development programs are assisting educators in aligning their curricula to meet workforce needs and to give students the tools for success when they enter or re-enter the workforce.

One example of the MATE Centers projects that link students, educators, and employers is the national ROV design and building competition co-sponsored by the Marine Technology Society ROV Committee. In addition to being fun and educational, this event connects high school and college students and faculty with employers from marine industries in order to highlight career opportunities and strengthen technical, problem solving, and teamwork skills.

URL: http://www.marinetech.org

OS21I-08 1105h

Outreach and Science: A Primary School Teachers Experience in the Arctic

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TEA: Teachers Experiencing Antarctica and the Arctic is a program funded by the National Science Foundation and is facilitated through Rice University, the Cold Regions Research and Engineering Laboratory and the American Museum of Natural History. The cornerstone of this program is a research experience in which selected K-12 teachers participate in polar expeditions. Immersion in the scientific process occurs through contact with a research scientist. The teacher is exposed to new technology and cutting edge research. The TEA website (address below) maintains the daily cruise journal. The TEA program aspires to improve science literacy, to change how science education is conducted in the classroom, and to alter the general public's attitude about science.

A research team from the University of Tennessee, as well as other institutions have been conducting long-term ecosystem research in the Bering Sea just south of St. Lawrence Island. The goal of this project is to study how hydrographic and other potential forcing factors may influence the benthic food source of threatened diving sea ducks (Spectacled Eiders) and marine mammals in this region. During a March 2001 icebreaker cruise on the USCGC Polar Star, educational experiences through the TEA program were shared with teachers on St. Lawrence Island, Nome, and Little Diomede Island in Alaska as well as students and the general public. The TEA experience includes interactions with teachers on Little Diomede Island in Bering Strait, the location of a NSF Long term Observatory (LTO) to measure seawater and marine mammal data in an effort to track long-term global change in the region. Select marine sites from the northern Bering and Chukchi Seas have been sampled annually as part of the oceanographic sampling program of the LTO project. Ultimately, results from the marine and land-based LTO project will be published and are also available on a public web site, http://arctic.bio.utk.edu

This presentation will outline the TEA experience obtained as part of these research efforts. Opportunities for professional growth, transfer of the research while in the field, public outreach, and present and future collaboration with the research team will be shared.

URL: http://tea.rice.edu/tea_stevensfrontpage.html

OS21I-09 1120h

Southeast Regional Aquatic Nuisance Species Education Network

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A critical need in the United States is a public education component to complement research on the types and impacts of Aquatic Nuisance Species (ANS) in the Gulf of Mexico Region. It is estimated approximately 6,500 nonindigenous species have established populations in the US (Pimentel, et al. 1999, Williams and Meffe, 1999). While only a subset of these directly and negatively impact indigenous species, nevertheless, the overall economic impact of these organisms is estimated to be approximately $138 billion per year (Pimentel, et al. 1999).

The Gulf of Mexico Program (2000) has released a report documenting by U.S. state, the current Priority Aquatic Nuisance Species of most concern in coastal areas. From this detailed listing of Priority Aquatic Nuisance Species, the Principal Investigators (PIs) for this regional educational project selected representative species as typical examples on which to focus this teacher education effort. The list also included a number of historically significant introduced species and included terrestrial and aquatic plants, a terrestrial vertebrate/mammal, an aquatic vertebrate/fish, and invertebrates. By selecting from different classes of organisms, the overall pertinence of the teacher education program was enhanced to accommodate the needs of both inland and coastal teachers, and teachers from the multi-state area included in this effort, i.e. Louisiana, Mississippi, Alabama, and Florida. Further, this selection facilitated meaningful field trips throughout the year while preserving a capability to view example non-indigenous species in the environment.

This project focused on ANS by addressing content needs of classroom teachers, who are now in turn, incorporating the latest scientific knowledge in these areas in their classrooms. Participating teachers now have enhanced content knowledge for nonindigenous species and related population ecology concepts, their regional and national impact, and management attempts. Previous research experience by the principal investigators indicates inservice teacher education for marine and coastal science content areas is an effective mechanism for reaching the general public, due in part to the scope of the general populace directly impacted by the public education system, i.e. through familial relationships with students, and the students and teachers themselves.

To date, four workshops have been completed with 72 teachers. Statistical measurement of changes in content knowledge of participants reflects significant increases in their understanding of identified content and concepts. Four additional workshops are scheduled for 2002 with funding provided by the Mississippi-Alabama Sea Grant Consortium and the Environmental Protection Agency. Additionally, the project has been expanded through funding from the National Sea Grant College program, Mississippi-Alabama Sea Grant and Florida Sea Grant to include teachers throughout Florida. Further, this expanded effort includes funding for 13 formal workshops, 57 school-based workshops, and one, national internet-enabled, virtual workshop. Finally, current funding includes costs for the publication and dissemination of three research reports and lesson plan packages for K-12 teachers over the next three years.

