# Oceanography Department

Captain Jessie C. Carman, USN
Chair

The U.S. Naval Academy's Oceanography Department executes one of the largest undergraduate physical oceanography programs in the nation. Within this context, the department's Academic Year 2005-2006 research productivity of meteorology, oceanography, and pedagogical research was especially noteworthy. The department's four tenure-track faculty and two Permanent Military Professors authored four refereed articles for publication, nine conference proceedings and made 16 conference presentations, many of which included midshipmen as co-authors.

Eight midshipmen completed Independent Research courses under the mentorship of faculty advisors. These midshipmen formally presented their project results to the faculty and members of the Academic Dean's staff at the end of each semester. Some of these midshipmen went on to present their results at national conferences.

In July 2005, the department hosted the 12th Maury Project Summer Workshop for twenty-three K-12 science teachers nationwide. Enhancing the scientific foundations and teaching methodology for K-12 science teachers in the area of physical oceanography continued as the project's primary focus

The Oceanography Department conducted its 17th annual summer oceanography cruise from 04 August to 12 August 2005. The midshipmen navigated nearly 600 nautical miles through the Delaware and Chesapeake Bays, the C&D Canal, and the Delaware River. This included two overnight transits, one from Philadelphia to Norfolk through the C&D Canal (239 nm) and one from Norfolk to Annapolis (148 nm). The midshipmen also collected oceanographic data throughout the Chesapeake Bay during this period, including one night evolution. Significant maneuvering evolutions consisted of 1 precision anchorage, 4 pier-side underways and moorings, and 14 on-station data collection evolutions.

## Sponsored Research

### MicroDEM UAV Development Work

Researcher: Professor Peter L. Guth
Sponsor: Boeing Corporation

The intent of this research and development activity is to transform MicroDEM into a reliable, high performance mission planning tool tailored to the specific terrain analysis and visualization requirements of Future Combat Systems, Homeland Security Services, and other allied applications. This enhanced product, when integrated into Boeing's optimization and role-based access control framework, will become a key enabler of M&CT's vision for Adaptive Autonomous Networks. This year we worked using MICRODEM as a GIS engine to perform viewshed calculations when called from Boeing's optimizing algorithms, and worked on rapid determination of good locations to place sensors without the need for laborious calculations.

### GIS/Remote Sensing Education for Midshipmen

Researcher: Professor Peter L. Guth
Sponsor: National Geospatial-Intelligence Agency (NGA)

This project continues to improve the GIS/Remote Sensing education provided to midshipmen at the U.S. Naval Academy and to provide outreach to the DOD through: 1) continued development of algorithms and techniques to merge and display geospatial data in an intuitive way; 2) purchase equipment, data, and software to use in classes and for midshipman research projects. Midshipmen honors students majoring in Oceanography will

use components of the proposed research and associated equipment in their honors independent research projects and will be given the opportunity to present their findings at a professional scientific conference. This year we purchased a navigation system to use with an remotely operated vehicle (ROV) for detailed survey work.

## Littoral Ocean Modeling Group

Researcher: Commander Henry Jones, USN
Sponsor: Naval Postgraduate School (NPS)

As the focus of Navy's attention shifts to littoral regions, higher resolution and re-locatable nested models have been developed to improve shallow-water operations. One of the scientific and technical challenges is to determine how much detail and accuracy in ocean wind data, air-sea fluxes and bathymetric resolution is needed to meet operational requirements. A series of sensitivity experiments are performed in multiple regions (Pacific West Coast, Portugal, Western Australia, Gulf of Mexico, and Chesapeake Bay) to evaluate the sensitivity of regional ocean models to variations in the aforementioned environmental fields.

## The Maury Project - Exploring the Physical Foundations of Oceanography

Researchers: Associate Professor David R. Smith and I.W. Geer, American Meteorological Society
Sponsors: Commander, Naval Meteorology and Oceanography Command, National Oceanic and Atmospheric Administration (NOAA), and the Office of Naval Research (ONR)

The Maury Project is a teacher enhancement program on the physical foundations in oceanography for pre-college educators. Each year approximately twenty-four teachers are brought to the United States Naval Academy to attend a summer workshop where they learn about fundamental concepts in physical oceanography. This includes a combination of lectures, hands-on laboratory exercises, field experiences, and tours of oceanographic facilities. Upon completion of the summer workshop, these teachers return to their respective states where they conduct peer-training sessions for other teachers using materials developed by project staff.

## DataStreme Ocean

Researchers: Associate Professor David R. Smith,
and I.W. Geer, J.M. Moran and R.S. Weinbeck, American Meteorological Society
Sponsor: National Oceanic and Atmospheric Administration (NOAA)

DataStreme Ocean is a teacher enhancement program for oceanography. This is a distance-learning course which uses the Internet to deliver instruction to pre-college educators. This summer, approximately 50 teachers were brought to Silver Spring, MD to attend a summer training workshop where they learn about fundamental concepts in physical oceanography. Upon completion of the summer workshop, these teachers return to their respective states where they serve as the leaders for the local implementation teams that mentor other teachers taking the distance learning course. Activities this year included planning for the training workshop and giving one presentation.

