to lower MM material by photochemical processes, but that the fraction of CDOM containing the active chromophore is unaffected on this time-scale. The opposite behavior was observed in a fresh to marine transition zone in early studies, where chromophores shifted to lower MM but fluorophores were unaltered.

OS22J-07 1535h

Size Distributions of Colloidal CDOM in Coastal Waters as Determined by Flow Field-Flow Fractionation

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Although numerous studies have examined the size distribution of dissolved organic carbon in seawater, very little information exists on the size fractionation of marine chromophoric dissolved organic matter (CDOM). Detailed measurements of CDOM size distributions may contain useful information pertaining to the provenance, reaction-states, and removal pathways of the chromophoric material.Flow-Field Flow Fractionation (Flow FFF) has been shown to partition marine colloidal organic matter into a continuum of hydrodynamic sizes, providing a novel means for characterizing the molecular weight spectrum of marine CDOM.

In this study, Flow FFF molecular weight/colloid size spectra of CDOM measured from within and adjacent to the Mississippi River plume are compared under high (April) and low (June) flow conditions. While size spectra of riverine CDOM were similar under both flow regimes, there were marked differences in the CDOM size spectra in adjacent waters. Size distributions found to be associated with elevated chlorophyll concentrations during June were generally absent or minimal in April when chlorophyll concentrations were much lower. These results are contrasted with findings from the Damariscotta River estuary (Maine) and from laboratory estuarine mixing experiments designed to assess how abiotic factors may affect CDOM size distributions.

OS22J-08 1550h

What Factors Control the Distribution and Dynamics of Chromophoric Dissolved Organic Matter in the Middle Atlantic Bight and other Coastal Regions?

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Through its absorption of ultraviolet and visible light, chromophoric dissolved organic matter (CDOM) can play an important role in the aquatic environment by reducing the penetration depth of potentially damaging ultraviolet radiation and through photochemical reactions leading to its degradation and the formation of biologically-available forms of nitrogen, low molecular weight organic compounds, trace gases and altered metal speciation. Thus knowledge of the factors that control its distribution and magnitude is important for understanding its impact on aquatic systems. Using field data from the Middle Atlantic Bight as well as from other coastal regions, combined with laboratory data, we will attempt to synthesize the available information to address this question. Topics that will be examined include CDOM optical properties, the relationship of CDOM absorption to dissolved organic carbon, and controls on CDOM distribution (sources and sinks).

OS22J-09 1605h

Chromophoric Dissolved Organic Matter (CDOM) in the Mississippi River Plume

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Chromophoric dissolved organic matter (CDOM) is an important, easily measured fraction of dissolved organic matter in seawater and plays a critical role in determining the optical properties of seawater that may be measured remotely. Sources of CDOM in coastal waters include terrestrial runoff, estuarine production, and coastal plankton (phyto-, zoo-, and/or bacterio-) production while a major sink is photodegradation. Additionally, coastal waters are highly dynamic with vertical variability of less than 1 meter and horizontal variability over 10s of meters or less. In order to examine the temporal and spatial variability adequately, in situ, real-time measurements were carried out with the ECOShuttle, a towed-undulating vehicle designed to study surface waters (2-50 m) in high resolution. In situ measurements include CDOM fluorescence (lex=330 nm, lem=450 nm), "hydrocarbon fluorescence" (lex=239 nm, lem=360 nm), Chlorophyll fluorescence, optical backscatter, dissolved oxygen, temperature, salinity and depth.

Two studies of the Mississippi River Plume in the Gulf of Mexico in June, 2000 and April, 2001 were conducted. In June, 2000, a very low flow period, over 1000 miles were covered in the area both to the east and to the west of the Birdfoot Region of the Mississippi River Plume yielding over 10 million in situ measurements of CDOM along with other relevant oceanic parameters. In April, 2001, a high flow period, over 900 miles were covered mostly outside the southwest pass region to the west. While the Mississippi freshwater CDOM endmember was similar in Spring and Summer, the Atchafalaya River endmember was $\sim$40 percent higher than the Mississippi in Summer and 100 percent higher in Spring. Since water for both rivers shares a common source, it appears that interactions with the undeveloped wetlands in the Atchafalaya River Watershed supplies a significant amount of CDOM to the "terrestrial" endmember and this source is magnified in the high flow period. Additionally, the effects of physical mixing, sunlight exposure, and subsurface phytoplankton production will be discussed.

