and sulfur speciation strongly correlate with the distribution of specific taxa within different microhabitats. These findings suggest that the chemical composition of hydrothermal fluids may control the different patterns of colonization and distribution exhibited by symbiont and nonsymbiont-bearing invertebrates. In addition, recent results of Amplified Fragment Length Polymorphism (AFLP) genomic fingerprinting studies indicate that the genetic relationships among recent invertebrate colonizers, including closely-spaced (400 meters) and distant (3000 meters) Riftia populations are consistent with larval dispersal and habitat colonization processes that retain the genetic integrity of individual vent assemblages via the discrete transport and settlement of larval cohorts in chemically suitable microhabitats. Detailed experiments coupling in-situ time-series chemical characterization of vent habitats and fine-scale genomic fingerprinting techniques, through the use of deep-submergence assets and long-term seafloor observatories, are poised to provide novel insights into the specific mechanisms structuring mid-ocean ridge ecosystems.

OS41L-12 1140h

Rates of Primary Productivity by two Hydrothermal Vent Vestimentiferan Tubeworms: *Riftia pachyptila* and *Tevnia jerichonana*

Peter Riad Girguis[1] (831-775-1826; girguis@mbari.org)

James Childress[2] (805-893-3203; childres@lifesci.ucsb.edu)

[1]Peter Riad Girguis, MBARI 7700 Sandholdt Road, Moss Landing, CA 95039, United States

[2]James Childress, University of California Santa Barbara Marine Science Institute, Santa Barbara, CA 93106, United States

Riftia pachyptila and *Tevnia jerichonana* are hydrothermal vent vestimentiferans that thrive at diffuse flow sites along the East Pacific Rise. Both species are symbiotic with carbon-fixing autotrophic bacteria. During shipboard high-pressure respirometry experiments, individuals of both species were maintained in a range of conditions found in situ. During these experiments, primary productivity rates were calculated from the net inorganic carbon uptake rates. Both *Riftia pachyptila* and *Tevnia jerichonana* have net inorganic carbon uptake rates (hereafter referred to as "primary productivity rates") that are comparable to the highest recorded rates of bacterial, algal and plant primary productivity in marine environments. Averaged net productivity rates of *Riftia pachyptila* were also comparable to the net productivity rates of communities such as mangrove swamps and coastal upwelling zones. While net microbial primary productivity at vents has not been well assessed, it is likely that primary productivity by fast-growing vestimentiferans contributes significantly to net primary productivity at hydrothermal vent communities. The ramifications and consequences of vestimentiferan primary productivity on community development and sustenance will be discussed.

URL: http://www.petergirguis.com/

OS41M HC: 323 C Thursday 0830h

Biogeoinformatics: Challenges at the Intersection of Biological, Biogeochemical, and Physical Data Over Multiple Scales of Space and Time II

Presiding: **K Stocks,** University of California, San Diego**; C S Jones,** University of California, Santa Barbara

OS41M-01 0830h

Patterns Emerging from the LOICZ Biogeochemical Budget and Typology Datasets

Dennis Swaney[1] (dps1@cornell.edu)

Steve Smith[2] (svsmith@soest.hawaii.edu)

Vilma Dupra[2] (vdupra@soest.hawaii.edu)

[1]Boyce Thompson Inst/Cornell University, Tower Rd, Ithaca, NY 14850, United States

[2]SOEST University of Hawaii, 1000 Pope Road, Honolulu, HI 96822, United States

As of November, 2001, the Land Ocean Interactions in the Coastal Zone (LOICZ) project has assembled nutrient budgets for over 170 coastal systems around the world, and, in a parallel effort, a database of over 100 global distributed environmental variables at the 1/2 degree scale. Integrating this information, diverse in both scale and data quality, has posed some formidable challenges. We discuss what we have learned so far about integration and scaling of these data in the search for global and regional patterns.

