light/dark cycle, especially for diatoms. Low temperature and low iron conditions reduce growth rate, but have only a small influence on the isotope fractionation factor. Our findings suggest that different strategies of nitrate utilization in different environments can cause fractionation values to range from 2-18 $^{o}/_{oo}$ when growing on nitrate as the sole nitrogen source, but not as a simple function of growth rate. Although the extremes are rarely seen in nature, the patterns seen in the laboratory allow us to make important generalizations about isotope fractionation by diatoms and other marine phytoplankton in a variety of ecologically important regions of the ocean. This is relevant to studies of modern biological processes in the water column and for the accurate interpretation of δ^{15}N in the sedimentary record.

OS22M-09 1550h

Relationship of Nitrogen Isotope Fractionation to Phytoplankton Size and Iron Availability During the SOIREE Southern Ocean Iron RElease Experiment.

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The ^{15}N composition of sediments has been used as a proxy for nitrate utilization in Southern Ocean surface waters to investigate the contribution of Southern Ocean productivity to glacial/interglacial changes in atmospheric CO_2 concentration. Interpretation to date has relied on a temporally constant isotope fractionation factor ε associated with uptake and assimilation of nitrate by phytoplankton. To investigate the reliability of this approach, during SOIREE we examined the relationships between the ^{15}N compositions of dissolved nitrate, size-fractionated (200, 70, 20, 5, 1 μm) suspended particulate organic nitrogen (PON), and sinking particles caught in traps suspended below the mixed layer. We found evidence for variations in ε with both cell size and iron availability. $\delta^{15}N_{PON}$ increased by several $^{o}/_{oo}$ with increasing cell size, both within and outside the iron-enriched patch. $\delta^{15}N_{PON}$ was a further 3-4$^{o}/_{oo}$ higher in size fractions dominated by large diatoms collected from within the iron-fertilized patch. Comparing the δ^{15}N of the large diatom dominated size fractions to the δ^{15}N of nitrate suggests relatively low ε values of 4-5$^{o}/_{oo}$, in contrast to values of 7-9$^{o}/_{oo}$ estimated from both enrichment of δ^{15}N of nitrate above the seasonal pycnocline and comparison of mixed layer nitrate δ^{15}N with sinking-particle δ^{15}N. We speculate that several factors contributed to this iron response, including the increase in abundance of large diatoms, higher growth rates, and an iron-stimulated shift from ammonium-based to nitrate-based production. To the extent that large diatoms are responsible for a large fraction of NO_3^- utilization, variation in $\delta^{15}N_{PON}$ and ε with size can affect the δ^{15}N recorded in diatom-dominated Southern Ocean sediments. Higher glacial δ^{15}N in Southern Ocean sediments may reflect increased iron availability, cell size, and growth rate along with increases in nitrate utilization; these effects must be considered in any quantitative scaling of δ^{15}N variations to extent of nitrate utilization.

OS22M-10 1605h

Holocene Variations in Saharan Dust Input to the North Atlantic and its Influence on Upper Ocean Nitrate

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The link between iron supply and surface ocean productivity has been explored in the modern ocean by a variety of experiments. However, both purposeful additions from boats and laboratory incubations require unnatural perturbations to the insitu biochemical system. We have measured the accumulation flux of dust in ODP core 658c to monitor the history of natural variations in dust supply from north Africa over the last 14 ka. Over 120 excess ^{230}Th measurements were made down core to normalize the dust percentage record for variations in the accumulation of other sedimentary components. This record shows a dusty Sahara/Sahel during the Younger Dryas and an abrupt shift to wetter environments at the beginning of the Holocene. The end of the African Humid period is marked by a sharp increase in dust accumulation at 5.5 ka.