OS22J-10 1620h

Optical Characterization Of Coastal Waters In The Gulf Of Mexico As A Function Of Multiple River Inputs

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A portion of dissolved organic matter consists of colored constituents known as colored dissolved organic matter (CDOM) or "gelbstoff". The unique chromophoric nature of dissolved organic matter allows us to use optical techniques to investigate the chemical composition of carbon and its cycling process. Much of CDOM in coastal environments is of terrigenous origin entering via run off from river sources. CDOM differs spatially and seasonally as a consequence of river discharge and mixing. However little has been done to elucidate optical properties of individual riverine endmembers. This presentation will characterize 10 riverine endmembers that flow into the Gulf of Mexico based on hyperspectral fluorescence, absorption, salinity, total organic carbon and seasonal variability. This presentation will also discuss how these properties alter as a consequence of mixing, photobleaching and biological activities

OS22J-11 1635h

Changes in the Optical Properties of Colored Dissolved Organic Matter in Coastal Regions of the Gulf of Mexico Between the Mississippi River and Florida Bay.

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Variations in concentration and optical properties of colored dissolved organic matter (CDOM) in river-dominated margins provide information on the chemical composition and cycling of carbon. Based on results from cruises during 2000 and 2001, we have observed large scale seasonal and spatial variability in CDOM optical properties (absorption coefficients, spectral slopes, position of the fluorescence maxima, fluorescence intensities, and fluorescence ratios) in the Gulf of Mexico. Although the primary forcing is due to quantity of freshwater runoff, strong regional variability in freshwater sources also plays a major role. We have observed a 5-fold variability in the concentration of CDOM observed in the rivers entering this part of the Gulf of Mexico, with lowest values in the Mississippi River endmember.

The enormity of mixing effects across the region makes observation of biological and photochemical effects challenging. We have used two approaches to distinguish between source and transformation effects: mixing models which include not only concentration but also optical properties of CDOM, and high resolution surface mapping of multispectral fluorescence properties. Results from the Mississippi plume, the Atchafalia plume, the West Florida Shelf, South Florida Rivers and Florida Bay will be presented.

OS22J-12 1650h

Dynamics of Chromophoric Dissolved Organic Matter (CDOM) in a Microestuary

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Characterization of chromophoric dissolved organic matter (CDOM) dynamics within an estuary requires identification of multiple sources, including terrestrial input from rivers, production in fringing marshes and in situ biological production. The required measurements in a large estuary present a daunting challenge due to temporal (tidal) variations over the time required for an adequate survey to be completed. However, in small estuarine systems, detailed surveys can be adequately completed by a miniature towed vehicle that has been developed at UMass Boston. This towed vehicle (Mini-Shuttle) is composed of an Endeco-YSI 2 foot V-Fin Hydrodynamic Depressor with a Falmouth Scientific 2 Micro CTD as the primary data acquisition system. CDOM is characterized by fluorescence at 370/440 nm excitation/emission provided by a Sea Point Electronics ultraviolet fluorometer.

The Mini-Shuttle has been deployed in several surveys of the 6 km long tidal portion of the Neponset River ($\sim$45 minute transects) a small estuary entering the Dorchester Bay region of Boston Harbor. The width of the Neponset River varies from 50 to 200m wide depending on tidal stage, and is less than 5m deep at high water through most of length. Extensive salt marshes adjacent to much of river have been protected from urbanization and significantly influence the dynamics of the estuary. In addition broad mud-flats exist between the narrow channel and the fringing marsh. The tide range is approximately 3 m, resulting in large exchanges between the estuary and Spartina marshes.

We will present results from two surveys, one conducted at high tide in the afternoon and the other at low tide on the following morning of July 19 and 20, 2001. We were able to resolve a strong vertical salinity/density gradient in the top meter of the water column. The CDOM approximately followed the expected pattern of higher values at lower salinity, but the dense data coverage provided by the Mini-Shuttle showed significant departures from a simple conservative relationship. There was an indication of mid-estuary sources of CDOM in concave-up CDOM-salinity curves for both days. However, at the same salinity, CDOM fluorescence was lower in the afternoon than in the morning. This pattern was mirrored by higher temperatures (relative to salinity) during the afternoon survey. We propose that these observations indicate a source of CDOM from the fringing marshes, with a reduction of fluorescence and increase in temperature during the afternoon due to solar radiation. Since the afternoon survey was conducted around low water, much of the water in the channel would have flowed off the mud flats and salt marshes, and been subject to intense sunlight in relatively shallow water, enhancing both solar heating and photobleaching of CDOM.