OS41M-02 0855h

Modeling and Model-Data Comparisons in the Monterey Bay area.

Reginaldo Durazo[1] (rdurazo@vigia.ens.uabc.mx)

Igor Shulman[2] (228-6883403; shulman@coam.usm.edu)

Jeff Paduan[3] (paduan@nps.navy.mil)

Leslie Rosenfeld[3] (lkrosenf@nps.navy.mil)

Steve Ramp[3] (sramp@nps.navy.mil)

[1]UABC-FCM, Ensenada, B.C., Mexico

[2]COMS, USM, Stennis Space Center, MS

[3]NPS, Monterey, CA

The fine-resolution numerical ocean model of the Monterey Bay Area (ICON model) has been developed under the NOPP "An Innovative Coastal-Ocean Observing Network" (ICON) project.

The ICON model's major elements are: the Princeton Ocean Model-based ICON ocean model is coupled to the larger-scale Pacific West Coast (PWC) model; the ICON model is forced with atmospheric products from coarser-resolution NOGAPS and finer-resolution COAMPS Navy atmospheric models; the ICON model assimilates HF radar-derived surface currents and MCSST data.

The focus of this paper is on: influence of coarser- versus finer-resolution atmospheric forcing on the model's predictive skills; impact of open boundary conditions and coupling with larger-scale PWC model on reproducing major hydrographic conditions in the Monterey Bay area; influence of heat fluxes versus MCSST assimilation on the ICON mixed layer depth predictions; impact of the HF radar surface currents assimilation on the ICON model predictions.

Qualitative and quantitative comparisons are made between observations and model predictions for the entire 1999 year as well as for August-September of 2000.

URL: http://coam.usm.edu/ICON

OS41M-03 0910h

Meso-Scale Eddies of the Gulf Loop Current as Spawning and Nursery Habitat for Scombrid Fishes

John T Lamkin[1] (305-361-4226; John.Lamkin@noaa.gov)

John J Govoni[2] (252-728-8727; Jeff.govoni@noaa.gov)

Tom D Leming[3] (228-688-1214; Thomas.D.Leming@noaa.gov)

Joanne Lyczkowski-Shultz[4] (228-762-4591; Joanne.Lyzckowski-Shultz@noaa.gov)

[1]Southeast Fisheries Science Center, NOAA, 75 Virginia Beach Dr., Miami, FL 33157

[2]NOAA Beaufort Laboratory, 101 Pivers Island RD., Beaufort, NC 28516

[3]NOAA Mississippi Laboratories Stennis Space Center Facility, Bldg 1103, Room 218, Stennis Space Center, MS 39529

[4]NOAA Mississippi Laboratories, Pascagoula, 3209 frederic Street, Pascagoula, MS 39567

Bluefin tuna, Thunnus thynnus and other scombrids spawn in the Gulf of Mexico in Late April, May, and into early June. The relationship between larval bluefin tuna and thermal fronts has been established through previous studies, while an assessment of eddies and their associated fronts as spawning and nursery habitat has not been undertaken. The coupling of physical, biological, and fisheries oceanography is requisite for the proper assessment and description of these features as spawning and nursery habitat. MESHES, Mesocale Eddy Scombrid Habitat Ecological Study, was designed to identity and describe eddies as spawning and nursery habitat by locating these features and collecting biological and physical data.

In 1995 we began a three year effort to examine cold-core cyclonic eddies in the eastern Gulf of Mexico. A large cold core cyclonic eddy was present in 1996, and 1997, and we present data from these two years. In both 1996, and 1997, a broad area of cold-core circulation was located to the north of the Loop current in the eastern Gulf of Mexico, and was present throughout the year. The eddies were approximately 160 km in diameter. In both years transects passed through the eastern portion of the cyclone, and into the Loop Current. Despite peaks in chlorophyl abundance, and a significant shallowing of the chlorophyl maximum, scombrid larvae were not abundant in the Gyre. Instead they appear to be concentrated in the upper 25 meters the of the interface between the cold-core ring - Loop Current