These abrupt shifts in dust supply to the North Atlantic represent a large deviation from the modern situation. Productivity in the nutrient starved Sargasso Sea and the Gulf of Mexico had much less total iron available in the early Holocene than these areas do today. In these nutrient poor surface waters, the δ^{15}N of the sinking nitrate reflects is a measure of nitrogen fixation relative to other processes, including local mixing and global denitrification. We use a high-resolution record of bulk sedimentary δ^{15}N from the Orca Basin, a saline anoxic depression in the Gulf, to constrain the balance between nitrogen fixation and these other processes in the overlying waters. At the start of the African Humid period there is a 1.5 per mil increase in δ^{15}N. This value stays high until the mid-Holocene when it falls back to about 2.5 per mil. These data are consistent with decreased nitrogen fixation, relative to denitrification, when iron supply drops, and the inverse when iron supply resumes at 5.5 ka. Using changes in boundary conditions from the paleo record, our study is in a sense a natural iron removal/addition experiment. The implied result is that iron is an important component of the surface marine ecosystems ability to fix nitrogen and can therefore play an important role in determining the limiting nutrient in the ocean.

OS22M-11 1620h

$U_{37}^{K'}$ and the Physiological Condition of Alkenone-Producing Cells Exported to Marine Sediments

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Alkenone unsaturation patterns ($U_{37}^{K'}$) are now commonly measured stratigraphically in marine sediments as a record for paleo sea-surface temperature (SST). Strong statistical correlation between nearly global measures of $U_{37}^{K'}$ in surface marine sediments and overlying mean annual SST underpins the method. Nonetheless, this statistical calibration displays considerable variability in the $U_{37}^{K'}$ value represented by a given SST, adding uncertainty to its use in paleothermometry. In this study, isothermal batch culture experiments were conducted with a key alkenone-producer, *Emiliania huxleyi*, to evaluate to what extent cell physiology could contribute to the observed variability in this empirical field calibration. In strain CCMP 55a, alkenone content and composition remained constant throughout exponential growth when nutrients (ortho-phosphate, nitrate) were replete. Stationary phase (nutrient-starved) cells continued to produce alkenones, amassing concentrations three or more times higher than those dividing exponentially (1.5-2 pg/cell). The $U_{37}^{K'}$ of the 'excess' alkenone was significantly lower (0.12 units) than expected. Alkenone content and composition of exponentially growing cells placed in darkness also changed significantly. Five days of darkness resulted in 80% decrease in cellular alkenone concentration and a 0.12 unit increase in $U_{37}^{K'}$. Given the established temperature response of $U_{37}^{K'}$ in exponentially growing cells of CCMP 55a (i.e. 0.034 units/°C), the range of physiological variability in alkenone unsaturation pattern noted in our experiments corresponds to a temperature uncertainty of $\pm$3.5°C. This magnitude of variability is not unlike the range observed in the statistical $U_{37}^{K'}$-SST calibration for surface marine sediments which begs the question: what is the physiological condition of alkenone-producing cells exported to marine sediments? The answer to this question may depend on the particular ocean location considered and have substantial bearing on how stratigraphic $U_{37}^{K'}$ records in marine sediments are interpreted paleoceanographically.

OS22M-12 1635h

Generation and Transfer of the Alkenone-Based Sea Surface Temperature Indicator in the Cariaco Basin Water Column: A Study of the UK'37 Index in Sediment Trap Materials from the CARIACO Time Series

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Monthly changes in water column temperature, primary production (PP), and biogenic fluxes were investigated through several annual upwelling cycles in the Cariaco Basin as part of the on-going CARIACO time series. The compositions of long-chain C37 alkenones in settling particles were determined in order to assess the reliability of these biomarkers as indicators of past sea surface temperature (SST). Seasonal upwelling caused significant and rapid changes in SST, PP and biogenic fluxes. Alkenone fluxes were poorly co-related to PP and organic carbon export from the euphotic zone. However, the alkenone unsaturation index (UK'37 ratio) closely followed the variations of SST in terms of timing and magnitude. Such data indicate that alkenone-synthesizing algae in the Cariaco Basin live near the surface during most of the year and rapidly adjust the unsaturation of these compounds in response to changes in temperature independently of variations in PP and plankton composition. Additionally, there was close agreement among the UK'37 ratios obtained from trap samples collected at different depths during the same period, indicating that the transfer of this signal to the sediments via particle settling occurs with little diagenetic alteration. The relationship between the UK'37 signatures of sediment trap materials and SST was generally consistent with the calibration equation developed by Prahl et al. (1988). The average alkenone-based temperatures derived from cumulative alkenone fluxes collected each year yielded values that were within 0.5 oC of the annual mean SST measurements. Such reliability between the alkenone-based and actual temperature estimates bode well for the application of the Prahl et al. (1988) equation to reconstruct past SST variability in the Cariaco Basin.

