The use of global-scale environmental data sets in conjunction with local-scale biological, ecological, and biogeochemical data has provided numerous opportunities to experience, and occasionally to address, the need to retain human participation in automated data management and application processes. We will present illustrative examples and suggest guidelines for appropriate types and levels of data automation and non-automation for various kinds of applications.

URL: http://www.kgs.ukans.edu/Hexacoral/

## OS41N HC: 319 B Thursday 0830h

### Stratified Coastal and Estuarine Circulation IV

***Presiding:*** **B Chant,** Rutgers University**; T F Duda,** Woods Hole Oceanographic Institution

#### OS41N-01 0830h INVITED

### The Turbulence Regime in Shelf Seas: Tidally-forced Convection in ROFIs

John H Simpson[1] (44 1248 382844; j.h.simpson@bangor.ac.uk)

Tom P Rippeth[1] (44 1248 51151; oss009@bangor.ac.uk)

Neil Fisher[1]

Eirwen Williams[1]

[1]University of Wales, School of Ocean Sciences , Askew St., Menai Bridge, Anglesey LL59 5EY, United Kingdom

The cycle of production and dissipation of turbulent kinetic energy is being determined for each of the characteristic regions of tidally energetic shelf seas. In continuously mixed and thermally stratified regions of the shelf seas, where surface buoyancy exchange dominates over horizontal advection, dissipation exhibits a regular M4 cycle which decreases in amplitude and increases in phase lag with increasing height above the bed. This behaviour is consistent with a model of shear production of TKE in an oscillating flow and involves more or less equal dissipation on the ebb and flood half cycles of the flow. By contrast, in a Regions Of Freshwater Influence (ROFI) where strong horizontal salinity gradients exist and the tide is essentially a standing wave, there is pronounced asymmetry between the ebb and flood phases of the tide. Tidal straining tends to stratify the water column on the ebb and may lead to a shut-down of turbulence in the upper half of the water column. On the flood, tidal shear acting on the density gradient tends to reduce stratification and can lead to "over-straining" towards the end of the flood with consequent release of potential energy which may drive convective motions with a consequent increase in TKE production and dissipation. New evidence from the FLY profiler and ADCP observations, for the occurrence of such convective motions and the consequent increase in turbulent production, will be presented along with a model simulation of the processes involved.

#### OS41N-02 0845h

### Kinematics of a pycnocline layer on the inner shelf off New Jersey

Andreas Münchow (302-831-0741; muenchow@udel.edu)

College of Marine Studies, University of Delaware, Robinson Hall, Newark, DE 19716, United States

During the summer months thermal heating stratifies waters off New York, New Jersey, Delaware, Maryland, and beyond even on the inner shelves. Here the water column is less than 30 m deep within about 30 km of the coast. Wind- and buoyancy-forced motions interact in shallow water to form regions of enhanced horizontal density gradients and attendant jets. The relevant horizontal scale is the internal Rossby radius of deformation L=ND/f where D is a vertical scale of motion, f is the local Coriolis parameter, and N is the stability frequency that depends on the vertical density gradient.

In many applications a density-stratified flow can be approximated reasonably well either as a contineously stratified or a 2-layer fluid. In the first case, the vertical scale of motion D is the total water depth while in the second case D is the thickness of the dynamically active layer. Analyses of observations off New Jersey shoreward of the 30-m isobath reveal that neither concept is particular useful as we frequently find three distinct "layers" there. Besides surface and bottom mixed layers, a contineously stratified layer occupies 30-50% of the water column. Its presence affects the flow field at a multitude of time scales. For example, at sub-inertial time scales detailed density and velocity measurements suggest that meso-scale baroclinic features couple the bottom mixed layer with the pycnocline layer above without extending into the surface layer. At shorter, near-inertial time scales analyses of individual events as well as rotary velocity spectra show much enhanced inertial oscillations centered at 4-m and 12-m below the surface with little kinetic energy energy at 8-m and below 16-m. This near-inertial feature can be rationalized as a co-oscillation of a surface mixed layer and a pycnocline layer below. The bottom mixed layer does not participate. Both inertial and subinertial features appear most pronounced during and following wind-forced upwelling events.

