Technical Report CHL-97-24
September 1997

THE 1990 DELILAH NEARSHORE EXPERIMENT: SUMMARY REPORT

Compiled by William A. Birkemeier, Cinde Donoghue, Charles E. Long, Kent K. Hathaway, Clifford Baron

U.S. Army Corps of Engineers
Waterways Experiment Station
3909 Halls Ferry Road
Vicksburg, MS 39180-6199

Revised: June 25, 2001

Prepared for: Headquarters, U.S. Army Corps of Engineers and Office of Naval Research

Contents

Preface

This report summarizes the primary data sets collected during the DELILAH nearshore experiment held in October 1990 at the Field Research Facility (FRF), Coastal and Hydraulics Laboratory (CHL), U.S. Army Engineer Waterways Experiment Station (WES). DELILAH was designed to investigate the physics of the nearshore zone using a large array of stationary and mobile instruments, video cameras, radar systems, and precision surveys. This report was prepared to document and publicize the DELILAH data set. It complements a growing series of technical papers, reports, theses, dissertations, and other results based on DELILAH data. These data are available electronically on-line or via other media such as CD-ROM.

The data presented here would not have existed without the combined efforts of the principal investigators, their students, technicians, and assistants. The staff of the FRF (Messrs. Eugene Bichner, William Grogg, Kent Hathaway, Clifford Baron, Charles Long, Herman C. Miller, Michael Leffler, Brian Scarborough, and Mrs. Dawn Miller) deserve special recognition. As hosts, they provided their time, commitment, and considerable field experience to ensure DELILAH's success. Dr. Jane Smith contributed to Appendix F, "Instrumented Sled." Mr. Kevin Kremkau helped to edit and prepare the final copy of the manuscript. Dr. Edward Thornton of the Naval Postgraduate School provided a technical review of the final version of this report.

DELILAH was sponsored by the U.S. Army Corps of Engineers (USACE), the Office of Naval Research and by the Naval Research Laboratory. This report was prepared under the Field Research Facility Analysis work unit USACE Civil Works Coastal Engineering Research and Development Program. Technical monitors were Messrs. John H. Lockhart, Jr., Charles Chesnutt, and Barry W. Holliday. CHL Program Manager was Mrs. Carolyn Holmes. Additional support was provided by the Coastal Dynamics program of the Office of Naval Research, Dr. Thomas Kinder; Program Manager.

The report was prepared under the direct supervision of Mr. Thomas W. Richardson, Chief, Engineering Development Division, CHL. General supervision was provided by Dr. James R. Houston and Mr. Charles C.Calhoun, Jr., Director and Assistant Director, CHL, respectively. Director of WES was Dr. Robert W. Whalin. Commander was COL(P) Bruce K. Howard, EN.

1 Introduction

During the fall of 1990, DELILAH, The ***D****uck* ***E****xperiment on* ***L****ow-frequency and* ***I****ncident-band* ***L****ongshore and* ***A****cross-shore* ***H****ydrodynamics*, was conducted at the U.S. Army Engineer Waterways Experiment Station, Coastal and Hydraulics Laboratory's, Field Research Facility (FRF) located in Duck, North Carolina (Figure 1). This experiment was conceived as an outgrowth of SAMSON, *The* ***S****ources of* ***A****mbient* ***M****icro****S****eismic* ***O****ceanic* ***N****oise* experiment which also occurred that fall. DELILAH was developed to take advantage of the directional wave information being obtained from the instruments installed and data gathered during SAMSON. These experiments deployed 87 instruments from the shoreline out to the 13-m depth contour, and collected a vast amount of data useful to many coastal research efforts. This report will first briefly describe SAMSON, but its purpose is to summarize the investigations and data collected only during DELILAH.