URL: http://organic.geol.sc.edu/cariaco.htm

OS22N HC: 323 A Tuesday 1330h

Western Pacific Marginal Seas IV

Presiding: **S Ramp,** Dept. of Oceanography

OS22N-01 1330h INVITED

Kuroshio Intrusion In Northern South China Sea

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Data recorded by three subsurface Acoustic Doppler Current Profilers (ADCPs) in the Luzon Strait (LS) showed the Kuroshio Current (KC) intruded steadily and persistently into the South China Sea (SCS) through the central LS. The monsoon had little impact on the intruded KC. Moored current velocity measurements about 240km west of central LS showed a persistent westward velocity component indicating that the KC intruded further westward into the northern SCS. The composite current velocity, calculated from shipboard ADCP measurements in 1991-2000, showed the intruded KC mostly curved clockwise and flowed out of the SCS through the northern LS. A northward current, originating from the west of northern Luzon, interacted with the intruded KC. The current was generally in a westward flow. Only a small branch flowed eastward through the southern LS out of the SCS. Across the LS,

the net westward transport in the upper 300m ocean was 3.3 Sv.

A similar feature of KC intrusion was found in the results of the Miami Isopycnic-Coordinate Ocean Model (MICOM), which uses forcing by the climatological wind stress calculated from the European Centre for Medium-Range Weather Forecast (ECMWF) wind. The model result, however, displayed a more significant seasonal variation.

OS22N-02 1350h

Moored Observations of Internal Solitons in the Northeastern South China Sea

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An array of seven oceanographic moorings were deployed across the continental shelf and slope near Dongsha Island as part of the ONR-sponsored Asian Seas International Acoustics Experiment (ASIAEX). The moorings spanned 82 to 350 m depth and sampled temperature, salinity, and velocity at 1 or 2 minute intervals from April 21 to May 19, 2001 (the intermonsoon). The mean flows were all southwest along topography at order 10 cm s-1, but had a significant onshore component near the shelf break. A weak, subsurface opposing flow, which might be interpreted as the South China Sea Warm Current, appeared occasionally over the continental slope. The tides were mixed, diurnal-dominant, and very complex due to the strong internal tides. The dominant feature of the data set by far was the highly nonlinear internal solitary waves, which were generated near the Luzon Strait and propagated WNW towards 292 true north at speeds varying between 100 and 140 cm s-1. The waves were most prominent during the increasing (waxing) stage of the fortnightly tide and absent during the decreasing (waning) phase. These were predominantly mode-1 waves with opposing horizontal velocities (order 130 cm s-1) above and below about 110 m depth. Vertical velocities were also observable with conventional ADCPs and exceeded 50 cm s-1 during the strongest events. The associated temperature changes at 100 m depth due to the thermocline depressions exceeded 10C at the 350 m mooring. Onshore of the shelf break, the Luzon Strait waves were joined by locally generated waves and waves refracted around Dongsha Island, resulting in an extremely complex wave field. A further study of their evolution and dissipation in shallow water is underway.

OS22N-03 1405h

Kuroshio Intrusion and the Circulation in the Northeastern South China Sea

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The Princeton Ocean Model is used to study the circulation in the South China Sea (SCS) and its seasonal transition. Kuroshio enters (leaves) the SCS through the southern (northern) portion of the Luzon Strait, which often results in an anticyclonic loop current west of the strait. The loop current separates near Dongsha Islands with the northward branch continuously feeding the South China Sea Warm Current at the shelf break and the westward branch to become the South China Sea Branch of the Kuroshio on the slope. The loop current also contributes to the Taiwan Warm Current.

