our results indicate that sediments have a different behavior associated with nitrogen cycling. The continental shelf appear as an ammonium sink (-3 $\pm$ 4 mmol m^{-2} d^{-1}) during winters periods and a source (8 $\pm$ 2 mmol m^{-2} d^{-1}) during spring-summer. While sediments in the bay, act all the year over as an ammonium source, in average 5 times higher in summer than in winter (5 mmol m^{-2} d^{-1}). Both places appear as a sink of nitrate all the year.

Higher oxygen levels underlying the sediments and low quantity and quality of organic matter (*i.e.* Fep/Chl-*a* ratio, C:N > 9) are correlated with ammonium fluxes to the sediment suggesting assimilation and/or nitrification processes, as during winter in the shelf. Anoxic conditions and high content of fresh organic mater, determine significant ammonification rates and positive ammonium fluxes (net ammonium release to the water column), in both places and a significant DNRA (17-20 % of the total ammonium fluxes) by conspicuous mats of *Beggiatoa* sp. in the bay. During summer, the continental shelf sediments, lost an important quantities of nitrogen due to high denitrification rates (3 $\pm$ 1 mmol m^{-2} d^{-1}) while is not significant in the bay (< 0.5 mmol m^{-2} d^{-1}) .

Benthic areas under high organic matter input and minimum oxygen conditions, during summer are important sources of nitrogen, as ammonium to the water column. This areas could also to be important sites of denitrification and a net nitrogen lost for the pelagic system. However, our results suggest that when the sediment chemical conditions are very reduced, as during summer in the bay, the denitrification could be inhibited and an other dissimilative nitrate reduction process, the DNRA could be important, contributing with the sediment ammonium source.

OS32B-134 1330h POSTER

Stratification Produces Productivity, and Other Processes you Haven't Seen Before: An Anoxic Pond Challenges our Understanding of Lacustrine Geochemistry

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Conventional understanding of lake dynamics tells us that when a closed lake becomes stratified, bottom waters will stagnate and putrefy as they are cutoff from atmospheric contact, while productivity in surface waters will slow as nutrients are sequestered into settling organic matter. Productivity increases when stratification breaks down and remineralized nutrients in the bottom waters are recirculated back to the surface. Here we present a different kind of system, an anoxic pond where stratification actually promotes productivity and reduced waters produce some unusual sediments.

Located on the island of Oahu, Hawaii, Ordy Pond is a 5 m deep eutrophic, murky, brackish, pond in which productivity is light-limited. A time series analysis of the water column and sediment production from April, 2000 through May, 2001 revealed high productivity, with chlorophyll on the order of 150 μg/L, and organic carbon fixation rates on the order of 530 mgC/m^2, despite a euphotic zone of less than a meter depth. Thermal stratification in the summer preceded a bloom of productivity that occurred presumably as photosynthesizers were able to remain longer in the euphotic layer. During the bloom, surface water oxygen exceeded saturation by 83% (O_2 = 0.381 mM, 12.21 mg/L). Bottom water sulfide was <0.5μM before stratification but exceeded 1.5μM 8 weeks later, coincident with similar increases of inorganic nitrogen, phosphorous, and carbon resulting from remineralized settling organic matter. In winter, as the vertical temperature gradient relaxed and diffusive mixing increased, surface waters became suboxic upon mixing with bottom waters that never exceeded 4% of oxygen saturation over the year.

Increased sediment production followed surface water productivity. Carbonate ^{18}O and ^{13}C are controlled by evaporation and productivity, respectively; ^{18}O is 2 per mil heavier and ^{13}C is 1.5 per mil heavier in summer than in winter. XRD analyses of trapped material found the carbonate to be a mixture of kutnahorite - $(CaMn)(CO_3)_2$ - and calcite. Kutnahorite was unexpected as it was not measured in the sediment cores collected from the pond. However, Ordy's chemistry is well within the zone of nitrate reduction where Mn(II) is stable, and the pond is oversaturated with respect to kutnahorite. We believe that somewhere within the sediment water interface (a 1.5 m thick unconsolidated layer), the kutnahorite is recrystallized to calcite in a process preserving the isotopic signature of the original carbonate.

