11 and 12 SeaPoint #2228 was used, but was removed due to low values, so is not included in this study.**

First, the dark values were found.

Dark Values: SeaPoint 4186 0.03ug/L (min value 0)

ECO 2216 0.04ug/L (min value 0)

Subtracting any further values from either fluorescence channel will lead to some negative values at depth since the jitter takes values down to 0.

The ECO read higher than the SeaPoint by an average of 30%, ranging from 0% to 80% at low CHL to 20% at high CHL.

The ECO was closer to CHL at high CHL (and CHL got very high during that cruise), while the SeaPoint was closer to CHL at low CHL.

The dark values were similar.

Comparisons with CHL are complicated by the fact that fluorometers tend to read lower on upcasts as the rosette drags water up with it, and the varying level of the CHL peak means the effect of incomplete flushing of Niskin bottles varies in sign. So there is no evidence that one of the fluorometers performed better than the other.

Having the two fluorometers perform similarly is the best judgment for whether the switch to ECO is ok.

We don’t expect perfect correspondence among individual sensors of either type, so this correspondence looks reasonably good.

Plots were made for each CTD as follows – to match what was done for 2024-002 study:

1. ECO vs SP

2. ECO-dark value vs SP-dark value

3. SP/ECO vs CHL

4. SP and ECO vs CHL

5. SP and ECO vs CHL – blow up of Plot 4 to show CHL<5ug/L.

6. SP/ECO vs ECO – showed little relationship.

Plots 1 & 2: There is little difference between the SeaPoint and ECO fluorometers. Subtracting dark values made an insignificant change.

Plot. 3 showed SeaPoint being higher than ECO when CHL was <0.2ug/L but they were very close above that level.

Plot 4. The fits of the SP and ECO sensors versus CHL shows reasonable agreement though the ECO is closer to CHL. Using corrected fluorescence made little difference to these fits.

CONCLUSIONS:

* The ECO 2216 fluorometer had a small dark value and compares quite well with the SeaPoint even without correcting using dark values.
* There is little difference between the two data sets. ECO fluorescence is closer to CHL at high CHL values while both sensors behave in a similar way at low CHL with the ECO a little noisier.
* This cruise was sampled CHL in very quiet waters where Niskin contents may not match ambient conditions, so the comparison with CHL will be subject to errors of variable sign depending on whether the CTD stopped above or below the CHL maximum.
* In the study of 2024-002 it was noted that SeaPoint fluorescence was much higher than ECO fluorescence at depths where chlorophyll was very low. No such rise in either fluorescence channel was observed, but this may be a feature that is related to particular regions and/or season.

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## 2024-006

**The CTD was switched after cast #43. SeaPoint #3641 was used for casts 1-43 and 4186 for and 45-105.**

**For all casts the ECO #2216 fluorometer was used.**

**One or both fluorometers produced no data from casts #61 to 79.**

First, the dark values were found by examining plots below 300db.

Dark Values: SeaPoint 3641 +0.085ug/L

 SeaPoint 4186 +0.001ug/L

ECO 2216 -0.014ug/L

Checking some very deep casts the dark values appeared to be negative for the ECO fluorometer. Using those values as an offset produced poor results, while values around 300db-500db worked better and were closer to the uranine test results, though still lower adjustments than those tests suggested. It was later determined from the performance of ECO 2216 during later casts (with a different SeaPoint) that had higher CHL values that an offset of +0.02ug/L was a better choice and that is closer to the uranine test results.

Using dark values for offsets will have to be done carefully with the ECOs – in very deep water values are often negative. And deep water may affect the ECO in some way that is not relevant to shallow water. The offset for the SeaPoint fluorometer was higher than expected, but was constant from 150db to 750db.

CASTS 6 to 39 – SeaPoint 3641 and ECO 2216

For the first group (Casts 6-39) the SeaPoint fluorescence was higher than the ECO by 18%.

When offsets were applied to both sensors, the SeaPoint was higher than the ECO by 2%.

The fit of ECO vs SP is in better correspondence at the origin after correction.

The next 2 plots show the difference before and after subtracting offsets:

The fit of both fluorometers vs CHL are also in better correspondence near the origin after correction although the change is slight for he ECO given a very small correction.

This is the first comparison that include SeaPoint 3641 and it was not one of the sensors that was included in the uranine tests done locally in early 2024.

There are no high CHL samples. For the highest, 1.4ug/L, the SeaPoint looks closer before and after correction. The ECO offset is too small to make a significant difference.

Correction does bring the SeaPoint fluorescence values closer to CHL, especially notable for very low CHL.

As CHL increases both fluorometers give values that get closer to CHL, as is usual for these sensors.