URL: http://newark.cms.udel.edu/~muenchow/os2002.html

#### OS41N-03 0900h

### Internal Tides in Juan de Fuca Strait: Observations and Model Predictions

Richard K. Dewey[1] (250-472-4009; rdewey@uvic.ca)

Yujiro Kitade[2] (ykitade@tokyo-u-fish.ac.jp)

[1]University of Victoria, P.O. Box 3055, Victoria, BC V8W 3P6, Canada

[2]Tokyo University of Fisheries, 5-7 , Konan 4 , Minato-ku, Tokyo 108-8477, Japan

Juan de Fuca Strait, in southeast British Columbia, is a broad uniform channel approximately 20km wide and 120km long. Water depths range from 100m in the east to 250m at the western entrance. Tidal currents in the region are strong (1 - 4 $ms^{-1}$), and during the summer months, the vertical stratification and shear are enhanced by the estuarine freshet of the Fraser River. Moored ADCP and thermistor chain data from the central-north region reveal significant internal tide signals. Peak vertical isotherm displacements are of the order 35m, but modulate throughout the spring-neap cycle. Based on the observed density stratification, a cut off frequency for the "free" propagating internal wave is estimated to be 11.3 hours. The internal tides, which arrive at both diurnal and semidiurnal periods, have the characteristics of first mode internal Kelvin waves. The energy density of the first mode internal tide accounts for approximately 71% (8.2 $Jm^{-3}$) of all the internal tide energy. The phase relation between isotherm displacements and the lower layer currents suggest that the internal tides are propagating westward along the northern side of the strait. The propagation and form of the internal tides were investigated with a simple analytical model, including Doppler shifting by the advection terms. Using barotropic tidal currents flowing over isolated bottom features, the observed wave forms and phases for the first mode internal tides were well simulated by a westward propagating internal Kelvin wave, suggesting a potential generation region south of Victoria. The observations and model predictions will be presented.

#### OS41N-04 0915h

### Flow Features at a Sharp Coastal Point

Kathleen A. Edwards[1] (206-543-1866; kate@ocean.washington.edu); Parker MacCready[1]; Geno Pawlak[2] (gpawlak@oe.eng.hawaii.edu); James N. Moum[3] (moum@oce.orst.edu); Jody M. Klymak[3] (jklymak@oce.orst.edu); Alexander Perlin[3] (aperlin@oce.orst.edu); Richard K. Dewey[4] (rdewey@uvic.ca)

[1]University of Washington, School of Oceanography Box 355351, Seattle, WA 98195-5351, United States

[2]University of Hawaii at Manoa, Dept. of Ocean and Resources Engineering 2540 Dole St., Holmes Hall 404, Honolulu, HI 96822, United States

[3]Oregon State University, College of Oceanic and Atmospheric Sciences 104 Ocean Admin. Bldg., Corvallis, OR 97331-5503, United States

[4]University of Victoria, Centre for Earth and Ocean Resources P.O. Box 3055, Victoria, BC V8W 3P6, Canada

In March 2001, flow features at Three Tree Point in Puget Sound, Washington were recorded on a cruise of the R/V Thompson. Three Tree Point is a sharp, relatively isolated headland extending 1.5 km into a background flow of 15 cm/s typical tidal magnitude. Measurements were obtained from the CHAMELEON microstructure probe as well as shipboard and moored ADCPs. The magnitude of flow at the point was approximately twice that of the predicted background flow. Crosschannel flows were equal in strength to alongchannel flows, and both varied significantly over the tidal cycle. Turbulent dissipation was greatest at maximum flood tide when a lee wave formed downstream of the point, manifest as a 50 m drop in isopycnals. At the tip of the point, the flow was strongly polarized towards offshore flow on both flood and ebb tide. In addition to these repeatable flow features, the flow had irregularities that may be associated with eddy generation. The evolution of the bottom boundary layer will be discussed.

#### OS41N-05 0930h

### Evolution of Tidal Vorticity in Stratified Coastal Flow

Geno Pawlak[1] (808-956-8100; gpawlak@oe.soest.hawaii.edu)

Parker MacCready[2] (parker@ocean.washington.edu)

Kate Edwards[2] (kate@ocean.washington.edu)

Ryan McCabe[2] (rmccabe@ocean.washington.edu)

[1]Department of Ocean and Resources Engineering University of Hawaii , 2540 Dole St., Holmes Hall 404, Honolulu, HI 96822, United States

[2]School of Oceanography University of Washington, Box 355351, Seattle, WA 98195, United States