OS32C HC: Hall III Wednesday 1330h

Paleoceanography of Warm and Cold Climates During the Cenozoic Cooling Trend

Presiding: **B J Haupt,** Penn State University

OS32C-135 1330h POSTER

Modeling the effect of changes in atmospheric CO_2 content on decadal climate variability and of large-scale orography on global teleconnections: Cenozoic case studies

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Reconstructions of atmospheric CO_2 partial pressure (pCO_2) indicate considerable variations of this greenhouse-gas concentration during the Cenozoic. We employ an atmospheric general circulation model (AGCM) of intermediate complexity to study how different pCO_2 values may affect decadal climate variability on a global scale. Moreover, sensitivity experiments for idealized changes in orography are used to assess the effect of Cenozoic plateau uplift on atmospheric teleconnection patterns. The employed AGCM is the PUMA-II model, which is based on the standard hydrodynamic equations. It includes a radiative transfer calculation with interactive clouds, large-scale and convective precipitation and surface fluxes of momentum, heat and moisture. The land-surface module includes the evolution of a temperature profile in the soil, soil hydrology and snow pack over land. Over oceans, sea-surface temperature (SST) is calculated from the energy balance and weak restoring to modern SST. Sea-ice is diagnosed from the SST field. The model resolution is approximately 5.6° × 5.6° in the horizontal (T21) with five equidistant terrain-following sigma levels defining the vertical coordinates. Despite its reduced complexity, the PUMA-II model represents the internal variability of the atmosphere, including midlatitude synoptic eddies, reasonably well. We will present results from 200-year model integrations for various pCO_2 values, ranging from 200 to 1000 ppmV. Based on an analysis of the low-frequency components of the global sea-level pressure and SST fields, we address the question to what extent pCO_2 changes may have induced variations in decadal climate variability during the Cenozoic. A set of additional sensitivity experiments is performed to investigate how the uplift of the Himalaya and Tibetian Plateau and of the Western Cordillera of North America affected large-scale atmospheric circulation patterns. Experiments with leveled Himalaya-Tibetian orogen and Western Cordillera are used to estimated atmospheric teleconnection patterns by means of eigen techniques.

OS32C-136 1330h POSTER

Diatom assemblage changes during the last 300 kyrs in the western subarctic North Pacific

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Sedimentary records spanning the last 300 kyrs were obtained from the Emperor Seamount (ES: 49° 44' N, 16° 19' E) and in the southern part of the Bering Sea (BOW-8A: 54° 47' N, 17° 55' E). Diatom assemblages in the records were analyzed in order to reconstruct paleoceanography in the western subarctic North Pacific. A secular change in diatom assemblages indicated mainly three things; 1) total diatom accumulation rates at site ES showed generally higher values than those at BOW-8A during the last 300 kyrs; 2) *Neodenticula seminae* is a dominant taxon in the region; 3) abundance of *Thalassiosira gravida*, known as an ice-edge indicator, at ES was relatively high as compared with that in the southern part of Bering Sea during the glacial period. The western subarctic North Pacific tended to have had a higher production of diatoms than the southern part of the Bering Sea in spite of the open ocean condition during the Late Quaternary. Sea-ice coverages had a stronger effect in the western subarctic North Pacific than the southern part of Bering Sea during the glacial period.

OS32C-137 1330h POSTER

Seasonal diatom succession across the Antarctic Polar Front: the key to high-resolution Southern Ocean paleoceanography?

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The Southern Ocean is a centerpiece in global biogeochemical cycles and ocean circulation. Recent drilling in the Atlantic Sector (ODP Leg 177, Shipboard Scientific Party, 1999) has recovered laminated diatom ooze sediments, spanning intermittently throughout the last 1.6 My (Pearce, unpublished), which potentially record a seasonal surface water productivity signal (Grigorov et al., in print).

