RARGOM Theme Session
On
Integrated Multidisciplinary Modeling
Campus Center, University of Massachusetts at Boston
Boston Massachusetts
July 15, 2004

AGENDA

08:30 – 09:30	**Pastries and Coffee and Poster Set-up**
09:30 – 09:45	**Welcoming Remarks and Logistics**
09:45 – 12:30	**Oral Presentations**
12:30 – 01:30	**Lunch and Poster Session**
01:30 – 03:00	**Discussion**
03:00 – 03:15	**Break**
03:15 – 04:00	**Discussion and Concluding Remarks**

ABSTRACTS

Oral Presentations

Modeling Coastal Ecosystem Dynamics

Chai, F., School of Marine Sciences, University of Maine

With recent advancing in biological observations and improving in coastal circulation modeling, ecosystem dynamics and its response to change of physical conditions can be investigated by developing and testing physical-biological models. A multiple nutrient and plankton ecosystem model has been implemented into two coastal circulation models, with the Princeton Ocean Model (POM) for the Gulf of Maine, and Regional Ocean Model System (ROMS) for the central California upwelling system focusing on the Monterey Bay region. The ecosystem model has the same structure and similar parameter values for both the Gulf of Maine and the Monterey Bay. Some preliminary results will be presented, and some of modeling issues will be shared and discussed.

A New Model System for the Gulf of Maine and Adjacent Coastal Regions

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A new coastal and estuarine management model system has been developed based on a finite-volume coastal ocean model (FVCOM). This system includes four components: 1) a mesoscale meteorological model (MM5), 2) the hydrodynamics model (FVCOM), 3) a multiple species NPZD model and 4) a computer interface GUI system. The regional MM5 model uses larger scale NCEP numerical weather model output to provide 3-5 day forecast fields of surface winds, wind stress, heat flux, precipitation, and evaporation with 10-km resolution, and nowcast and hindcast fields that incorporate real-time NDBC buoy and coastal wind measurements. FVCOM is driven by tidal forcing at the open boundary over the deep ocean and shelf, the MM5 surface forcing fields, freshwater discharge from rivers and groundwater sources, and the upstream coastal current over the Scotian shelf. FVCOM also includes a wet/dry point treatment that allows simulation of flooding and drying processes in an estuarine-tidal creek-salt marsh intertidal complex. A nudging data assimilation method is incorporated into FVCOM, so that available in-situ real-time data can be used to improve model environmental simulations and prediction. Two ecosystem models (the NPZD and a Lagrangian-based IBM model) have been developed

to run offline using FVCOM output. The GUI interface system allows users to visualize the distributions and animations of selected physical, biological and chemical state variables. As part of the Georges Bank GLOBEC program, this FVCOM system has been used to simulate the 3-D circulation, temperature and salinity fields in the Georges Bank/Gulf of Maine region for the years 1995 and 1999 with excellent results. FVCOM features an unstructured grid, which allows the model grid to be easily extended to cover the inner shelf, near-shore region (including embayments, estuaries, and the intertidal zone) with high horizontal resolution.

Assimilating *in-situ* Measurements into the Coastal Ocean Model through the Adjoint Inversion: A Hindcast Study of the Gulf of Maine Coastal Circulation

He, R.[1], D. J. McGillicuddy[1], K. W. Smith[2], D. R. Lynch[2], J. P. Manning[3], and C. A. Stock[1]

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Data assimilation (DA) in the coastal ocean is a relatively new and rapidly developing field. So far, most of DA studies applied sequential estimation methods of nudging and/or optimal interpolation. Such techniques blend models with observations directly, using a variety of algorithms with which the relative weights of data and model are calculated. In contrast, DA through adjoint inversion has shown considerable promise and advantages. Such techniques infer model inputs (e.g. parameters, forcing functions, boundary conditions, etc.) that minimize the misfit between observations and predictions. One major distinction between adjoint inversion and sequential estimation is that solutions resulting from the former obey the ocean model dynamics.

During the last several years, the Dartmouth modeling team has made significant progress in the development of the adjoint technique for the direct assimilation of *in-situ* data via inversion for the unknown sea level elevation at open boundaries. We implement and examine the utility of this technique in this work to study the coastal circulation and the material property transport in the Gulf of Maine in May-June 2003. *In-situ* measurements include moored and ship-board ADCP currents, coastal sea levels, and trans-shelf temperature and salinity fields, which in together are used to invert for both the tidal band and the weather band sea levels at the offshore open boundary. The model solution is validated through the inter-comparison between modeled and observed drifter trajectories. As demonstrated by an overall trajectory divergence, this data assimilation system provides decent model skill and thus a reliable working tool to interpret material property transports and physical/biological processes in the costal ocean.

