OS21A HC: Hall III Tuesday 0830h

Hyperspectral Remote Sensing of Nearshore and Open Ocean Environments I

Presiding: **C L Leonard,** Science and Technology Intl.**; J Campbell,** University of New Hampshire

OS21A-01 0830h POSTER

Towards Closure of *In Situ* Upwelled Radiance in Coastal Waters

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Dynamic coastal processes alter in-water optical properties and have a significant impact on the measurements and interpretation of upwelled radiance and thus, remote sensing data. Upwelled radiance, $L_u(\lambda, z)$, is an important quantity for the determination of the appearance of a water body, water column visibility, and for remote sensing. Traditionally, $L_u(\lambda)$ is measured about 1 m below the sea surface. This paper provides a method for estimating water-leaving radiance, $L_w(\lambda, 0^+)$, which is the quantity estimated by remote sensors, given measurements of either inherent optical properties (IOPs) or the radiance attenuation coefficient, $K_L(\lambda)$. *In situ* observations of upwelled radiance were made during the HyCODE project in coastal New Jersey (< 25 m water depth) using two different methods: 1) HyperTSRB and 2) profiled spectroradiometers. These measurements were compared with radiative transfer model estimates that used complementary measurements of IOPs for Hydrolight 4.1 model inputs. $K_L(\lambda)$ was computed using data from the profiling spectroradiometers to determine upwelled radiance at 0.66 m below the sea surface ($L_u(\lambda, 0.66)$), just below ($L_u(\lambda, 0^-)$), and just above the sea surface ($L_w(\lambda, 0^+)$, also using the *n*-squared law for radiance). Additionally, a tuning factor, determined using Hydrolight, is introduced to estimate $L_w(\lambda, 0^+)$ from HyperTSRB-measured $L_u(\lambda, 0.66)$. Average agreement between HyperTSRB and spectroradiometers with Hydrolight was within 10% at the blue wavelengths, within 25% at the green, and within 40% at the red wavelength; r^2 was greater than 0.92 in all cases. Water column optical properties changed drastically from nearshore (turbid) to offshore (clearer) due to the presence of an upwelling front. This front resulted in decreasing magnitudes and flattening of upwelled radiance spectra from nearshore to offshore.

URL: http://www.opl.ucsb.edu/hycodeopl.html

OS21A-02 0830h POSTER

Errors Generated by the Use of a Linear Model of Optical Diffuse Reflectance in Coastal Waters

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Diffuse reflection coefficient or diffuse reflectance of light from water body is an informative part of remote sensing reflectance of light from the ocean. Diffuse reflectance contains information on content of dissolved and suspended substances in seawater. Diffuse reflectance is an apparent optical property that depends not only on inherent optical properties of the seawater, but also on the parameters of illumination. The dependence on inherent optical properties is expressed as a dependence on a ratio of backscattering coefficient bB to absorption coefficient a. In the open ocean under diffuse illumination of the sky diffuse reflectance R is linearly proportional to the ratio of bB to a, i. e R=k*bB/a, with k=0.33 according to Morel and Prieur. The abovementioned linear equation is very good for the Type I open ocean waters. It is also acceptable for certain types of coastal waters. In fact, it is valid for all types of waters when the ratio of bB to a is less than 0.1. From physical considerations R should always lie between zero and one for any ratio bB/a between zero and infinity. The linear equation fails to pass this criterion, i. e. it exceeds unity when bB/a becomes greater than 1/k, or a < k*bB (highly scattering water with a lot of very small particles). It means that indiscrete use of the linear equation for coastal waters, when parameter bB/a exceeds limitations of smallness, can cause unacceptable errors in processing of in situ and remote sensing optical information. In order to estimate possible errors in determining diffuse reflectance we used four approaches to generate diffuse reflectance as a function of bB/a, or g=bB/(a+bB). The first two approaches are based on numerical calculations using Monte Carlo and Mobleys Hydrolight programs, and the third approach was theoretical. The input values of bB/a have been varied from very small to very large numbers. It was found that numerically and theoretically generated results for all varieties of input parameters satisfactory correspond to the available experimental data. Then we compared values produced by a linear model and estimated possible errors. The results of this analysis show that linear model may be very inadequate in some important coastal water conditions. For the reasons to avoid possible unacceptable errors it is advisable to avoid using linear model to process information related to coastal (Type II and III) waters. Alternative analytical non-linear equations that generate correct values of diffuse reflectance for any combination of bB and a are proposed.