OS41M-04 0925h

Circatidal Activity Rhythms in Ovigerous Blue Crabs *Callinectes sapidus*: Implications for Selective Tidal-Stream Transport

Richard A Tankersley[1] ((321) 674-8195; rtankers@fit.edu)

Richard B Forward[2] ((252) 504-7610; rforward@duke.edu)

Patricia N Pochelon[1] (ppochelon@fit.edu)

[1]Florida Institute of Technology, Department of Biological Sciences 150 W. University Blvd., Melbourne, FL 32901, United States

[2]Duke University Nicholas School of the Environment, Duke Marine Laboratory, Beaufort, NC 28516, United States

Prior to larval release, ovigerous blue crabs *Callinectes sapidus* migrate seaward from low-salinity areas of estuaries to spawn near the entrance. Previous studies found that ovigerous crabs use selective tidal stream-transport (STST) to enhance the rate and efficiency of down-estuary transport. Crabs enter the water column during nocturnal ebb-tides and remain on or near the bottom at all other times. Possible behaviors contributing to this tidal vertical migration pattern are (1) a circatidal swimming rhythm, and (2) behavioral responses to environmental factors. We tested the hypothesis that active upward movement into the water column on ebb tides is the result of an endogenous rhythm in activity. Ovigerous crabs were collected near Beaufort Inlet, North Carolina, during July-August 2001 and swimming activity was recorded for 3 to 5 d under constant conditions with a time-lapse video system. Crabs with egg masses containing late-stage embryos ($<$ 6 days from hatching) displayed a circatidal activity rhythm with two activity peaks per lunar day. In most cases, maximum swimming activity occurred near the time of expected slack-water before ebb in the field. Following larval release, the activity of most crabs became arrhythmic. Similarly, this rhythm was not expressed by gravid females possessing egg masses containing early-stage embryos ($>$ 7 days from hatching). These results are consistent with field observations of the migratory behavior of crabs obtained using ultrasonic telemetry and support the hypothesis that a tidal rhythm in swimming is the behavioral basis of ebb-tide transport in ovigerous *C. sapidus*.

OS41M-05 0940h

Field Observations of Ebb-Tide Transport of the Blue Crab *Callinectes sapidus* Near a Barrier Island Inlet Using Ultrasonic Telemetry

Sarah D. Carr[1] (sdcarr@email.unc.edu)

Richard A. Tankersley[2] (rtankers@fit.edu)

James L. Hench[1] (hench@marine.unc.edu)

Richard B. Forward[3] (rforward@duke.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

[2]Department of Biological Sciences Florida Institute of Technology, 150 West University Boulevard, Melbourne, FL 32901, United States

[3]Duke University Marine Laboratory, 135 Duke Lab Road, Beaufort, NC 28516, United States

Female blue crabs *Callinectes sapidus* migrate from low salinity estuarine regions to high salinity regions near the ocean to release their larvae. In order to characterize movement patterns during these spawning migrations, we used ultrasonic telemetry to track ovigerous crabs near Beaufort Inlet, North Carolina, during July-August, 2001. Crabs with mature egg masses were caught in the estuary during nocturnal ebb tides, tagged with ultrasonic transmitters, and quickly released in the vicinity of Beaufort Inlet. Crabs were then tracked by boat using an ultrasonic receiver and hydrophone. Current measurements were obtained while tracking using a boom-mounted shipboard ADCP.