Net volume flux through the Luzon Strait exhibits remarkable seasonal variation. From May to January, the net flow through the strait is from the Pacific into the SCS at an average of 3.3 Sv. The maximum inward flux of 7.5 Sv occurs in September. The net flux is from the SCS to the Pacific between February and April with a mean flux of 1.8 Sv. Volume fluxes through other straits and the water balance in the SCS are also presented in this paper.

OS22N-04 1420h

Hysteresis of a western boundary current leaping across a gap with application to the Kuroshio penetrations into the South China Sea

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An idealized problem of a western boundary current of Munk thickness L_M flowing across a gap in a ridge is considered using a single-layer depth-averaged approach. For the gap half-width $a \geq 4.55 L_M$ the boundary current may leap across the gap due to inertia, characterized by the Reynolds number Re, completely choking off water exchange between the two basins or penetrate through the gap as a loop current depending on previous evolution. As the boundary current slowly accelerates, transition from the penetrating to leaping regime happens when the width of a zonal jet near the gap becomes comparable with a, implying the Reynolds number $Re_P \simeq (a/L_M)^3$. On the other hand as the boundary current slowly decelerates, the leaping regime persists while the meridional advection dominates the β-effect in a wiggle of the current core within the gap, implying that the leaping regime breaks at $Re_L \simeq a/L_M$. Thus hysteresis occurs over the range of Reynolds numbers $Re_L < Re < Re_P$.

An interesting application of this problem may be to the flow in Luzon Strait. It was long ago recognized (Nitani, 1972) that the Kuroshio may either leap across the strait or penetrate well into the South China Sea as a loop current, possibly depending on the season. An analysis of typical scales suggests that normally the Kuroshio can leap across Luzon Strait. However, during periods when its strength is substantially reduced, it may penetrate into the South China Sea. Thus multiple states and hysteresis are likely to occur. Farris and Wimbush (1996) found a relationship between the loop-current stage (derived from satellite infrared images) and the wind-stress history: the Kuroshio penetrations occur when the time-integrated strength of the northeast monsoon exceeds a threshold value. This is in qualitative agreement with the present theory in the sense that the penetrations occur when the Kuroshio is weakened by the monsoon blowing in the opposite direction.

OS22N-05 1435h

Transport Reversals at Taiwan Strait during October and November, 1999

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The transport through Taiwan Strait is generally positive from the South China Sea to the East China Sea even during the winter when northerly monsoon prevails. From September to December, 1999 transport was measured with bottom mounted acoustic Doppler current profilers at 4 locations across the Taiwan Strait near 25N. The time series shows strong transport reversals with a biweekly period. These observed transport reversals are examined by applying analytic solutions, a numerical ocean model and the prediction from a real-time North Pacific Ocean data-assimilating model.

Wind stress explains a majority of the transport reversals. The reversals are forced by a combination of local wind and remote wind at Yellow and East China Seas. The connection between the Yellow and East China Seas wind stress and the transport reversals at Taiwan Strait is provided by coastally trapped waves. The waves are generated by the northerly winter wind bursts at the Yellow Sea and enhanced across the East China Sea by alongshore wind.

URL: http://www7320.nrlssc.navy.mil/npacnfs_www/

OS22N-06 1450h

A Globally Relocatable Tide Model Applied to Western Pacific Marginal Seas

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The U.S. Naval Research Laboratory has developed a globally relocatable tide/surge forecast system. This system runs on a UNIX platform but was designed originally for PC-based use and is referred to as PC-Tides. The core of the system is a barotropic ocean model that may be run in 2-D or 3-D mode. The model is forced with boundary conditions from a global tide model and/or surface winds and pressures. Ocean bathymetry is derived from the U.S. Navy's DBDB-V data base interpolated to a 3-minute global grid. Atmospheric forcing from the Navy's global or regional models is provided through the METCAST system in order to provide real time forecasts.