URL: http://www7333.nrlssc.navy.mil/~haltrin/

OS21A-03 0830h POSTER

Hyperspectral Remote Sensing of Sea Surface Temperature and Emissivity With GIFTS

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Geostationary Imaging Fourier Transform Spectrometer (GIFTS), a revolutionary instrument for remote sensing of the earth's surface and atmosphere, will be launched in 2004. Revolutionary algorithms are required to process the data collected by such advanced instrument. As an example, a new approach to remote sensing of sea surface properties will be presented that takes full advantages afforded by the GIFTS data. Assuming the atmosphere is nonscattering and reflection is specular, the surface emissivity can be expressed as:

emiss=(r_toa-r_up-r_down*tau_sfc)/[(B(Ts)-r_down)*tau_sfc]

where r_toa is radiance at the top-of-atmosphere measured by satellite, r_up and r_down are upward and downward atmospheric radiances, tau_sfc is surface transmittance, B(Ts) is Planck function of skin temperature Ts, and spectral dependence of all terms is omitted for clarity. Two conclusions can be drawn from this version of radiative transfer theory. (1) If estimate of Ts is lower (higher) than actual Ts, the derived emissivity will be higher (lower) than the actual value. (2) In the spectral region of weak absorption lines, downward radiance increases and surface transmittance decreases, amplifying the difference of derived and actual emissivity as "spikes" in otherwise smooth emissivity spectrum. An optimization procedure uses these upward or downward spikes to set search direction, sequentially reduce interval of uncertainty, and terminate when exact solution is found or, in the presence of instrument noise, the spikes is sufficiently small.

URL: http://barrage.ssec.wisc.edu/muri

OS21A-04 0830h POSTER

Influence of Subsurface IOP Structure on the Remote Sensing Reflectance During the 2001 HyCODE Campaign

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During most of the summer 2001 HyCODE field campaign a region of clear-over-turbid water existed near the 50 m isobath. Clear water (a(488)=0.05 m-1) was observed to exist in the top 10 m of the water column. At 10 m the magnitude of the inherent optical properties increased rapidly (a(488)=0.12 m-1) and continued to increase with depth to 20 m (a(488)=0.24 m-1) below which is decreased. Using the measured inherent optical properties we apply radiative transfer modeling to examine the difference between reflectance from a case with a homogeneous clear layer and a case with the subsurface structure present. By displacing the clear-turbid interface we examine how an internal wave field would modulate the remotely sensed reflectance. Measured remotely sensed reflectances are then used to determine if internal waves were observed.

OS21A-05 0830h POSTER

Remote sensing of seagrass and bathymetry in the Bahamas Banks using high resolution airborne imagery

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Extensive losses of seagrass beds in recent decades have focused attention on the need for fast, reliable methods to evaluate the distributions of seagrass. Ocean color remote sensing provides an invaluable tool for mapping heterogeneous seagrass distributions in optically shallow waters. Using in situ optical data obtained in the shallow banks off Lee Stocking Island, Bahamas, we developed simple methods for estimating bathymetry and leaf-area index (LAI) of the seagrass Thalassia testudinum (turtlegrass) from remote sensing reflectance. Bathymetry was mapped using spectral ratios that explain 97% of the variability in depth from over 3000 data points. Bottom reflectance was retrieved from remote sensing reflectance using bathymetry and tables of depth-averaged attenuation coefficients. The computed bottom reflectances were consistent with in situ measurements made over areas of dense and sparse turtlegrass. These algorithms were applied to high resolution imagery obtained from the Ocean Portable Hyperspectral Imager for Low-Light Spectroscopy, Ocean PHILLS, in June 1999 and May 2000. We related LAI measured from diver-surveys at stations within the image to modeled bottom reflectance. The relationship between seagrass LAI and bathymetry ad the stability of the seagrass beds in this region will be explored.