## The Effect of Climatic Oscillations on the Transport and Ingress of Larval Fish to Estuaries in the Southeast United States

Researcher: Assistant Professor Cecily Steppe
Sponsor: Naval Academy Research Council (NARC)

Recent research has shown the strong impact of climatic forcing on Pacific fish stocks, yet relatively few studies have focused on the role of climate variation in driving the dynamics of Atlantic species. Nevertheless, global-scale climate forcing may potentially have significant effects on Atlantic populations, especially those in the Southeastern United States Atlantic Bight. In particular, tele-connections from the ENSO cycle may influence larval recruitment to Southeastern US estuaries. Specifically, high river discharge, anomalous wind patterns, and changes in the position of the Gulf Stream front may alter the circulation on the continental shelf and subsequently reduce the survival of shelf-spawned species by transporting larvae away from suitable nursery habitat inshore. Likewise cooler sea-surface temperatures may prolong larval development and potentially reduce larval survival. This study correlates time series of monthly Southern Oscillation Indices (50-80 years) with sea surface temperature; wind velocity and direction; and discharge from 12 rivers on the east coast of the US to assess the potential influence of

the ENSO cycle on transport and survival of winter-spawned fish larvae. Implications for the population dynamics of Atlantic menhaden, spot, Atlantic croaker, and pinfish, are discussed.

# Independent Research

## 3-D Simulation of Tidal Currents in Monterey Bay

Researchers: Commander Emil Petruncio, USN, and
Jeff Paduan and Leslie Rosenfeld, Naval Postgraduate School (NPS),
and Igor Shulman , Naval Research Laboratory (NRL)

The Navy requires accurate 3-D forecasts of coastal ocean currents. Accurate representation of baroclinic (or "internal") tides presents a major challenge to achieving this goal. The Naval Postgraduate School and the Naval Research Laboratory are collaborating on a 3D numerical simulation of ocean circulation in the Monterey Bay region, where very energetic internal tides have been observed. Although the model includes tidal forcing, an assessment of model accuracy in reproducing internal tides has yet to be conducted. This project identifies internal tide "hot spots", compare model predictions to observations, assess the performance of open boundary specifications, and aids efforts to more accurately simulate tidal currents in other coastal areas.

## Synoptic Distribution of Crab Larvae near the Mouth of Delaware Bay: Influence of Nearshore Hydrographic Regimes

Researchers: Assistant Professor Cecily N. Steppe and C.E. Epifanio

The southern Middle Atlantic Bight encompasses an area of ocean extending along the east coast of North America from Long Island to Cape Hatteras. Subtidal circulation in this region is influenced by strong coastal currents emanating from the mouths of three large estuaries (Hudson, Delaware, and Chesapeake) and extending southward along the shoreline. The strength of these buoyancy-driven currents diminishes with distance from their sources, and areas immediately north of each of the estuaries are known to have weak subtidal flow. These estuaries support large populations of fiddler crabs (*Uca* spp.) and blue crabs (*Callinectes sapidus*) near their mouths. These taxa are known to export larvae to the adjacent continental shelf where they undergo development through a number of zoeal stages and a single megalopal stage. Results of recent modeling studies predict that larvae entrained within the coastal currents are lost to the parent estuary, while larvae that escape entrainment are likely to be recruited into populations in the natal system. In this paper we describe results of a study designed to test the hypothesis that areas of weak subtidal flow serve as retention zones for estuarine crabs that export their larvae to the continental shelf. Our study assessed the distribution of crab larvae within a ~200 $km^2$ region encompassing the mouth of Delaware Bay (ca. $39^o$ N, $75^o$ W). We conducted simultaneous plankton tows at 3 stations, each located in a different hydrographic regime. Samples were collected every 30 minutes throughout a complete tidal cycle. One station was located 15 km within the bay, near the northern shore; one within the source region of the coastal current near the southern terminus of the bay at Cape Henlopen; and one in an area of weak subtidal flow near Cape May at the northern terminus of the bay. The coastal-current station was characterized by low concentrations of newly hatched *C. sapidus* and *Uca* zoeae, while the station located in the region of weak subtidal flow had high densities of advanced larval stages of the two taxa. In complete contrast, the station located within the bay was dominated by both early and advanced stages of the mud crab *H. angustifrons*, a species known to retain its larvae within estuarine systems. These results provide a unique "snap shot" of the synoptic distribution of crab larvae in three distinct hydrographic regimes in the mouth of a major estuary and support existing hypotheses concerning dispersal and retention of larvae in this kind of system.

## The Effect of Chemical Cues from a Food Patch on the Distribution of *Callinectes sapidus* Larvae

Researcher: Assistant Professor Cecily N. Steppe

This investigation uses field observations to investigate the role of biological and physical processes in maintaining patches of crab larvae. The specific questions addressed include the following: 1) Are crab larvae correlated in space with areas of high primary productivity, as measured by chlorophyll-*a* concentration? 2) Are *C.*

*sapidus* larvae correlated in space with physical oceanographic features, such as fronts, that may aggregate them? 3) How quickly do patches of crab larvae disperse in the coastal ocean, as measured with cluster of satellite-tracked surface drifters?