The lifespan of a tidal eddy generated by flow around a coastal headland is examined. The longevity of tidally generated vortical flow structure is a key parameter in the establishment of residual coastal flows. Various flow regimes may result from interactions between long-lived vorticies generated by coastal bathymetry. Tidal flow around a headland, for example, can result in either flow towards (long-lived vortices) or away from the coast (short-lived vortices). Longevity is, in turn, a function of dissipation by boundary friction or by baroclinic mechanisms such as lee wave generation. Field observations of a tidal headland eddy at Three Tree Point, WA (USA) are presented. The temporal evolution of the flood tide separation eddy is examined from its generation, through the eddy release at the turn of the tide, until its dissipation during subsequent tidal cycles. Ship-based acoustic profiling examines the vertical structure of the velocity field and subsurface drogued drifters are used to track the horizontal motion of the flow structure. Drifter tracks from successive days at similar phases of the tide indicate that flow structure is repeatable. The combined set of drifter tracks is used to obtain an estimate of eddy lifetime. Dissipation rates for vorticity are then inferred. Time scales for vorticity decay of less than a tidal period are significantly shorter than simple estimates using boundary friction would imply. This finding suggests that the internal wave response of the stratified flow over the sloping headland plays a significant role in the dissipation of vorticity. Field observations are compared with results from numerical modeling that also suggest that baroclinic effects are significant.

URL: http://oe.eng.hawaii.edu/∼gpawlak/three_tree_point.htm

#### OS41N-06 0945h

### Hydraulic Controls in Partially Mixed Estuaries

William C. Boicourt[1] (410-221-8426; boicourt@hpl.umces.edu)

Arnoldo Valle-Levinson[2]

Cathy Lascara[2]

Michael Roman[1]

Shenn-Yu Chao[1]

[1]University of Maryland Center for Environmental Science, Horn Point Laboratory, P.O. Box 775, Cambridge, MD 21673, United States

[2]Center for Coastal Physical Oceanography, Old Dominion University, Crittenton Hall, 768 West 52nd Street, Norfolk, VA 23529, United States

While hydraulic controls have been discovered in strongly stratified estuaries such as fjords, observational evidence for their existence in partially mixed estuaries has been sparse. High-resolution time series obtained from an undulating towed vehicle, a towed ADCP, and moored instrumentation have confirmed an active hydraulic control, surprising in its scale and intensity, in the middle reaches of Chesapeake Bay. Secondary flows associated with this control are of the same order as tidal velocities. A region of strong surface convergence is associated with active subduction, creating subsurface temperature, chlorophyll, and oxygen maxima extending 10 km landward from the control point. Tidally modulated, large-amplitude lee waves are active, typically associated with a three-layer density structure. Velocity profiles also show three-layer flows, even in the markedly two-layer density structure of the seaward shoal region. The mid-depth landward velocity maximum appears to be attached to the bottom at the point where inflowing water exits its broad Rappahannock Shoals and enters the narrow Deep Trough of the Bay. This maximum is stronger than the 40-cm/s tide, resulting in extended intervals of unidirectional landward flow. Wind-driven motion

and mixing can apparently trigger a change in the internal sluicegate, initiating strong gravity flows lasting as long as two weeks. The leading edge of these flows propagate at an internal bore speed of approximately 10 cm/s and are detected as salinity jumps at landward moorings. Snapshot measurements in the fall suggest that the landward flowing flow can at times be choked completely. A comparison of salinity records landward of the hydraulic control point with river-flow suggests that these shorter-term modulations of hydraulic controls exert more influence on the landward salt transport than previously appreciated.

## OS41N-07 1020h

### Subtidal Current Variability in the Long Island Sound Outflow Region

David S. Ullman[1] (401-874-6138; d.ullman@gso.uri.edu)

Daniel L. Codiga[2] (860-405-9165; d.codiga@uconn.edu)

[1]Graduate School of Oceanography, University of Rhode Island, South Ferry Road, Narragansett, RI 02882, United States

[2]Department of Marine Sciences, University of Connecticut, 1084 Shennecossett Road, Groton, CT 06340, United States