Ten crabs were tagged during the spawning season. Tracking duration ranged from $<$ 1 h to $>$ 37 h. Three crabs were tracked through the initial night ebb and

displayed behavior consistent with ebb-tide transport, a vertical migration pattern where an animal enters the water column during ebb tide and remains at the bottom during flood tide. The crabs were transported seaward in the water column during nocturnal ebb tides and stopped moving shortly (within 1 h) after the beginning of the subsequent flood tide. Although some movement was observed during flood tides and diurnal ebb tides, this movement was of limited duration and distance and generally against prevailing currents. One crab was tracked through a second nocturnal ebb tide. Seaward transport began again shortly after the onset of the second nocturnal ebb and ended shortly after the beginning of the subsequent flood. While migrating on nocturnal ebb tides, crabs exhibited an unexpected "hopping" behavior, in which they alternated between rapid transport in the water column and remaining stationary at the bottom. This hopping behavior resulted in net transport that was less than a third of what would be predicted for passive particles transported by the currents near the crabs.

OS41M-06 1015h

Data Base and Atlas of Hydrochemistry for the Arctic Ocean

Roger Colony[1] (907 474 5115; rcolony@iarc.uaf.edu); Ye. G. Nikiforov[2]; Sergey M. Pivovarov[2] (pivovarov@actor.ru); O. M. Pokrovsky[2]; Sergey M. Priamikov[2]; Leonid A. Timokhov[2] (ltim@aari.nw.ru)

[1]IARC/Frontier, P.O. Box 757335, Fairbanks, AK 99775, United States

[2]Arctic and Antarctic Research Institute, 38 Bering St., St. Petersburg 199397, Russian Federation

The AARI and IARC have initiated a project to bring hydrochemistry data (silicate, phosphates, dissolved oxygen, nitrate, nitrite, and pH) of the Arctic Ocean into a common database and to produce an electronic atlas. Hydrochemistry data from about 21,000 stations and 500 arctic expeditions have been assembled. Most of the data are from Russian programs and span the period 1950-1995. Quality control procedures are described. The database is in two forms – the data as transcribed from the original logbooks and the data as edited under QC procedures. Appropriate flags are employed.

The data now reside on Version 1.0 of the electronic atlas, which includes analyzed horizontal fields, selected sections, and representative vertical profiles. Above 500 meters, the data are grouped into late winter (Feb-April) and late summer (Aug-October); below 500m the data are analyzed independent of season. The mean horizontal fields are shown at selection of depths, fourteen above 500 m and nine horizons below 500m. Additionally, the mean fields are supplemented by fields of interannual variability.

The data, meta-data, a short monograph, and the figures are available on a CD. The data are organized to be easily visualized by Ocean Data Viewer; Schlitzer, 2001. A second phase of this project is envisioned, during which additional data will be solicited and the scientific use of the data will be promulgated.

OS41M-07 1030h

Sea Surface Salinity Measurements in the Historical Database

Stephan Howden D. Howden[1] (228 688-5284; stephan.howden@usm.edu)

Frederick M. Bingham[2] (910 962-2383; binghamf@uncwil.edu)

Chester J. Koblinsky[3] (301 614-5697; chet@neptune.gsfc.nasa.gov)

[1]University of Southern Mississippi, Department of Marine Science 1020 Balch Blvd., Stennis Space Center, MS 39529-9904, United States

[2]University of North Carolina at Wilmington, Center for Marine Science 5600 Marvin K. Moss Lane, Wilmington, NC 28409, United States

[3]NASA, Goddard Space Flight Center, Greenbelt, MD 20771, United States

We have examined historical distributions of sea surface salinity (SSS) observations in the World Ocean Database 98 (WOD98) database. We find that SSS in much of the world's ocean is measured infrequently or not at all. 35% of one degree squares in the world ocean (open and coastal, excluding the Arctic Ocean) had no observations of SSS in the historical database, and 88% had less than 10. Systematic sampling of SSS (more than 10,000 observations per year globally) did not start until after 1960. Most SSS observations in the WOD98 are concentrated in the North Sea and coast of northern Europe, the east and west coasts of North America and around Japan. About 1/3 of SSS measurements are in coastal waters.