An array of sediment traps, as part of the AESOPS program, deployed in the Indian Sector samples marine snow on its way from the surface waters to the sediment (Honjo et al., 2000). These are complimented by fluff layer and top 0.5 mm sediment surface samples. Analysis of the sinking diatom assemblage, demonstrates how the surface water productivity signal is altered before it is recorded into the sediments and thus a more critical examination of the sediments can be achieved.

The aim of this combined study is two fold: to establish the seasonal change in the diatom assemblage across the Polar Front and its alteration through the water column; use the diatom seasonal succession to test the hypothesis that laminated sediments from the Atlantic Sector contain an annual signal, and potentially act as a long-term sediment trap of seasonal flux.

Grigorov, I., R. Pearce & A. Kemp. Southern Ocean laminated diatom ooze: potential for paleo flux studies, ODP Leg 177, Site 1093. Deep-Sea Research, in print

Honjo, S., R. Francois, S. Manganini, J. Dymond, R. Collier, 2000. Particle fluxes to the interior of the Southern Ocean in the Western Pacific sector along 170 W. Deep-Sea Research II, 47 p.3521-3548

Shipboard Scientific Party, 1999. Leg 177 summary: Southern Ocean Palaeoceanography. In Gersonde, R., Hodell, D.A., Blum, P. et al., 1999. Proceedings of the Ocean Drilling Program, Initial Reports, vol. 177. College Station, TX (Ocean Drilling Program). 1-67

OS32C-138 1330h POSTER

Glacio-Eustatic Control on Plio-Pleistocene Sedimentation Along the Northern California Ocean Margin

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Over the last 3.5 million years major climatic and tectonic changes have resulted in high frequency fluctuations in relative sea level adjascent to the northern California shoreline. A detailed record of these changes is preserved in two sedimentary sequences currently exposed along the coast – the neritic to nonmarine Merced Formation near San Francisco and the bathyal to neritic Rio Dell Formation north of Cape Mendocino. With the goal of deciphering the Plio-Pleistocene paleoenvironmental histories of these expanded ocean margin sequences, detailed stratigraphic sections were measured and described from the lower portion of the Merced Formation and from the Upper Rio Dell Formation. Samples taken approximately every 4 meters have been analyzed for benthic foraminiferal assemblage, palynological assemblage, stable carbon and oxygen isotope composition of foraminiferal carbonate, and organic geochemistry (polycyclic aromatic hydrocarbons, alkanes). Variation in these parameters appears to demarcate glacial and interglacial cycles. These results generally support previous interpretations of glacio-eustatic control on the cyclicity of sedimentary facies within the Merced and Rio Dell formations.

OS32C-139 1330h POSTER

Multi-proxy Assessment of North Atlantic Intermediate Water During the Last Glacial Maximum and Younger Dryas

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Extensive scientific investigation has shown that ocean circulation has experienced changes through time. Studies of numerous sediment cores of the North Atlantic show that these changes in ocean circulation coincide with climate changes. In this study a three proxy approach is taken in order to determine how climate and ocean circulation are linked in the North Atlantic, where North Atlantic Deep Water (NADW) is the predominat modern water mass. This project focuses on the time interval from the last glacial maximum (LGM) through the deglaciation to the Holocene interglaciation, paying particular attention to the Younger Dryas cold interval. The three proxies used to analyze the sediment cores are the stable isotopes of carbon and oxygen in microfossil foraminifera, the radioisotopes 231Pa and 230Th in bulk sediment, and the grain size distribution of the sortable silt. During glaciation, ODP Site 984 at 1.6 km on the Bjorn sediment drift along Reykjanes Ridge was centrally located in Glacial North Atlantic Intermediate Water (GNAIW). As deglaciation began, there was a dramatic reorganization of the predominant water masses as nutrient rich water invaded the site. Small climate oscillations during glaciation appear to be a response to changes in the strength of the intermediate circulation. Strengthening of the bottom currents at the site is associated with warmings, while weakening currents are linked to cooling. The same relationship occurs at the onset of deglaciation and through the Younger Dryas. 231Pa/230Th data collected from core 103GGC on the Little Bahama Bank at 1 km indicate strong intermediate-water circulation during the Last Glacial Maximum (LGM) and the Younger Dryas, and weak circulation at the onset of deglaciation and the Holocene. These data show strong correlation with Cd/Ca data recorded in the same core by Marchitto et al. (1998). A comparison of the 231Pa/230Th and Cd/Ca data to comparable results from the Bermuda Rise indicates that the rates of production of NADW and GNAIW alternate from the LGM through deglaciation, although not always in equal proportion.