OS21A-06 0830h POSTER

A Comparison of Hyper-spectral and Multi-spectral Imagery of Monterey Bay

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New advancements in the realm of satellite oceanography have opened up avenues to describe the oceans from a more synoptic perspective. Imagery used to study large-scale ocean dynamics has improved to include finer spectral, spatial and temporal resolutions. One example of these improvements comes from Airborne Visible/Infrared Imaging Spectrometer (AVIRIS) hyper spectral imagery in comparison to the present use of the Sea-viewing Wide Field-of-view Sensor (SeaWiFS) and Advance Very High Resolution Radiometer (AVHRR) for ocean color and temperature analysis. AVIRIS is a unique airborne sensor that uses a channel range of 224 bands for each scene and has a spatial resolution of 20 meters per pixel. The multi-spectral SeaWiFS and AVHRR platforms have 8 and 5 bands, respectively, and a nominal resolution of 1100 meters. With the use of 224 spectral bands and a 50 fold spatial resolution increase, oceanographic processes can be described in greater detail and new traits may be extracted from the imagery. On October 13, 2000, AVIRIS performed an over flight of the Monterey Bay region and five lines of data were acquired with a total

of 33 scenes of the bay. The data were processed for geometric and atmospheric corrections. The first processing algorithm designated the geographic latitude and longitude of each scene. A completed mosaic of the region will follow, with the 33 scenes arranged to form a composite of the Monterey Bay. Atmospheric corrections included the use of the Atmospheric CORrection Now (ACORN) Mode 3 processing algorithm in conjunction with the known in-situ values from HOBI Labs, Inc., HyrdroRad instrumentation (a portable radiometer). The HyrdroRad empirical data was measured concurrently with the AVIRIS over-flight. A comparison of spatial, temporal and spectral resolution was applied to SeaWiFS and AVHRR imagery. The same day composite for an AVHRR and SeaWiFS image overlaying AVIRIS data provides a contrast of the two. In the future, other applications will include accessory pigment analysis of phytoplankton and supervised classification of spectral features. This will provide the ability to ascertain which oceanographic features are resolvable with AVIRIS imagery compared to more commonly used imagery sources.

OS21A-07 0830h POSTER

Constraint of a Reflectance Inversion Model to Derive Particulate Absorption and Backscattering Spectra

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Particle composition and size distribution impact the magnitude and spectral shape of absorption and backscattering, the inherent optical properties that determine remote sensing reflectance. Roesler & Perry (1995) proposed an inversion model that derives spectral absorption and backscattering coefficients from spectral reflectance measurements. In its original form, this model used assigned spectral shapes, chosen to be broadly representative, for each component of absorption and backscattering, and derived the magnitude of each component via a non-linear least squares regression. However, we know that there is variability in the actual spectral shapes of the components, and that we can gain a better understanding of particle characteristics by examining that variability. In this study, we explore the possibility of allowing spectral shapes, as well as component magnitudes, to vary within the solution to the model. Tripton and gelbstoff absorption are modeled as exponential functions of wavelength, and particle backscattering as a hyperbolic function, all with variable spectral slopes. We test this model with measurements of remote sensing reflectance (PRR, Biospherical), absorption and attenuation (ac9, WETLabs), and backscattering (Hydroscat 6, Hobilabs) in the Damriscotta River, Maine during August 2001. As expected, interactions occur among components with similar spectral shapes and the model is unstable if all of the terms are allowed to vary simultaneously. However, if certain subsets of terms are allowed to vary, absorption and backscattering components are well reproduced. Individual components are best reproduced using particular subsets of variables. Our results suggest that allowing some constrained variation in spectral shape within the model can produce component spectra that are representative of specific particle populations. This derivation of absorption and backscattering spectra can provide a mechanism for obtaining more detailed information regarding particle composition and size distribution from reflectance data.