PCTides has been evaluated as a real time forecast system for regions along the east and west coasts of the U.S. by comparing the model's forecast to real time observations. Results of these evaluations showed an average amplitude error of 10 cm and a phase error of 30 minutes.

PCTides has also been applied to several regions in the western Pacific and evaluated against observations in the form of coastal stations and bottom mounted ADCPs. Specific examples of PCTides hindcasts and forecasts for the Yellow Sea and South China Sea will be presented and discussed.

OS22N-07 1525h

Effect of Vertical Grid Representation on simulated circulation in the East Asian Seas

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A newly developed ocean model is used to demonstrate the effect that different vertical coordinate systems have on simulating the oceanic circulation in the East Asian marginal seas (The Japan/East, Yellow, and East China Seas). The HYbrid Vertical Coordinate Ocean Model (HYCOM) is used for the simulations. HYCOM is typically configured so that it is isopycnal in the open, stratified ocean, but smoothly reverts to a terrain-following coordinate in shallow coastal regions, and to z-level coordinates in the mixed layer and/or unstratified seas. In this study, we use HYCOM in that configuration, but also with other vertical configurations, including pure isopycnal mode, pure z-mode, pure sigma mode, and various sigma-z combinations. Additionally,. the impact on the number of layers (or levels) is examined. The horizontal grid resolution of the simulations is 1/24 degree, and open boundary conditions are provided by a 1/6 degree Pacific Basin version of HYCOM. Wind stress and heat flux components are from the ECMWF 10 m reanalysis. The number of layers/levels ranges from 15 to 26. The results indicate that about 20 layers is sufficient, if the vertical density profile (i.e. water mass distribution) is accurate. Particular attention is given to the pertinent coastal currents, although large-scale circulation patters, such as the branching of the Tsushima Warm Current from the Kuroshio, the Nearshore Branch of the Tsushima Warm Current, and the northward pulsing of the Yellow Sea Warm Current in response to northerly wind bursts are also examined. While all vertical coordinate configurations can simulate most large-scale circulation features reasonable well, it is demonstrated that the hybrid sigma-z-isopycnal configuration is optimal for accurately simulating the current systems simultaneously in shallow and deep water.

OS22N-08 1540h

Reconstruction of Paleo- Winter Monsoon Strength and Ocean Circulation Over the Last Glacial Cycle in the Northern South China Sea

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Variations in nitrogen isotopic composition (δ^{15}N) and total chlorin accumulation rate (AR) are employed as proxies to reconstruct oceanic nitrate inventory, the balance between denitrification and N fixation, and paleoproductivity in a sediment drift deposit recovered from the northern South China Sea (SCS) during ODP Leg 184 (Site 1144). Sub-surface and deep waters of the N. SCS are sourced from the shallow Kuroshio Current and Pacific Intermediate Water respectively. Their relative importance in determining sedimentary δ^{15}N and paleoproductivity on glacial/inter-glacial timescales has been altered by changes in equatorial circulation, summer- and winter-monsoon intensity and relative sea-level. The location and unusual configuration of this marginal basin renders it especially sensitive to such changes.

Assuming complete annual nitrate utilization based upon modern water column measurements, low δ^{15}N values during glacial stages are interpreted as a reflection of reduced remote denitrification in the Eastern Tropical North Pacific (ETNP) source waters, while much of the warmer marine isotope stage (MIS)3 and last inter-glacial were characterized by high denitrification. However, intermittent intervals of anomalously low δ^{15}N values are interpreted as reflecting the regional contribution from N fixation in W. Pacific surface waters, transmitted to the site by the shallow Kuroshio Current. Millennial-scale variations during MIS3 suggest N-fixing organisms flourished at a time of enhanced dustiness recorded during cold stadials in the Greenland ice-core records. Indeed, higher frequency variations in both ETNP denitrification and local N fixation appear to be coherent with a hemispheric response to Dansgaard-Oeschger events recorded at high latitudes.

