Adding remote sensing data products to the nutrient management decision support toolbox

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Introduction

Some of the primary issues that manifest from nutrient enrichment and eutrophication (Figure 1) may be observed from satellites.

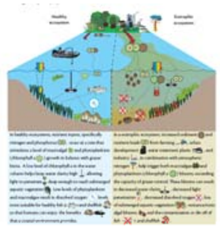


Figure 1. Conceptualization of the impacts of nutrient over-enrichment on coastal systems (Bricker et al. 2007).

For example, remotely sensed estimates of chlorophyll *a* (chl*a*), total suspended solids (TSS), and light attenuation (Kd) or water clarity, which are often associated with elevated nutrient inputs, are data products collected daily and globally for coastal systems from satellites such as NASA's MODIS (Figure 2).

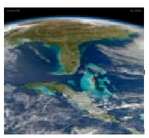


Figure 2. MODIS natural color image of the southeastern U.S. and coastal waters.

The objective of this project is to inform water quality decision making activities using remotely sensed water quality data. In particular, we seek to inform the development of numeric nutrient criteria. In this poster we demonstrate an approach for developing nutrient criteria based on remotely sensed chl*a*.

Materials and methods

The overall project approach includes

- Assess the potential methods and data requirements for developing numeric nutrient criteria
- Collect optical data at study sites (Figure 3) and use found data from the estuarine and oceanographic community for calibrating imagery
- Develop time-series data (mid-1980s to the present) of remotely sensed chl*a*, TSS, and Kd at spatial resolutions of 500-1000 m for each study system
- Implement methods for numeric nutrient criteria (EPA 2001) using remote sensing data products
- Benchmark GOMA's sense of the use, usefulness, and usability of the implemented methods

We demonstrate the use of remote sensing data by implementing a method for establishing numeric nutrient criteria based upon a statistical distribution, or "reference" condition, approach (EPA 2001).

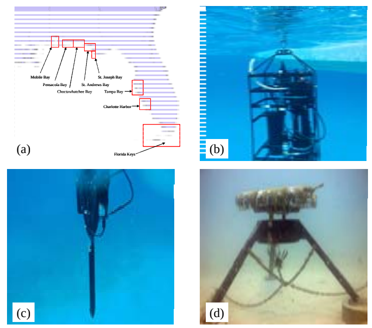


Figure 3. (a) Study sites. Optical instrumentation used includes (b) AC-s, (c) HyperPRO, and (d) optical water quality monitor.

Results

Monthly optical and chemical data are being collected in the Florida panhandle estuaries (Figure 4) and are used to calibrate remote sensing products for chl*a*, TSS, colored dissolved organic matter (CDOM), and light attenuation (Kd).

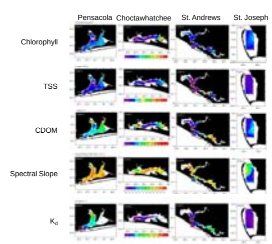
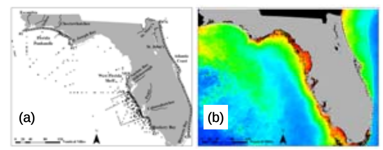


Figure 4. Field observations of chlorophyll *a*, suspended sediment (TSS), colored dissolved organic matter (CDOM), the spectral slope of CDOM (a proxy for lability), and light attenuation (Kd) in the estuaries of the Florida Panhandle. Monthly surveys of these systems over a 3-year period is providing the data necessary for calibrating remote sensing imagery of these systems.

The "reference" condition method (EPA 2001) was applied to the coastal segments of Florida's state waters (Figure 5a) using calibrated remote sensing estimates of chl*a* (Schaeffer et al. in review). Field measurements of chl*a* data, used for calibration, were obtained from various sampling programs (Figure 5).



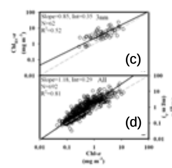


Figure 5. (a) Field measurements of chlorophyll *a* (Chl-*a*) and FL coastal segments. (b) Remotely sensed chlorophyll *a* (Chl_{RS}-*a*). (c) Relationship between field and remotely sensed estimates within 3 nautical miles and (d) for all the stations in panel (a).

The satellite observations provided an accurate estimate of chl*a* for the coastal segments within Florida's state waters (Figure 5c). Subsequently, the remotely sensed estimates of chl*a* were extracted as 8-day averages from each segment for the period of the satellite record (1997 to 2009). This process generated a large sample size (n = 593) for each coastal segment. The statistical distributions of chl*a* in each segment are presented in Figure 6.

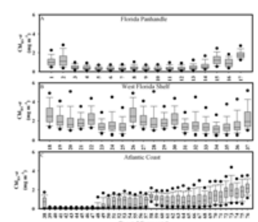


Figure 6. Chl_{RS}-*a* boxplots for the coastal segments using data from 1997 to 2009. Boxplots present the median (black line), the 25^{th} and 75^{th} quartiles (boxes), the 10^{th} and 90^{th} percentiles (whiskers), and minimum and maximum (black dots).

The large number of observations provided by the satellite data allowed for the analysis of the chl*a* statistical distribution properties within each coastal segment (e.g. Figure 7a). The statistical distributions were then used to estimate potential criteria values for each coastal segment (Figure 7b; Schaeffer et al. in review).

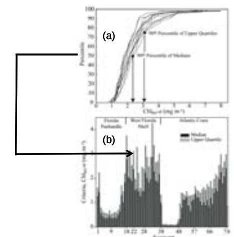


Figure 7. (a) Annual cumulative distribution functions (n = 12) for Chl_{RS}-*a* in segment 22 (outside Tampa Bay) for 1998 through 2009. The estimate of the 90^{th} percentile of medians and upper quartiles (75^{th} percentile), which are 2.3 and 3.1, respectively, could potentially be used as criteria values. (b) Computed potential criteria values for all 76 coastal water segments.

Conclusions

For many coastal systems, satellite observations are available and provide continuous spatial and temporal coverage. These observations may be used to implement criteria development methods such as the reference condition approach, or where accurate loading estimations are available, the empirical stressor-response approach (EPA 2001). The success of this project will be measured by our ability to demonstrate and transfer these approaches to decision-makers.

Literature cited

Bricker, S., B. Longstaff, W. Dennison, A. Jones, K. Boicourt, C. Wicks, and J. Woerner. 2007. Effects of Nutrient Enrichment In the Nation's Estuaries: A Decade of Change. NOAA Coastal Ocean Program Decision Analysis Series No. 26. National Centers for Coastal Ocean Science, Silver Spring, MD. 328 pp.

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For further information

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