OS21A-08 0830h POSTER

Bottom Albedo Derivations From ROV Measured Remote Sensing Reflectance Over a Sandy-Seagrass Area Near Lee Stocking Island, Bahamas

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Measurements collected with a remotely operated vehicle provide data used to derive bottom albedo and optical properties for a shallow water environment near Lee Stocking Island, Bahamas. Optical model inversion techniques were applied to hyperspectral measurements of remote-sensing reflectance to derive water absorption and backscatter coefficients. Using these derived water properties, path attenuation and radiance effects were removed from bottom observations to derive bottom albedos. Histograms from multispectral, hyperspatial video images were used to determine the albedo range of optical end-members observed in the scene: sand and seagrass. Variations of spectral signatures for optical end-members on a cloudy day caused by path adjacency effects are shown to influence the reflectance measurements. On sunny days additional uncertainty is expected due to wave-focusing and shadow effects. Low-altitude albedo histograms for heterogeneous scenes demonstrate higher contrast between sand and grass than is observed at higher altitudes, even after correction for path radiance and attenuation effects. For example, reflected light from bright sand scatters into the field of view for darker grass, increasing the apparent grass albedo when viewed from higher altitudes. Evidence provided suggests that simple bottom classifications based upon expected albedo values for scene end members are in error. This methodology allows for analysis of individual end-members and their collective influence on the total upwelling light signal at various altitudes, and suggests that remote-sensing retrievals of accurate bottom albedos for heterogeneous and high-contrast components of the bottom setting will not be possible without corrections for path adjacency effects.

OS21A-09 0830h POSTER

Deconvolution of Spectral Measurements to Derive Optically Active Constituents in Turbid Coastal Waters.

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Quantitative estimates of phytoplankton absorption are central to bio-optical productivity models and are a key component for field programs dependent on delineating specific algal classes. Estimating phytoplankton absorption from bulk *in situ* measurements is difficult given the absorption of Colored Dissolved Organic Matter (CDOM) and detritus, which becomes especially significant in optically-complex coastal waters. We have developed a method that deconvolves the bulk absorption, as measured with a Wetlabs ac-9, into the respective contributions of CDOM, detritus, and three spectral classes of algae (chlorophyll c-, chlorophyll b-, and phycobilin-containing). As part of NASA and ONR research at the Long term Ecosystem Observatory (LEO-15), we validated the approach with over 580 discrete filter pad absorption estimates for the 2000 and 2001 field seasons. The R^2 between measured and ac-9 predicted absorption was 0.88 for the 2000 field season, with no major spectral bias except in the wavelengths associated with phycoerythrins. When particulate spectra were deconvoluted into the three major spectral classes of phytoplankton, with chlorophyll a-c containing groups being prevalent, the R^2 was 0.62. This approach was found to be limited by the availability of wavelengths as measured by the ac-9. Application of the inversion model to deconvolute both discrete filter pad absorption spectra as well as *in situ* hyperspectral data will be examined and demonstrated.

OS21A-10 0830h POSTER

Measurement of the Diffuse Attenuation Coefficient, K (490), With the LASH Hyperspectral Sensor

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This papers describes the estimation of K (490), the diffuse attenuation coefficient of seawater at 490nm, by application of the new SeaWiFS K (490) algorithm to the LASH hyperspectral sensor system. The application of real-time K (490) measurement to the optimization of hyperspectral detection algorithms is discussed.