For much of the last glacial cycle, paleoproductivity was decoupled from δ^{15}N, and instead seems to reflect the extent of the global nitrate inventory stimulated by elevated dust fertilization, and regional mixed-layer deepening associated with the relative intensity of the winter monsoon. Since chlorin AR exhibits strong glacial/inter-glacial variability, transfer of a detailed δ^{18}O-based chronostratigraphy for the last ~1 Myr facilitates calculation of a long-term sedimentary decay constant for this proxy. Applying this decay correction, an extended record of chlorin AR shows very strong coherence with winter monsoon intensity over the mid- and late Pleistocene and likely represents a novel tracer for paleomonsoon intensity in this Pacific Marginal Sea.

OS22N-09 1555h

The Structure and Eastward Extension of the Changjiang River Plume in the East China Sea

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The hydrographic structure and offshore extension of freshwater plume discharged from the Changjiang (also known as the Yangtze) River in the northern East China Sea were investigated by analyzing conductivity-temperature-depth (CTD) data and drifter trajectories collected during the summers of 1997 and 1998. From June to early September when southerly winds prevail, the plume tends to move northeast in the Chinese coastal area, and then separates from the coastal zone to travel eastward over 400 km offshore across the western shelf of the northern East China Sea. During other seasons when northerly winds prevail, the plume is confined to the Chinese coast. In the summer, the plume in the mid-shelf, confined to a thin surface layer 10 to 15 m thick, extends eastward in the form of patches of low-salinity water rather than spreading as a tongue-shaped pattern from the Changjiang mouth. The eastward movement of patches in the western shelf is primarily due to upwelling favorable southerly winds that prevail in the summer monsoon. Upon reaching the vicinity of Cheju-do, an island in the middle of northern East China Sea, the patches are advected to the Korea/Tsushima Straits by either the Cheju Warm Current or a northward-flowing mean current of the Kuroshio Branch Current, and then finally flow into the East/Japan Sea.

OS22N-10 1610h

Summary of Observations and Modeling of Optical Properties in the Yellow Sea

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This paper reports on the work that was performed on the Korean coast of the Yellow Sea in collaboration with the West Fishery Center of the National Fishery Research and Development Institute of Korea from 1996 to 1999. It includes data and analysis from four seasons: June and October 1996, April 1998, and February 1999. A description of the seasonal changes of individual Inherent and Apparent Optical properties is discussed. Although, the location of the thermocline appeared to have influenced the vertical distribution of the optical properties during June and October, the major contributor to the spatio-temporal variability of the Yellow sea is the tidal current at all depths in all the seasons. Other factors influencing the distribution appear to be the type of bottom and particle size. The largest magnitudes of the optical properties were found in areas of fine sediment and strong tidal current. Coastal stations reported the highest values of backscattering and attenuation coefficients at all seasons. The lowest values were found in offshore areas and at the surface. In general, the costal optical environment of the Yellow Sea was found to be dominated by backscattering from particles during the time of this study. There were some isolated areas in which the absorption processes dominated the scattering processes. These occurred where blooms of the blue-green algae Synechococcus spp. were found. The findings from our seasonal optical studies in Korea, enabled the construction of an environmental optical model to extract spectral attenuation coefficient and backscattering coefficient with respect to depth using environmental parameters, exclusively

OS22N-11 1625h

Evaluation of Satellite Ocean Color Algorithms in East Asian Marginal Seas

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Current standard ocean color algorithms perform best in open ocean (Morel Case-1) waters where optical properties are dominated by phytoplankton and pure water. In turbid coastal waters (Case-2) optical properties diverge significantly from Case-1 waters and current algorithms are not generally valid.