OS21I-10 1135h INVITED

The Role of Scientists in Public Policy

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Science education has expanded to include a number of non-traditional approaches directed at a wider audience. Likewise, the professional responsibilities of scientists have broadened to include public outreach and involvement with the policy processes of government. Citizen scientists have a significant role to play in the shaping of policy, public opinion, and the ways in which research results are applied in the broader society. However, these non-traditional roles in education and outreach can be time consuming and need to be carefully focused and conducted if they are to be effective. They also need to be adequately recognized and rewarded within the profession.

Of special significance to larger-scale natural sciences, like limnology and oceanography, is the role that they play in setting policy around longer-term ecological effects (long-range pollutant/nutrient transport, acid-rain lake impacts, climate change, etc.). Well before public awareness raises these issues to thresholds of political action, scientists are aware of the problems and can play an early role in shaping public reaction and any eventual political activity.

OS21I-11 1205h

Educational Outreach Efforts of the Monterey Bay Aquarium Research Institute (MBARI)

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The overall goal of this session is to challenge ocean scientists to take a leadership role in national science education reform. One important challenge and contribution is to engage ocean scientists in conveying the excitement and value of their research to ocean sciences educators, K-12 and post-secondary students, and the general public. This talk will review and preview the educational outreach efforts of MBARI staff and of the institution itself. These efforts include "Cruising to the Classroom" expedition webpages, an internship program, and strong links to an informal educational institution, the Monterey Bay Aquarium.

URL: http://www.mbari.org

OS21J HC: 318 B Tuesday 0830h

Application and Assessment of Coastal Sediment Transport Models II

Presiding: **C Harris,** Virginia Institute of Marine Science**; R P Signell,** NATO/SACLANTCEN

OS21J-01 0830h INVITED

A systems approach to sedimentation modeling for the twenty-first century

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The Distributed Marine Environmental Forecast System (DMEFS) project is examining methods of calculating ocean variables using modern High Performance Computing (HPC) methods. One of the requirements of the project is to develop a forecast capability for sediment-related marine properties, such as optical scattering and bottom scour. As part of this requirement, we are examining the characteristics of different methods of making sedimentation and hydrodynamic calculations concurrently in a distributed HPC environment. The application of such a system is not necessarily limited to DOD interests. A few common applications for sedimentation modeling are water quality, engineering, geological, and naval. These applications have a common thread in that they all must calculate the quantity of sediment being entrained and/or transported in the coastal ocean. They differ in time and spatial scales of application, however. These differences make it difficult to construct a single sedimentation model for all applications.

There are five basic paradigms for constructing coastal ocean hydrodynamic/sedimentation modeling systems: (1) In the tracer paradigm the sedimentation model uses the same equations as the hydrodynamic. Some of the sediment calculations are independent but vertical and horizontal mixing processes are identical to the hydrodynamic model. It is simple to code this type of model but difficult to debug and the hydrodynamics must be run every time a different sedimentation run is needed. (2) The coupled paradigm uses an independent sedimentation model that is based on the same spatial grid as the hydrodynamic. It must also run with the hydrodynamic model but the time constraint is relaxed somewhat. Independent vertical mixing can be calculated and feedback is more limited. (3) The linked paradigm differs from the coupled only in that no feedback is allowed with the hydrodynamic model. (4) In the stand-alone paradigm, the sedimentation model is completely independent of all hydrodynamic forcing. All forcing fields must be interpolated in space and time to the sedimentation domain. No feedback is possible. (5) The distributed paradigm has the advantages of the stand-alone with respect to spatial and temporal independence but also the feedback of the tracer paradigm.

All of these paradigms have been used at one time or another, with the tracer method being most common. However, the rapid advancement in distributed HPC resources favors the distributed paradigm, which allows each model (e.g., currents, waves, surf, sedimentation, morphodynamic) to run in the appropriate configuration for optimal performance. Furthermore, research funded by the Common High Performance Computing Software Support Initiative (CHSSI) directly supports development of the distributed paradigm. Thus, our efforts in the DMEFS project are towards a standalone model that will be later incorporated into the final modeling and data system.

OS21J-02 0855h

ECOMSED: Some History and Its Future

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The process of planning for a Community Sediment Transport Model (CSTM) is currently underway with broad participation from academia, industry and government. One of the objectives is to evaluate existing sediment transport models, their inherent formulations, and to develop a suite of test cases to evaluate the models. A possible candidate for such a model is ECOMSED. It was designed to simulate with as much realism as possible three-dimensional, time-dependent distributions of cohesive and noncohesive sediments in marine and freshwater systems. A distinct feature of the model is the direct coupling of the sediment transport module with modules for hydrodynamics and wind waves. The component models are designed to execute in conjunction with each other so that output from one model is directly linked to the other models. The models all share the same numerical grid structure and underlying numerical solution techniques.

The development of ECOMSED has its origins in the mid 1980s with the creation of the Princeton Ocean Model and its version for estuaries and the coastal ocean, ECOM. In the mid 1990s, concepts for sediment resuspension and settling developed by Lick at UCSB and incorporated in a depth averaged cohesive sediment transport model were extended to three dimensions within the ECOM modeling framework. Over the last several years, ECOMSED was enhanced to include better bottom shear stresses through the Grant, Glenn, Madsen submodel for bottom boundary layer physics, surface wave models, noncohesive sediment transport, and dissolved and sediment-bound tracer capabilities. Model performance has been evaluated by appealing to a series of simple test cases designed to isolate specific processes and by application of the model to real-world situations. For this presentation, sediment resuspension, transport and deposition in Green Bay will be discussed.

The future potential of incorporating ECOMSED as the basis for a CSTM and inherent issues will be also discussed. The model has evolved over time using internal HydroQual funds. The idea is to now bring ECOMSED into the public domain in a way that will balance the needs of the research community and still protect HydroQuals consulting practice.

OS21J-03 0910h

Development of a 3-D Eulerian Particle Tracking System for the Prediction of Sediment Transport Under the Action of Waves and Currents.

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Regular satellite imagery for Lake Michigan revealed the formation of an early spring coastal turbidity plume. This turbidity plume is an annual, early spring which is characterized by the evolution and the near-shore-off-shore transport of a 10 km wide plume of entrained particulate matter over a distance of 200 km along the shore of Southern Lake Michigan. This spring plume is directly related with the general near-shore advective and diffusive transport mechanisms which control the cross-shore transport of the suspended mass. However, the relationship between the plume and these transport processes has not been extensively studied.

The present work is part of the greater ongoing research project EEGLE (*Episodic Events - Great Lakes Experiment Program*) sponsored by the *National Science Foundation* and the *National Oceanic and Atmospheric Administration Coastal Ocean Program*. Important objectives of this research are (*a*) to investigate the physical processes related to the genesis, evolution and the disappearance of the recurring spring plume of suspended particulate matter in Southern Lake Michigan, (*b*) to determine the origin(s) of the suspended particulate matter (and associated constituents), (*c*) to determine the path(s) and eventually the fate of the transported particulate matter and (*d*) to predict and quantify the behavior of the sediment plume in the lake.

The traditional *Eulerian* modeling approach for the determination of the circulation patterns and transport of the suspended particulate matter, though more accurate than a purely *Lagrangian* approach, cannot identify both the origin(s) and the path(s) of the particulate matter in suspension. Therefore, an extension to the traditional *Eulerian* modeling approach is considered in this work with the introduction of a *multi-source, multi-grain size* sediment transport model formulation, in order to identify the primary and immediate sources of plume materials and to quantify the amount of material re-mobilized.

The complexity of the physical processes involved in the generation and evolution of the spring plume are being addressed by the use and coupling of the following five models: (*a*) the CH3D, a three dimensional circulation model, (*b*) the SED, a sediment model (for the sediment entrainment and transport), (*c*) the WCBLM, a bottom boundary layer model (to resolve the near bottom physics and stratification effects), (*d*) the WAM, a water wave model (to resolve the deep water wave field) and (*e*) the SWAN, a shallow water wave model.

Upon completion of this research, a validated, adaptable modeling system would be established to: (*a*) determine the controlling processes for the cross-shore transport and the re-distribution of the sediments and (*b*) predict and quantify the behavior of the sediment plume in the lake.

OS21J-04 0925h

Sediment Transport Predictions using a Coupled Modeling System

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Sediment transport in the marine environment is a complex process involving combined wave and current forcing and feedback mechanisms related to bedload and suspended sediment. The level of nonlinear interaction and interdependency has meant that regional scale models of sediment transport have generally employed simplifications ranging from the drastic (e.g. the omission of wave forcing) to the pragmatic (e.g. the use of a fixed bed roughness).

