Project number: CIMP-001
Title: Monitoring the Water Quality Parameters of Mayagüez Bay
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INTRODUCTION

Mayagüez Bay is a semi-enclosed bay in the west coast of Puerto Rico that suffers spatial and temporal variations in phytoplankton pigments and suspended sediments due to seasonal discharge of local rivers. Several years ago a joint project with researchers from NASA-Stennis Space Center and the University of Puerto Rico at Mayagüez intended to use remote sensing for a better understanding of the land-sea interface in this bay. However, the complexity of bay's optical properties and certain limitations of the technology at that time made it very difficult. Most recently new methods and instruments have been used as part of this project, allowing a better study of the bio-optical properties of Mayagüez Bay. Our results demonstrate that large spatial and temporal variability of bay's optical properties makes very difficult to apply conventional bio-optical algorithms. The available data demonstrate that improved algorithms and different remote sensing techniques are necessary for this coastal region. The third year of this project is focus on this goal and it is helping to continue the efforts that started several years ago toward the application of remote sensing for land-sea interface studies in Mayagüez Bay.

OBJECTIVES

The main goal of this third-year is to improve the remote sensing techniques for a better estimation of water quality parameters in coastal waters. In order to accomplish this goal, the specific objectives are:

1. Evaluate the spatial and temporal variability of the bio-optical properties.
2. Correlate water quality parameters and bio-optical properties.
3. Perform inverse modeling of the remote sensing reflectance curves.
4. Develop bio-optical algorithms for Mayagüez Bay.

SEASONAL SAMPLING

The regular sampling for the dry season of this year was performed during January 12-14 of 2003 along the Mayagüez Bay. As in previous years the sampling was done from inshore to offshore waters, covering the Añasco, Yagüez, and Guanajibo Rivers, and the regions affected by the dumping of the tuna factory and the sewage pipe. Figure 1 shows the location of the stations. Twenty-four (24) stations were sampled with an optical package, in which 12 stations had ancillary data.

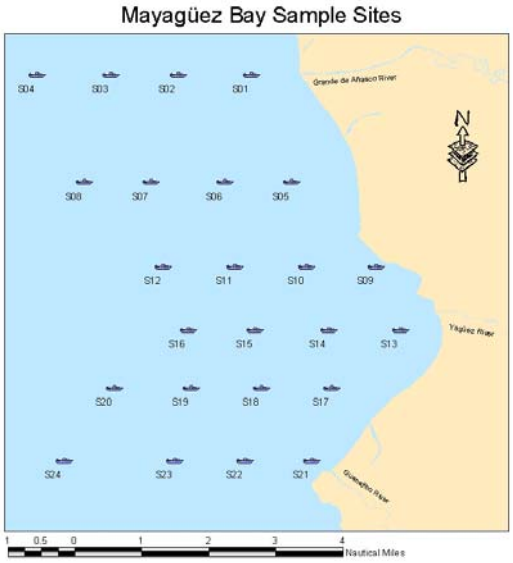

Figure 1: Sampling Stations in Mayagüez Bay.

An optical package with several instruments was used to measure profiles of different water properties (Figure 2). A CTD (Seabird SBE-19 with pump) measured temperature and salinity. A small fluorometer (Model WetStar from Wet Labs) measured chlorophyll fluorescence. The spectral transmittance, $c(\lambda)$, and spectral adsorption, $a(\lambda)$, was measured over nine wavelengths with the AC-9 meter (from Wet Labs). The backscattering coefficient, $b_b(\lambda)$, at six wavelengths was measured with the HydroScat-6 (from Hobi Labs). Upwelling radiance, $L_u(0^-, \lambda)$, and downwelling irradiance, $E_d(0^-, \lambda)$, was obtained using a submersible radiometer (Model OCR-200 from Satlantic). $L_u(0^-, \lambda)$ and $E_d(0^-, \lambda)$ values will be used to calculate the diffuse attenuation coefficient (K). Water-leaving radiance, $L_w(\lambda)$, and the above-surface downwelling irradiance, $E_d(0^+,\lambda)$, was measured using the GER 1500 spectroradiometer. $R_{rs}(\lambda)$ will be calculated from the ratio between $L_w(\lambda)$ and $E_d(0^+, \lambda)$.

Figure 2: Bio-Optical Rosette at UPRM.

The optical measurements from the profilers will be compared with water samples measurements collected at surface and middle depth (this last is based on station maximum depth). Total particulate absorption, $a_p(\lambda)$, detritus absorption, $a_d(\lambda)$, *in vivo* phytoplankton absorption, $a_{ph}(\lambda)$, and the absorption of colored dissolved organic matter, $a_g(\lambda)$, were determined using the standard NASA protocols for validation of ocean color sensors. Concentration of phytoplankton chlorophyll-a, suspended sediments, and nutrients were also determined. All data collected during the cruises have been added to the GIS database that is being prepared for Mayagüez Bay using ArcGIS.

Our previous work has demonstrated that the seasonal changes of rainfall, and therefore the river discharge, appear to be the principal factor regulating the bio-optical properties in Mayagüez Bay, including the phytoplankton populations. Anthropogenic activities in the river basins affect the composition of the rivers input and the characteristics of the water masses entering the bay. The western basin of Puerto Rico is highly developed and deforested, which favors erosion and transference of soil particles into the river waters. These suspended particles increase scattering and absorption, effectively attenuating light, but also increase nutrient concentrations. Our last sampling during January of 2004 is considered to be during the dry season. Similar to previous years, bottom suspension of sediments and organic matter by wind and waves seems to be especially important during this season. This effect is clearly showed in the shallow areas, especially close to the coast and in the southern portion of the bay (Figure 3).