Surface thermal fronts are frequently observed during summer and winter over the inner continental shelf in the region influenced by the outflow from Long Island/Block Island Sounds. This area is the focus of the ongoing observation/modeling project Front-Resolving Observational Network with Telemetry (FRONT, www.nopp.uconn.edu), with both remote-sensing (HF radar, AVHRR, SeaWiFS) and in situ (moored ADCP, CTD) observational components. Analysis of approximately 1.5 years of low-pass filtered HF radar (CODAR) derived surface currents shows a great deal of spatial structure as well as temporal variability on both seasonal and synoptic timescales. During summer, strong ($\sim$30 cm/s) southwestward monthly-mean surface flow is observed roughly coincident with the thermal front location during that season. Monthly-mean currents are much weaker during winter. Historical hydrographic data from the region show that the vertically integrated cross-frontal density gradient (a proxy for the surface to bottom thermal wind shear) has a strong seasonal signal with largest gradients in summer. Near-bottom currents from moored ADCPs are used with this estimate to assess the magnitude of the seasonal surface current fluctuation that is due to buoyancy forcing. Other mechanisms including wind forcing and tidal rectification will also be discussed with regard to their effect on the seasonal cycle in surface currents. Synoptic scale (several-day) variability in CODAR low-pass currents appears to be predominantly wind forced, with high vector correlation between wind and surface current. The mean veering of the surface current relative to the wind exhibits substantial spatial variability, with clockwise veering generally increasing with water depth as predicted by simple Ekman theory. Current profiles from moored ADCPs are used to assess the depth dependence of the wind-driven and seasonal responses in the context of the seasonal cycle of stratification in the region.

## OS41N-08 1035h

### Observed Subtidal Currents on an Inner Continental Shelf Influenced by Baroclinic Estuarine Exchange Flow

Daniel L Codiga (860-405-9165; d.codiga@uconn.edu)

University of Connecticut, Avery Point, 1084 Shennecossett Rd, Groton, CT 06340, United States

Interaction between coastal waters and the Long Island Sound - Block Island Sound (LIS/BIS) estuary system extends to a region of the inner continental shelf offshore from Montauk Point, NY and Block Island, RI. An array of upward-looking bottom-mounted profiling current meters and moored profiling CTD instruments has been deployed as part of the Front-Resolving Observational Network with Telemetry (FRONT) project (www.nopp.uconn.edu). The sampled area has complex topography that deepens offshore from $\sim$20 m to $\sim$60 m and includes a canyon-like incision leading toward a narrow channel near the center of the mouth of BIS. In addition to severe seasonal shifts due to the familiar competition between solar heating and wind mixing, the stratification is modulated by fluctuations in the salinity of the estuarine outflow on seasonal and shorter timescales as driven by river input to LIS. While tidal fluctuations dominate current and hydrographic profiles, time-series records of multiple-month duration are used to examine mean currents and subtidal flow fluctuations. Long-term means indicate shallow currents are nominally alongshore southwestward and reach 20-30 cm/s toward the landward side of the array, where there is also an offshore flow component. This is interpreted as buoyant estuarine outflow deflected by Coriolis. Further offshore the surface flow weakens to 5-10 cm/s and is nearly alongshore, as typifies the ambient New England shelf circulation. Mean currents veer clockwise with depth to become increasingly shoreward in the lower half of the water column; along the bottom, motion is directed onshore and converges toward the channel, reaching strengths of up to 10 cm/s. This is interpreted as the deep portion of baroclinic estuarine exchange flow. The horizontal and vertical structure of subtidal fluctuations is described and the relative contribution of wind, freshwater input, and spring-neap tidal variations as forcing agents is assessed. A summary is given of the differences in these features between fall and spring deployments, characterized by relatively weaker and stronger stratification respectively.

## OS41N-09 1050h

### Combining Measurements and a Circulation Model in the Block Island Sound Outflow Region with a Linear, Barotropic Inverse Model

Christopher A Edwards[1] ((860) 405-9157; christopher.edwards@uconn.edu)

Philip S Bogden[2] ((207) 773-0423; bogden@gomoos.org)

Todd A Fake[1] ((860) 405-9067; fake@oceans.dms.uconn.edu)

[1]University of Connecticut, Department of Marine Sciences 1084 Shennecossett Road, Groton, CT 06340, United States

[2]GoMOOS, PO Box 4919, Portland, ME 04112-4919, United States

A coastal ocean observing system has been developed in the shelf waters outside of Block Island Sound in the Mid-Atlantic Bight. This region is dynamically active, with strong tides, complex bathymetry, and substantial horizontal buoyancy gradients. Narrow fronts are regularly observed in temperature, salinity, and ocean color. The observing system includes both data collection and circulation modeling modules, which are connected through the use of a linear, barotropic inverse model. Depth-averaged ADCP records are used to generate 2-dimensional, subtidal, along-shelf flows that minimize data-model misfit and inverse model errors. These fields provide boundary conditions for a 3-dimensional, stratified, general circulation model (MITgcm) and improve agreement between the interior mooring records and the forward model. However, errors remain and can be attributed to the underlying assumptions of the inverse model. Linear versus quadratic drag laws result in only small error. Larger model-data discrepancies are associated with the absence of vertical shear. The largest error results from the omission of momentum advection in the inverse model. This talk will discuss the modeling component of this observing system and the errors that result from the use of the linear, barotropic inverse model for one set of observations in this region. We will compare strong versus weak constraint inverses and discuss alternate methods to reduce model-data errors associated with nonlinear advection.

