Improved estimation of phytoplankton abundance and fine-scale water quality features via simultaneous discrete and semi-continuous surveys

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Phytoplankton abundance is driven by light and nutrient availability which in turn is controlled by larger-scale regional processes such as climatic variability and global teleconnections. However, estimates of phytoplankton abundance and distribution are largely built on evidence gathered from coarse (on the order of kilometers), discrete grab sampling networks where the overall set of measured parameters is limited and whose spatial representativeness is unknown. As a result, estimates of phytoplankton abundance can be subject to a high degree of uncertainty and the ability to resolve fine-scale (on the order of meters) water quality features relevant to ecosystem management can be limited.

In the present study, we use a combination of discrete sampling and underway (semi-continuous) flow-through sampling to better constrain estimates of phytoplankton abundance and to better identify the presence, shape, and locations of fine-scale water quality features (boundaries of abrupt change) in a case study set in Florida Bay, USA. We show that phytoplankton abundance is best estimated using a combination of discrete and underway sampling involving simultaneous collection of not only chlorophyll fluorescence but also potential interference materials such as colored dissolved organic matter. Finally, we show that water quality boundaries identified on the basis of underway sampling differ from discretely identified boundaries and are related to climatic variability as well as specific landscape features. These findings have significant implications for algal bloom detection, watershed management, and environmental monitoring both for our case study location and for estuaries in general.

water quality,Everglades,cyanobacteria,Florida

# Introduction

Phytoplankton abundance plays a critical role in structuring ecosystem processes in subtropical estuaries. For example, unusually high abundance reflects the onset of phytoplankton blooms which can decrease light penetration in the water column causing decreased seagrass growth and benthic productivity . Furthermore, phytoplankton abundance is often used as an indirect measure of nutrient loading, eutrophication, and overall ecosystem status. As such, it is important to understand the numerous factors that control phytoplankton abundance.

Typically, phytoplankton abundance is assumed to be regulated by light and nutrient availability which in turn is controlled by a variety of regional processes such as advective transport, benthic-pelagic coupling, and climatic variability as well as global processes such as teleconnections and atmospheric oscillations. However, the evidence for these relationships rests on two features of existing datasets, the accuracy of phytoplankton abundance estimates and the design of monitoring networks from which the data is collected. For example, one of the most common methods of quantitative phytoplankton abundance estimates, which involves measuring chlorophyll fluorescence as a proxy for abundance, is subject to known inaccuracies related to the presence of potential interference materials such as colored dissolved organic matter. Furthermore, the distributed nature of most monitoring networks where stations are separated by distances on the order of kilometers means that it is difficult to estimate within-basin spatial variability (i.e. on the order of meters).

In the idealized case where watershed exports are low in potential interference materials and the spatial grain of sampling networks is well-aligned with the water quality pattern of interest the aforementioned issues may not apply. However, such idealized cases are likely to be rare. Numerous studies have found that estuaries are commonly subject to high inputs of potential interference materials (e.g. color dissolved organic matter). In addition, long-term (static) sampling networks, which may initially be well-aligned with prevailing water quality patterns, can fall out of alignment either on a temporary basis due to seasonal variation or on a more permanent basis due to alterations in estuary circulation or changes to the upstream watershed. As a result, data collected from grab sampling networks may not be able to resolve water quality features (e.g. locations of abrupt change and hereafter referred to as “water quality boundaries”) either on the basin or sub-basin scales. Although such boundaries may arise simply from climatic variability or the presence of natural landscape features they may also arise from individual management actions such as opening of water control structures. In an ecological sense, establishing the presence, shape, location, and extent of these boundaries is critical as they are important sites of biogeochemical processing. In an applied sense, shifts in these boundaries over time can be a measure of management efficacy in estuaries where alterations in overland freshwater inputs (likely increases) are a key management target.

Here, we present a method to better constrain estimates of phytoplankton abundance and to better identify within-basin variability in such estimates using a combination of discrete sampling and underway (semi-continuous) flow-through sampling. In a case study set in Florida Bay, USA we specifically ask the following questions: Can quantitative estimates of phytoplankton abundance be improved with simultaneous measurement of chlorophyll fluorescence as well as potential interference materials? How do the shape and location of water quality boundaries develop in relation to landscape features and climatic variability? Our hypothesis, which was based on the findings of prior studies using discrete sampling, was that we would find distinct and persistent boundary points between the numerous sub-basins that make up Florida Bay especially at the transition between the central and eastern bay during periods of high watershed export (Figure 1).

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Here are two sample references: (Glibert et al. 2009).

# References

Glibert, P.M., C.A. Heil, D. Rudnick, C. J. Madden, J. Boyer, and S. Kelly. 2009. “Florida Bay: Water Quality Status and Trends, Historic and Emerging Algal Bloom Problems.” *Contributions in Marine Science* 38: 5–17.