OS22K HC: 318 B Tuesday 1330h

Application and Assessment of Coastal Sediment Transport Models III

Presiding: **C Sherwood,** USGS MS-999**; R P Signell,** NATO/SACLANTCEN

OS22K-01 1330h

Buoyant Plume Lift-off Zones as a Test of Coastal Sediment Transport Models

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Development of broadly useful coastal sediment transport models requires that they be tested against "challenging" data sets that represent situations of geologic interest. It is also helpful if some theoretical understanding of sediment transport processes in the environment is available, with which to interpret model results. We argue that the strong salinity gradients, broad size distributions, and particle transformations (e.g., those due to aggregation) characteristic of buoyant-plume lift-off zones combine to provide a strong test for such models. During periods when shelf sedimentation is occurring, plume lift-off zones will typically occur at or close to the ocean entrance of a river estuary. A broad range of sediments will be present, in extreme cases ranging from clay to gravel. Very strong horizontal gradients in bedstress, water-column turbulence levels, salinity, suspended particulate matter (SPM) concentration, and sometimes wave energy may also occur. Because of these strong horizontal gradients, the SPM distribution may be far from a local, vertical equilibrium. Horizontal advection of SPM typically manifests itself in a departure of the maximum concentration level from the bed. In the presence of strong advection, the SPM profile may be "upside-down", with maximum concentrations in the near-surface, outflowing river water, rather than in the intruding oceanic water mass. Another challenging characteristic of plume lift-off zones is that the character of sediment transport can change, as river flow increases, from retention in the estuary to export to the adjacent ocean. During low to moderate flows, landward near-bed transport up the SPM concentration gradient predominates, whereas high to extreme flows cause seaward transport near the surface or throughout the water column. We employ joint optical and acoustic SPM measurement methods to interpret sediment transport in the Fraser River mouth in 1999 (during extreme high flow) and 2000 (with a normal spring freshet). This approach provides detailed transects of SPM concentration and transport, verified against calibration samples. This data set is of interest as a stringent test of any potential model, and also because the tectonic stability of the actively growing Fraser River delta is a serious concern. Theoretical analyses will be used to place the results in a broader context of temperate estuaries.

OS22K-02 1345h INVITED

Flood Layer Formation on the Northern California Shelf by Near-bed Gravitational Sediment Flows and Oceanographic Transport

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A thick, newly deposited layer of sediment was created between water depths of 50-70 m by a large flood of the Eel River, Northern California in January, 1997. The deposit accounted for about 20% of the sediment delivered by the flood; the fate of the missing sediment is unknown. Sediment delivery was confined to water depths shallower than 30m. Mechanisms proposed to explain the apparent cross-shelf transport include dispersal by oceanographic currents, resuspension by energetic waves, and gravitationally forced transport of a thin layer of fluidized mud. Field observations indicated that these processes were active, but could not determine their relative significance, or whether these mechanisms alone explain the deposit. Available numerical models could not fully address these questions, because none accounted for the full suite of processes.

A three-dimensional, hydrodynamic model that includes sediment transport has been modified to account for a thin, near-bed layer of fluidized mud. The enhancements were based on a previously developed one-dimensional (across-shore) model that agrees with observations from the Eel River shelf. The thickness of the fluid mud layer equals the height of the wave boundary layer (∼5-10 cm). Sediment concentration and flux within the layer are based on a near-bed reference concentration and a balance between gravitational forcing and frictional drag. The three-dimensional representation accounts for advection, and exchange of sediment and momentum between the fluid-mud layer and the overlying water.

The model is used to simulate flood dispersal on the Eel River shelf, and to evaluate the relative importance of transport within the near-bed, fluid-mud layer as compared to suspended sediment transport. Wind forcing influences the volume of sediment that escapes the shelf, and wave magnitude impacts the volume of the deposit and its cross-shelf location. Settling properties of fine-grained sediment are critical for determining the volume and timing of deposition. Cross-shelf transport by gravitational forcing appears to be necessary to produce a deposit similar in volume, location, and timing, to that seen in 1997.

OS22K-03 1405h

Modeling of Critically-Stratified Gravity-Driven Sediment Transport on the Eel River Continental Shelf.