OS21A-11 0830h POSTER

Relationship of light scattering at an angle in the backward direction to the backscattering coefficient

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We revisit the problem of computing the backscattering coefficient based on the measurement of scattering at one angle in the back direction. Our approach uses theory and new observations of the volume scattering function (VSF) to evaluate the choice of angle used to estimate bb. We add to previous studies by explicitly treating the molecular backscattering of water bbw and its contribution to the VSF shape and to bb. We find that there are two reasons for the tight correlation between observed scattering near 120° and the backscattering coefficient reported by Oishi (Appl. Opt. 29, 4658, 1990), namely, that 1. the shape of the VSF of particles normalized to the backscattering does not vary much near that angle for particle assemblages of differing optical properties and size, and 2. the ratio of the VSF to the backscattering is not sensitive to the contribution by water near this angle. We provide a method to correct for the water contribution to backscattering when single-angle measurements are used in the back direction, for angles spanning from near 90° to 160°, that should provide improved estimates of the backscattering coefficient.

TUE

OS21A-12 0830h POSTER

Light Scattering Measurements in the Coastal Zone, Gulf of Mexico

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Measurements of the spectral volume scattering function (VSF) were made in shallow waters off of Panama City, Fl. The VSF was measured at 1 degree resolution from 10 170 degrees using the General Angle Scattering Meter (GASM). Measurements were performed at 4 depths and 6 visible wavelengths. Over the 2 week period of measurements the VSF (when normalized to some angle, such as 10 degrees) was very constant at the top and bottom of the water column. At intermediate depths the normalized VSF varied between that seen at the top or bottom of the water column, depending on other environmental factors.

The small angle scattering was measured through the point spread function (PSF), but only at a single wavelength (500nm). The variation of the PSF with optical pathlength was similar to measurements previously performed in deep clear water, and other coastal areas, however the relationship was much more noisy. This was probably due to the difficulty in getting an accurate measure of the optical pathlength correlated with the PSF measurement, but could also have been due to very large particles (marine snow) in the water column. These large particles would have been difficult to measure with the instrumentation used to obtain the beam attenuation and absorption (AC-9).

OS21A-13 0830h POSTER

Characterization and Calibration of a Hyperspectral Coastal Ocean Remote Sensing Instrument

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The non-linear responses of marine optical signals have made coastal ocean areas of Case 2-type waters a challenging environment for remote sensing. Hyperspectral remote sensing with its continuous, high-resolution spectral information has long promised to help in unraveling some of the difficulties by bringing to bear the mathematical tools of imaging spectroscopy onto the non-linear problem. However, these tools require a high confidence in the absolute radiometric calibration of the hyperspectral sensor. During the 2001 Hyperspectral Coastal Ocean Dynamics Experiment (HyCODE) at the Long-term Ecological Observatory-15 m (LEO-15) site off the coast of New Jersey, we collected multiple days of high altitude imagery in support of the ONR objectives to develop in-situ optical hyperspectral algorithms and nowcast-forecast techniques. An explanation of the calibration techniques and data produced by the Portable Hyperspectral Imager for Low Light Spectroscopy II (PHILLS II) will be presented, as well as comparisons between the hyperspectral imagery and in-situ data.

OS21A-14 0830h POSTER

Application of Remote Sensing Multitemporal/Multisensor Data Analysis and GIS Database for Coastline Change Monitoring and Nearshore Morphology Detection in Rio Grande do Norte State, Northeast Brazil

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The objective of this study was to define an operational methodology using remote sensing and geographic information system techniques for monitoring and predicting shoreline change and nearshore composition/structure identification in northeast Brazilian EW-oriented coastline. This area is inserted on the PETROBRAS oil exploration research. The multitemporal approach used remote sensing technology either on a large scale with the most aerial photos and medium scale with SPOT-HRV/HRVIR and Landsat TM/ETM+ satellite data integrated through a GIS database with ancillary maps (eg. topography, bathymetry, geology), physical parameters (eg. currents and wind velocity/direction, tidal observation, beach profile) and sediment analysis (eg. in situ vanveen collected samples).

The temporal images comparison method (visual/digital) was applied for qualitative and semi-quantitative (images spatial resolution dependent) data analysis of sediment budget to this coastal system. The results showed that most accretion areas are due to sediment capture on E-W oriented sand spits while erosion areas are linked to large scale bottom morphology. The changes are mainly due to longshore drift contributions and negative sediment budget.

Knowing that detecting features on remotely sensed imagery is dependent upon the type of targets on surface, size, association and tone distribution, many digital image processing procedures were tested to provide enhanced images to a properly interpretation. Using RGB and IHS color composites allowed to distinguish between carbonate, terrigenous and mixed sands deposits in nearshore until around 25 meters depth. Seawater in this coastal region was very clear at the time of satellite scanning path. Highly turbid water was concentrated in a zone a few hundred meters large beside beach line through which huge quantities of sand and clay are transported to the west by currents parallel the shoreline. The sediment character distribution were confirmed by analysis of vanveen collected samples. High-pass filtering applied to single visible or infrared bands highlighted some important offshore morphologic features that can represent successive beachrocks lines, sandbars strongly oriented probably sustained by structurally controlled blocks edges, as well as sand waves highly dependent upon the deep currents. Regional lineaments maps of coastal zone obtained by directional filtered images combined with actual land forms features and drainage system showed a indisputable evidence of continuity offshore of these morphostructural lineaments.

The study confirmed that remote sensing and GIS integration techniques are essential tools for shoreline morphodynamic controls, nearshore composition detection, offshore features identification, monitoring and predicting onshore-offshore sediment budget balance on cyclic movement.

OS21B HC: Hall III Tuesday 0830h

Novel Techniques for Chemical Characterization in Marine Systems II

Presiding: **H E Hartnett,** Rutgers University**; L Minor,** Old Dominion University

OS21B-15 0830h POSTER

Mass spectrometric characterization of 13C-tracers: applications for biogeochemical study

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Stable isotope tracers have been widely used to study biogeochemical cycles of carbon and nutrients. A new mass spectrometric approach was developed in my lab to characterize 13C-lipids in tracer microcosm experiments. The principal of this approach was based on the quantitative shifts in m/z of 13C-lipids characteristic fragments. The shifts vary with carbon number and labeling content in these fragments. In biogeochemical tracer experiments, the 13C-labeled (uniformly or specifically) lipids can be readily distinguished from natural counterparts by calibrating with a series of mixtures of 13C-labeled and unlabeled standards. New 13C-labeled lipid compounds produced from organic matter degradation can be monitored by examining 13C fragments in their mass spectra. An advantage of this approach is the capability of examining intramolecular relationship between organic substrates and metabolism products by analyzing details of mass spectra. For example, analysis for labeling content of newly produced compounds (partially- or uniformly-labeled) indicated two different metabolism pathways: resynthesis and inter-transform from substrates. This approach has been successfully applied to study (1) effects of redox conditions on organic matter degradation, (2) role of benthic macrofauna in sediment diagenesis of algal material, and (3) influences of biological and physical mixing processes on organic carbon cycling.

OS21B-16 0830h POSTER

Nanomolar Detection for Phosphate and Nitrate Using Liquid Waveguide Technology.

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The ability to detect ambient concentrations of nitrate and phosphate is of vital importance in understanding the cycling of these nutrients, particularly in the oligotrophic regions of the worlds oceans. Various methods and novel technologies have been employed over recent years to address the problems of analysing these nutrients at the ambient nanomolar concentrations found in oligotrophic oceanic regions. With advances in long path-length Liquid Waveguide Capillary Cells there is the ability to use these in conjunction with sensitive segmented flow colorimetric analysis systems to produce analytical methods for the nanomolar detection of nitrate, nitrite and phosphate. Preliminary data are presented here for phosphate concentrations from samples analysed during a cruise to the nutrient deplete Eastern Mediterranean Cyprus Gyre region, with a detection limit for phosphate of less than 2 nanomoles per litre. Also reported are nitrate results from the surface waters of the oligotrophic Northern Indian Ocean with a detection limit of 1 nanomole per litre.