Recent advances in high performance computing now permit the fully coupled prediction of basin-wide sediment transport using the highly iterative system specified by unsimplified contemporary bottom boundary layer theories. This functionality is included in the COupled MArine Prediction System (COMAPS), which consists of coupled, parallel-processing versions of the CH3D-SED circulation and sediment transport model and the WAM wind-wave model.

The wave-current bottom boundary layer (WCBL) coupling module in COMAPS accounts for combined wave and current shear stresses, mobile bed roughness, and stratification due to suspended sediment. WCBL provides CH3D-SED with bottom roughnesses, bottom shear stresses, and reference concentrations. The SED model then calculates bedload and suspended load sediment transport using the concept of an active transport layer subject to erosion and deposition. SED accounts for multiple noncohesive sediment size classes, bed armoring, and the effects of suspended sediment on fluid density and turbulence.

This paper will present an analysis of the COMAPS sediment transport predictions from Adriatic Sea hindcasts. Most notable are the rapid offshore transport of fine sediment and the basin-scale effects of nearshore wave-enhanced erosion. Comments will also be offered concerning the difficulties encountered in meaningfully linking the coupled boundary layer theories and the SED model, and achieving consistent convergence of the iterative system.

OS21J-05 0940h

Three-Dimensional Modeling of Circulation and Sediment Transport in the Nakdong Estuary of Korea

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Nakdong River is the second largest one in Korea, which is characterized by complex bottom topography and current systems. Numerous sand bars are well developed in Nakdong Estuary, and the systems and the flow patterns have been changed remarkably since the construction of the river barrage. This study is focused mainly on the tidal currents and the transitional processes of the sand bar systems in the estuary. A three-dimensional numerical model was developed and applied to investigate the flow system, the sediment transport and the sand bar formation in the estuary. The model include a three-dimensional hydrodynamic model and a sediment transport model. The finite difference form of the governing equations was solved using ADI integration scheme. Therefore, the tidal current and the sand bar systems were discussed qualitatively using the numerical model, the LANDSAT images and the aerial photography. The numerically predicted results for the formation of the sand bar were compared with LANDSAT images, and the agreement between the model and the image was reasonably encouraging. Tidal-driven current and the river fresh water played important role to form the sand bar. From the results, we can see that the governing factors of the sediment transport in the estuary are the tidal energy, the river discharges and the incident wave energy, and the remarkable formation changes of the sand bar occur according to the season. The straight channel construction in the eastern side of the river mouth increases the tractive forces in runoff, consequently the sediment discharge rate increases. Then, the deposited sediment in offshore will be redistributed by the wave and the current. The magnitude of the tidal flow and the river discharge are the dynamic factors controlling the intensity and the location of the turbidity maximum.

OS21J-06 1015h INVITED

Morphodynamic Modelling Using Delft3D - Recent Developments and Validation Studies

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Delft3D is a software package developed and supported by WL — delft hydraulics which is used by staff, external clients and researchers around the world to model two- and three-dimensional free surface flow and transport problems. The DELFT3D package consists of a number of integrated modules that together allow the simulation of 2DH or 3D flow (under the shallow water assumption), computation of the transport of water-borne constituents such as salinity and heat, short wave generation and propagation, sediment transport and morphological changes, and the modelling of ecological processes and water quality parameters.

The standard approach that has been validated in many field verification studies consists of a combination of depth-averaged flow, driven by tides, wind and waves; wave propagation using a spectral wave model (HISWA or SWAN); quasi-3D bedload and suspended load transport and bed level updating using an explicit scheme. A large number of morphodynamic validation studies has been carried out over the past decade(e.g. Steijn et al, 1998). Hydrodynamic field validation studies include e.g. Morris et al., 2001.

Recent developments follow the following research directions:

- moving to larger time-scales using an approximation of the reaction of sediment transport to bottom changes, which reduces run times by an order of magnitude and allows a study of the behaviour of the model over much longer time periods (e.g. Roelvink et al, 2001);

- moving to intra-wave group time-scales, where long-period motions caused by radiation stress modulations and shear instabilities are resolved and the evolution of complex beach bathymetries is simulated over periods of days to months (e.g. Reniers et al., 2000)

- moving from depth-averaged to full 3D flow and transport description. The present version of Delft3D-FLOW now solves the transport of various fractions of sediment (sand or silt) and the evolution of the morphology within the flow calculation. In this way we can now include the effect of sediment concentration on density and through this on turbulence damping and density currents (Lesser et al, 2001).

This model has undergone a number of laboratory verifications and is presently used in several field validation studies, at scales ranging from the North Sea to estuaries, coastal inlets and coastal stretches. The presentation will discuss the formulations and the confrontation with field data.

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URL: http://hydr.ct.tudelft.nl/wbk/public/roelvink/download.htm

OS21J-07 1035h

Observations and Predictions of Ripple Development on a Complex Shoreface

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A field study of bedform behavior over spatially varying substrates was conducted on a shoreface on the east coast of New Zealand's North Island under conditions that included fair-weather and two significant storm events. The questions motivating the studies were: how do complex substrates differ from uniform substates and how well do existing models account for those differences? Repeated sidescan sonar surveys were used in conjunction with coring, diver observations and bed elevation analysis to map large-scale patterns of bed roughness. Contrasting rough and smooth beds characterized the study area. The rough areas were composed of coarse sand (d50 = 0.75mm) and exhibited ripples with heights and lengths of 25 cm and 100 cm respectively. The rough sand surface was covered in places by a 40cm layer of fine sand supporting smaller ripples with heights and lengths of 5cm and 20cm. Contacts between the two surfaces were sharp and appeared to maintain their position despite highly energetic conditions over a seven-month period. Three tripods supported acoustic Doppler velocimeters (ADVs) for measuring wave/current turbulence and bed elevation as well as acoustic backscatter sensors (ABSs) for measuring suspended sand concentrations and bed elevation. One tripod was deployed over the rough surface at a depth of 22 m and two were deployed on the smoother surface at depths of 22 m and 13 m. The altimetry records from the ADV and ABS sensors were used to construct time series of bedform evolution at each of the sites during two storms and intervening fair-weather. Steep wave orbital ripples prevailed throughout the deployment on both surfaces but were most pronounced on the coarse substrate. The smooth site exhibited greater ripple mobility than the coarse site. Changes in ripple dimensions at the coarse site appeared to be limited mainly to the two storm events. The observed bedforms, orbital velocities and wave periods were used to evaluate the applicability of the models of Wiberg and Harris and Nielsen for predicting ripple dimensions. The Wiberg and Harris model adequately predicted the small ripples observed at the smooth site. Although both models under-predicted the height of the large ripples at the rough site, the Nielsen model showed the closest fit to observations. Discrepancies between observed and predicted bedform evolution suggest that existing models may not adequately explain the behavior of bed roughness on a complex shoreface.

OS21J-08 1050h

The Effects of Spatially Complex Shoreface Roughness on Boundary Layer Turbulence and Wave Friction

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Three instrumented tripods were deployed on a complex shoreface over contrasting substrates in order to examine the effects of spatially varying bed roughness on boundary-layer turbulence and bed wave friction. The field area was located off the east coast of New Zealand's North Island. The five-week deployment period included two storm events. The morphologically rough areas were composed of coarse sand and exhibited ripples with heights and spacings of 25 cm and 100 cm, respectively. This rough substrate was overlain in adjacent regions by a thin layer of fine sand with a much smoother surface on which typical ripple heights were 5 cm and lengths were 20 cm. Contacts between the two surfaces were abrupt. The tripods supported acoustic Doppler velocimeters (ADVs) for measuring three-dimensional turbulence and bed elevations; acoustic backscatter sensors (ABS) for measuring suspended sand; vertical arrays of electromagnetic current meters; and upward-facing acoustic Doppler current profilers (ADCPs). Dimensions of local roughness elements were used together with local burst-averaged wave parameters estimated from tripod data to predict local wave friction factors, fw, via Swart's empirical formula. For the high-energy events, this gave fw values of 0.13 for the rough site and 0.06 for the smooth site. Higher values of fw prevailed under low and moderate waves. Spectra of the fluctuating vertical velocity components, w', from both smooth and rough sites showed good fits to -5/3 slopes within the inertial sub range enabling independent estimates of bed stress to be made via the inertial dissipation method. Employing these independent estimates of bed stress to obtain corresponding values of fw indicates that fw was in fact similar at both sites but in the neighborhood of only 0.02-0.03 during high waves. Under low to moderate waves, fw exceeded 0.1 and was near the spatial average of predicted values but did not exhibit significant differences between surfaces. The relative uniformity of fw suggests that eddy viscosity within the lower part of the bottom boundary layer may have been controlled more by spatially averaged roughness than by local roughness over the heterogeneous bed. The low fw values, relative to predictions, during high waves suggest that under high-energy conditions a plane bed may replace ripples over both types of surface. These results imply that existing models of both fw and bedform geometry do not adequately explain the morphodynamic behavior of this complex shoreface.