### Contributing to the Establishment of the Naval Academy in the Chesapeake Bay Scientific Community

Researcher: Associate Professor Mário E.C. Vieira

A NORTEK Aquadopp acoustic Doppler profiler was acquired by the Oceanography Department under Prof. Vieira's supervision. The instrument was deployed on the bottom of the Severn River, one hundred meters off the Hendrix Laboratory, and is providing data in real time every 60 seconds. The data consists of current speed and direction every 30 cm between the bottom and the surface, water pressure and temperature. The data are available in real time at ftp://noaa.chesapeakebay.net/USNA. These data are provided to an Oceanography Department webpage designed to display it in real time. The data are provided also to the CBOS (Chesapeake Bay Observation System), a NOAA-funded initiative to research the oceanography of the Chesapeake Bay.

Concomitantly a multidisciplinary education and research center was formed at USNA by faculty in several academic departments. This Center for Chesapeake Bay Observation and Modeling (CCBOM) will facilitate the integration of research efforts (such as the Nortek data described above) into wider regional initiatives. As a result the U.S. Naval Academy became a partner in the ongoing scientific projects taking place in the Chesapeake Bay.

## Midshipman Research Course Projects

### Geomorphometry from LIDAR DEMs: Issues of Scale and Comparison to Cartographic DEMs

Researcher: Midshipman 1/C Jean Hyde, USN
Adviser: Professor Peter L. Guth

Digital elevation models (DEMs) provide a window to view the characteristics of the landscape. A number of point and area parameters allow quantitative description of topography from gridded DEMs. The United States has cartographic DEMs with 10-30 m spacing, combined in the seamless National Elevation Dataset (NED) with 1/3-1 arc second spacing. LIDAR DEMs are becoming increasingly available with horizontal spacing around 1 m, and NED now has limited such DEMs with about 3 m (1/9 arc second) spacing. We have investigated a range of geomorphic parameters, including elevation and slope, to determine how values computed from LIDAR DEMs compare to coarser cartographic DEMs. Because of the small horizontal spacing, accurate computation of geomorphic parameters requires that LIDAR DEMs use floating point values to store elevations. LIDAR DEMs continue the trends seen with other DEMs, with steeper computed slopes as the horizontal DEM spacing decreases. While LIDAR DEMs can improve the characterization of terrain, for many applications the differences compared to cartographic DEMs will be marginal.

### Assessment of a 3D Simulation of Tidal Currents in Monterey Bay

Researcher: Midshipman 1/C Kendra McClellan, USN
Adviser: Commander Emil Petruncio, USN

The Naval Postgraduate School (NPS) and the Naval Research Laboratory (NRL) are collaborating on a 3D numerical simulation of ocean circulation in the Monterey Bay region, where very energetic internal tides have been observed. Although the model includes tidal forcing, an assessment of model accuracy in reproducing internal tides has yet to be conducted. This project uses ray tracing techniques to compare theoretical internal tide propagation to model output. The primary focus is on internal tides in Monterey Submarine Canyon, where previous field observations are used for comparison. MATLAB® is used to produce graphical depictions of model output and ray traces.

## Assessing the Effects of the 1997 El Niño and the 1998 La Niña Events on Antarctic Cyclones through the Analysis of Satellite Imagery

Researcher: Midshipman 1/C Rebecca Wolf, USN
Adviser: Associate Professor David R. Smith and Visiting Assistant Professor Ted Maksym

Antarctic cyclones formed in the Southern Ocean are synoptic scale storms that serve an integral part of the global atmospheric circulation. Based on an understanding of synoptic scale cyclones and ENSO events the purpose of this investigation is to discern any effects of the 1997 El Niño and the 1998 La Niña events on Antarctic cyclones. This study utilizes infrared satellite imagery to gain an essential understanding of the frequency of Antarctic cyclones. The storms were tracked over a three-year period (1997-1999), during the months of June, July, and August. The frequency of the tracked cyclones and the location of cyclogenesis were compared for each month of the three years. There was an increase in frequency of storms during the El Niño event in 1997 while the La Niña event in 1998 showed the least amount of storms tracked for the three year period. Even though there was not enough data collected for statistical analysis this study suggests that there could be an influence of ENSO events on the frequency of synoptic scale cyclones surrounding Antarctica. This study also compares several locations of cyclogenesis to determine any variations in cyclone distribution due to ENSO events.

## Validation of a Theory for Ice Formation in Freezing Drizzle Events

Researcher: Midshipman1/C Alyssa Saunders, USN
Adviser: Associate Professor David R. Smith and Dr. Marcia Polotovich (UCAR/RAL)

The causes of in-flight aircraft icing are still not completely understood. The prediction models of when icing should occur are being improved to reflect the knowledge gained about the causes of in-flight icing. The factors identified, up to this point, are the liquid water content of the clouds, the air temperature in the clouds, and the presence of large super-cooled water droplets. It is important to understand not only these factors, but the types of icing they cause. The current standard model predicts broad areas of icing and has a high false alarm rate. An area where current modeling efforts are inadequate for freezing drizzle events and how such conditions affect ice formation, especially for aircraft icing.

The purpose of this project was to examine actual weather conditions associated with freezing drizzle events. This study is based on the theory presented by Korolev and Isaac (2005) which states that freezing drizzle events coincide with large super-cooled liquid droplets (diameter exceeding 75 μm) at the cloud tops. To determine the validity of the theory, freezing drizzle events from January 2004 to May 2005 were compared to satellite imagery of cloud top droplet size. Results from the study show how well the observations validate the theory of ice formation as postulated by Korolev and Isaac.

