

# Optical Imaging of the Nearshore

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## LONG-TERM GOAL

The long term goal of nearshore processes research has been to develop a predictive understanding of the fluid dynamics of a random wave field shoaling over the complicated bathymetry of a natural beach, and the response of the beach to those overlying wave and current motions. Traditionally, this has involved forward prediction based on models and seed data. However, it has now been broadly recognized that prediction of nonlinear systems such as the nearshore will inevitably fail at long time scales, so that knowledge of a coastal environment will depend on frequent data updates, likely acquired through innovative remote sensing techniques. Understanding and exploitation of the physics of optical remote sensing in the nearshore and the potential for coupling of remote sensing data with numerical models is a major long-term thrust of this work.

## OBJECTIVES

The principle objective for the past and current year is the successful participation in the NCEX field experiment, addressing the propagation of a random wave field over an abrupt canyon bathymetry in Southern California. The science objectives of the Coastal Imaging Lab (CIL) at NCEX are to contribute to the community understanding of the evolution of the incident wave field (principally the refractive aspects of wave propagation) over the submarine canyon and of the resulting nearshore circulation.

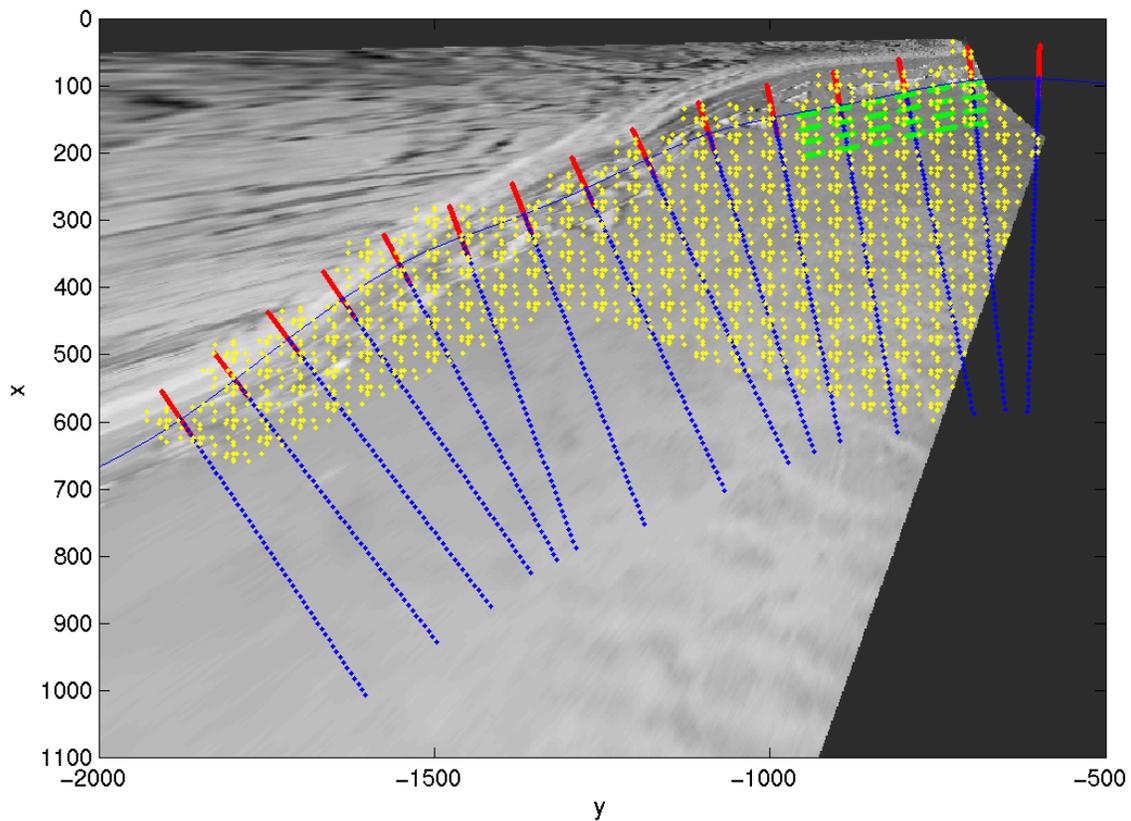
In addition, we continue to pursue understanding of the Large Scale Coastal Behavior (LSCB; variability at time scales of years to decades and length scales of kilometers) in different nearshore environment types.

## APPROACH

At the time of writing, the CIL is immersed in participation in the NCEX field experiment. This community effort provides not only a number of interesting science challenges, but also many opportunities for ground-truth testing of optical remote sensing techniques. We intend to use these data to continue testing of the recently completed Optical Current Meter algorithm [*Chickadel et al.*, in press] under the different wave conditions of Pacific swell on a low-sloping beach. Because wave refraction is a major aspect of this experiment, we have developed a broad area pixel time series technique to estimate the wave direction field based on a “tessellation” array, so named due to its repeating lag-array sub-tile (Figure 1). Comparisons with ground truth will be made where available.

Well-resolved wave direction maps will be computed over approximately 2 km of beach. In collaboration with Dr. Todd Holland at NRL-SSC and Dr. Tom Lippmann at Ohio State University, the CIL will collect and digitize wave runup data over approximately 4 km of beach to detect longshore modes trapped by the submarine canyons. We will also test a technique for the direct optical estimation of radiation stress gradients, the primary forcing term for nearshore circulation. Data from these collections as well as from longshore optical current meters will be merged in numerical models in joint work with Drs. Tuba Ozkan-Haller of OSU and Jim Kirby of NRL-SSC.