OS21J-09 1105h INVITED

Morphological Modelling of Linear Sandbanks

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Coastal morphological models include hydrodynamic and sediment transport processes coupled through a bottom evolution module based on sediment conservation. There are two main types of such models: (a) initial sedimentation erosion (ISE) models which predict net sediment transport rates and directions using the flow field and then predict areas of erosion and accretion; and, (b) medium-term morphodynamic (MTM) models that includes the effect of the changes in bottom topography on the flow field. In the latter type of model, sea bed changes due to sediment accretion and deposition alters the flow field and creates a feedback process between the flow field and bed morphology. In this presentation, the development and application of both ISE and MTM type of models to examine the dynamics of coastal sandbanks will be presented.

Linear sandbanks or sand ridges are located globally in areas where there are strong currents and an abundance of sand. They are present on continental shelves, near coastal regions, in embayments and in estuarine regions. Because of their relative size, they have a significant influence on the local flow field. Therefore, morphological models are a powerful tool to examine their formation and maintenance. In this presentation, recent developments in morphological models as applied to these systems will be outlined using examples from the Western Australian coastal region which contains both tidal and non-tidal regions where linear sandbanks occur.

URL: http://www.cwr.uwa.edu.au/~pattiara/agubanks

OS21J-10 1125h

Sediment Accumulation via Deposition and Erosion of Fluid mud in the Hudson River Estuary

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Bottom mounted tripod observations of bed elevation, suspended sediment concentration, and water velocity taken during a nine-month period from October 2000 through June 2001 revealed that deposition takes place as series of transient large deposition and erosional events on individual tidal cycles which accumulate during a several spring tidal cycles to leave a seasonal deposit which is of the same magnitude as the individual tidal cycle events. During the fall of 2000 the region near the turbidity maximum was net erosional with losses of approximately 10 cm. During the spring of 2001 approximately 15 to 20 cm of deposition was observed at the tripod site one month after the seasonal freshet as the sediment that had been transported to the lower estuary during the freshet returned landward.

This deposition occurred after pulses of mobile fluid mud were created on each ebb tide of the spring tides. This mobile fluid mud appears to be the product of frontal convergence between the landward near-bed estuarine circulation and seaward ebb tidal flows. At the slack tide after the ebb this mobile fluid mud settled out of suspension over a period of 1 to 1.5 hours into deposits of stationary fluid mud approximately 15 cm thick. These transient deposits were then eroded in the subsequent flood tide, however the erosion was generally smaller than the deposition leaving behind a net deposit of 2-4 cm per tidal cycle. This process was repeated over several spring tidal cycles to create the net 15 cm of deposition. Hydrodynamic controls vs. sediment supply controls of the relative balance between erosion and deposition will be examined. Cores taken near the tripods show stratigraphy that is the product of this rapid depositional process whereby gross deposition and erosion is far greater than net deposition. These processes represent a challenge to the sediment modeling community as hydrodynamic, suspended sediment, and fluid mud processes must all be accounted for in order account for the observed depositional rates.

TUE

OS21J-11 1140h

Sediment Transport and Trapping in the Hudson River Estuary: a Tough Test for a 3-Dimensional Model

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An estuarine turbidity maximum (ETM) resides within the Lower Hudson River estuary at intermediate salinities on the west side of the channel. Detailed water-column observations show that a strong salinity front persists within the ETM. A convergence of flow at the head of this front results in the focusing of suspended sediment, causing rapid accumulation under certain conditions. An acoustic altimeter recorded sedimentation rates as high as 1 cm per minute during a particularly intense trapping event. The magnitude of this sediment convergence is highly dependent on fortnightly variations in tidal amplitude. High tidal flows associated with spring tides enhance vertical mixing and intensify the front within the ETM. In addition, suspended sediment concentrations increase dramatically during spring tides. The observations indicate that the trapping occurs during the late stage of the ebb, when the near-bottom velocity behind the front drops below the threshold for resuspension.

The observations collected from the Hudson ETM provide an excellent test-bed for a three-dimensional, sediment transport model. The Regional Ocean Model System numerical model (ROMS) is used to simulate the hydrodynamics within the Hudson River estuary and to assess the ability of a simple sediment transport scheme to reproduce the sediment transport regime observed within the Hudson. Model results show an inherent three-dimensionality in the mechanisms responsible for sediment transport and trapping within the ETM. During flood tide sediment is transported up-estuary, primarily on the deeper, east side. A transverse, secondary circulation sweeps sediment to the west side of the channel. During ebb tide, the model reproduces the observed salinity front within the ETM, and the pattern of sediment trapping is similar to the observations. A comparison of the observed and modeled deposition and erosion rates provides a challenging test of the model performance.