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Gravity-driven transport and deposition of fine sediment derived from the Eel River in northern California has been shown to play a key role in the formation of the mid-shelf flood deposit on the adjacent continental margin. Analytical and numerical modeling results based upon the theory that the sediment carrying capacity of near-bed gravity flows is controlled by a negative feedback mechanism that maintains the Richardson number at its critical value, are compared with observations collected from the mid-shelf of the Eel margin. Modeling results reasonably reproduce observed time-series of down-slope velocity and bed elevation change, as well as large-scale patterns of deposition, knowing only the surface wave forcing and shelf bathymetry. Predictions of deposition suggest that the magnitude of wave energy is more important than the magnitude of the flood event in controlling the thickness of mid-shelf gravity-driven deposition following floods of the Eel River. Higher wave energy increases the capacity for critically stratified gravity flows to transport sediment to the mid-shelf and results in greater gradients in flux and hence deposition. The bathymetry of the Eel margin plays a critical role in controlling the location of gravity-driven deposition. Predictions indicate that in the region offshore of the river mouth, the seaward increasing mid-shelf slope associated with the concave downward subaqueous delta causes gravity-driven flux divergence, preventing significant mid-shelf gravity-driven deposition and favoring sediment transport off-shelf or into Eel Canyon. Fifteen to twenty kilometers north of the river mouth, seaward decreases in shelf slope lead to greater flux convergence by gravity-driven flows, and hence greater deposition despite a smaller input of river sediment. Far enough from the river mouth the supply of sediment from the river plume eventually diminishes sufficiently to prevent significant gravity-driven deposition.

OS22K-04 1420h INVITED

A Comparison of Different Approaches to Modeling Erosion and Deposition of Fine Sediments

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The bottom boundary conditions for erosion and deposition are two of the most important aspects of fine sediment transport modeling. There are, however, almost as many different approaches to specifying and parameterizing these boundary conditions as there are fine sediment transport models. These differences reflect the different backgrounds and goals of model developers, but they also betray a general lack of consensus on the nature of erosion and deposition processes. Erosion and deposition boundary conditions may interact with other model assumptions as well, significantly affecting predicted suspended sediment behavior. For example, the choice of whether to assume exclusive or simultaneous erosion and deposition can affect the phase lag between maximum shear stress and maximum sediment suspension, depending on the form of the erosion formulation and on whether the model includes single or multiple sediment classes. This paper explores different approaches to modeling erosion and deposition of fine sediments and their implications for fine sediment transport prediction. Diagnostic tests using a one dimensional numerical model with different boundary condition formulations and suspended sediment treatments are presented to illustrate similarities and differences between predicted behaviors. Total resuspended sediment load and the phase lag between forcing and response are highlighted as integrated measures of behavior. The need for and nature of a sediment bed model also are considered.

OS22K-05 1440h

Spectral Analysis of Near-bed Velocity Measurements at an Intertidal Estuarine Mudflat

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Wind waves and tidal currents are known to dominate the boundary layer processes of intertidal, estuarine mudflats, and thus the suspension and transport of sediments. We show that remotely forced ocean waves can be a small, but potentially important source of near-bed velocity and shear stresses as well. Over a two week period in February, 2001 we deployed an autonomous SonTek Hydra system mounted on a lightweight aluminum frame on a mudflat in Central San Francisco Bay. Instruments deployed included an acoustic Doppler velocimeter (ADV) for high-resolution velocity measurements, an optical backscatter sensor (OBS) for sediment concentration measurements, and a conductivity-temperature (CT) sensor for temperature and density measurements. Data was logged in bursts of 45 seconds at a rate of 10 Hz, and repeated every 5 minutes. Logging continued through wet and dry periods over an entire spring-neap cycle, and thus included the variation of near-bed velocity and shear stress over a range of timescales.

Results show that during large ebb tides, tidally forced flows dominate the near-bed dynamics during calm conditions. Wind waves dominate whenever wind blows over the bay from the south and southwest, as occurs during winter storms. During periods when tidal forcing is limited and wind waves are small, remotely forced ocean swells become an important energy source. These motions appear in the burst samples at frequencies between 0.1 and 0.04 Hz and their energy correlates well (R=0.9) with ocean swell measured from a buoy offshore of San Francisco. Spectral analysis of data shows that the average energy of ocean waves per tide varied between 2% to 15% of total energy load. Moreover, extreme values in the distribution of ocean waves bring episodic bursts of greater energy onto the estuarine mudflat, which may influence local suspension of sediments.