We continue to pursue our understanding of LSCB, principally through the collection of long time series of nearshore morphology change in the Argus Program. Twelve Argus sites at a suite of different beach archetypes collect hourly images of changing morphology. Finally, we continue to collect monthly GPS survey data from Agate Beach on the Oregon Coast to study the seasonal and interannual variability of this dissipative beach.



**Figure 1. Pixel Instrument sampling array for NCEX. The background is a merged, rectified snapshot of the NCEX field area, combining images from three cameras, and spanning approximately 1 km in the cross-shore and 1500 m in the longshore. Yellow dots show the 1842 pixels of the tessellation array to measure wave direction and depth. The blue cross-shore lines indicated pixel transects designed to allow depth transect estimates (an older technique). Green, longshore-oriented pixel lines allow measurement of cross-shore transects of longshore currents at six longshore locations. Red transects allow measurement of wave runup.**

## **WORK COMPLETED**

The principal activity over the past year has been preparation for NCEX. A key component was the development of Argus III, the next generation of Argus technology incorporating digital firewire cameras. Argus III stations allow a roughly two-fold increase in resolution and a tremendous improvement in sampling capability. NCEX is the first site for Argus III testing. At the time of writing, NCEX work has begun, with camera installation complete and the regular program of Argus collection and regular surveying now in progress.

Final work on the Optical Current Meter technique has now been completed and published [*Chickadel et al.*, in press], and this technique is now in regular use both in the CIL Argus program and with other Argus Users around the world.

We have continued work on LSCB, exploiting the long time series of time-exposure images that have been collected through the Argus Program. Of particular interest have been characterization of inter-annual variability in nearshore morphology [*Ruessink et al.*, in review], and characterization of large-scale rhythmic morphologies from four sites occupied by Argus Stations [*Enckevort et al.*, in review].

## **IMPACT/APPLICATION**

The development of a robust set of optical remote sensing techniques opens many doors. From the point of view of the U.S. nearshore processes research effort, Argus data continues to provide surprising and wide-ranging data that are available quickly on the web. Long time series, such as can really only be collected by a program like Argus, have proved themselves invaluable to understanding previously unsuspected inter-annual variability in the nearshore. We expect that Argus will have a large impact on the NCEX field program due to the range of fluid variable estimates such as peak wave direction that can be made with a fine granularity. These will complement and supplement the in-situ arrays during the actual experiment.

The impact of Argus on society is becoming increasingly apparent. In addition to the 12 sites run by the Coastal Imaging Lab, there are now more than 13 sites being operated by others worldwide. Argus is the focus of a three year EU program (CoastView), designed to integrate Argus into everyday Coastal Zone Management practices.

## **TRANSITIONS**

Argus technology has been embraced by NRL-SSC in a program run by Dr. Todd Holland. We continue to have strong collaboration with his group, including cooperative work associated with the VISSER station at Camp Pendleton and a second station at Waveland, MS. In fact, the Argus data base, now spanning about 60 site-years of data, is actively mirrored at NRL-SSC for both back-up and collaboration purposes. Many aspects of Argus technology have fed into Navy METOC activities, principally through the LRS program and continuing interactions with government and contractor scientists in that program. Transition of LRS to the WSC has required considerable collaboration and has provided many opportunities for Argus-associated research to find application at NAVOCEANO. We continue collaboration with the U.S. Army Corps of Engineers both through Bill Curtis at Vicksburg and through the FRF on a variety of Argus issues. Argus is now becoming “mainstream” in Europe with the beginning of the CoastView EU program for the integration of Argus into standard Coastal Zone Management practice. Argus has been transitioned to commercial availability through

transition agreements between OSU and Northwest Research Associates (for North America) and Delft Hydraulics (for the rest of the world).

## **RELATED PROJECTS**

- 1 - Joint work with Dr. Todd Holland, NRL-SSC
- 2 - Collaboration and data sharing of pixel time stack data with Dr. Jim Kaihatu or NRL-SSC
- 3 – Collaboration with Melody Bledsoe and Houston Costolo of the WSC at Navoceano on nearshore remote sensing
- 4 – LRS program collaboration
- 5 – EU CoastView Program (2002 – 2005)
- 6 – Numerous collaborations with the Field Research Facility

## **REFERENCES**

- Chickadel, C.C., R.A. Holman, and M.F. Freilich, An optical technique for the measurement of longshore currents, *Journal of Geophysical Research*, in press.
- Enkevort, I.M.J.v., B.G. Ruessink, G. Coco, K. Suzuki, I.L. Turner, N.G.P. Plant, and R.A. Holman, Observations of nearshore crescentic sand bars, *Journal of Coastal Research*, in review.
- Ruessink, B.G., K.M. Wijnberg, R.A. Holman, Y. Kuriyama, and I.M.J. van Enkevort, Inter-site comparisons of interannual nearshore bar behavior, *Journal of Geophysical Research*, in review.

## **PUBLICATIONS**

- Chickadel, C.C., R.A. Holman, and M.F. Freilich, An optical technique for the measurement of longshore currents, *Journal of Geophysical Research*, in press.
- Enkevort, I.M.J.v., B.G. Ruessink, G. Coco, K. Suzuki, I.L. Turner, N.G.P. Plant, and R.A. Holman, Observations of nearshore crescentic sand bars, *Journal of Coastal Research*, in review.
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## **PATENTS**

None

## **HONORS/AWARDS/PRIZES**

SECNAV/CNO Chair in Oceanography, 2003-2007