We plotted frequency histograms of SSS for some selected one degree squares in the North Atlantic and tropical Pacific. We found most frequency histograms to be non-Gaussian. The main departure from normal distribution is due to anomalous low salinity measurements creating a negative skewness. These anomalous low salinity values may be due to rainfall events, but there are other plausible physical mechanisms. There were also areas where the distributions were bimodal due to the presence of fronts. The non-Gaussian nature of the distributions in the areas examined is both a short-term and long-term phenomenon. That is, the distributions are skewed on a nearly instantaneous (1 month) basis and averaged over long time periods (1+ years). The implication for validation studies for remote sensing missions is that the studies must make enough measurements of SSS to determine the extent to which the probability density is not Gaussian.

URL: http://www.fredbingham.com/sss/wod98

OS41M-08 1045h

A Limited Area, Operational, Coastal Ocean Model of the South Atlantic Bight with Far Field Ocean Model Forcing and Data Assimilation

Rick Luettich[1] (252-726-6841 x137; rick_luettich@unc.edu); Brian Blanton[1] (brian_blanton@unc.edu); Alfredo Arechavaleta[1] (alfredo@email.unc.edu); Cisco Werner[1] (cisco_werner@unc.edu); Harvey Seim[1] (hseim@email.unc.edu); Chris Naimie[2] (chris.naimie@dartmouth.edu); Dan Lynch[2] (daniel.r.lynch@dartmouth.edu); Eric Sills[3] (sills@ncsc.org); Dennis McGillicuddy[4] (dmcgillicuddy@whoi.edu); Pat Welsh[5] (pat.welsh@noaa.gov)

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

[2]Thayer School of Engineering, Dartmouth College, Hanover, NH 03755, United States

[3]North Carolina Super Computing Center, 3021 Cornwallis Rd., Research Triangle Pk, NC 27709-2889, United States

[4]Applied Ocean Physics and Engineering, Woods Hole Oceanographic Institution, Woods Hole, MA 02543, United States

[5]National Weather Service, 13701 Fang Dr., Jacksonville, FL 32218, United States

Our objective is to build an operational system for limited-area forecasting of the coastal ocean. This system is applied in the South Atlantic Bight (SAB), although it is modular in design and portable to other waters. It takes advantage of recent advances in (i) shelf circulation modeling, (ii) large scale ocean modeling to derive far field boundary conditions and (iii) real time data acquisition and assimilation.

The limited area model consists of the three-dimensional, nonlinear, baroclinic, QUODDY/TRUXTON/CASCO forward/inverse modeling system operating on a grid that covers the SAB continental shelf from northern Florida to southern North Carolina. This system is currently driven by nowcasts/forecasts from the 32 km Eta meteorological model (National Weather Service) for surface boundary conditions and nowcasts/forecasts from a regional, high-resolution, vertically-integrated ocean model (ADCIRC) for barotropic open water boundary conditions. We are also working toward coupling it with an operational, basin-scale ocean model capable of providing nowcasts of Gulf Stream hydrography and dynamics (e.g., HYCOM, Univ of Miami, or COFS, NOAA) for initial and open water boundary conditions on baroclinic fields. Satellite derived SST data and real time observational data from in-situ instrumentation located at towers that comprise the South Atlantic Bight Synoptic Offshore Observational Network (SABSOON) will be assimilated into the QUODDY/TRUXTON/CASCO solution. Observational System Simulation Experiments are currently being conducted to develop effective sampling and assimilation strategies.

Model output is web served at www.ncsc.org/nopp/sabsoon and routinely includes nowcast/forecast waterlevels at 43 NOS US East Coast and Gulf of Mexico stations from the ADCIRC run (no data assimilation) and waterlevel, velocity and density fields in the limited area model domain (with data assimilation). This information is sought for improved regional navigation, for interpretation of physical and biological data (including ocean color data) in the SAB, for design of sampling programs in this region and to provide high resolution sea surface temperature and sea-air moisture fluxes to a fine grid, 9 km version of the Eta meteorological model that is being run in research mode by the NWS.