## OS41N-10 1105h

### Turbulent Budgets and Model/Data Comparison for AUV-Based Sampling in the FRONT Coastal Front

Edward R Levine[1] (401 8324772; levineer@npt.nuwc.navy.mil)

Louis Goodman[2] (508 910-6375; lgoodman@umassd.edu)

Rolf G Lueck[3] (250 721-8918; rlueck@uvic.ca)

Christopher A. Edwards[4] (860 405-9157; christopher.edwards@uconn.edu)

[1]NUWC, Newport Division, Code 8211, Newport, RI 02841, United States

[2]SMAST, Univ. of Mass. -Dartmouth 706 South Rodney French Blvd., New Bedford, MA 02744, United States

[3]SEOS, University of Victoria PO Box 1700, Victoria, BC V8W 2Y2, Canada

[4]Dept. of Marine Sciences, University of Connecticut 1084 Shennecossett Road, Groton, CT 06340, United States

As a part of the NOPP FRONT experiment offshore of L. I. Sound, estimates have been made of the terms in the turbulent kinetic (TKE) and temperature variance budgets. These estimates are based on observations performed with a REMUS AUV customized with a suite of turbulence and fine scale sensors. Data were obtained during May 2001, near the tidal mixing front off Montauk Point, as predicted by a coastal version of the MIT General Circulation model. For the TKE budget, turbulent production and dissipation estimates compare within a factor of 2, with the turbulent buoyant mixing term estimated to be an order of magnitude smaller. For the temperature variance budget, in some cases, the production term approximately balances the thermal dissipation term. Observations near the predicted tidal mixing front show estimates of dissipation rate of $10^{-7}$ to $10^{-6}$ W/kg, eddy diffusivities of $10^{-4}$ to $10^{-3}$ m$^2$/s, and eddy viscosities of $10^{-3}$ m$^2$/s. In addition, thermal dissipation rates of $10^{-8}$ to $10^{-7}$ ($^\circ$C)$^2$/s, mixing efficiencies of $10^{-2}$ to $10^{-1}$, and Richardson numbers, $10^{-1} to 10^0$. The buoyancy Reynolds number versus Froude number diagram suggests strongly a regime of isotropic turbulence. In general, these turbulence estimates are in agreement with model predictions.

URL: http://nopp.uconn.edu

## OS41N-11 1120h

### AUV measurements of plume dispersion in a stratified, near-coastal flow

Derek A Fong[1] (650-723-1825; dfong@stanford.edu)

Mark T Stacey[2] (510-642-6776; mstacey@socrates.berkeley.edu)

Stephen G Monismith[1] (650-723-4764; monismith@ce.stanford.edu)

[1]Environmental Fluid Mechanics Lab, Dept. of Civil and Environmental Engineering, Stanford University, Stanford, CA 94305-4020, United States

[2]Dept of Civil Engineering, University of California, Berkeley, 509 Davis Hall, Berkeley, CA 94720-1710, United States

The dispersion of a passive scalar released from a near bed source is examined in the shallow near-shore waters at the Field Research Facility at Duck, NC. A fluorescent dye, Rhodamine WT is released for several hours during several flow conditions from a bottom source in May 2001. The dye concentration field is measured using a state-of-the-art autonomous underwater vehicle programmed to measure dye concentrations field at a fixed altitude over the bottom topography. The plume is tracked at distances up to 1 km from the source. Concurrent fixed point measurements of the velocity and density fields are also recorded near the source.

The first order plume advection downstream is well documented using a simple progressive vector analysis of the fixed ADCP measurements near the source. Additionally, the plume's vertical extent is consistent with the position of the bottom mixed layer thickness relative to height of the near bed source. An analytic expression for the plume's concentration as a function of radial distance for the source is developed for a scale-dependent dispersion coefficient and compared with previous investigations and tested against the "4/3-law." The role of meandering and time scales of variability in the plume evolution are also considered.