Data Synthesis and Modeling of Lobster Recruitment in the Gulf of Maine

Incze, L.[1], H. Xue [2] , C. Wilson [3], R. Steneck [2], Y. Chen [2], R. Wahle [4], P. Lawton [5], F. Page [5], N. Pettigrew [2], D. Townsend [2], D. Greenberg [6], D. Brooks [7], N. Wolff [1], D. Xu [2] and E. Annis [8]

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We are building a mechanistic model of lobster population recruitment by combining life history data with a spatially explicit circulation model for larval transport, geological data for settlement, and a size-structured growth model for fishery production in the western Gulf of Maine. Life history and vital rate data come from a variety of observational and experimental programs, and one challenge has been to construct life tables that are consistent with both small-scale (experimental and observational) and population-scale (assessment and fishery) data. We will present our over-all strategy for model development and evaluation, with an emphasis on the coupled (bio-physical) larval transport system.

Towards Validating Gulf Of Maine Circulation Models With Drifter Observations

Manning, J., NOAA Northeast Fisheries Science Center, 166 Water St, Woods Hole, MA 02543

Recent satellite-drifter deployments by New England lobstermen are providing valuable observations of surface currents needed to validate coastal-ocean circulation models. The drifters, built by Southern Maine Community College Marine Science students, have GPS transmitters that provide hourly fixes in realtime. Over 20 units, most entrained in the Maine Coastal Current, are expected to pass by (or possibly enter) Mass Bay this summer. While the density structure is evidently dominating the mean pathway, wind drives much of the spatial and temporal variability. Episodes of both downwelling and upwelling events are documented. The preliminary observations of this study, funded by the Northeast Consortium, will be presented along with simulated particle tracks.

The Formation of a High Nutrient and Low Dissolved Oxygen Pool in Central Cape Cod Bay During Summer

Jiang, M., M. Zhou and G. Wallace, Department of Environmental, Coastal and Ocean Sciences, University of Massachusetts Boston, 100 Morrissey Blvd., Boston, MA 02125

Numerical experiments using a water quality model have suggested the existence of a high nutrient pool in central Cape Cod Bay during summer, which is supported by measurements of nutrients in the water column and trace metals in surface sediment. The high nutrient pool is associated with intensive nutrient regeneration processes, which lead to low dissolved oxygen in the pool. The generation and maintenance of this pool are studied and its implications to the fate of organic matters in Massachusetts and Cape Cod Bays are discussed.

Lagrangian Simulations in the Gulf of Maine

Lynch, D. R., A. Bilgili, K. W. Smith, J. A. Proehl, Dartmouth College, Hanover, NH 03755

Lagrangian trajectories will be displayed for a) Georges Bank Frontal System, b) the Great Bay Estuarine System, and c) the Gulf of Maine Coastal Current. The Georges Bank trajectories illuminate the dynamics of transport near the mixing front on the North Flank. QUODDY forecasts were achieved at sea and in real time, assimilating shipboard and networked data. Mimicking a dye release experiment, ensembles of particles are released and tracked. The distribution shows extreme sensitivity to the wind forecast, exhibiting dramatic asymmetry in space-time. The ensemble properties in terms of mean location and variance are reported. The effect of shear dispersion is quantified. The diffusive generator for this process is a Level 2.5 vertical closure, operating in tidal time in highly-structured horizontal and vertical advective fields.

The Great Bay trajectories illuminate the residence time issues for material in this small coastal embayment, and the exchange probabilities with the coastal ocean. Very large ensembles support three different residence time calculations, as well as a Markov model of transition probabilities among 6 geographic boxes. This work is aimed in the long run at modeling the transport, trophic transfer and fate of toxic substances in this system.

The Coastal Current trajectories are focused on life-cycle closure of *Alexandrium fundyese* populations. The life cycle of this dinoflagellate involves a cyst stage in the benthos, occupied between seasons of vegetative growth. Individual-based trajectories are initiated in the cyst beds and the process of vegetative growth, encystment, and return to the benthos are simulated as Lagrangian ensembles. The possibility of life cycle closure for this organism is related to the ability to deduce the vital rates of the population and their dependencies.

