OS31B HC: Hall III Wednesday 0830h

CDOM in the Coastal Ocean: Transformation Processes and Their Effects on Optical Properties II

Presiding: **D Coble,** University of South Florida**; D D Clark,** Chapman University

OS31B-09 0830h POSTER

Observed Variation in the Photoreactivity of CDOM From Freshwater, Estuarine, and Marine Sources in the Chesapeake Bay

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Though it is now well known that CDOM is removed in estuaries and in the coastal ocean, the mechanisms behind its removal remain unclear. The current paradigm is that CDOM is removed principally through sunlight photooxidation to smaller, biologically labile compounds and to CO2. However, the coastal ocean represents a dynamic environment in which CDOM originating from freshwater (F), estuarine (E), and marine (M) sources is mixed by tidal cycles. The mixing of different water masses exposes these CDOM sources to a range of physicochemical properties, which might alter the photoreactivity (PRx, measured as the amount of absorbance change per Joule of sunlight absorbed) of CDOM. Thus, it is not known how PRx of bulk CDOM, nor of individual CDOM sources, varies at different locations in the coastal ocean. We have begun to investigate the photoreactivity of CDOM from three stations (F, E, M) in the Chesapeake Bay (CB). CDOM greater than 1000 Daltons was isolated from each station by tangential flow filtration (TFF) and then added back in a 3 x 3 matrix to the TFF filtrate water from each station. Thus, we had 9 treatments representing the mixing of CDOM sources in the CB (permeate/CDOM: M/M, M/E, M/F, E/M, E/E, E/F, F/M, F/E, F/F). TFF removed 47% of M-CDOM, and 67 and 79% of E- and F-CDOM, respectively.

Each treatment was exposed in quartz bottles to ambient sunlight during the season that CDOM was sampled. Absorption coefficients (a_d) were measured from 280 to 500 nm by spectrophotometry, and PRx was calculated as the integrated photobleaching (decrease in a_d) from 280 to 500 nm. Absorption coefficients decreased in nearly all treatments except early experimental manipulations that used mercuric dichloride as a microbial inhibitor. However, the percent loss of absorbance varied among treatments and with season. For example, in August 2001, integrated photobleaching was greatest in the M/M treatment (46%) and lowest (5%) in the F/E treatment.

Surprisingly, we did not find large variations in photoreactivity among treatments using integrated absorbance over all wavelengths. The mean PRx for all treatments was 2.62 x 10-6 m/J. We observed the most variation in PRx seasonally within treatments (range 3.64 x 10-8 to 6.13 x 10-6 m/J), as opposed to roughly 3 fold variation among different CDOM sources and in different mixing environments. The data suggest that season and transport, rather than source, play the dominant role in determining CDOM photoreactivity by delivering fresh, reactive material to the coastal ocean. Different physicochemical environments apparently play a secondary role in CDOM photoreactivity. Our continued study of this phenomenon will provide detailed information on the relationship between carbon source and optical properties in the coastal ocean. Specifically, we will calculate photobleaching rates and apparent quantum yields, obtain CDOM fluorescence matrices, and measure geochemical parameters of our CDOM manipulations in the Chesapeake Bay.

OS31B-10 0830h POSTER

A Multicomponent Model of Chromophoric Dissolved Organic Matter (CDOM) Bleaching

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Light absorption by chromophoric dissolved organic matter (CDOM)has a number of important effects on the aquatic environment. These include modification of the underwater light field, with consequent effects on remote sensing and aquatic biology, and the initiation of all photochemical processes, some of which lead to destruction of the light-absorbing portions of CDOM (photobleaching). We have developed a model describing the effects of monochromatic and broad-band UV and visible radiation on the optical absorption spectra of CDOM in several samples. These samples include a Suwannee River Fulvic Acid standard material and samples from the Delaware Bay and the Chesapeake Bay. First order bleaching behavior of multiple superimposed component chromophores was assumed to control the overall bleaching behavior of these CDOM samples. The spectra and decay characteristics of multiple independent chromophores were calculated by iterative pseudo-inverse minimization of the model functions applied to the spectra of CDOM bleached with monochromatic light. The bleaching behavior calculated from the monochromatic experiments was then used to reproduce the broadband bleaching behavior of the CDOM samples.