When the data were sorted so that only cases with CHL>0.3ug/L are included the two channels are very close before correction and SeaPoint is lower than ECO after correction. It is normal to see SeaPoint fluorescence drop relative to CHL as CHL rises. There are insufficient data and too many unknows (such as flushing of Niskins and performance of the fluorometer during stops) to establish which sensor is more reliable, though the ECO is closer to CHL in general.

The SeaPoint offset is larger than usually seen and may indicate a problem with that sensor.

CASTS 45 to 105 – SeaPoint 4186 and ECO 2216

Moving on to the later casts, there are not many data but the range of CHL is much larger.

The dark values found for the two sensors are both small, 0.001 for the SeaPoint and 0.02 for the ECO. Note that the ECO signal is noisy and that is an estimated median value at 300db.

The SeaPoint was lower than the ECO by 5% before correction and by 2% after correction.

The fits are very similar (offset forced to =0).

There was only 1 CHL value <0.2ug/L so the performance at very low CHL could not be assessed. but the 2 are very close above that level with the ECO usually a little higher.

The comparison with CHL after correction shows the ECO to be closer than the SeaPoint. The difference ECO-SP ranged from -0.9 to +1.1ug/L when one outlier was excluded.

The SeaPoint and ECO fluorometers differ most when CHL is very low.

The data and more plots in file SeaPoint\_ECO\_Data\_For\_Comparison.xlsx.

CONCLUSIONS:

* When offsets were applied based on dark values the two types of sensors compared well. Both SeaPoint fluorometers tended to read too high at very low CHL. The ECO is generally closer to extracted CHL except at very low CHL.
* SeaPoint 3641 had a higher offset than usual, but looked ok when that offset was subtracted.
* SeaPoint 4186 looked fine.
* ECO2216 looked fine.
* Having high CHL values lends confidence to the conclusion that the ECO fluorometer #2216 is performing similarly to the SeaPoint fluorometers.
* There are likely errors due to incomplete flushing of Niskin bottles which can vary in sign given subsurface maxima in fluorescence. This could account for high fluorescence when CHL is very low – the sample might come from deeper than the fluorometer readings. Above the maximum the opposite occurs so the fluorometer may appear to be reading low. There may also be issues with how fluorometers work while the CTD is stopped.

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## 2024-069

**SeaPoint #4186 and ECO #2216 fluorometers were used for all casts.**

First, the dark values were found by examining plots below 300db.

Dark Values: SeaPoint 4186 +0.012ug/L

ECO 2216 -0.03ug/L

Checking some very deep casts the dark values had some negative values for the ECO fluorometer, but this is jitter around positive values. Values were near zero for both fluorometers in very deep water but at 500db the ECO had values around 0.03ug/L.

As noted during 2024-006 using dark values for offsets will have to be done carefully with the ECOs – in very deep water values are often negative. And deep water may affect the ECO in some way that is not relevant to shallow water. Since the technicians now do uranine tests and can set the configuration files for ECOs appropriately, it is not surprising to find the two data sets are close without correction.

The dark values found for the two sensors are both small, 0.001 for the SeaPoint and 0.03 for the ECO. Note that the ECO signal is noisy and that is an estimated median value.

The SeaPoint was lower than the ECO by 5% before correction and by 2% after correction.

The fits are very similar (offset forced to =0).

Applying corrections brought the intercept closer to 0, but moved values of both fluorescence channels further from CHL values. The differences are slight.

The comparison with CHL before and after correction shows little change. the ECO to be closer than the SeaPoint. The difference ECO-SP ranged from -0.9 to +1.1ug/L when one outlier was excluded.

The ratio of SeaPoint/ECO versus CHL shows quite a flat distribution once CHL is >2ug/L. Before and after correction showed little change.

The data and more plots in file SeaPoint\_ECO\_Data\_For\_Comparison.xlsx.

CONCLUSIONS:

* The two types of sensors compared well. Both SeaPoint fluorometers tended to read too high at very low CHL. The ECO is generally closer to extracted CHL except at very low CHL but the differences were small.
* SeaPoint 4186 looked fine.
* ECO2216 looked fine.
* Having high CHL values lends confidence to the conclusion that the ECO fluorometer #2216 is performing similarly to the SeaPoint fluorometers.
* There are likely errors due to incomplete flushing of Niskin bottles which can vary in sign given subsurface maxima in fluorescence. This could account for high fluorescence when CHL is very low – the sample might come from deeper than the fluorometer readings. Above the maximum the opposite occurs so the fluorometer may appear to be reading low. There may also be issues with how fluorometers work while the CTD is stopped.