OS32C-140 1330h POSTER

Frustule-Bound Nitrogen Isotopes: Observations From Cultured Diatoms and From Late Quaternary Diatom-Rich Sediments From the Gulf of Alaska

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Nitrogen isotope records from bulk-sediment are sometimes used to infer changes in paleoproductivity. In High-Nutrient Low-Chlorophyll (HNLC) regions, δ^{15}N interpretation might seem relatively straightforward, as past increases in productivity in open systems with constant rates of upwelling should have drawn down surface nitrate concentrations and fractionation by phytoplankton would have driven the remaining pool to heavier values. However, in the Gulf of Alaska, an HNLC region, the δ^{15}N record in ODP Hole 887B is at odds with this simple interpretation. Rapidly deposited diatom-rich layers up to 1 m thick occur intercalated with diatom-poor clay throughout the core, and are coincident with Ba/Al enrichments. Despite all indications that the diatom layers respresent episodes or periods of enhanced export production, bulk sedimentary δ^{15}N values are relatively lighter within the diatom layers, implying increased relative nitrate abundance, not depletion. In order to constrain better the source of this counterintuitive signal, diatom frustules were separated from the bulk sediment by flotation, and all exposed organic matter was oxidized using perchloric and periodic acids at 135°C. Surviving nitrogen is believed to represent a proteinaceous frustule-bound component, protected within an opaline matrix from the ravages of food chain effects and diagenesis. Early results show that, within the diatom-rich intervals, frustule-bound δ^{15}N is significantly lower than the bulk sediment, by 1 to 2$^{o}/_{oo}$. Furthermore, there is variability within the frustule-bound δ^{15}N profile not evident in the bulk-sediment record. Finally, the frustule-bound δ^{15}N within the diatom-rich layers appears to be lighter than frustule-bound δ^{15}N in diatom-poor sediment, confirming the paradox presented by the bulk-sediment record. Frustule-bound nitrogen may represent fossil diatom-biomass nitrogen, a possibility currently being explored with cultured diatoms following the same acidic oxidation technique. If so, it suggests that, during the high diatom production intervals, surface nitrate was in even greater excess in the Gulf of Alaska than it is today. These observations point to an extraneous control, such as iron, on export production.

OS32D HC: Hall III Wednesday 1330h

Stratified Coastal and Estuarine Circulation III

Presiding: **M S Lozier,** Earth and Ocean Sciences, Duke University**; A Münchow,** College of Marine Studies, University of Delaware