OS21J-12 1155h

Application of Wave Shoaling Schemes to Models of Coastal Sediment Transport

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The major forcing for models of coastal sediment transport is derived from the waves. Typical 2-D and 3-D numerical model will take wave conditions at an offshore boundary and shoal the waves across the model domain through the application of a wave transformation model. The resulting wave characteristics then enter into the flow dynamics largely through radiation stress and bottom stress terms. Due to their contribution to bottom stress terms, they are also fundamental in sediment dynamics. As the wave transformation models utilized in this type of scenario are solved at each grid point, they are typically applied at relatively fine space scales, O(m). This is in contrast to the larger scales, O(km), over which such models are tested and validated. Similarly nearshore circulation models are typically validated on simulated geometries with idealized bathymetry. Thus the adequacy of existing wave transformation models for inclusion in models of coastal sediment transport is poorly tested.

In order to investigate this problem, standard wave transformation models have been run on real straight coast bathymetry with a grid spacing of 10m. Uniform waves are input on the seaward boundary and shoaled up to the break point. The results indicate remarkable longshore variation in both amplitude and incidence angle. To illustrate the significance of the longshore variability, the results are fed into a simple one-dimensional longshore current model. In this straight coast environment, the predicted longshore currents vary by a factor of 4. This result highlights the strong level of variability input into coastal sediment transport models by such wave transformation schemes. To further understand the source of this variability, the role of input spectral shape is investigated. The importance of different aspects of shoaling physics is also examined through the selective inclusion of wave interactions and wave diffraction. A comparison with field data will also be performed in order to estimate how real is the variability.

OS21K HC: 319 B Tuesday 0830h

Indian Ocean and Indonesian Throughflow Variability From Models and Observations III

Presiding: **R Murtugudde,** ESSIC/Univ of Maryland**; J T Potemra,** University of Washington

OS21K-01 0830h

The Indonesian Throughflow [ITF]: how Warm is it? Where Does it go?

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Temperature and ocean current time series obtained within the Makassar Strait from December 1996 to July 1998 are used to calculate ITF heat transport and to assess its influence on Indian Ocean heat divergence. The transport weighted temperature of the flow through Makassar Strait, which is the ITF primary channel, is approximately 15C. The mean heat transport averages 0.55 PW relative to 0C, and 0.41 PW relative to 4C. Heat transport appears to vary with ENSO phase, lower during El Nio, higher during La Nia. In the Indian Ocean, ITF water within the thermocline is advected westward by the South Equatorial Current (SEC), near 12S. Upon reaching the western boundary the SEC bifurcates. The fate of the north turning component varies with season. In the boreal summer, the Somali Current transports ITF water well into the northern hemisphere. However, some ITF thermocline water turns eastward before reaching the equator, entering the South Equatorial Counter Current (SECC) near 5S. The SECC and SEC form the Southern Equatorial Gyre, within which summer Ekman induced upwelling transfers ITF water from the thermocline into the surface layer, to eventually be transferred to the south. In winter the SECC route at 5S persists, though the Somali Current reversal prohibits spreading across the Equator. The southward flowing limb of the SEC bifurcation persists throughout the year. ITF thermocline water passes through the Mozambique Channel towards the Agulhas Current. For realistic consideration of the ITF component within the Agulhas Current, the heat flux divergence of ITF waters within the Indian Ocean north of 30S is found to be insignificant. Our results provide support for model studies and hydrographic geostrophic inverse calculations that indicate the ITF heat, derived from the Pacific Ocean, is ultimately lost to the atmosphere in the southwest Indian Ocean.

OS21K-02 0845h

Teddies and the Origin of the Leeuwin Current

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The outflow from the Indonesian Seas empties approximately 57 Sv of surface Indonesian Throughflow water into the southern Indian Ocean (at roughly 12S). Using an analytical nonlinear one-and-a-half-layer model, it is shown that, immediately after emptying into the ocean, the outflow splits into two branches. One branch carries approximately 13 percent of the source mass flux and forms a chain of high amplitude anticyclonic eddies (lenses) immediately to the west of the source. The second branch carries the remaining 87 percent of the mass flux via a coastal southward flowing current. These results are in agreement with numerical simulations. It is suggested that the eddies recently observed to the west of the Island of Timor are a result of the above eddies generation process and that our new nonlinear process also explains why some of the Indonesian Throughflow water forms the source of the Leeuwin Current.

