# Ocean Optics 2007 class project: Inherent optical properties of the Damariscotta River Estuary: what is happening at the river-sea interface?


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## INTRODUCTION

Estuaries have characteristically strong environmental gradients, driven by freshwater input and tidal forcing, that result in highly complex optical patterns due to the dissolved or particulate water constituents present, especially on the seawater/freshwater interface. The contrast between the physical and chemical properties of riverine and marine waters controls processes (Andersen, Jakobsen et al. 2005) such as mixing, exchange, and accumulation of dissolved and particulate material between the two water types (Zutic and Legovic 1987). Here we examine the optical properties of the Damariscotta River Estuary, with a special emphasis on the seawater/freshwater interface.

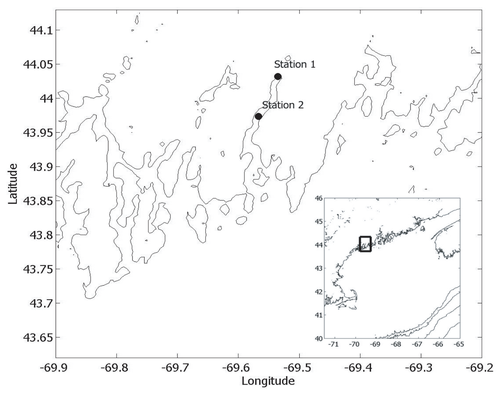


Figure 1. Damariscotta River Estuary with stations 1 and 2. Location of the Damariscotta River Estuary on the coast of Maine, USA (inset map).

## MATERIALS AND METHODS

Measurements were made at two stations in the Damariscotta River Estuary on July 13, 2007 aboard the R/V Ira C. A seabird SBE37 CTD measured conductivity, temperature and depth; a WetLABS ac9 in-situ spectrophotometer measured attenuation and absorption at 9 wavelengths; a WetLABS ECO BB9 measured scattering at 9 wavelengths (400, 440, 488, 510, 532,595, 660, 715 and 880); and a WETSTAR provided measurements of chlorophyll fluorescence.
Two consecutive profiles were made at each station. Total and dissolved attenuation and absorption were measured using a WetLABS ac9 in situ spectrophotometer.
Colored dissolved organic matter spectral slope (S) was calculated following:

$$a_{diss}(\lambda) = a_{diss}(532) * e^{-S\,(\lambda - 532)}$$

where measurements from wavelengths smaller than 650 nm were used to avoid values with low accuracy (Twardowski, Boss et al. 2004).

## RESULTS AND DISCUSSION

Station 1 (upper estuary) revealed a strong riverine influence, with temperature and salinity driven stratification. The surface brackish layer was warmer and less salty than the bottom seawater layer (21-21.5 C and 29 PSU, versus 20-20.5 C and 29.7 PSU). Station 2 (lower estuary) had higher salinity and lower temperature values throughout the whole water column (Figure 2). The upper riverine water layer was still present at the surface, but with lower temperatures (16.5°C) and higher salinity (30.5 PSU) than those encountered at Station 1.
Chlorophyll absorption profiles were monotone at both stations, with small subsurface maxima in both fluorescence and absorption measurements located in the upper part of the water column. The subsurface chlorophyll maximum (SCM) was in the upper (riverine) layer at station 1, but in the lower (marine) layer at station 2.The maximum particulate backscattering signal was associated with the marine layer at both stations.

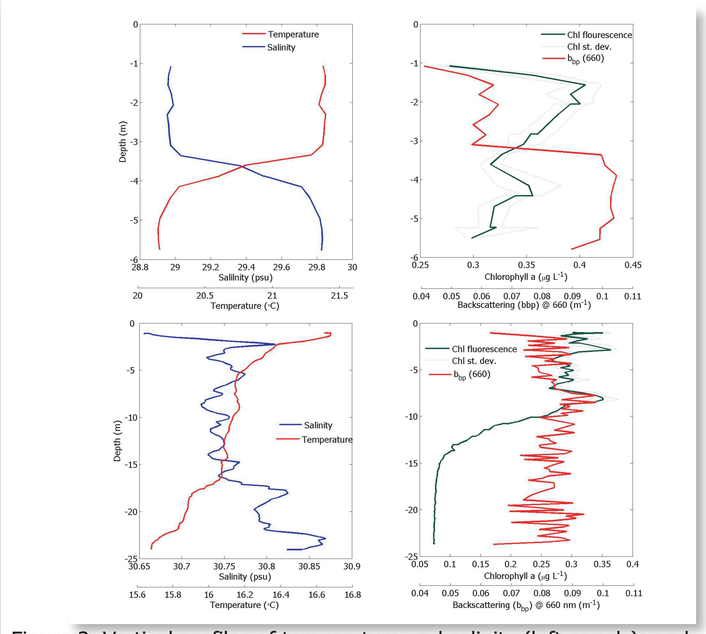


Figure 2. Vertical profiles of temperature and salinity (left panels); and chlorophyll fluorescence and backscattering on 660 nm measured with BB9 (right panels), for both of the stations (Station 1 top, Station 2 bottom panel).