OS32D-141 1330h POSTER

Wilkinson Basin Water-Mass Structure

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Studies of the Wilkinson basin water mass structure are conducted. Data from the June 1982 Brooks survey is used for the initial study of water mass characteristics and distributions. Parameters of Maine surface, intermediate, bottom, and slope waters are derived from the Brooks 1982 CTD casts and developed from cluster analysis using a distribution function for cluster point diffe rences in temperature, salinity, and depth. The cluster analysis yields two distinct surface water masses, one of which is warme r and less salty. The percentage of the water volume occupied by each of the five water masses is derived and expressed as a fun ction of depth and CTD cast location. An EOF analysis of the water mass temperature, salinity, and percent volume occupied is undertaken. The cloud of points represen ting each water mass in terms of temperature, salinity, and depth are derived through cluster analysis and identified as matrix elements in the SVD and covariance analysis. In one approach the vertical variances of temperature, salinity, and percentage con tent are reconstructed. In another approach the vertical temperature and salinity is reconstructed through an EOF decomposition of each water mass's cloud of points and a summation over all of them for the resultant vertical distribution. These approaches are first steps towards a feature model based on water masses. The means, standard deviation, and ranges of the water masses are derived in T,S,D space. Worthington diagrams of volumes occupi ed with existing T,S span is computed and identified for each water mass. A EOF based representation of water masses in T,S spac e is pursued. The dynamical picture is brought into the interpretation of the Wilkinson basin water mass structure. The dynamics at the locati on of each water mass is considered. The physical processes acting on each water mass in terms of formation and modification are interpreted from a GOM point of view.

URL: http://www.agu.org/meetings

OS32D-142 1330h POSTER

Using Hydrographic Data and Satellite Imagery to Describe and Estimate Mixing Across Tidal-Mixing Fronts on Georges Bank

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Tides represent an important physical forcing on Georges Bank (GB). Tidal mixing keeps central GB (<60m) well mixed year round. Deeper portions of GB vertically stratify due to positive heat/buoyancy input from late spring to early fall (May-October), with tidal mixing fronts (TMF) forming between well-mixed and stratified waters. It has been shown that TMF and shelf/slope fronts (SSF) can be located using sea surface temperature (SST) frontal segments from satellite-derived Advanced Very High Resolution Radiometer (AVHRR) SST data, and automated cloud-clearing and edge detection algorithms. This project investigates the physical process known as "bolus transfer" which is the separation and flux of eddies across fronts due to baroclinic instabilities. Our goals are to determine if this process is a major contributor to cross-frontal mixing, and resolve their mean size and seasonal cycles for determination of their interannual variability. Work is being completed through an analysis of hydrographic data and SST frontal data from AVHRR satellite imagery. The frontal segments from the satellite images are extracted, detrended, and analyzed for the northern and southern frontal regions on Georges Bank to find a common wavelength or meander scale to be compared with the hydrographic bolus transfer scale (internal Rossby radius of deformation) data. When completed, our project may assist in estimating the amount of nutrients and biology that is advected across these fronts from bolus eddies.

URL: http://celtic.cmast.umassd.edu

OS32D-143 1330h POSTER

Direct Observations and Modelling of the Secondary Circulation Associated with a Tidal Mixing front in European Shelf Seas.

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Observations in stratified shelf seas consistently reveal thin layers of phytoplankton associated with tidal mixing fronts and the base of the thermocline. This implies a continuous supply of nutrient rich water to the frontal zone and the level of the thermocline. A possible candidate mechanism is the weak cross-frontal density driven circulation associated with such fronts. While measurement of the along frontal flow is readily achieved, direct observations of the speed and extent of the transverse circulation is difficult.

Two dye release experiments were performed using rhodamine-wt injected at the sea bed in a bottom frontal zone in the North Sea during August 2000 and 2001. Dye was tracked for 76 hours, providing the first direct evidence of cross-frontal flow in European shelf waters. The results are discussed in the context of high resolution numerical model predictions of the flow regime and the source of nutrients required to sustain continual summer time primary production in a shelf seas environment.

OS32D-144 1330h POSTER

The spatial and temporal relationship between biomass and hydrography on New Jersey's inner shelf during the summer of 2001.

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As part of the Hyperspectral Coupled Ocean Dynamics Experiment (HyCODE) remote and in situ observations of the ocean's color were made on New Jersey's inner shelf to characterize its relationship to coastal circulation processes. During the summer of

WED