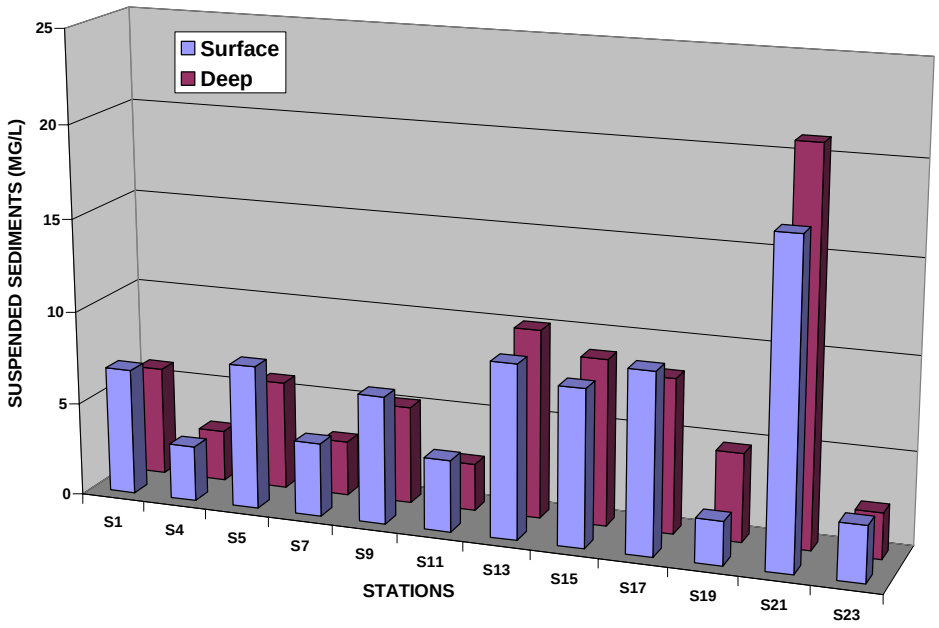

Figure 3: Suspended sediments at Mayagüez Bay during the sampling of January 2004

The nutrient concentrations for selected stations were:

Station	NO2+NO3	NO2	NO3	PO4	SiO2	NH4
1s	0.62	0.07	0.55	0.12	7.87	0.43
1p	0.03	0.04	0.00	0.05	1.89	0.21
4s	0.00	0.02	0.00	0.01	2.25	0.04
4p	0.00	0.01	0.00	0.00	1.66	0.02
5s	6.37	0.14	6.23	0.69	6.23	0.14
5p	0.07	0.05	0.03	0.03	2.16	0.09
9s	0.01	0.04	0.00	0.02	2.40	0.00
9p	0.13	0.03	0.10	0.06	2.40	0.28
13s	0.06	0.13	0.00	0.22	5.93	0.05
13p	0.01	0.11	0.00	0.16	4.61	0.06
21s	1.21	0.42	0.79	0.58	13.20	0.14
21p	N/A	0.33	N/A	0.57	3.17	0.07

IMAGE PROCESSING

Sea-viewing Wide Field-of-view Sensor (SeaWiFS) images were obtained from DAAC and processed using the NASA developed software called SeaDAS for the six previous sampling periods of this project. These are:

DRY SEASON	WET SEASON
April 24-26, 2001	October 2-4, 2001
February 26-28, 2002	August 20-22, 2002
February 25-27, 2003	October 7-9, 2003

The available SeaWiFS images were processed using SeaDAS to obtain the concentration of Chlor-a in Western Puerto Rico centered at the Mayagüez Bay (Figure 4). The processing allowed us to determined critical problems with the data. Since we are working in coastal waters the signal from Mayagüez Bay is highly affected by the bottom, suspended sediments, and colored dissolved organic matter. Therefore the default SeaDAS algorithm for Chlor-a failed in providing numbers for most of the coastal region. This is the case of the example image in Figure 4, where large region of the bay is masked in black color by the software after the processing. We are now working with NASA people in order to fix this problem and allow the program to provide numbers that we can use to evaluate the accuracy of the algorithm. Another problem with the SeaWiFS images is related to cloud cover (Figure 4). Mayagüez Bay is highly affected by clouds, especially during the rainy season. In order to solve this problem we have processed all the images available in a nine days period around the sampling dates. The images will be used to calculate the mean for each period. This way we can reduce the effect of clouds.

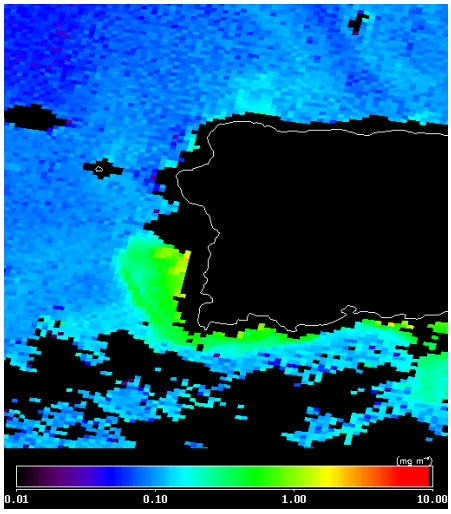

Figure 4: Example of SeaWiFS image collected during February 28, 2003.