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Nearshore Canyon Experiment Covers Basic Research Through Operational Use

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Scripps Canyon is one of the most studied underwater canyons in the world. Its narrow gorge, with three branches, steep slopes and depths of greater than 500 meters, offers a multitude of research possibilities. The Office of Naval Research (ONR) brought together more than a dozen scientific and technical agencies to focus on this canyon during the Nearshore Canyon Experiment (NCEX). Investigators from the Naval Research Laboratory's Marine Geosciences and Oceanography Divisions played an important role.

NCEX was designed to understand the effect of the canyon on nearshore "processes, including the evolution of surface gravity waves propagating across the continental shelf through the shoaling region and surf zone, and the corresponding inner shelf and breaking wave-driven nearshore circulation, sediment transport, and bathymetric change," according to ONR. The exercise will contribute to the understanding of nearshore dynamics, remote sensing in the nearshore and the assimilation of remotely-sensed data and numerical models of nearshore circulation.

NCEX was a shared cooperative research experiment (with little duplication of effort) designed to look at coastal regions with complex bathymetry in support of operational concerns to the Navy. These concerns include amphibious landings, rip currents, expeditionary warfare and mine countermeasures. Although the focus was basic research, tasks within the experiment were designed to identify how well existing wave models work, and how they need to be modified or further developed to support difficult applications such as complex bathymetry.

Dr. Todd Holland, leader of NRL's Littoral Dynamics Team, and his team went to the canyon region as part of NCEX in the Fall 2003 to conduct various experiments and collect valuable information. "We're working from basic research through transition to operational use all in one exercise," said Dr. Holland. These efforts included measurements obtained from underwater autonomous vehicles, airborne video cameras, commercial satellite imagery, digital motion imagery, and even jet-ski-based echo soundings. Of major interest, to the team, was how modeled surf conditions, rip currents, and other littoral phenomena depend upon accurate bathymetry estimates. Having a variety of different sampling tools not only allowed for comparisons between the models and measurements, but also enabled simulation of how the models would have performed under sampling conditions consistent with military exercises. Dr. Holland's team focused on four efforts funded by the Office of Naval Research: Surfzone Characterization from Airborne Platform, Remotely Sensed Littoral Dynamics, Autonomous Underwater Vehicle Nowcasting, and transitioning littoral remote sensing capabilities to operations.

Two of the projects, Surfzone Characterization from an Airborne Platform (a joint program with Areté Associates) and Remotely Sensed Littoral Dynamics (a joint program with Oregon State University), use multi-channel digital video cameras installed to study the nearshore. Model boundary conditions, such as bathymetry, and forcing conditions such as offshore wave height and wave period/direction were determined using these remote sensing data streams. The conditions were then used to drive numerical models run by Dr. James Kaihatu, from NRL's Coastal and Semi Enclosed Seas Section, that estimate what happens landward of a particular location with respect to waves and currents - where the waves are the highest, the location of rip currents, the strength of an alongshore current. Coupled with video coverage, this information can provide "what's happening right here" data which is useful for amphibious landings or swimmers.