OS22K-06 1515h

Predicting Sediment Transport on the Shelf: Lessons From the Grand Canyon

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The rate at which sediment is transported by water is more sensitive to changes in velocity or shear stress than to changes in grain size of sediment on the bed. Consequently, most sediment-transport models and field studies focus on parameterizing changes in flow rather than changes in bed sediment. Recent work in Grand Canyon, however, has shown that bed sediment becomes substantially finer when tributary floods introduce fine sediment to the mainstem Colorado River, and the bed becomes coarser when it is winnowed during intervening periods. The resulting changes in grain size on the bed are proportionately so much greater than changes in flow that bed sediment is the dominant control of sediment transport in the river.

Given that grain size of the bed can change substantially, it might be argued that the key question to ask when modeling a natural sediment-transporting flow is whether changes in transport are regulated mainly by changes in flow or by changes in grain size on the bed. The answer to this question determines whether research should focus on the relation between flow strength and sediment transport or focus on the rate at which sediment of different grain sizes is supplied to the flow (or both). This questions is also applicable to sediment transport on the shelf. Observations of modern and ancient shelf deposits demonstrate that grain size can vary substantially between storm and non-storm conditions, and at least one study has found that changes in bed sediment grain size must be incorporated in shelf sediment transport models (Harris and Wiberg, 2001).

Two new approaches have been developed to address this problem of grain size evolution on the bed; one is theoretical (Rubin and Topping, 2001), and the other is observational and technological. The theoretical approach uses concentration and grain size of suspended sediment to calculate: (1) changes in grain size of bed sediment, and (2) the relative importance of flow and bed sediment in regulating transport. The technological approach uses an underwater digital microscope to measure changes in grain size on the bed. Both approaches can be applied to the shelf as well as fluvial systems.

References

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OS22K-07 1530h

Non-local Sediment Transport: The Importance for Sorting on the Inner Shelf

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In many models, sediment flux depends only on local hydrodynamic conditions. However, when hydrodynamic conditions change (in a Lagrangian frame of reference) faster than a suspended sediment concentration profile can adjust, a non-local treatment of sediment transport can be essential. This lag in the suspended-sediment adjustment plays a key role in a new hypothesis for the origin of nearshore seabed (shoreface and inner continental shelf) features that consist primarily of a marked grain size sorting on large scales. In this environment, where wave motions and mean currents interact with a bed that is commonly composed of mixed grain sizes, a simple feedback (described below) could produce spontaneous sediment sorting. 'Rippled scour depressions,' swaths of coarse sediment on the order of a hundred meters wide and extending up to kilometers from shore, are currently interpreted as the imprint of alongshore-localized, offshore-directed storm currents, although such currents have not been observed and are not expected theoretically. We hypothesize, however, that the simple feedback could produce such features under the influence of the dominantly alongshelf currents commonly observed during storms, without invoking any heterogeneity in the current pattern.

The coarse sediment of rippled scour depressions is typically arranged into large wave-generated ripples. Sharp boundaries separate these coarse domains from intervening areas with finer sediment and much smaller ripples. Divers have observed that fine sediment can be suspended an order of magnitude higher over the coarse domains than over the fine areas, because of the turbulence generated as wave motions interact with the large ripples. Any mean current can advect this sediment past the coarse domain. This interaction will tend to reinforce the sorting, because fine material entrained from the coarse domain will be deposited preferentially in an adjacent fine domain. Starting from random variations in bed composition, the greater grain-size and bedform roughness in an area with slightly coarser sediment could winnow fine material locally in the same way. This feedback will tend to produce a sorted pattern. To investigate whether these interactions operating over a spatially and temporally extended domain could produce large-scale sorted features with the characteristics of rippled scour depressions, we have developed a simple numerical model. In this model, rather than explicitly simulating relatively small-scale hydrodynamics, we parameterize the combined effects of wave motions and mean currents on sediment transport as a function of bed composition (as a proxy for ripple size).

Without treating the lag in suspended-sediment transport, the spatial pattern of these features could not be addressed. For example, all of the fine sediment advected past a coarse domain would be deposited at the edge of the domain; coarse and fine patches would tend to have the narrowest widths allowed by the model grid. While other models have treated this lag in an approximate way, the approaches employed do not explicitly consider the height of the sediment concentration. We have designed a very different treatment of non-local transport that does involve this factor, which we hypothesize to be significant in this inner-shelf context.