## A Case Study of the Nor'easter of 28 February 2005

Researcher: Midshipman 1/C Michelle Aleszczyk, USN
Adviser: Associate Professor David R. Smith

The paper investigates the Mid-Atlantic cyclone which occurred from 28 February 2005 to 01 March 2005. This winter storm generated over the Gulf of Mexico and it proceeded in a northeasterly track up the east coast of the United States. Using data collected primarily from NOAA products, this study examines the parameters which combined to strengthen the storm. These parameters include surface analysis charts, 300mb and 500mb charts, 24-hr precipitation charts, maximum and minimum temperature charts, sounding profiles, as well as climatological data. The four primary stations from which the progress of the storm was evaluated are Atlanta, GA, Morehead City, NC, Baltimore, MD, and Brookhaven, NY. While this weather situation was not a classic example of a Nor'easter, it certainly contributed significant snowfall to Washington, DC and surrounding areas.

## The Impact of Hurricanes on Flooding of Inland Water Bodies and the Accuracy of Models to Predict This Flooding

Researcher: Midshipman 1/C Katherine Mahan, USN
Adviser: Associate Professor David R. Smith

Hurricane Isabel and the significant storm surge and flooding it produced had a huge impact on the United States Naval Academy and the entire Chesapeake Bay region. Of all the damage and devastation wrought by hurricanes, storm surge is by far the largest contributor to this damage. There are currently several numerical models which are used to predict storm surge in particular areas. Determining the accuracy of these models is vital to understanding which models are most useful in predicting flooding. In turn, this understanding is helpful in preventing or reducing the death and destruction associated with drastic storm surges by providing coastal areas with forewarning. This paper examines the impact Hurricane Isabel had on the Chesapeake Bay region with respect to flooding though the analysis of the observed and predicted CO-OPS water levels along with the water level output of NOAA's SLOSH model for eight locations in the bay area. Through comparing the CO-OPS observed storm surge with the SLOSH model's predicted storm surge, the overall accuracy of the SLOSH model was determined. With the exception of three difficult-to-model locations, the SLOSH model analyzed was found to be fairly accurate. Contributing factors to the storm surge such as wind direction and strength, pressure, and location of the hurricane help to explain why the SLOSH program predicted the values it did and why the observed water levels turned out to be what they were. The three stations which were least accurately modeled were discussed, focusing on their locations as a reason for the inaccuracies. Ideas for ways to improve the SLOSH model program were given.

## Effect of ENSO Teleconnections on Winds and Larval Ingress in the Southeastern United States

Researcher: Midshipman 2/C Allison B. Barlow, USN
Adviser: Assistant Professor Cecily N. Steppe

While numerous studies on the effects of ENSO events on Pacific fisheries have been conducted, little is known about the effects of these teleconnections in the coastal Atlantic on fish populations. To research this problem, nineteen years of archived wind data sets from the east coast of the US were analyzed relative to monthly averages of the SOI for those years to determine whether or not a significant relationship exists. A significant correlation between positive SOI values indicating La Niña events and stronger northerly winds during the month of March was observed near Cape Lookout, NC, which is close to important estuaries such as the Newport River and Beaufort Inlet. The larvae of several fish species are recruited into these estuaries during March, and stronger northerly winds associated with ENSO would transport the larva across the continental shelf and into the estuaries.

## Settlement of Mud Crab Megalopae and Juveniles (*Rhithropanopeus harrisii*) in the Severn River, Annapolis, MD, USA

Researcher: Midshipman 1/C José Gonzales, USN
Adviser: Assistant Professor Cecily N. Steppe

The white-fingered mud crab (*Rhithropanopeus harrisii*) is an ecologically-important member of mesohaline coastal communities. While it has been used extensively in laboratory experiments on crab larval behavior, there have been few published studies on its settlement in the field. To this end, of *R. harrisii* post-larvae settlement in the Severn River, Annapolis, Maryland, USA was monitored in the fall of 2005. Four replicate passive collectors were deployed and sampled daily August- October 2005. Samples were preserved in the field by standard methods. Post-larvae and juvenile crabs were later removed from the samples and identified to species in the lab. Results indicated high settlement indicated high settlement of post-larvae and adults in August and September, with few occurring later in the sampling season. Other taxa found included amphipods and annelids. These data provide a foundation for future studies of settlement within the Severn River by indicating the appropriate seasonal time frame for high-intensity sampling, as well as baseline post-larval and juvenile concentrations with which to compare future settlement.

# Publications

## Journal (Refereed) Manuscripts

GUTH, Peter L., Professor, "Geomorphometry from SRTM: Comparison to NED", *Photogrammetric Engineering & Remote Sensing, special issue based on Shuttle Radar Topography Mission - Data Validation and Applications Workshop, Reston, VA,* Vol.72, No.3, 2005, pp. 269-277.

> The Shuttle Radar Topography Mission (SRTM) produced near-global 1" and 3" DEMs. The cartographically derived National Elevation Dataset (NED) provides a mechanism to assess SRTM quality. We compared 12 geomorphometric parameters from SRTM to NED for about 500,000 sample areas over the continental US. For basic parameters like average elevation or relief, the two data sets correlate very highly. For more derived measures like curvature and higher moments (skewness and kurtosis), the correlations are much lower, with some parameters essentially uncorrelated between the two DEMs. Correlations improve after restricting analysis to region with average slopes greater than 5%, and the SRTM data set compares more closely to simulated 2" NED than to 1" NED. SRTM has too much noise in flat areas, increasing average slope, while in high relief areas SRTM over smoothes topography and lowers average slopes. The true resolution of 1" SRTM DEMs proves to be no better than 2".