THU

## OS41N-12 1135h

### Stratified Three-Dimensional Circulation at a Barrier Island Inlet

James L. Hench[1] (252-726-6841 ext.178; hench@unc.edu)

Brian O. Blanton[1] (Brian_Blanton@unc.edu)

Richard A. Luettich[1] (Rick_Luettich@unc.edu)

[1]Institute of Marine Sciences, University of North Carolina at Chapel Hill, 3431 Arendell Street, Morehead City, NC 28557, United States

Recent observational data indicate that local circulation patterns at shallow inlets can have marked three-dimensional structure. We report on a combined observational and modeling study directed toward reproducing these spatial structures and understanding their underlying dynamics. Our study is based at Beaufort Inlet, North Carolina; a typical barrier island inlet with depths ranging from 5-15 m, and an inlet width of 1 km. The semidiurnal tide dominates the circulation with 1 m amplitude and maximum currents in excess of 1.5 m/s. Near inlet circulation fields were measured with 5 ADCP/CTD moorings. In addition, brief intensive shipboard ADCP/CTD measurements were made across a slice of the inlet throat, as well as on anchor stations over complete tidal cycles. Concurrent with the observations, a highly detailed model of Beaufort Inlet was constructed with high resolution bathymetry and shoreline geometry. Simulations were run with a three-dimensional, fully nonlinear, time-stepping, finite element model with Mellor-Yamada 2.5 and Smagorinsky turbulence closures. Horizontal nodal spacing was 50 m at the inlet and 11 sigma levels were used (yielding nearly 600,000 active computational nodes). We will present analyses of the three-dimensional flow kinematics and dynamics, model skill, and sensitivity tests. Both barotropic and baroclinic cases will be discussed, as well as the implications for lateral shear, mixing and exchange.

### OS41N-13 1150h

#### Internal waves and plume fate in a coastal stratified environment off Huntington Beach

Darek J Bogucki[1] (dbogucki@usc.edu)

Larry G Redekopp[2] (redekopp@spock.usc.edu)

Andrzej J Domaradzki[2] (jad@spock.usc.edu)

[1]RSMAS/Applied Marine Physics, University of Miami 4600 Rickenbacker Causeway, Miami, Fl 33149-1098, United States

[2]University of Southern California, Department of Aerospace and Mechanical Engineering, Los Angeles, CA 90089-1191, United States

We address the observed signature of internal waves (IW) near the beach and connects it with concurrent data. The internal wave effect was clearly visible in high resolution photographs. The IW were observed very close to the beach (O(100m) m away) and their effect on local transport was stronger than either surface swell or alongshore advection. We propose that IW may be the dominating factor determining the fate of pollutants in the near shore zone off Huntington Beach area under typical conditions. We have analytically determined the properties and fate of long internal waves originating at the shelf break (60 m deep water) and finishing in the surf zone -approximately 5-10 m deep water. The analysis of IW properties is complemented with remote hyperspectral data with from aerial photographs and Synthetic Aperture Radar (SAR). This approach together with mooring data provides a synoptic picture and general idea about internal wave generation and propagation and impact on surf zone transport. In addition we numerically examine plume behavior associated with discharge of sewage of Orange County Sanitation District (OCSD). We have used Direct Numerical Simulation (DNS) and Large Eddy Simulations (LES) programs currently used to simulate and predict behavior of OCSD outfall plume under different conditions.

## OS41O HC: 316 C Thursday 0830h

## Transport and Transformation of Biogeochemically Important Materials in Coastal Waters IV

***Presiding:*** **J L Largier,** Scripps Institution of Oceanography**; J A Barth,** College of Oceanic and Atmospheric Science

### OS41O-01 0835h

#### Oceanic and Atmospheric Structure and Evolution Observed by Aircraft During COAST 2001

John M. Bane[1] (919-962-0172; bane@unc.edu)

Sara M. Haines[1] (919-962-1253; sara_haines@unc.edu)

Melanie F. Meaux[1] (919-962-0020; verdier@email.unc.edu)

[1]Department of Marine Sciences, University of North Carolina, Chapel Hill, NC 27599-3300, United States

Twenty-seven flights with an instrumented aircraft were made to observe the structure and evolution of the ocean and lower atmosphere over the Oregon continental margin during the COAST summer 2001 field program. Flights were executed in a manner that coordinated with and extended measurements made by the COAST ship and moored instrumentation efforts. Aircraft measurements were made of oceanic surface temperature, oceanic subsurface temperature to depths up to 500m, upper-ocean color, atmospheric wind, temperature, humidity and pressure.