OS22K-08 1545h INVITED

Sediment Transport Modeling in the Nearshore Community Model

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A variety of sediment transport modeling approaches are being incorporated into a computational model that will be made available to the scientific and engineering community. The nearshore community model is being developed under NOPP sponsorship to predict waves, hydrodynamics, and bathymetric change in depths less than approximately 10 meters and over time scales ranging from hours to days. The sediment transport component of the model is limited to sandy sediment with well sorted sizes, as is typical in a sandy beach environment. The sediment transport submodels predict the local flux of sand as a function of the local waves, hydrodynamics, and seabed characteristics. There are several models and formulae adapted from existing literature that provide estimates of the local sediment flux. These options vary substantially in complexity and depend primarily upon the level of detail of the physical processes that are included. Some of the submodels also predict the temporal and spatial variations in sediment concentration and sediment flux with different levels of detail.

We are also conducting research aimed at improving the local prediction of sediment transport. The interrelationships between fluid turbulence, suspended sediment, and bedform geometry are being explored. Preliminary results indicate that incorporation of the recent time history of the hydrodynamic forcing results in a significant improvement in the prediction of the suspended sediment concentration. New models for bedload sediment transport under sheet flow conditions are being developed based upon a two-phase approach. Finally, we will present results from an investigation of the effects of fluid acceleration upon bedload sediment transport.

URL: http://chinacat.coastal.udel.edu/~kirby/NOPP/index.html

OS22K-09 1605h

Sediment Transport Modeling in the Nearshore and Surf Zone

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In recent years, computer hardware and software advances have made high speed computing available on many smaller computing platforms. When coupled with developments in numerical solution algorithms and improved understanding of sediment transport processes, it is possible to increase the capability of high-end sediment transport modeling, and provide it for general use. As part of the Office of Naval Research project STRATAFORM, we have developed a sediment transport model SLICE, which builds upon these advances. Recently the model has been enhanced to include surf zone processes as part of the Office of Naval Research Mine Burial project. The SLICE model is a time-dependent, two-dimensional (2DV), process-based coupled hydrodynamic, sediment transport and morphodynamic model based on a numerical solution to the shallow water approximation to the Reynolds-averaged Navier-Stokes Equations, the k-l type turbulence closure equations, an advection-diffusion equation (for suspended sediment transport) and the Exner equation (for morphology). SLICE represents a short to medium (days to centuries) time-scale evolution of continental shelf morphology and stratigraphy. It simulates hydrodynamics, sediment erosion, transport, deposition and bed elevation changes for arbitrary, initial bed profiles in response to wind, wave and tidal forcing. SLICE includes representations of a) wave-current boundary-layer interaction, b) density stabilization of turbulence due to suspended sediment, c) bed armoring, d) bedform generation and bottom stress partitioning, e) multiple grain sizes, and f) fully coupled morphological changes. The SLICE model contains specialized numerical methods to provide accurate and efficient numerical solutions. Four prominent features of the model are a) a highly refined mesh near the bed, b) the incorporation of wave effects in the turbulence model, c) the use of Lagrange multipliers to enforce mass continuity, and d) the use of block- tridiagonal solution methods. The model has successfully reproduced the time-dependent flow and suspended sediment transport measurements in flow tunnel experiments. It has also been verified against a time-series of flow and suspended sediment concentration vertical profiles measured with benthic boundary layer tripods. The wind-driven hydrodynamics has compared favorably with surface velocity data collected as part of the Rutgers Codar program. Recently the SLICE model has been enhanced to represent surf zone processes. The changes were made to test capabilities of predicting the rates of sedimentation as they effect mine burial in near shore regions. The model has incorporated the effects of wave transformations, radiation stress, wave breaking and wave asymmetry on hydrodynamics, sediment transport and morphology. These enhancements allow for applications in complex environments, including local and external sediment sources and both non- breaking and breaking waves. Each of the new enhancements has been tested against theoretical, laboratory and field data, and the model has been implemented to simulate storm conditions in the nearshore region. The results show that the model robustly predicts the redistribution and accumulation of local and external sediment sources. As expected, the predicted sedimentation is sensitive to the storm intensity and external rate of external sediment supply, but it also is strongly dependent upon antecedent conditions as well as the directions of the wind and waves.