Metal Distributions in the Water Column and Sediments of Boston Harbor, Massachusetts and Cape Cod Bays – An Integrated Modeling Approach.

Wallace, G. T., F. Pala, L. Li, M. Jiang, M. Zhou and C. Krahforst, Department of Environmental, Coastal and Ocean Sciences, University of Massachusetts at Boston, 100 Morrissey Blvd., Boston, MA 02125

Data acquired on metal concentrations in the water column and sediments of Boston Harbor, and Massachusetts and Cape Cod Bays by a large number of investigators and agencies have provided a rich data base that provides information on their source and distribution. We have used that data to develop a simple sediment-water dynamic equilibrium model to describe the coupling of water column and surface sediment concentrations of metals. With the advent of increasingly sophisticated physical circulation models for this area we now have the capability to explore the possibility of integrating the sediment-water equilibrium model with the physical circulation models and use the existing data to verify both water column and surface sediment metal distributions in the Harbor and Bay. Use of contemporary and historical source strength data to predict the water column distribution of metals using simple conservative transport of selected metals has been completed as have refinements of the sediment-water dynamic equilibrium model. The results are consistent with available data. Exploration of the appropriate temporal and spatial scales over which such modeling efforts might be most useful are currently in progress.

The Gulf of Maine Circulation Forecast System

Xue, H., School of Marine Sciences, University of Maine

A circulation nowcast/forecast system was developed for the Gulf of Maine as an integral component of the Gulf of Maine Ocean Observing System (GoMOOS) technical program. The system has been used to produce daily and short-term forecasts of the circulation and physical properties in the Gulf of Maine. One of the expectations is that the system can provide consistent SST to fill in AVHRR gaps and eventually produce reliable 3D temperature and flow fields for fishery applications. We first present the framework of the nowcast/forecast system, which includes an algorithm to assimilate satellite derived SST. Comparisons between the modeled and the observed temperature and velocity (both in situ and satellite derived) are discussed. In general, the assimilation algorithm is stable and produces SST patterns mimicking the AVHRR. Seasonal variations in temperature and the coastal current are well reproduced. Correlation between the modeled and observed fields in the synoptic band is summarized for individual buoys in monthly bins.

The Short-Term Wind Driven Water Exchange between Massachusetts Bay and the Gulf Of Maine

Zhou, M. and M. Jiang, Department of Environmental, Coastal and Ocean Sciences, University of Massachusetts Boston, 100 Morrissey Blvd., Boston, MA 02125

A hydrodynamic model is developed to understand the short term circulation patterns in response to wind events in Massachusetts and Cape Cod Bays (MB). The results from observations and model simulations reveal that the surface circulation in the MB frequently shows an anti-cyclonic or cyclonic pattern with coastal upwelling or downwelling in response to strong south or north winds during the summer season. The Ekman pumping in response to surface winds transports the bottom waters between the Gulf of Maine and MB. The intruding bottom water from the GOM will eventually upwell in the upwelling area because little vertical exchange will occur in stratified areas over Stellwagen Basin. The nutrient-rich deep Gulf of Maine water will significantly enhance the primary productivity, and other biochemical processes in MB.

Posters

Estuary/Ocean Exchange and tidal Mixing in a Gulf of Maine Estuary: A Lagrangian Modeling Study

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A Lagrangian particle method embedded within a 2-D finite element code, is used to study the transport and ocean-estuary exchange processes in the well-mixed Great Bay estuarine system in New Hampshire, USA. The 2-D finite element model, driven by residual, semi-diurnal and diurnal tidal constituents, includes the effects of wetting and drying of estuarine mud flats through the use of a porous medium transport module. The particle method includes tidal advection, plus a random walk model in the horizontal that simulates sub-grid scale turbulent transport processes. Our approach involves instantaneous, massive [≈ 600,000] particle releases that enable the quantification of ocean-estuary and inter-bay exchanges in a Markovian framework. The effects of the release time, spring-neap cycle, riverine discharge and diffusion strength on the intra-estuary and estuary-ocean exchange are also investigated.

The results show a rather dynamic interaction between the ocean and the estuary with a fraction of the exiting particles being caught up in the Maine Coastal Current and swept away. Three somewhat different estimates of estuarine residence time are calculated to provide complementary views of estuary flushing. Maps of residence time versus release location uncover a strong spatial dependency of residence time within the estuary that has very important ramifications for local water quality. Simulations with and without the turbulent random walk show that the combined effects of advective shear and turbulent diffusion, is very effective at spreading particles throughout the estuary relatively quickly, even at low (1 m^2/sec) diffusivity. The results presented here show that a first-order Markov Chain approach has applicability and a high potential for improving our understanding of the mixing processes in estuaries.