Atmospheric structure varied throughout the summer on periods ranging from diurnal to several days (the atmospheric synoptic scale), and an atmospheric temperature inversion typically, though not always, developed during episodes of northerly winds. An inversion rarely accompanied southerly winds. The principal oceanic response to atmospheric forcing was the onset of upwelling during sustained northerly wind events. The persistence of upwelled conditions for a number of days after the demise of northerlies (and sometimes the change to southerlies) was observed in ocean temperature and color fields. The nearshore upwelling band and separated upwelling jet over Heceta Bank were clearly delineated in the oceanic temperature field, and the chlorophyll field, as indicated by upper-ocean color data, followed these patterns. Small, nearshore regions of elevated chlorophyll concentrations were also seen and were related to terrestrial effects such as outflows from coastal rivers and lagoons. These and other characteristics will be discussed in detail in this presentation.

URL: http://www.marine.unc.edu/cool/coast

### OS41O-02 0850h

#### The Coastal Ocean Response to Summertime Downwelling Favorable Winds off Oregon

Jack A Barth[1] ((541)737-1607; barth@coas.oregonstate.edu)

Stephen D Pierce[1] ((541)737-2425; spierce@coas.oregonstate.edu)

[1]College of Oceanic and Atmospheric Sciences, Oregon State University, 104 Ocean Admin Bldg, Corvallis, OR 97331-5503, United States

On the strongly wind-driven continental margin of the northeast Pacific ocean, seasonal upwelling drives high biological productivity. During the summer when winds are generally upwelling favorable, there are periods when the winds are weak ("relaxed") or strongly downwelling favorable. During June 2000 and again in August 2001, the oceanic and ecosystem response off Oregon to strong summertime downwelling was observed. During the downwelling event, northward winds lasted 3-4 days and reached speeds of up to 40 knots. The surface layer warmed by about 4C over the entire continental shelf as warm oceanic surface water was advected onshore. The southward upwelling jet and the accompanying tilted isopycnals that existed before the downwelling event persisted, but were located over the mid- to outer shelf. Downwelled isopycnals were found within 15 km of the coast. Northward currents in excess of 0.2 m $s^{-1}$ were found inshore of the 70 m isobath and were continuous over the entire study region (130 km alongshore). Prior to the downwelling event, chlorophyll fluorescence was confined to the upper 20 m and was highest adjacent to the coast. During strong northward winds, high chlorophyll was downwelled with the isopycnals near the coast. Chlorophyll was distributed throughout the water column in water depths less than about 70 m. Details of the time evolution of the coupled physical and biological response to summertime downwelling will be presented. The response to strong downwelling favorable winds is compared with that accompanying wind relaxation. In the latter, N-S pressure gradients, e.g. as created by flow-topography interaction, can drive inshore flow northward, but without the accompanying downwelled isopycnals.

URL: http://damp.oce.orst.edu/coast

### OS41O-03 0905h

#### Effects of Topography on Currents During an Upwelling Relaxation Event

Sheila OKeefe[1] (5417373708; sokeefe@coas.oregonstate.edu)

P Michael Kosro[1] (5417373079; kosro@coas.oregonstate.edu)

J A Harlan[2] (3034976032; jharlan@etl.noaa.gov)

[1]College of Oceanic Atmospheric Sciences, 104 Ocean Admin Bldg. Oregon State University, Corvallis, OR 97331-5503, United States

[2]NOAA/ERL/ETL, R/E/ET1, 325 Broadway, Boulder, CO 80303, United States

Upwelling events along the west coast of North America are separated by relaxation events in which the winds weaken or even reverse to downwelling-favorable. These events influence alongshore and cross-shelf transport, including larval dispersal. Upwelling conditions tend to produce southward and offshore advection, while downwelling conditions tend to produce northward and onshore advection. Eddies and other mesoscale current features modify these larger-scale advection patterns.