Ocean spectral reflectance (Rrs) data and supporting in situ measurements (chlorophyll-a, suspended solids, particulate and dissolved absorption, particulate organic carbon) were collected in the western Pacific and East Asian marginal seas including the Sea of Japan (East Sea), East China Sea and South China Sea (near Hong Kong and the Pearl River estuary). Comparison with Case-1 Rrs chlorophyll-a relationships shows that in Case 2 waters Rrs is highly variable and can be either higher or lower than corresponding Rrs of Case-1 waters at similar chlorophyll-a concentration. Normalizing the Rrs spectrum to a Rrs value at a longer wavelength reduces the effects of particle scattering and enhances the effects of absorption. Rrs ratios in the turbid coastal waters show distinct clusters that diverge significantly from Case-1 relationships and cause significant overestimation of chlorophyll-a when using standard Case-1 algorithms. The divergence from Case-1 waters of Rrs - chl-a relationships for the Asian waters studied are caused by the non-correlation of chl-a with inorganic and organic detrital particles, and dissolved material. Using ship-based data with simultaneous observations from SeaWiFS, we observed significant errors in retrieval of both chl-a and normalized water leaving radiances for certain conditions. Atmospheric correction errors caused by turbid atmospheres as well as the complexity of Case-2 waters both contribute to these errors.

OS22O HC: 316 A Tuesday 1330h

Maintaining Deep Ocean Stratification I

Presiding: **R Pinkel,** Scripps Institution of Oceanography**; J Ledwell,** Woods Hole Oceanographic Institution

OS22O-01 1335h

Initial Results of the Salt Finger Tracer Release Experiment

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Microstructure surveys and a tracer release experiment were performed in the thermohaline staircase region in the western tropical North Atlantic. The Salt Finger Tracer Release Experiment involved staircase sampling and tracer injection in January-February 2001 and a tracer survey with further microstructure profiles in November 2001. The goal was to quantify the vertical dispersion of tracer due to the action of salt fingers within the staircase, and relate this to the observed dissipation levels. Typical profiles displayed 6-12 mixed layers in the main thermocline between 200 and 600 m depth. The tracer was injected at a depth of about 400m in a mixed layer with a temperature near 10 C. Elevated thermal dissipation was observed at the high gradient interfaces between mixed layers. This signal displays a close variation with the theoretical salt finger growth rate, consistent with the "frozen growth" similarity solutions for salt fingers. Interfaces varied from 0.5m to over 10m in thickness, possibly due to high mode internal waves. There was also a tendency for the thinnest interfaces to be found when the vertical shear was weakest. This is suggestive of an interplay between salt finger convection and shear instability in controlling the interface thickness. Preliminary results of the November tracer survey will be reported.

URL: http://www.whoi.edu/science/PO/dept/

OS22O-02 1405h

The temperature-salinity relationship in NATRE

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Measurements of temperature (T) and salinity (S) from the North Atlantic Tracer Release Experiment (NATRE), in the eastern North Atlantic, are used to study the interplay of processes that stir tracers along density surfaces with processes that mix tracers across density surfaces. The data consist of a grid of 100 vertical profiles regularly spaced over an area of 400x400 km. We show that the Central Waters of the main thermocline are characterized by an extremely tight T-S relationship and small thermohaline fluctuations. Below, at the level of the Mediterranean Outflow (900-1400 m), thermohaline fluctuations are much larger and characterized by strong density compensation. That is, there are large T-S intrusions along density surfaces.

Double-diffusive processes are often invoked as an explanation for the formation of T-S intrusions. Here we take the alternative view that T-S fluctuations are created by mesoscale eddies that stir the large scale thermohaline gradients. The argument stems from theoretical work by Hua and collaborators on quasi-geostrophic dynamics and goes as follows. The outflow of Mediterranean waters creates a large scale salinity gradient along isopycnals. Mesoscale motions, being almost parallel to isopycnals, are effective at increasing temperature and salinity fluctuations along isopycnals, but they are ineffective at creating small scale density variability. The consequence is that, at small scales, T-S fluctuations tend to be larger than density ones and there is density compensation. Further up in the water column, where the T-S relationship is tight, this process cannot work, because there is no large scale thermohaline gradient along isopycnals to stir.

Numerical simulations of a fully-turbulent quasi-geostrophic stratified flow confirm that mesoscale dynamics can account for the different levels of thermohaline variability observed throughout the water column.

TUE