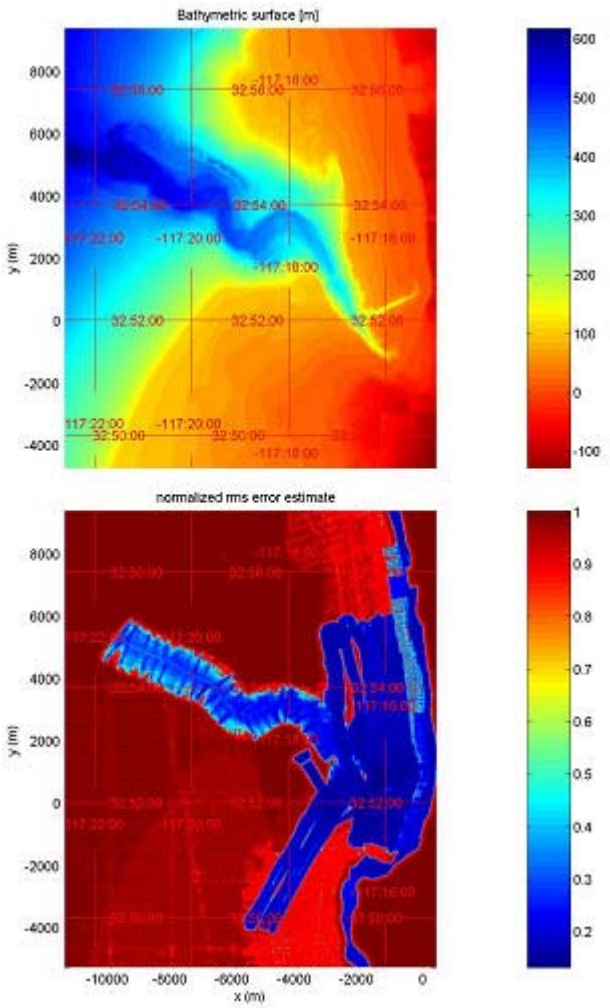
Video was also used to provide high-resolution estimations of nearshore currents and sediment transport. To study these, Dr. Holland, along with Mr. Tim Kooney, from NRL's Littoral Dynamics Office, and Jack Puleo (formerly of the Littoral Dynamics Office) used a method known as particle image velocimetry (PIV) to measure the water velocity in the surf region. A pair of stationary video cameras, placed on the National Marine Fisheries Service building, and an easily relocateable video camera, were used to record nearly 600 hours of video totaling nearly 2 terabytes of data. Initial comparisons of the PIV results with information from instruments deployed by the Naval Postgraduate School and the University of Massachusetts Radar Department show high similarity in results.

ONR and the Space and Naval Warfare Systems Command (SPAWAR) sponsored the Autonomous Underwater Vehicle-based Nowcasting Rapid Transition effort, which used an AUV to derive bathymetry that can serve as a boundary condition for Dr. Kaihatu's wave model. The AUV - called REMUS - was built by Hydroid, part of the Woods Hole Oceanographic Institute and operated by scientists from SPAWAR, WHOI and Scripps in coordination with Dr. Brian Bourgeois, from NRL's Positioning, Navigation and Timing Office.

"Our position on this project was to determine what could be done with the data from REMUS," said Dr. Nathaniel Plant, from NRL's Littoral Dynamics Office, "and how well it [the REMUS] performs in measuring the bathymetry from this very complex region." This proved to be a challenge. The AUV needs to stay at a certain depth above bottom in order for accurate measurements. The varying canyon depths created a variety of vessel performance issues that must be addressed, but in general showed the feasibility of the coupled nowcasting approach.

A concept known as "Bathymetry merging" also emerged from the NCEX projects. Dr. Plant used data from a variety of bathymetry sources - jet skis mounted with acoustic sounders and GPS, wheeled vehicles that mapped the beach, instruments on a push-around dolly, and 4-wheel drive vehicles mounted with GPS - and merged them into one bathymetric surface. Drs. Plant and Holland developed this merging tool to take all of the different data sources (and associated qualities), fit them together so they sit atop each other, and allow interpolation to a new grid or a new time. "You could ask for a specific data and the tool would know how to mathematically get the information, and it provides the error associated with making that decision," said Dr. Holland.

"Today, our Navy is operating within the littoral environment," states LCDR Troy Teadt, Military Deputy for NRL's Marine Geosciences Division. "We only expect to operate more extensively in this region in the future." An Operational Commander requires knowledge of the Battlespace, in this case the littoral environment, to optimize their planning and ensure success in the execution of their operations. The results from experiments like NCEX are instrumental in the development and optimization of models and tools that will provide that much needed knowledge to the Operational Commander.



Interpolated bathymetry (top, scale in meters) of the NCEX study area. The estimation error (bottom) indicates high quality (blue means low error) where high resolution surveys were conducted.

NRL conducted high-resolution surveys using Real Time Kinematic Survey system mounted to this specially-designed vehicle.

Photo of a rip current taken from a National Marine Fisheries camera on October 24, 2003.

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