A sequence including upwelling, reversal to downwelling, and return to upwelling occurred in May 1996 near Cape Blanco, Oregon. Wind measurements indicate upwelling-favorable conditions through May 16, 1996. On May 17-18, 1996 a storm moved through the area with strong downwelling-favorable winds. After the storm, winds again were upwelling-favorable. During this period, a Seasonde coastal-based radar system measured surface currents in the Cape Blanco area, extending approximately 40km offshore by 30km alongshore. CTD casts, Seasoar tows, and mooring data provide subsurface data during this period. These data provide detailed observations of current behavior throughout the upwelling event and subsequent wind reversal, including the formation of an anticyclonic eddy over a topographic high, which reverses to cyclonic when winds return to upwelling-favorable. These detailed observations provide an opportunity for analysis of the dynamics behind formation of an eddy over a topographic high and its impact on cross-shelf transport.

### OS41O-04 0920h

#### Model simulations of Eulerian and Lagrangian aspects of the upwelling circulation over the Oregon shelf

Jianping Gan[1] (541-737-2865; gan@coas.oregonstate.edu)

J. S. Allen[1] (541-737-2928; jallen@coas.oregonstate.edu)

[1]College of Oceanic and Atmospheric Sciences, Oregon State University, 104 Ocean Admin. Bldg., Corvallis, OR 97331, United States

Time-dependent, three dimensional circulation on the continental shelf off Oregon is studied using the Princeton Ocean Model (POM). The objective is to combine Eulerian and Lagrangian analyses to better understand water particle movement associated with the temporal and spatial variability of upwelling dynamics on the Oregon shelf. The Lagrangian analysis is implemented through the calculation of the evolution of three conservative tracer fields that are initialized, respectively, with each of the three model coordinates. Ideally, this allows calculation of water particle displacement for every particle. A limited-area high resolution curvilinear grid ($\triangle$x, $\triangle$y<1.5 km, $\sigma$=45) with realistic Oregon bottom topography is used. A model domain with periodic alongshore boundary conditions is chosen for the study. The response of the coastal ocean during summer 1999 upwelling conditions to forcing by observed wind stress and heat flux is examined. The model-produced alongshore velocities compare favorably with ADCP current measurements, with better agreement found on the inner shelf. The model fields show that the large variations of the shelf bottom topography associated with Heceta Bank and the large variations of the coastline provided by Cape Blanco exert major influences on the shelf circulation and the associated density fields. The time mean surface temperature field indicates stronger upwelling over Heceta Bank and south of Cape Blanco. The Lagrangian analysis shows significant alongshore variation in the onshore paths of upwelled water. In particular, intensified onshore and vertical displacements of water particles are found over Heceta Bank and south of Cape Blanco, coincident with the locations of stronger upwelling. Relatively large onshore flows in the interior of the water column over the shelf are found in these locations. An examination of Eulerian term balances in the alongshore momentum equation shows that stronger onshore flows in these regions are associated with a northward pressure gradient force. Strong nonlinear advective effects in the coastal jet along the western edge of the bank contribute to the generation of a northward ageostrophic pressure gradient force and to the formation of a local cyclonic circulation. Lagrangian analysis shows that onshore flow occurs in the bottom boundary layer on the southern edge of the bank. The southward transport of water at the surface veers offshore following the isobaths over the bank, while northward transport of water particles occurs at depth south of the bank.

### OS41O-05 0935h

#### Microstructure Measurements From a Towed Undulating Platform and Their Relationship to Mesoscale Circulation and Bottom Topography

Michael W. Ott[1] ((541) 737-2991; mwott@coas.oregonstate.edu)

Anatoli Y. Erofeev[1] ((541) 737-4656; aerofeev@coas.oregonstate.edu)

Jack A. Barth[1] ((541) 737-1607; barth@coas.oregonstate.edu)

James N. Moum[1] ((541) 737-2553; moum@coas.oregonstate.edu)

Alexander Perlin[1] ((541) 737-2990; aperlin@coas.oregonstate.edu)

[1]College of Oceanic and Atmospheric Sciences, Oregon State University, 104 Ocean Admin. Bldg., Corvallis, OR 97330, United States

Compared with conventional free-falling profilers, the use of a microstructure instrument on a towed, undulating platform, such as the recently-developed MicroSoar, allows for a more rapid survey of the distribution and magnitude of turbulence over a larger area. Such an overview is clearly important in our effort to understand the interplay between wind events, turbulence, and mesoscale circulation. One of the specific hypotheses to be tested by the Coastal Ocean Advances in Shelf Transport (COAST) experiment, whose broad aim is to examine the effect of wind-driven processes on cross-shelf transport off the Oregon coast, is that patterns of turbulence on the shelf during both upwelling and downwelling conditions are influenced by fronts and jets, and the levels of turbulence can reach sufficient intensity to influence the mesoscale circulation.