NATUNEWICZ, Cecily C., Assistant Professor, (co-author), "Dynamics of Larval Patches: Spatial Distribution of Fiddler Crab Larvae in the Delaware Bay and Adjacent Waters," *Marine Ecology Progress Series,* Vol. 293, 2005, pp. 177-190.

> In this paper we present results of a four year investigation of the dynamics of patches of fiddler crab larvae (*Uca* spp.) in southern Delaware Bay and the nearby coastal ocean. The study encompassed all stages in the early life history of the crabs and included high-frequency sampling of newly hatched zoea larvae, detailed measurements of patch dimensions in the open waters of Delaware Bay and the coastal ocean, determination of trajectories of patches of zoeae using satellite technology, and observations of the characteristics of patches of megalopae as they were transported back into the estuary. We also conducted numerical-model simulations of the early stages of patch formation and compared model outcomes to real-world observations. Results of earlier investigations have shown that fiddler crab larvae are hatched near the time of high tide during nocturnal spring tidal periods. Our results indicate that newly hatched fiddler crab larvae are exported from small tidal rivers in a long continuous stream lasting through the ensuing ebb-tide phase. These patches of larvae appear to result from synchronized spawning of large numbers of females. Along-stream dimensions of the patches at our sampling site were at least 8-9 km, and maximum densities of larvae were as high as $3 \times 10^4$ $m^{-3}$. Only part of each patch exited the river during the first ebb tide following hatching. Numerical simulations showed that the remaining portion of the initial patch exited the river during subsequent ebb tides following hatching. Upon reaching open waters of Delaware Bay, the patches assumed quasi-circular shapes with apparent diameters ranging from about 500 to 1800 m. The numerical simulations showed a similar change in shape of patches as they entered Delaware Bay. Trajectories of bay patches were strongly influenced by tidal circulation, which resulted in the transport of larvae back and forth along the shore of the bay at tidal frequency. Several patches of *Uca* larvae were also observed on the inner shelf near the mouth of the bay. Shelf patches contained substantial numbers of advanced-stage zoea larvae, supporting the notion that patches remain integral throughout the duration of larval development. Further support for this idea came from the observed patchy distribution of megalopae as they were transported back to juvenile habitat in marshes fringing the bay.

SMITH, David R., Associate Professor, (co-author) , "The Maury Project, DataStreme Ocean and Online Ocean Studies: AMS Initiatives in Ocean Science Education", *Marine Technology Society Journal*, Vol. 39, No. 4, 2005, pp. 64-70.

> The American Meteorological Society has two teacher enhancement programs for the ocean sciences. The Maury Project, established in 1994, is a partnership with the United States Naval Academy and SUNY College at Brockport, with significant support from the National Science Foundation, the Navy and NOAA. This program is a two-week summer workshop that focuses on the physical foundations in oceanography.

In its eleven-year tenure, approximately 275 educators from kindergarten through university levels have attended one of its two-week summer workshops at the U.S. Naval Academy. This unique partnership provides a program of instruction that focuses on the physical foundations of oceanography.

Teachers who attend the Maury Project summer workshops are provided with a learning experience that enables them to understand the structure and dynamics of the oceans and methods for measuring its physical properties. They learn about the agencies that are involved with oceanic research and operational activity and why the oceans are important to these agencies. In addition, resource materials in the form of modules are provided to the workshop participants so they can conduct workshops for their peers. These peer-training sessions have been a highly effective mechanism to distribute instructional materials to teachers both nationally and internationally. Modules include such topics as shallow ocean water waves, ocean tides and coastal upwelling. To date, over 1200 Maury peer-training sessions have reached over 20,000 teachers both nationally and internationally. This partnership comprised of a professional society, scientific and operational agencies working as colleagues with the precollege educational structure provides an excellent model for enhancing the study of the marine and coastal environments.

STEPPE, Cecily N., Assistant Professor, (co-author), "Effects of Coastal Transport on Larval Patches: Models and Observations," *Estuarine, Coastal, and Shelf Science*, Vol. 67, No. 1, 2006, pp. 145-160.

We used a combination of field observations and numerical modeling to examine the physical mechanisms responsible for the evolution and transport of patches of blue crab larvae in the mouth of Delaware Bay. The observations consisted of larval collections and surface salinity measurements taken along a moving spatial grid whose origin was determined by a satellite-tracked drifter. Examination of field observations revealed a slender larval patch that was aligned with salinity contours. Measurement of the salting rate of the larval patch indicated that the patch moved through the offshore edge of a buoyant plume due to wind-driven upwelling circulation.

A numerical model that provided realistic simulations of the flow field at the mouth of Delaware Bay and the adjoining coastal ocean was used to examine the physical mechanisms responsible for the movement and evolution of the patch. We conducted a series of simulations in which we separately examined the effects of tides, buoyancy-driven flow, and wind-driven transport. Results showed that both tides and buoyancy-driven flow tend to elongate an initially square fluid element. Although winds alone have little effect on the shape of a patch, wind-driven flow can effectively move a patch through a complex flow field in which the deformation by tides and buoyancy-driven circulation can have significant effects.

This study represents the first observation and analysis of a larval patch that remains intact while moving through the edge of a buoyant plume. It provides new insight into the shape of larval patches in Delaware Bay and any region with strong buoyancy- and tidally-drive flow, suggesting that typical larval patches are not characterized by equal across-shelf and along-shelf dimensions but instead are slender shapes that aligned with the flow field.

# Conference Proceedings

GUTH, Peter L., Professor, (co-author), "The Effects of DEM Re-interpolation on Viewshed Computations," *MilGeo2005 Proceedings, Sixth International Conference on Military Geology and Geography*, University of Nottingham, United Kingdom, 12 pages, June 2005.

Viewsheds, or weapons fans, represent one of the most important military applications of digital elevation models (DEMs) because many radars, radios, and direct fire weapons systems rely on line-of-sight. Because of the importance of this function, and the number of computations required, optimization of inter-visibility computations has been a goal for military terrain analysis software. One common optimization requires the source DEM to use Universal Transverse Mercator (UTM) coordinates because a square, rectangular grid simplifies computations. Unfortunately, the best DEMs currently available use geographic coordinates. Several programs require re-interpolation of such DEMs to a UTM grid before use in inter-

visibility computations. The effects of DEM re-interpolation, which shifts grid points' variable distances both horizontally and vertically, were investigated. Because peaks and ridges largely control inter-visibility, and most interpolation algorithms will tend to displace the location of these high points and drop their elevations, re-interpolation affects inter-visibility computations. The effects of this re-interpolation should be analyzed for better situational awareness, most importantly in military applications.

GUTH, Peter L., Professor, "Challenges for Military Application of High Resolution DEMs," *MilGeo2005 Proceedings, Sixth International Conference on Military Geology and Geography*, University of Nottingham, United Kingdom, 14 pages, June 2005.

Digital elevation models (DEM) provide many uses for military terrain analysis. The US military currently has Digital Terrain Elevation Data and Shuttle Radar Topographic Mission with spacing of 1 to 3 arc seconds (about 30-100 m) covering virtually all potential operating areas. Widespread use of higher resolution data (1-5 m) requires addressing a number of issues. Standardization is required for efficient data indexing and tiling, critical as resolution and size of the data sets increase. Arc-second spacing allows integration of multi-resolution data, since the highest resolution data may never be collected world-wide. Tile size must be defined, as current specifications for full one degree cells become unworkable beyond 0.4 sec (10 m) data. Horizontal resolution must be increased beyond 1 m to avoid vertical stairsteps. Many LIDAR DEMs provide a "bare earth" surface, removing vegetation and buildings, but military users need multiple data sets for visualization and to account for different effects of vegetation and buildings on inter-visibility.

GUTH, Peter L., Professor, (co-author), "Using DEMs to Register Oblique Photographs and Web Cameras", *Proceedings of the ASPRS 2006 Annual Conference*, Reno NV, 11 pages, May 2005. (CD-ROM)

Algorithms and software to use digital elevation models (DEMs) to register oblique photographs and web cameras were developed. After registration, the coordinates of every ground pixel in the image can be computed and allows use of the image for coordinate digitization and area measurement. Registration requires the camera location (latitude and longitude and elevation above ground, most easily obtained from a GPS unit), and three angles: the azimuthal heading of the camera, the upward or downward pitch of the camera, and a sideways tilt. The camera angular orientation proves the most difficult to accurately obtain with current cameras and orientation sensors. From these six camera parameters a synthetic perspective view from the DEM is created with the same field of view and pixel size as the photograph, which is compared to the photograph. Using alpha blending of the DEM view and photograph, the camera position is iteratively adjusted to best match the DEM view with the photograph. Imagery or vector overlays may also be draped on the DEM in the perspective view, and road intersections or other features are used to compare the photograph with the synthetic view and improve the estimated camera position. While DEM resolution, camera resolution, and lens optics limit the accuracy that can be achieved with this method, the procedure works well for many monitoring and surveillance applications. Improved sensors for camera orientation will greatly extend the potential uses of the algorithms.

HOPPE, L.M., Midshipman, USN, and SMITH, David R., Associate Professor, "Development of Nor'easters during El Niño." Preprints of the *18th Symposium on Climate Variability and Change*, American Meteorological Society, Boston, MA, January 2006. (CD-ROM)

A significant wintertime event along the East Coast is a marine cyclone called the Nor'easter. These storms occur when cold air from the continent interacts with warm air and water just offshore, associated with the Gulf Stream. This paper investigates whether El Niño events have any influence on the development of such storms. This paper looks at winter storms for the 1983-84, 1997-98, and 2004-05 events. The number of extratropical cyclones, intensity of these cyclones and the central and minimum pressures of the cyclones were gathered. By comparing these data, conclusions were made regarding the generation and movement of Nor'easter storms. The storms during El Nino events were pushed further south due to the jet stream being pushed further south. The frequency of storms increased during strong El Nio years (e.g., 1983-'84 or 1997-'98). Although the ability to predict when or where these storms will occur is difficult at best, this study provides clues to better understand the effect of El Niño on these extratropical marine cyclones.

HYDE, J., Midshipman, USN, and GUTH, Peter L., Professor, "Geomorphometry from LIDAR DEMs: Issues of Scale and Comparison to Cartographic DEMs," *Proceedings of the ASPRS 2006 Annual Conference*, Reno, NV, 12 pages, May 2005. (CD-ROM)

> Digital elevation models (DEMs) provide a window to view the characteristics of the landscape. A number of point and area parameters allow quantitative description of topography from gridded DEMs. The United States has cartographic DEMs with 10-30 m spacing, combined in the seamless National Elevation Dataset (NED) with 1/3-1 arc second spacing. LIDAR DEMs are becoming increasingly available with horizontal spacing around 1 m, and NED now has limited such DEMs with about 3 m (1/9 arc second) spacing. A range of geomorphic parameters, including elevation and slope, were investigated to determine how values computed from LIDAR DEMs compare to coarser cartographic DEMs. Because of the small horizontal spacing, accurate computation of geomorphic parameters requires that LIDAR DEMs use floating point values to store elevations. LIDAR DEMs continue the trends seen with other DEMs, with steeper computed slopes as the horizontal DEM spacing decreases. While LIDAR DEMs can improve the characterization of terrain, for many applications the differences compared to cartographic DEMs will be marginal.

GUTH, Peter L., Professor, (co-author), "Filling Holes in SRTM DEMs using ASTER DEMs," *MilGeo2005 Proceedings, Sixth International Conference on Military Geology and Geography*, University of Nottingham, United Kingdom, 14 pages, June 2005.

> The Shuttle Radar Topography Mission (SRTM) collected elevation data over 80% of earth's land area. For most locations this represents the best quality, freely available digital elevation models (DEMs) with horizontal resolution of 1-3 arc seconds. SRTM DEMs have data gaps caused by steep terrain or unfavorable surfaces. In contrast to the short SRTM mission, the ongoing Advanced Space-borne Thermal Emission and Reflection Radiometer (ASTER) is slowly collecting DEMs using stereo near infrared imagery with a horizontal resolution of 30 m. Statistical measures show extremely high correlations between ASTER and SRTM DEMs. Because ASTER and SRTM represent independently produced DEMs, ASTER can fill holes in SRTM data. ASTER data requires horizontal and vertical shifts to match SRTM data. We assume SRTM data is correct, and after shifting we fill SRTM holes with an interpolated ASTER elevation ASTER cannot fill all holes in SRTM data, but offers a reasonable quality, fully automated mechanism to fill many voids.

SMITH, David R., Associate Professor, (co-author), "EWOC 2006 – An International Conference to Promote Meteorological and Oceanographic Education", Preprints of the *15th Symposium on Education*, American Meteorological Society, Boston, MA, January 2006. (CD-ROM)

> This summer the Seventh International Conference on School and Popular Meteorological and Oceanographic Education (also known as EWOC 2006) will convene in Boulder, Colorado. These conferences provide educators from around the world a forum to share information about their initiatives to promote the study of weather, ocean and climate. Since the first such conference held at Oxford, UK in 1983, educators have described programs, demonstrated materials, conducted workshops and exchanged ideas on how to enhance educational activities for the atmospheric, oceanic and related sciences. This year, the program includes the following themes: the role of learned societies in educational outreach; enhancing public awareness of meteorology and oceanography through the media; teacher training; business and education partnerships for meteorology and oceanography; student-centered educational programs; cyber-infrastructure and computer-based learning for meteorology and oceanography; science, society and schools; education and outreach for the coastal and marine environment; indigenous perspectives of weather, climate and oceans; promoting diversity and enhancing the involvement of under-represented groups in meteorology and oceanography; informal education for meteorology and oceanography; international education programs and collaborations. This paper explores the history of the conference, provides details about the upcoming conference and gives interested parties and opportunity to learn more about this international event.

SMITH, D.R., Associate Professor, (co-author), "The Maury Project and DataStreme Ocean: AMS Initiatives in Ocean Science Education", Preprints of the *Oceans 2005 Conference, Marine Technology Society/IEEE Oceanic Engineering Society*, September 2005. (CD-ROM)

The American Meteorological Society has two teacher enhancement programs for the ocean sciences. The Maury Project, established in 1994, is a partnership with the United States Naval Academy and SUNY College at Brockport, with significant support from the National Science Foundation, the Navy and NOAA. This program is a two-week summer workshop that focuses on the physical foundations in oceanography. In its eleven-year tenure, approximately 275 educators from kindergarten through university levels have attended one of its two-week summer workshops at the U.S. Naval Academy. This unique partnership provides a program of instruction that focuses on the physical foundations of oceanography.

Teachers who attend the Maury Project summer workshops are provided with a learning experience that enables them to understand the structure and dynamics of the oceans and methods for measuring its physical properties. They learn about the agencies that are involved with oceanic research and operational activity and why the oceans are important to these agencies. In addition, resource materials in the form of modules are provided to the workshop participants so they can conduct workshops for their peers. These peer-training sessions have been a highly effective mechanism to distribute instructional materials to teachers both nationally and internationally. Modules include such topics as shallow ocean water waves, ocean tides and coastal upwelling. To date, over 1200 Maury peer-training sessions have reached over 20,000 teachers both nationally and internationally. This partnership comprised of a professional society, scientific and operational agencies working as colleagues with the pre-college educational structure provides an excellent model for enhancing the study of the marine and coastal environments.