Values of colored dissolved organic material (CDOM) absorption were high throughout the water column at station 1. The greatest differences were observed in absorption coefficients in the blue portion of the spectrum, where surface layer values for dissolved absorption were three times as high in Station 1 as Station 2. The opposite pattern can be observed in CDOM spectral slope, where values are higher in Station 2 than in Station 1. Higher values of CDOM are expected in the upper part of the estuary due to the terrestrial sources of organic material. Marine water is usually associated with lower CDOM, since the only sources are in-situ biological processes. In our dataset, the change in the amount of CDOM is a function of the photodegradation and change in CDOM source along the estuary. This is accompanied by an increase in the spectral slope of CDOM, possibly due to accumulation and flocculation processes on the seawater/freshwater interface as well as the changing source of CDOM. At both stations, the lowest CDOM slope (Station 1 - 0.0077 m-1 and Station 2 - 0.013 m-1) and concentrations were found in the SCM, whether it was situated below or above the freshwater/saltwater interface.

Table 1. Values of the colored dissolved organic matter spectral slope calculated using both ac9 and spectrophotometer data, particulate backscattering and backscattering ratio. .

| Station | Slope – ac9 $a_{diss}$(CDOM) | $a_{diss}$(532) | $b_{bp}$ (532) | $b_p$(532) |
|---|---|---|---|---|
| 1, surface | 0.0074 | 0.34 | 0.07 | 0.027 |
| 1, chl maximum layer | 0.0077 | 0.32 | 0.11 | 0.43 |
| 1, deep | 00082 | 0.3 | 0.1 | 0.025 |
| 2, surface | 0.0121 | 0.0928 | 0.078 | 0027 |
| 2, chl maximum layer | 0.0113 | 0.0902 | 0.011 | 0.036 |
| 2, deep | 0.0125 | 0.0850 | 0.1 | 0.033 |

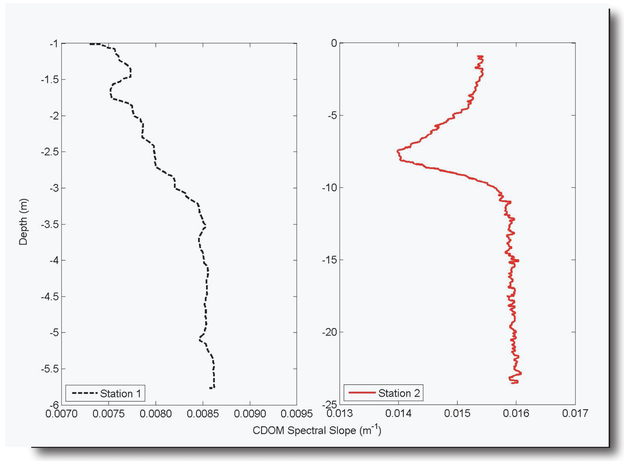


Figure 3. Profile of the colored dissolved organic matter spectral slope for the Station 1 (left panel) and Station 2 (right panel). Note the minimum on the 7-8 m depth layer and difference in the depth scale.

The low spectral slope observed in our study could be a result of aggregation associated with the phytoplankton population and mediated by the freshwater/seawater interface. Under the influence of a strong salinity gradient, active surface material formed by phytoplankton could cause dissolved organic material to accumulate, possibly resulting in a lower CDOM slope like the one observed in this study (Figure 3). The accumulation of such particulate material may explain the higher backscattering signal associated with the SCM (Figure 2), since phytoplankton are known to have a low backscattering signal. The less pronounced backscattering layer found in Station 1 could be a product of water column instability in the upper estuary, likely due to the shallow depth and inconsistent riverine influx, preventing the formation of a stronger particulate layer.

This brief study illustrates the use of optical properties to explore processes associated with the estuarine environment. Changes and instabilities in the CDOM pool indicate intriguing physical, biological and chemical processes in this extreme environment, where identifying the cause at a particular point requires use of an interdisciplinary approach while piecing together a diverse set of measurements.

Ocean optics class 2007


## ACKNOWLEDGEMENTS

We would like to thank all of our fellow students in the class, for their help with the field work and discussion. Additionally we would like to thank our professors Mary Jane Perry, Collin Roesler, Curtis Mobley and Emmanuel Boss, our teaching assistants Wayne Homer Slade and Michael Sauer, the crew of the R/V Ira C, the cooks for feeding us and Paula Bontempi for being our professor and good angel.
Ocean Optics Class 2007, has been supported through NASA grant, and work on this paper has been additionally supported by NASA Earth and Space Science Fellowship Grant NNX06AF88H to I. Cetinic.


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