OS21K-03 0900h

On the Splitting of Main Currents in the Indonesian Seas

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A regional baroclinic model of the Indonesian Seas circulation, based on the Princeton Ocean Model, has been developed. Fifteen levels in the vertical has been chosen to resolve the vertical structure of the circulation. The horizontal resolution of about 10km provides a sufficiently accurate description of the bottom topography in the area. Four ports were introduced to simulate the Mindanao Current inflow into the region; the North Equatorial Counter Current outflow to the Pacific; the North Guinea Coastal Current inflow into the region; and the resultant outflow to the Indian Ocean. The normal velocity at the ports was specified parametrically using a simple distributions in the vertical and horizontal directions. The parameters were adopted in such a way to make these distributions compatible with observations. The tangential velocity at the ports was prescribed zero. The action of local winds is easily incorporated into the model. The temperature and salinity at the ports are taken from the Levitus data.

The results of barotropic experiments showed that the splittings of simulated currents between the Lombok Strait and the Flores Sea and between the Makassar Strait and the Malucca Sea differ substantially from the splitting schematics based on the analysis of observations. The analysis of baroclinic experiments is presented to reveal the influence of baroclinicity on the structure of splitting patterns. The effect of local winds is studied as well.

OS21K-04 0915h

Model of Kelvin Wave Transmission Through a Strait: Application to Lombok Strait

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Observations have shown that Kelvin waves generated in the equatorial Indian Ocean and propagating down the Indonesian coast can significantly impact the branch of the Indonesian Throughflow passing through the Lombok Strait. However, the extent to which these waves can impact the straits further down the coastal waveguide is still uncertain. A $1\frac{1}{2}$-layer numberical model study by Qiu et al. (1999) showed virtually all of the Kelvin wave energy in the 30-85 day intraseasonal band propagating through the Lombok Strait, even though the model strait had a width of only $\frac{1}{3}$ of the local Rossby radius R. More than $\frac{1}{2}$ of a Kelvin wave's energy flux is carried by the part of the wave further offshore than $\frac{R}{3}$-how is this energy able to 'squeeze through' such a narrow gap?

A solution for a strait with idealized dynamics and geometry was found using a combination of numerical and analytical techniques. This solution verifies the plausibility of the above phenomenon, while providing physical insight to the cause. The key to understanding is that a Kelvin wave passing from a narrow channel into an open sea will always reflect part of its energy back along the channel. In the case of a strait between two seas, this necessarily sets up a resonance condition similar to the classical optics problem of multiple beam interference. The solution then becomes sensitive to the channel length to wavelength ratio ($\frac{L}{\lambda}$), with a resonance peak near $\frac{L}{\lambda}$=0. In particular, a strait od any width will tend toward 100% transmission as the wave frequency tends to zero, as long as the dynamics remain linear and inviscid. An idealized simlation of the Lombok Strait shows that this limit is indeed approached even in the relatively high frequency intraseasonal band investigated by Qiu et al.

OS21K-05 0930h

Baroclinic structures of the Indonesian Throughflow and the Indian Ocean in numerical ocean models

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The baroclinic structures of the Indonesian Throughflow affect the structure in the Indian Ocean and vice versa. Tally (2001) showed the distinct low sanliity intermediate water from the Indonesian Seas, which is different from the Anterctic Intermediate water in the Indian Ocean. Spall (2001) suggested that dissipation along the west coast of Australia may significantly influence the vertical structure of the Indonesian throughflow and circulation around Australia, and hence the property flux between the Pacific and Indian Oceans. In this study, vertical distribution of the Indonesian Throughflow in association with baroclinic structure in the Indian Ocean is investigated using a layer model and a GCM. Sensitivity to flux, diapycnal mixing, and topography are tested. Diapycnal mixing is especially crucial to the intermediate circulations. Both in the layer model and GCM, there is a deep maximum of the Throughflow transport corresponding to the inflow from the Antarctic Intermediate Water of the Pacific Ocean. This flow forms a zonal jet in the Indian Ocean and separates from the AIW in the southern Indian Ocean. If this deep core is artificially blocked, the AIW from the southen boundary dominates in the Indian Ocean.

OS21K-06 0945h

SST dynamics in the warm water pool of the eastern Indian Ocean

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The warm water pool (where the sea surface temperature (SST) exceeds 28°C) in the eastern Indian Ocean has important implications to monsoonal climate system and its variability. The dynamics governing SST variability on seasonal-to-interannual timescales are investigated by using in situ measurements, satellite observations, and a newly calculated surface flux product. In particular, the study has inferred the relationships between SST and upper ocean thermocline and between SST and satellite sea surface height (SSH). The analysis indicates that SST dynamics in the warm water pool of the eastern Indian Ocean differ from those of the western Pacific Ocean.