# Report Documentation Page

*Form Approved*
*OMB No. 0704-0188*



| | | |
|---|---|---|
| 1. REPORT DATE<br>**30 SEP 1997** | 2. REPORT TYPE | 3. DATES COVERED<br>**00-00-1997 to 00-00-1997** |

| | |
|---|---|
| 4. TITLE AND SUBTITLE<br>**Bubble Size Distributions and Wave-induced Water Flows in the Littoral Zone** | 5a. CONTRACT NUMBER<br>5b. GRANT NUMBER<br>5c. PROGRAM ELEMENT NUMBER |
| 6. AUTHOR(S) | 5d. PROJECT NUMBER<br>5e. TASK NUMBER<br>5f. WORK UNIT NUMBER |
| 7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES)<br>**University of California, San Diego,Scripps Institution of Oceanography,Marine Physical Laboratory,La Jolla,CA,92093** | 8. PERFORMING ORGANIZATION REPORT NUMBER |
| 9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES) | 10. SPONSOR/MONITOR’S ACRONYM(S)<br>11. SPONSOR/MONITOR’S REPORT NUMBER(S) |

12. DISTRIBUTION/AVAILABILITY STATEMENT
**Approved for public release; distribution unlimited**

13. SUPPLEMENTARY NOTES

14. ABSTRACT

15. SUBJECT TERMS

| 16. SECURITY CLASSIFICATION OF: | | | 17. LIMITATION OF ABSTRACT | 18. NUMBER OF PAGES | 19a. NAME OF RESPONSIBLE PERSON |
|---|---|---|---|---|---|
| a REPORT<br>**unclassified** | b ABSTRACT<br>**unclassified** | c THIS PAGE<br>**unclassified** | **Same as Report (SAR)** | **2** | |

**Standard Form 298 (Rev. 8-98)**
Prescribed by ANSI Std Z39-18

# BUBBLE SIZE DISTRIBUTIONS AND WAVE-INDUCED WATER FLOWS IN THE LITTORAL ZONE

Grant B. Deane
Marine Physical Laboratory
Scripps Institution of Oceanography
University of California, San Diego
La Jolla, CA 92093-0238
email: grant@mpl.ucsd.edu
Phone (619) 534-0536   Fax (619) 534-7641
Award Number: N00014-97-1-0288

## LONG-TERM GOAL
The long term objective is to quantify the role of air bubbles in breaking wave and surf noise and understand their effect on high-frequency propagation through the ocean.

## SCIENTIFIC OBJECTIVES
The immediate objective is to measure the bubble size distribution in high void fraction bubble plumes beneath breaking surf with an optical instrument.  Breaking waves, both on the shore line and the open ocean, create high void fraction bubble plumes near the ocean surface.  Bubbles with radii of order 10's of micrometers to 10's of millimeters are created and initially packed into dense clouds which persist for 10's of seconds and have void fractions of air in the range O(0.1) to O(1).  These plumes have a significant impact on the production and propagation of sound in the littoral zone.

Bubble size distribution measurements in high void-fraction, wave-induced bubble plumes are difficult to make.  The large void fractions of air in the plumes make acoustic instruments for bubble sizing either inoperable or the measurements difficult to interpret. Optical imaging methods have proven more effective in producing usable data, and the aim here is to develop an optical instrument which operates in high void fraction plumes.

## APPROACH
Two optical instruments and an underwater video camera were deployed in February, 1997 in the surf zone north of Scripps Pier as part of the NRL/Scripps bubbles experiment.  One of the instruments was a laser-based imaging system designed to measure very small bubbles with radii order 10 microns, and was deployed on a frame in the surf zone.  The second optical system was a modified underwater camera intended to gather data on larger bubbles with radii order 100-1000 microns.  Optical data on bubble plumes were collected over a 10 day period.  An acoustic resonator and 6 acoustic Doppler sonars were also deployed in collaboration with David Farmer from the Institute of Ocean Sciences, BC to make acoustical measurements of bubbly water in the breaking zone.

## RESULTS

The laser-based imaging system developed a mechanical fault early in the deployment, and did not provide usable data. The camera deployment, however, was successful and provided a valuable data set on the spatial and temporal distribution of bubbles in the wave-induced plumes. Analysis of the images taken is labor-intensive, and is on-going. The initial results indicate that quantifying the production of bubbles and their subsequent evolution in time will be achieved.

## IMPACT/APPLICATION

The presence of bubbles in the littoral zone has a significant impact on the transmission and absorption of high frequency sound. The bubbles are created by breaking waves, and after their initial injection are transported through the water column by the processes of turbulent diffusion, buoyancy and convection in long-shore currents and rips. The overall problem of understanding the distribution of the bubbles and their impact on high frequency acoustics in the surf zone begins with their initial injection into the water column. The optical data in the initial bubble plume properties and its subsequent evolution in time will form an important component of modeling efforts to predict the distribution and transport of bubbles in the surf zone.

## TRANSITIONS

The laser-imaging system deployed as part of this experiment has been modified to overcomes a number of problems traditionally associated with optical bubble measurements. The new instrument was deployed in storm conditions in the open ocean off the west coast of Vancouver Island in a collaborative study of the marine boundary layer and air-sea gas transfer with David Farmer.