OS21B-17 0830h POSTER

Iron Isotopic Compostion of Marine Samples

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Iron is an essential micronutrient in the ocean and a limiting nutrient in high nitrate, low chlorophyll (HNLC) regions of the ocean. Although the importance of iron in the ocean has been recognized in the past decade, it is difficult to study because of its complex chemistry and behavior, and the difficulty in obtaining measurements without contamination. Fractionation of iron isotopes could be an effective tool to investigate and quantify the marine geochemistry of iron. Initial studies of iron isotopes show measurable fractionation in both abiotic and biological processes (Bullen and McMahon, 1997; Beard and Johnson, 1999; Zhu et al., 2000; Anbar et al., 2000; Belshaw et al., 2000). For example, a 1.4 permil (56/54 Fe) variation in iron isotopes of seawater over the past 7 Ma has been inferred from a paleorecord of iron isotopes reconstructed from a Fe-Mn nodule (Zhu et al., 2000). This study will address questions about the iron cycle using direct measurements of stable Fe isotopes in marine samples. Trace metal clean plankton tows were collected in the tropical eastern Atlantic (10°N, 45.5°W), filtered, and then measured for their iron isotopic composition. Measurements were made using a Micromass IsoProbe Multi-collector ICPMS. This system uses a hexapole collision cell to reduce molecular interferences and improve transmission. Initial results using a microflow PFA nebulizer, argon and hydrogen collision gases, and standard-sample bracketing give an external precision better than 0.2 (2σ) permil in the 56/54 Fe. Iron was mobilized from plankton tow samples by two different digestion methods: nitric acid/hydrogen peroxide digestion and muffle furnace combustion. Then the iron was purified by anion exchange chromatography. Replicates of one plankton tow sample have an iron isotopic value that is 0.42 ± 0.2 (2σ) permil depleted relative to measured igneous rock samples (56/54 Fe ratio). This measurement demonstrates that iron in the upper ocean is fractionated from continental rock sources. It is possible that this iron isotope fractionation is due to marine organisms, although other possibilities must first be ruled out (e.g. fractionation during release from dust). If the iron fractionation is biological, iron export from the euphotic zone should lead to progressive light isotope depletion, similar to the carbon and nitrogen isotope systems. Iron stable isotope measurements may thus yield information about the degree of iron utilization in the upper ocean.

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The Use of Staining Techniques and Flow Cytometry to Identify and Isolate POM Subclasses for Organic Mass Spectrometric Analyses

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Flow cytometric sorting is a useful technique for identifying and isolating sub-populations of particles within natural particulate organic matter (POM) samples. It has recently been used to isolate phytoplankton and non-phytoplankton "detrital" particles on the basis of chlorophyll autofluorescence and forward light scatter. Because autofluorescence was used to distinguish "phytoplankton" from "detritus" no preservation or staining techniques were necessary. Therefore, by applying direct temperature-resolved mass spectrometry (DT-MS) to the sorted subclasses, a comparison of the chemical characteristics of "phytoplankton" and "detritus" was made(1,2). While this is a useful initial approach for demonstrating the morphological and chemical heterogeneity of water-column POM, it suffers from distinct limitations. Non-fluorescent cells, such as heterotrophic bacteria and zooplankton (that have not just eaten a phytoplankton cell) are included within the "detrital" pool of POM. In this study we attempt to include these cells within our POM subclasses.

In order to identify bacterial and eukaryotic cells within natural aquatic particle samples, various nucleic acid stains (SYTO 16, DAPI, SYTOX, etc.) are being tested. In addition to optimizing staining times and concentrations, we are examining the effects of the staining procedures on the molecular-level characteristics of the stains. Although the relative sensitivities of the stains to various cell and virus types need