OS22K-10 1620h

AUV-based Flow and Turbulence Gradient Measurements: The Wish of a Modeler

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The morphological evolution of the coastal ocean is the result of gradients in sediment transport which in turn depend on the gradients of the hydrodynamic forcing. For example, theoretical work on the development and maintenance of linear ridges and data on peak tidal flows in the sandbanks of the southern North Sea, suggest that the bottom stress expected in the swales between the banks is of the order of 1N/m2 and increases by a factor of order 2 over the crest of the bank. Despite this large spatial variation of stress, measurements are either limited to single points only or averaged over the entire wavelength of the shoals. Thus, observations sufficient to constrain the spatial variability of flow in general and bottom turbulence in particular produced by models are virtually non-existent and our understanding on the development and maintenance of such linear features is limited. Further, the validation and/or calibration of numerical models is based on comparisons with stationary time-series. However, the accuracy of these models is controlled by their ability to predict the gradients that are actually present in the marine environment. Measurements of flow and turbulence from moving platforms such as Autonomous Underwater Vehicles (AUVs) provide a unique opportunity for attempting the spatial mapping of flow and turbulence over uneven topography, as is the case over ridges. These types of data can be used both for process studies as well as for data assimilation in numerical models.

We present flow and turbulence data collected over a linear sand bank using an ADCP and an ADV installed on the AUTOSUB AUV. Harmonic least-square analysis was performed to the data to examine the spatial variability of the tidal and sub-tidal component of the flow. The interaction of the flow with the topography and in particular the veering of the tidal M2 ellipse clockwise to the main axis of the ridge as predicted by analytical theoretical models is reproduced by the measurements at a high spatial resolution compatible to those of numerical models. Also, for the first time we were able to accurately map the spatial variability of the subtidal flows. The clockwise subtidal flow around the bank was confirmed and the location of flow reversal was found to be located on the stoss side of the bank some 200m before the bank crest. The subtidal flow across the bank was found to be away from the crest of the bank in accordance to the theory by Johns and Dyke (1972). This is the first data showing this agreement between theory and measurements in the across ridge direction. The same data from the ADCP and the log-profile theory were used to estimate bottom shear stress and bottom drag coefficients across the bank.

These data are used to close the tidal and subtidal momentum balance equations in the along and across bank directions. The data presented provide an example of future routine data collection procedures for the calibration of models.

OS22K-11 1635h

Observing and Modelling Suspended Sediment Transport Over Ripples in Combined Wave-Current Flow

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Detailed measurements of hydrodynamic conditions, bedforms and suspended sediments have been obtained using the multi-sensor PIP (POL Instrument Package) deployed from a small jack-up barge in a small tidal inlet in Portugal. Detailed measurements of bed morphology, turbulence and suspended sediment obtained over highly mobile bedforms are used to investigate vertical flow structure and the processes of sediment entrainment and bedform migration in combined wave-current flows. Comparisons are made between measured rates of sediment transport and a number of existing sediment transport expressions frequently used in marine applications. Based upon the present data, a new semi-empirical model of has been developed that simulates the measured instantaneous re-suspension events and time-average suspended sediment concentration profiles. Together the field observations and the numerical model contribute to the understanding of the physical mechanisms driving sediment transport in the marine environment.

OS22K-12 1650h

An Evaluation of the Mass-Balance Equation for Suspended Sediments Using an Eddy Diffusivity Parameterization

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A statistical average of the continuity equation for suspended sediments leads to a simple balance between upward turbulent diffusion and gravitational settling. This result has formed the basis of sediment transport studies for nearly a century and, with an appropriate turbulent closure scheme, it is routinely used to model vertical distributions. Despite its widespread use, it is almost never evaluated, unlike the momentum equation, to determine the conditions for which the simple balance holds. The present study focuses on a depth-integrated form of the mass-balance equation in the context of predicting suspended sand concentrations over ripples in a wave-dominated continental shelf environment. The results indicate that for two widely used eddy diffusivity closures the depth-integrated sediment concentration is strongly correlated with the turbulent sediment flux. The results show further that the balance holds for heights above the predicted wave boundary layer thickness only when the closure scheme is formulated in terms of the combined stress. This has implications for modeling sediment transport in wave-dominated environments over ripples, in which the present state-of-the-art bottom boundary layer models may be significantly under predicting the spatially averaged thickness of the wave boundary layer.