SMITH, David R., Associate Professor, (co-author), "A Decade of AMS DataStreme Courses - Teachers Using Earth System Information", Preprints of the *15th Symposium on Education,* American Meteorological Society, Boston, MA, January 2006. (CD-ROM)

The DataStreme Project has become the precollege teacher enhancement flagship of the American Meteorological Society's Education Program. Three courses [DataStreme Atmosphere, DataStreme Ocean and DataStreme Water in the Earth System (WES)] have aided over 10,000 teachers to develop Earth system science competency. Following course participation teachers become Earth system science resource persons in their schools and districts. Further, the use of telecommunicated Earth system environmental information has been shown to be both exciting and highly motivational for students.

DataStreme Atmosphere, which began as the DataStreme Project in 1995, has served as the prototype for all AMS' DataStreme courses. DataStreme courses are offered locally by Local Implementation Teams (LIT), typically three members who are master teachers or scientists. They serve as mentors to the teachers whom they recruit. Course content is provided by a custom text and benchmark investigations coordinated by AMS' DataStreme Central. The text and the first halves of investigations are provided to the participants at the first semester meeting with weekly investigation completions based on current environmental data being delivered via the course website. The LIT also provides two additional meetings and weekly mentoring while participants work toward content mastery.

The unique blend of collegial work on specially crafted learning investigations utilizing current Internet-delivered real-time data is highly motivating and authentic. Teachers in turn bring this content interest and immediacy to their colleagues and classrooms.

# Presentations at Professional Meetings and Conferences

GUTH, Peter L., Professor, (co-author), "The Effects of DEM Re-interpolation on Viewshed Computations," MilGeo2005, Sixth International Conference on Military Geology and Geography, University of Nottingham, United Kingdom, 19 - 22 June 2005.

GUTH, Peter L., Professor, "Filling Holes in SRTM DEMs using ASTER DEMs," MilGeo2005, Sixth International Conference on Military Geology and Geography, University of Nottingham, United Kingdom, 19 - 22 June 2005.

GUTH, Peter L., Professor, "Challenges for Military Application of High Resolution DEMs" MilGeo2005, Sixth International Conference on Military Geology and Geography, University of Nottingham, United Kingdom, 19 - 22 June 2005.

GUTH, Peter L., Professor, "DEM Research at USNA", National Geospatial-Intelligence Agency Academic Research Program (NARP) Symposium, Washington, DC, September 2005.

GUTH, Peter L., Professor, appeared on "The Battle of Big Hole", Battlefield Detectives, on the History Channel, first airing 3 February 2006.

HOPPE, L.M., Midshipman, USN, and SMITH, David R., Associate Professor, "Development of Nor'easters during El Niño," 18th Symposium on Climate Variability and Change, American Meteorological Society, Atlanta, GA, 29 January – 2 February 2006.

SMITH, D.R, Associate Professor, (co-author), "The Maury Project and DataStreme Ocean: AMS Initiatives in Ocean Science Education", Marine Technology Society (MTS)/ Institute of Electrical and Electronics Engineers (IEEE) Oceans 2005 Conference, Washington, DC, 18-23 September 2005.

SMITH, David R., Associate Professor, (co-author), "EWOC 2006 – An International Conference to Promote Meteorological and Oceanographic Education", American Meteorological Society, Atlanta, GA, 29 January - 2 February 2006.

SMITH, David R., Associate Professor, and JONES, Henry, Commander, USN, (co-authors), "The Maury Project: A Partnership to Promote Educational Outreach on the Physical Foundations of Oceanography", American Geophysical Union (AGU) Ocean Science Meeting, Honolulu, HI, 20 - 24 February 2006.

SMITH, David R., Associate Professor (co-author), "A Decade of AMS DataStreme Courses - Teachers Using Earth System Information," 15th Symposium on Education, Atlanta, GA, 29 January - 2 February 2006.

STEPPE, Cecily N., Assistant Professor, and BARLOW, A., Midshipman, USN, (co-authors), "The Effect of Teleconnections from El Niño on River Discharge, Wind, and SST in the Middle Atlantic Bight and Southeastern Atlantic Bight, USA; Consequences for Fisheries", American Geophysical Union (AGU) Ocean Science Meeting, Honolulu, HI, 20 - 24 February 2006.

STEPPE, Cecily N., Assistant Professor, (co-author), "Effects of Coastal Transport on Larval Patches: Models and Observations", Estuarine Research Federation, Norfolk, VA, October 2005.

VIEIRA, Mário E. C., Associate Professor, (co-author), "Hydrodynamic Conditions and Planktonic Variability in a Salt Wedge Estuary (Douro, Portugal)", Summer 2005 Meeting of the American Society of Limnology and Oceanography, Santiago de Compostela, Spain, 19 - 24 June 2005.

VIEIRA, Mário E. C., Associate Professor, and SMITH, David R., Associate Professor, (co-authors), "The Maury Project: a Summer Workshop for Teachers on the Physical Foundations of Oceanography", Summer 2005 Meeting of the American Society of Limnology and Oceanography, Santiago de Compostela, Spain, 19 - 24 June 2005.