OS31B-11 0830h POSTER

Diurnal Photochemical and Biological Processes of CDOM in Southern California Coastal Waters

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CDOM absorbs sunlight and undergoes a series of photochemical reactions to produce hydrogen peroxide and other photoproducts. Hydrogen peroxide is a strong oxidizing agent that may cause or contribute to bacterial instability. Controlled experiments were conducted with ocean water collected from Huntington Beach, California to assess the effects of sunlight on populations of sewage indicator microorganisms found in the surf zone. Elevated levels of these bacteria are a consistent cause of beach postings and closures at this site. Ocean water samples were collected at approximately 12 am to isolate surf zone water that had not been exposed to sunlight for more than five hours. Experiments were conducted in which one set of water samples in 15-gallon aquariums were exposed to sunlight and one set of samples was kept under 6-mil black plastic sheeting. Temperature were kept as equal as possible by placing the aquariums in water reservoirs maintained at comparable temperatures. From 4 am until 11 pm various parameters, such as pH, temperature, salinity, dissolved oxygen, were measured hourly. Ultraviolet light irradiance measurements were read every 15 minutes. Hourly samples were removed and measurements of fecal coliform and enterococcus bacterial populations were determined, as well as hydrogen peroxide levels in the samples. A sharp increase in hydrogen peroxide levels and a significant decrease in bacterial populations occurred in the sunlight exposed aquariums as the sun rose. Hydrogen peroxide levels and bacterial populations did not show similar changes in the ocean waters kept in the dark, indicating a possible contribution of hydrogen peroxide from CDOM in the dramatic reduction of bacterial populations in those aquariums exposed to sunlight.

OS31B-12 0830h POSTER

The Optical Effects of CDOM Sorption to Particles

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CDOM sorption to particles has significant implications for the biogeochemistry of the water column and possibly the optical properties of the hydrosol as well. There is growing evidence that a substantial fraction of coastal organic matter is tightly associated with suspended minerals and that some portion of this organic material may be attributable to colored humic substances. How the absorption and fluorescence associated with CDOM are transferred to the particulate fraction and what the resulting effects are on the bulk optical properties are not well known. The interaction may alter the physicochemical nature of the organic material and thus its optical properties. Adsorption onto particles will also package the colored material, which could result in a self-shading effect, decreasing bulk absorption of light. The scattering properties of the particulate fraction may also be altered due to the effects of absorption by the organic coating and the disparate refractive indices of the coating and the particle. These issues are investigated with laboratory work and theoretical modeling. The overall importance of CDOM adsorption on the optical properties of the bulk dissolved and particulate fractions in coastal waters is evaluated.

OS31B-13 0830h POSTER

Chromophoric Dissolved Organic Matter (CDOM) Dynamics and Seasonality During Three Atlantic Meridional Transect Cruises.

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Chromophoric Dissolved Organic Matter (CDOM) is one of the main light absorbing constituents in oceanic waters, but the constraints of its spatio-temporal variability in the surface ocean have been poorly investigated. Here, we present data from three Atlantic Meridional Transect (AMT) cruises from the UK to Uruguay, covering a wide range of biogeographical provinces. These include the fringes of oceanic gyres in the north and south Atlantic as well as the Canary Island, Mauritanian and equatorial upwelling regions. Samples were collected from over 100 CTD casts within the upper 250 m of the water column. CDOM levels in surface waters vary by more than one order of magnitude regionally, and indicate significant seasonal differences. CDOM spectral properties suggest autochthonous production in the vicinity of the deep chlorophyll maximum and efficient photochemical breakdown in surface waters. We will discuss implications of in-situ formation and photochemical breakdown for CDOM distribution, optical properties and photo-reactivity.

OS31B-14 0830h POSTER

Characterization of the relationship between CDOM, hydrophobic content, photo-oxidation, and biodegradation in terrestrial and wetland-derived DOM in the Sacramento-San Joaquin Delta.

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Variation in the amount and quality of wetland-derived and terrestrial organic material entering estuarine and marine environments remains essentially unknown. Over the past two years we have examined

the seasonal variation in the quality of organic material added by a variety of wetland types and terrestrial inputs within the Sacramento-San Joaquin Delta, and in the San Francisco Estuary. Samples were collected from 13 sites from throughout the system and a variety of analyses were performed, including a determination of the content of hydrophobic material, characterization of the UV absorbance and fluorescence properties, and quantification of the susceptibility to biodegradation both prior to and subsequent to photodegradation.

Samples were generally humic-rich, averaging over 75% hydrophobic content, and varying from 74 to 86%. However, variation in hydrophobic content between samples corresponded to changes in the optical properties. Samples were generally refractory with respect to biodegradation, with on average near 11% of the DOM susceptible to biodegradation prior to photoexposure, and in the majority of cases photoexposure resulted in lowered degradability. Finally, for all qualitative and quantitative parameters measured, seasonal variation was much greater than differences between wetland types.

OS31B-15 0830h POSTER

Variability of Hydrogen Peroxide, a CDOM Photochemical Product, in a Surf Zone

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The hydrogen peroxide radical is formed in marine ecosystems when sunlight reacts with colored dissolved organic matter (CDOM), or humic materials, that are naturally occurring in coastal waters. The surf zone of the ocean is a turbulent environment. To measure the variability in hydrogen peroxide concentrations within a surf zone, water samples were collected in ankle deep water at Huntington Beach (N33^{o}38.494', W117^{o}58.837') every thirty minutes for a twenty-four hour period from 9pm September 14, 2001 to 9pm September 15, 2001. Samples were analyzed to determine the concentration of hydrogen peroxide by the peroxidase method using a field fluorometer. The pH, turbidity, salinity and temperature were simultaneously determined. The optical properties of the samples were analyzed using UV/VIS and fluorescence spectroscopy. The observed hydrogen peroxide concentrations display variability on three time scales, the diurnal, tidal and high frequency. The pH levels observed in the samples were consistently between 7.9 and 8.2. The salinity of the water collected was mostly constant at 32.5 ppt, with a few dips and spikes that may indicate the contribution of different source waters. The hydrogen peroxide levels fluctuate more when the tide is flooding than when it is ebbing, with values changing by 100 nM during the flood tide and 10 nM during the ebb tide. The concentrations of hydrogen peroxide at night and in the early morning were low, ranging from 10-20 nM. During the afternoon, levels fluctuated between 150-350 nM with variability in peroxide being highest during the daylight hours. The variance in the diurnal cycle of the hydrogen peroxide concentrations correlates with those in the turbidity and temperature, and is anticorrelated with the diurnal cycle of bacteria present in the water. Turbidity ranged from 2 and 8 NTU and temperatures were 18 to 22^{o} Celsius. The bacteria are fecal indicator bacteria (E. coli), a common cause of beach closures along the southern Californian coastline. The bacteria follow a diurnal cycle with levels highest during the early morning and lowest in the late afternoon. With increasing sunlight the temperature of the water rises, the turbidity decreases and the concentrations of hydrogen peroxide increase, while bacteria fall sharply. This relationship illustrates the connection between photochemical and biological processes in a marine surf zone.

OS31B-16 0830h POSTER

Sources and Optical Properties of Colored Dissolved Organic Matter in a Southern California Salt Marsh

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The Santa Ana River serves as a primary drainage basin for the urbanized area of Orange County, and is a main discharge point into the coastal waters of Huntington Beach, California supplying the ocean with colored dissolved organic matter (CDOM). In the dry season when there is low rainfall, there is no flow from the Santa Ana River and all output flow is derived from the surrounding salt marshes. During times of high tide, this area is flooded with ocean water and in an ebb tide, drains out to the ocean. In order to identify the output sources of CDOM, three locations in this area were sampled during six tidal cycles, from June 26, 2001 to July 21, 2001. Stations W5 and W4 are salt marshes. Samples were taken at the tidegates where the marsh exits to the Santa Ana River. Station W5, located farthest from the discharge point, is in a large salt marsh that is the visiting site of a native bird population. Station W4 is in a smaller marsh that is surrounded by an oil refinery and a trailer park that has a duck feeding station. Station W2 is a sampling location 100ft up from the meeting point of the Santa Ana River to the ocean. Three samples were taken from each station for each tidal cycle: one at the peak of the high tide, one right after the high tide, and one at the lowest point of the ebb tide. It is hypothesized that the salt marshes are a major source of CDOM, especially during ebb tides. The water collected was analyzed for salinity and pH. Absorbance and fluorescence were measured with a UV/Vis spectrometer and a fluorometer. Salinity remained in the range of 31-33 ppt. The pH fluctuated between 7.3 and 7.85, with the lower pH values generally occurring during the low tide. In general, absorbances were higher for station W5 than W4 and both were higher than W2. In comparing flood tides with ebb tides, absorbances were about two to three times higher for ebb tides than for flood tides. A linear correlation between the UV/Vis absorbance at 254 nm versus 285 nm suggested that there is no significant difference between the material entering and leaving the sloughs, indicating a single source of CDOM. Absorbances were consistently higher on ebb tides, when there is less dilution of the water leaving the salt marshes, confirming that the salt marshes are a source of CDOM.

OS31B-17 0830h POSTER

Photochemical Decomposition of Chromophoric Dissolved Organic Matter in Surface Water

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To simulate photochemical and microbial decomposition in surface water, GF/F-filtered (0.7-μm pore size) lake water was exposed to solar radiation for 70 d. During that time 95% of CDOM was lost in the exposed water, while the loss was 8% in darkened replicates. The respective losses of DOC were 46% and 16% in exposed and darkened waters, respectively. In the exposed waters S-values increased from 0.016 nm^{-1} to 0.027 nm^{-1}, while no changes were observed in darkness. The quantum yield for photochemical decomposition of CDOM changed only little during the exposure, despite marked decomposition of CDOM. Quantum yield indicated that the UV-band of solar radiation was responsible for 75% of photochemical decomposition of CDOM at the surface, but in the optically deep water column visible (400-700 nm) radiation contributed 58% to photochemical decomposition. The results indicate that solar radiation decomposed CDOM rapidly, while ca. 50% DOC resisted both microbial and photochemical decomposition. This non-chromophoric DOM may contribute to old recalcitrant oceanic DOM.

OS31B-18 0830h POSTER

Sensitivity of CDOMs Optical Characteristics to Natural Degradation Processes.

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Experiments with photodegradation of CDOM show that the sensitivity of terrestrial CDOM to photobleaching decreases with distance from the sources. Data were collected in the watershed to a Danish estuary (Horsens Fjord), in the estuary itself and in open waters (Kattegat Baltic Sea). Sensitivity to photobleaching was highest in small streams and springs, decreased after passage through lakes and the estuary, with the lowest values found in open coastal waters. We suggest that the most coloured fraction of CDOM is the most sensitive to photochemical degradation and therefore is the first to disappear when CDOM is exposed to light. Thus a gradient is established from the watershed, through the estuary to the open water end member, reflecting the increase in light exposure through the system. Data for photodegradation and changes in optical properties through the system are presented.

OS31B-19 0830h POSTER

Examining CDOM Fluorescence Variability Using Principal Component Analysis: Seasonal and Regional Modeling of Three-Dimensional Fluorescence in the Gulf of Mexico

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Excitation emission matrix spectroscopy (EEMS) has proven valuable in characterizing the fluorescence of colored dissolved organic matter (CDOM). The parameters of wavelength and intensity contained within each matrix present a large amount of qualitative and quantitative information regarding CDOM composition and variability. The challenge for researchers has been incorporating all the information available from EEMS when comparing fluorescence changes within even a small data set. Principal component analysis (PCA) allows entire matrices to be used to determine similarities and differences in CDOM fluorescence. Variability within the data set is expressed as a series of linear terms, resulting in a more comprehensive assessment of changes in CDOM fluorescence. PCA has been used successfully to discriminate coastal from open ocean seawater off Puget Sound based on fluorescence properties. In this paper, we will present PCA results from a more comprehensive data set to develop a model of seasonal and regional CDOM variability within the Gulf of Mexico.

OS31B-20 0830h POSTER

Light-induced molecular transformations of riverine Dissolved Organic Matter (DOM) and how they impact DOM bioavailability

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The impact of light-induced transformations on the bioavailability of different DOM sampled along the river continuum was investigated on a seasonal base in the Tagliamento River, Italy. DOM fractionation (ultrafiltration and C18 solid phase extraction) revealed that up to 80% of isolated riverine DOM consisted of hydrophilic low-molecular weight (LMW) organic compounds and about 20% was made up by aliphatic and aromatic compounds. The bacteria dominantly utilized LMW DOM. In general a 4-hour exposure of all DOM fractions to the simulated full solar spectrum resulted in a release of less soluble, but higher oxidized hydrophilic LMW organic compounds, and Fe(II), a concomitant net production of hydrogen peroxide, and in a reduction (20-90%) in DOM bioavailability. Reactive species, such as organic peroxides and hydroxyl radicals, appear to induce a strong short-term inhibition on bacterial utilization of irradiated DOM. Iron-catalyzed phototransformations of DOM significantly decreased the microbial turnover of organic carbon compounds, and therefore appear to play a critical role in the cycling and transport of DOM in this highly oligotrophic system.

OS31B-21 0830h POSTER

Allochthonous CDOM is a Low Quality Substrate for Microbial Growth in Coastal Waters.

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Colored dissolved organic matter (CDOM) of terrestrial origin is rapidly removed from waters draining continental margins. The mechanisms (and their rates) necessary to explain this disappearance are not well understood. Generally, rates of bulk DOM biodegradation are low and relatively invariable in estuarine transects. Our current hypothesis is that physicochemical changes in mixing waters through an estuary may change the optical and biogeochemical properties of CDOM, thus altering its microbial utilization. In this study, 100 liter water samples were collected during transects from offshore marine to freshwater stations in the Chesapeake Bay, USA. CDOM was concentrated using tangential flow ultrafiltration (TFF) and natural bacterioplankton were concentrated on 0.2 m filters from 3-5 watershed locations. Incubations were performed within days of collections wherein each sample's bacteria was incubated at in situ temperatures in "CDOM-free" TFF permeates with the addition of each station's CDOM concentrate. Bacterial production, respiration, DOC concentration, cell numbers, bulk CDOM fluorescence, specific CDOM fluorescence and viral abundance were measured over the course of 2-4 week incubations. Five separate samplings were conducted representing early and mid spring, summer, fall and winter. Allochthonous CDOM was generally degraded at a higher rate than autochthonous CDOM for all stations sampled and marine bacteria degraded more freshwater CDOM than marine CDOM. Similarly, freshwater bacteria often degraded more marine CDOM than freshwater CDOM. Bacterial production rates did not show any predictable trends with source of CDOM added. However, bacterial growth efficiencies (BGE) calculated from bacterial production and respiration measurements, were found to be lower in incubations amended with allochthonous CDOM. This indicates that allochthonous CDOM was preferentially respired rather than incorporated into cellular material, and thus behaved as a low quality food source for natural bacterioplankton. Bacterial conversion of terrestrially-derived organic matter to CO2 in the coastal margin may help to explain the lack of terrestrial character found in biomass and natural organic matter in oceanic waters and sediments. We are currently using these data to develop a model of organic matter degradation through coastal estuaries in which the allochthonous component is always preferentially biodegraded. This model will be presented as a means to explain how relatively constant rates of DOM degradation through a coastal transect may still account for a significant fraction of allochthonous DOM removal.

OS31B-22 0830h POSTER

Carbon Cycling in Mangrove Ecosystems

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Mangrove forests occupy around 105 km2 worldwide, and cover 75 percent of the tropical and subtropical coastlines of the Americas (Field 1995). These highly productive ecosystems are traditionally viewed as large exporters of carbon and other nutrients to adjacent coastal zones. Limited work has been done to quantify carbon recycling within these systems and to identify the export sources from tropical mangrove ecosystems. There are several potential sources of organic matter that need to be considered: terrestrial sources, the mangrove vegetation, and marine sources including sea grasses and phytoplankton. These sources may be traced using stable isotopic signatures of carbon, nitrogen and sulfur. This study investigates nutrient cycling in mangrove forest sediments by comparing the stable isotopic signatures of organic matter buried in the sediment with those from terrestrial, mangrove and marine plants in a variety of mangrove ecosystems on the Yucatan Peninsula, Mexico (Dittmar, Lara et al. 2001; Kendall, Silva et al. 2001). This work may also elucidate the role of anthropogenic impacts affecting nutrient cycling within the mangrove ecosystem, a growing concern in heavily populated tropical coastal regions.

Dittmar, T., R. J. Lara, et al. (2001). River or mangrove? Tracing major organic matter sources in tropical Brazilian coastal waters. Marine Chemistry 73: 253-271.

Field, C. (1995). Impact of expected climate change on mangroves. Hydrobiologia 295: 75-81.

Kendall, C., S. R. Silva, et al. (2001). Carbon and Nitrogen isotopic compositions of particulate organic matter in four river systems across the United States. Hydrological processes 15: 1301-1346.

OS31B-23 0830h POSTER

Optical Properties of CDOM Derived From Copepod Grazing Processes

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Copepod grazing has been shown in previous studies to be an important fraction of the dissolved organic matter (DOM) pool. Yet their influence on the colored fraction of DOM has not been studied. A better understanding and characterization of chromophoric dissolved organic matter (CDOM) in ocean waters will (1) aid in determining the biological processes involved in its creation, (2) establish its contribution to carbon cycling, and (3) improve estimates of water color by remote sensing. This study aims to identify changes in ocean color attributable to copepods by characterizing optical properties of seawater specific to by-products of copepod grazing activity.

Experiments were conducted in the Gulf of Maine to investigate if copepod grazing influences CDOM composition. The optical analysis of CDOM was conducted by monitoring absorbance of dissolved organic matter (CDOM) as well as a more specific fraction of that pool, fluorescent dissolved organic matter (FDOM). FDOM is a more sensitive measurement capable of resolving smaller changes that may be attributable to biological inputs or removals. Optical absorbance and fluorescence spectra were collected from both treatment and control bottles that were incubated onboard ship for 24 h. Results from this study found that CDOM and FDOM increased throughout the experiment in treatment bottles. These changes in the composition of CDOM and FDOM during the 24 h grazing experiments will be discussed within the context of biological processes occurring during the incubation, including a possible microbial impact.

OS31B-24 0830h POSTER

Cycling of colloidal organic carbon and nitrogen during estuarine phytoplankton blooms

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While dissolved organic matter in the ocean plays a significant role in the global carbon cycle, understanding the dynamics of marine organic pools has been hampered by poor characterization of their composition and lability. To establish the influence of phytoplankton blooms on the cycling of dissolved and particulate organic carbon and nitrogen, we conducted a field study during a series of blooms in a small, shallow, enclosed embayment on Shelter Island, NY, USA. Using cross-flow filtration with a 1 kDa membrane, we collected high and low molecular weight (HMW & LMW) dissolved organic matter (DOM; less than 0.2 um), along with POM (greater than 0.7 um). Results demonstrated a significant, and near equivalent enhancement in levels of particulate and dissolved organic carbon during phytoplankton blooms under both high nitrate and nutrient deplete conditions. Size fractionated results indicated that HMW organic carbon was responsible for most (80 percent) of the DOC enhancement during blooms, as increases in LMW organic carbon were small. In contrast, substantial amounts of organic nitrogen were produced in all size fractions (particulate, HMW and LMW) during blooms. Contrary to hypotheses that C-enriched DOM accumulates only under nitrogen deplete conditions, we observed that the accumulation of C-enriched DOM was more dependent on algal species composition than ambient inorganic nitrogen levels, as DOC:DON ratios were higher during periods of elevated nitrate compared to low nitrate conditions dominated by phytoplankton with heterotrophic capabilities. An excess of HMW organic carbon formation rates (7 uM per day) over decay rates (5 uM per day) suggests that recalcitrant colloidal organic carbon formed during phytoplankton blooms could contribute to the older age of the world's DOC pool.

OS31B-25 0830h POSTER

Variability in the Relationship between Colored and non-Colored Dissolved Organic Matter in the Mississippi River Plume

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We studied the relationship between dissolved organic matter (DOC) concentrations and light absorption coefficient of colored dissolved organic matter (CDOM) in coastal waters of the Gulf of Mexico influenced by the Mississippi River Plume. Two stations within the Mississippi River were sampled twice per month over seven months to determine the temporal variability of the relationship between DOC and CDOM for the end-member. We also collected surface water samples for CDOM and DOC analyses and measured above water reflectance along the Mississippi River Plume. In this paper, we evaluate the variability of the CDOM-DOC relationship and its usefulness in the determination of DOC concentrations using passive optical sensors.

OS31C HC: Hall III Wednesday 0830h

Viruses and Prokaryotes in Aquatic Systems III

Presiding: **S W Wilhelm,** University of Tennessee**; W H Jeffrey,** University of West Florida

OS31C-26 0830h POSTER

The Phage Genomic Tree

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The most abundant biological entities in the ocean are phage, yet little is known about their biodiversity or geographical distribution. The biggest limitation to addressing these issues is our inability to characterize uncultured phage species, primarily because there is not a single genetic element that is conserved in all phage. Based on the overall similarity of 99 completely sequenced phage genomes, we propose a novel taxonomic system for classifying phage. The Phage Genomic Tree groups phage into taxa that predict several aspects of phage biology and correspond well with the current, morphology-based International Committee on Taxonomy of Viruses system. Additionally, each taxa in the Phage Genomic Tree has at least one conserved genetic marker which is shared by all members. We are