OS22K-13 1705h

Modelling Water Column Structure and Suspended Particulate Matter on the Middle Atlantic Continental Shelf During The Passages of Hurricanes Edouard and Hortense

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The present contribution is motivated by the desire to elucidate the processes that contributed to the evolution of observed thermal structure and resuspension of particulate matter during and after the passages of two hurricanes, Edouard and Hortense, within a two week period in late-summer 1996. A unique set of high temporal frequency measurements of the vertical structures of physical and optical properties was obtained at a mooring site near the Middle Atlantic Bight continental shelf-break (70 m water depth). These data provided insight and initial conditions for the physical model used for this study. The model accounted for wind and bottom current generated turbulence, surface waves, wave-current interactions, tides, and depth-dependent density driven circulation. We find that the most important process controlling the thermal water column structure during and following the passage of Hurricane Edouard was the wind stirring. Differences between the model results and the observations of thermal structure may have been caused by advection, which is not included in this one-dimensional model. There is also clear evidence of internal tides in the observations, whereas the model could not reproduce this effect. A suspended particulate matter (SPM) model is included as a module of the physical model to examine sediment resuspension processes. It is concluded that wave-current bottom shear stress was clearly the most important process for sediment resuspension during and following both hurricanes. Discrepancies between modelled and observed SPM are attributed to the presence of biological material in the surface waters and changes in sediment properties (flocculation and de-flocculation) during and following the passages of the hurricanes.

OS22L HC: 316 C Tuesday 1330h

Coupled Biophysical Processes, Fisheries Resources, and Climate Variability in Coastal Ecosystems of the Northeast Pacific Ocean IV

Presiding: **W Crawford,** Fisheries and Oceans Canada**; A J Hermann,** Joint Istitute for the Study of the Atmospere and the Oceans

OS22L-01 1330h

Water-Column Stability, Phytoplankton Distribution and Zooplankton Abundance During Summer in Prince William Sound, Alaska

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During summer of 1997 and 1998 we measured stability in the upper water column (rate of change in sigma -t in upper 20 m), fluorescence profiles, and abundance of herbivorous and carnivorous zooplankton in four study areas of Prince William Sound (PWS). In 1998 the upper water column was more stable than in 1997. Stability also differed among areas, with the same pattern both years, probably due to consistent sources of fresh water around PWS. Mean depth of the chlorophyll maximum (DCM) was shallower in 1998, and areas with higher stability had shallower DCM. Herbivorous zooplankton were more abundant in 1998, and occurred in higher numbers where DCM was shallower. Abundance of carnivorous zooplankton was unrelated to numbers of herbivores. These relationships suggest that increased stability during summer in the northern Gulf of Alaska leads to higher production of zooplankton, as proposed in the Optimal Stability Hypothesis. There are indications that variation in the planktonic ecosystem propagated through the food web, affecting planktivorous fishes and piscivorous seabirds.

OS22L-02 1345h

Satellite-measured Seasonal and Interannual Variability of Chlorophyll in the Gulf of Alaska

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We present a synoptic summary of chlorophyll variability on seasonal and interannual timescales for the Gulf of Alaska (GOA) as observed in four years (1997-2001) of SeaWiFS ocean color data. Low light levels and/or cloud during November January prevent examination of winter patterns. EOF analysis of the climatological annual cycle shows a dominant pattern (88%) of shelf-intensified chlorophyll (a factor of 3 or more) around the entire basin with peaks in May and again (but more weakly) in August and September. The second and third modes (4 and 2%) capture April-June chlorophyll peaks on the shelf and most importantly, patterns strongly related to bathymetry (the 500m isobath) west of Kayak Island (144W). Interannual variability is examined using an EOF decomposition of the 48 month time series. A gulf-wide amplification (mode 1, 77%) of the annual cycle occurred during 1999 and 2000. The second and third modes (4 and 3%) show chlorophyll peaks obviously linked to bathymetry in the western GOA and a more diffuse enhancement on and off the shelf in the eastern GOA during April-May of 1999-2000. Cross-shelf chlorophyll variability (0-400 km offshore) is more closely examined in five locations relevant to ongoing GLOBEC research. Chlorophyll is typically shelf-intensified and decays offshore, but becomes strongly enhanced over the shelf break in the western GOA (off Seward and Kodiak Island). During 1999 and 2000 the spring blooms extended farther offshelf in all locations and were enhanced by a factor of 3 over spring 1998. A portion of the observed variability results from recurring eddies (100-300 km scales) evident in the imagery immediately seaward of the 500m isobath west of 144W. Results are examined in relation to the annual cycle of wind forcing, gyre-scale circulation and larger scale signals emanating from the Northeast Pacific and ENSO.

OS22L-03 1400h INVITED

The Gulf of Alaska Ecosystem: An Interdisciplinary View After Four Years

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The results from four years of sampling under the Long-Term Observation Program (LTOP) in Gulf of Alaska GLOBEC, combined with measurements from a biophysical mooring in the North Pacific Marine Research (NPMR) program show a complex and highly variable water circulation pattern that greatly affects

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