Spring Bloom on the Central Georges Bank in 1999: Its Origin and Fate

Ji, R.[1], C. Davis[1], C. Chen[2], R. Beardsley[1] and G. Cowles[2]

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The possible sources and transport time scales of water parcels on the central portion of Georges Bank (inside 60-m isobath) have been estimated to examine the origin and fate of the spring phytoplankton bloom in that region. An "off-line" Lagrange particle trajectory approach was used in this study. The hydrodynamic flow field was interpreted from hourly model outputs of FVCOM (Finite Volume Coastal Ocean Model), which was driven by the realistic meteorological forcing from MM5 model output, with inclusion of SST and observed current velocity data assimilation. Particle trajectory results show that the “blooming” water in the southern part of the central Bank during February and March was mainly from the northern and northwestern edge of the Bank and was relatively older than the “non-blooming” water in the north. The water parcels on the central Bank had average exposure time (time spent inside 60-m isobath) of about 20 days, and tended to leave south- or southwest-ward. Moreover, particle trajectory results also suggested that the phytoplankton bloom on the central Bank has a limited potential contribution as food source for zooplankton population in the deeper flank areas.

Use of an Integrated Hydrodynamic Model to Predict Trace Metal Distributions in Massachusetts Bay

Li, L., G. Wallace, and M. Jiang, Department of Environmental, Coastal and Ocean Sciences, University of Massachusetts at Boston, 100 Morrissey Blvd., Boston, MA 02125

Use of an integrated hydrodynamic model to predict trace metal distribution in the water column may be a powerful tool to assist the study of trace metal behavior in coastal waters in many ways. The Massachusetts and Cape Cod Bays Hydrodynamic model has been run and calibrated for more than 10 years and proved to be a useful tool to simulate physical parameters. Continuing the success of the Hydrodynamic model, a Water Quality Model was integrated into it in 1995 and is still under development now. In this study, trace metal elements have been integrated into the hydrodynamic made to predict annual mean trace metal distributions in the water column of the Bays. After initial runs with the selected metal, Cu, the results look meaningful and may help us better understand the biogeochemical processes affecting metal distributions in the system. We intend to explore the use of different time scales and processes to better resolve water column distributions if necessary and, after verification of the model by comparison with field observations, link the observed water column distributions to surface sediment concentrations of selected metals.

Resolve the Coast or Loose the Data

Smith, K. W., D.R. Lynch, Dartmouth College, Hanover, NH 03755
B. Blanton, F. Werner, R. Leuttich, University of North Carolina at Chapel Hill, NC

The effects of coastal resolution on data assimilation are studied in the context of estimating the M2 tide from NOS coastal tide gauge data. It is found that complex bays and estuaries can have large near field effects. When data are in a region affected by these features, fitting a shelf scale model to the data by adjusting barotropic boundary forcing can destroy a solution that is otherwise credible. The successful assimilation of coastal tide data requires adequate resolution of the coastal features near the data.

Directions to RARGOM Integrated Modeling Workshop once on Campus:

You may park on either the Lower or Upper level garage near the Science Building (stay in left lane as you enter the garage). Note parking is $6 payable when you exit. Look overhead for signs to the Science Building elevators. Go up to the Plaza level (1^{st} floor) and find your way to the new Campus Center. Those of you arriving by subway or walking from the nearby Doubletree hotel can take the free shuttle bus at the subway station that will drop you off on the opposite end of the campus from the Campus Center. Walk up the stairs from the bus stop to the plaza level and walk to the far end of the campus to get to the Campus Center. See maps of first and third floor below.) Once in the Campus Center go towards the front (waterside) part of the building and take the elevator to the third floor. There should be signs as you exit the elevator pointing the way to Ballroom C where the workshop will be held. There are also lots of maps of the Campus center layout for each floor near each entrance to the building and near the elevators. If all else fails just ask for directions or go down to the ground level lobby where there is a help desk. Coffee, juice and pastries will be available at 8:30 AM.

We will have an internet connection if one is needed for use during the workshop. You will have to have your computer DHCP configured to access the internet. Unfortunately our wireless network is not up yet. We would prefer to use a single (PC) computer for presenting so please have your talk on CD or memory stick for transfer to the computer and load it before the morning session starts if possible.

1st and 3rd floor Maps: