was lower than for nighttime, *f*-independent underway *CF* measurements (0.74 vs. 0.90 in Figs. 5A and 3A, respectively).

This may also explain the only marginal improvement in the $CF(PY^{-1}\text{-}1)$ correlation with HPLC *CC* as compared to the *CF* correlation for the dark-adapted samples ($R^2 = 0.83$ vs. 0.80 in Figs. 5B and 3B, respectively). If our interpretation is correct, the *PQ* variability in *CF* was minimized by using PSII saturating excitation, but the *CF* magnitudes in the morning samples were still moderately *NPQ*-affected because of their incomplete recovery from *NPQ* (empty dots in Fig. 3B). This "leftover" *NPQ* effect was not manifested in the $CF(PY^{-1}\text{-}1)$ parameter, but the overall transect variability in the PSII photochemical functionality might have affected the $CF\left(PY^{-1}-1\right)/CC$ relationship.

Similar comparisons for the *CF/PY* parameter revealed significant improvements in correlations with HPLC *CC* retrievals for both the underway and sample measurements: $R^2 = 0.93$ vs. −0.22 in Figs. 5C and 3A; $R^2 = 0.96$ vs. 0.80 in Figs. 5D and 3B. Though the use of *CF/PY* parameter was not justified by the simplified biophysical model and needs further consideration, the *CF/PY* ratio may be advantageous vs. the $CF(PY^{-1}\text{-}1)$ parameter for minimizing the effects of both *NPQ* and *PQ* variability on the accuracy of *CC* fluorescence assessments. For evaluation, the linear regression relationship $CC = 1.88 CF_U/PY_U$ between *CC* and underway fluorescence measurements at the sampling locations (Fig. 5C) was used to calculate the *CC* transect distribution (light green line Fig. 2). As evident from comparison with the independent *CC* sample measurements, the concurrent *CF* and *PY* measurements provided accurate high-resolution *CC* data despite the significant *NPQ* and PSII physiological variability in the water masses.

7. Conclusion

The biophysical analysis and field measurements show that significant (up to 15-fold) photo-physiological variability in fluorescence yield is one of the major factors contributing to the overall variability in *in vivo* chlorophyll fluorescence per unit of chlorophyll concentration. The fluorescence yield and PSII photochemical efficiency are controlled by *PQ* and *NPQ* mechanisms and depend on incident light intensity, phytoplankton "light history", PSII photochemical functionality, and other physiological factors. Minimizing the *PQ* and *NPQ* magnitudes can help to reduce the variability and improve the accuracy of *CC* fluorescence assessments. This can be achieved via isolation of the measurement volume from ambient light, PSII saturating fluorescence excitation, optimization of phytoplankton exposure to the excitation, and phytoplankton dark adaptation before the measurements. If the measurement conditions do not allow for dark adaptation (e.g., *in situ* or flow-though underway measurements from a moving platform), concurrent measurements of variable fluorescence can be used to adjust fluorescence intensity for non-photochemical quenching developed due to prior exposure to ambient light. The field evaluation in estuarine waters of the Chesapeake and Delaware Bays showed significant potential of this approach for improved fluorescence assessments of chlorophyll concentration. Nonetheless, it needs evaluation in more diverse coastal and offshore oceanic waters. An improved biophysical model needs to be developed to account for the complexity of the photo-physiological mechanisms involved.