OS41M-09 1100h

What you see is not Always What you get. Comparison of a Zooplankton-Imaging Sensor (SIPPER) With Concurrent Optical Plankton Counter and net Data From the Gulf of Mexico.

Andrew W Remsen[1] (7275533970; aremsen@marine.usf.edu)

Scott Samson[2] (7275533915; samson@marine.usf.edu)

Thomas L Hopkins[1] (7275531501; thopkins@marine.usf.edu)

[1]University of South Florida College of Marine Science, 140 7th Ave S., St. Petersburg, FL 33701, United States

[2]Center for Ocean Technology University of South Florida, 140 7th Ave S., St. Petersburg, FL 33701, United States

Zooplankton were sampled in the eastern Gulf of Mexico using the High Resolution Sampler (HRS) that has the capability of simultaneously imaging and collecting zooplankton in a multiple cod-end net carousel. Imaging was carried out by the Shadowed Image Particle Profiling and Evaluation Recorder (SIPPER) developed at USF. Additionally, an optical plankton counter (OPC) was also part of the instrument suite. Comparison of net, SIPPER and OPC data indicate that each sensor has inherent strengths and weaknesses that need to be accounted for in zooplankton studies. Net sampling consistently underestimated important groups of zooplankton most especially gelatinous and fragile organisms that are probably destroyed, damaged or extruded during collection. SIPPER often imaged these organisms at abundances many times higher than that estimated by the nets. For example, Larvacean abundances calculated using SIPPER were often 300-1000% more abundant than that estimated by net sampling. SIPPER at its present imaging resolution often undersampled compared to nets, the small calanoid and poecilostomatoid copepods that are important components of low-latitude systems and that are at the low-end of OPC detection limits. The OPC generally agreed with SIPPER estimates of total particle abundance and size spectra but offered nothing in the way of identification, which was expected in a high-diversity ecosystem. However, the presence of the cyanophyte Trichodesmium, oftentimes the most abundant organism imaged by SIPPER, was rarely found intact within the net samples. Therefore reliance on net samples and OPC data alone to determine zooplankton and particle population structure within the water column may significantly underestimate important components of the plankton. The inclusion of imaging instruments is therefore recommended for comprehensive sampling of the zooplankton.

THU

OS41M-10 1115h

The Concept or the Number: Problems of Scale, Precision, Visualization, and Communication

Robert W Buddemeier[1] (785-864-2112; buddrw@ku.edu)

Bruce A Maxwell[2] (610-328-8081; maxwell@swarthmore.edu)

Jeremy D Bartley[1] (785-864-2112; jbartley@kgs.ukans.edu)

[1]Kansas Geological Survey, University of Kansas 1930 Constant Avenue, Lawrence, KS 66047, United States

[2]Swarthmore college, Swarthmore College, Swarthmore, PA 19081, United States

Increasingly, information can move in an automated fashion from sensing device to database to analytical tool to final product, often with an admixture of other data and substantial transformation or processing along the way. Disciplinary conceptual models of such processes are based implicitly on assumptions that everybody agrees on and knows the appropriate pathway and form and presentation of the product. These assumptions are not valid in cross-disciplinary applications, where checkpoints and alternative pathways in data flow and processing are critical. Shared visualization (in 2, 3, 4, or even more dimensions) is vital to scientific cooperation and communication, but raises the geographers dilemma: the most rigorous or scientifically accurate representation is often not the most subjectively informative. Particularly when different types of variables (intensive/extensive, classified/continuous, skewed/normally distributed) are combined in a single analysis or model, mismatches in units, data handling, or transformations may compromise the desired results. For example, unit conversions alter apparent precision, and differences between latitude-longitude and equal-area grid systems are immaterial for normalized variables (concentrations or surface densities), but can be critically important if quantitative budgets are desired.

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

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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 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