SAMSON

This experiment, sponsored by the Office of Naval Research, was an investigation into the causes of ocean bottom microseisms (very small fluctuations which can create significant noise in underwater acoustic transmissions). In order to monitor these microseisms, a number of different arrays of instruments were deployed. To measure the directional wave field and to monitor nonlinear pressure fluctuations at depth, which may excite the

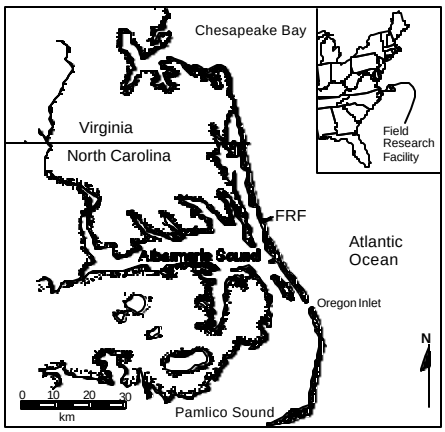

Figure 1. Location of the Field Research Facility

microseisms, the Scripps Institution of Oceanography deployed an array of 24 pressure sensors and 1 current meter at a depth of 13 m. This array covered an area 300 m by 300 m and is referred to as the "13-m array" throughout the remainder of the report (Figure 2). This effort was conducted by Dr. Robert Guza and Dr. Thomas Herbers with assistance from Dr. Steven Elgar and Dr. Joan Oltman-Shay. The 13-m array was deployed in August 1990 and operation began in September 1990. Although SAMSON officially ended at the end of November, the 13-m array continued to collect data until June 1991.

The 13-m array was operated in conjunction with the existing FRF directional wave array located directly landward in 8 m of water, and henceforth referred to as the "8-m array." This array, operated by Dr. Charles Long, consisted of a cross of pressure sensors with nine sensors located in a shore-parallel line and six in a cross-shore line (Figure 2).

Three additional arrays were deployed to measure the microseisms. Dr. Tok Yamamoto (University of Miami) deployed an array of five Ocean Bottom Seismometers (OBS) along the same 13-m depth contour as the Scripps' array. These not only recorded the microseisms but could also be used to measure the directional wave field. A large array of land-based seismometers was deployed across the state of North Carolina by Dr. John Nabelek (Oregon State University) and another OBS array was deployed in deeper water across the continental shelf.

Although data collected from the 8-m and 13-m arrays discussed above provided useful directional wave information for DELILAH, there was a separate array deployed closer to shore, referred to from here on as the "DELILAH array." This array and the DELILAH experiment are summarized in the remainder of this report.

DELILAH

The idea for DELILAH originated during the later planning stages of SAMSON. Simultaneous collection of wave and current data from 8-m and 13-m depths led to the suggestion that similar inshore data would provide information necessary to characterize the entire surf zone. Experience with earlier experiments, such as DUCK85[1] and SUPERDUCK,[2]helped to refine the

[1]Mason, C., Birkemeier, W. A., and Howd, P.A. (1987). "An Overview of DUCK85, a Nearshore Processes Experiment." *Proceedings of the Coastal Sediments '87 Conference*, American Society of Civil Engineers.

[2]Crowson, R. A., Birkemeier, W. A., Klein, H. M., and Miller, H. C. (1988). "SUPERDUCK Nearshore Processes Experiment: Summary of Studies, CERC Field Research Facility," Technical Report CERC-88-12, U.S. Army Engineer Waterways Experiment Station, Vicksburg, MS.

objectives, instrumentation plan, required equipment, and general logistics for DELILAH. The objectives were:

a. To measure the wave and wind forced three-dimensional nearshore dynamics with specific emphasis on infragravity waves, shear waves, mean circulation, setup, runup, and wave transformation.

b. To monitor the bathymetric response to these processes.

Investigators

The DELILAH investigators, their organizations at the time of the experiment, and general areas of scientific interest are listed below.

U.S. Army Engineer Waterways Experiment Station, Coastal and Hydraulics Laboratory:

William Birkemeier - Morphology.
Kent Hathaway - Runup, infragravity waves, morphology, remote sensing.
Charles Long - Incident and reflected directional wave spectra.
Nicholas Kraus - Longshore currents.
Jane Smith - Vertical current profile, 2-D circulation.
Todd Walton - Runup.
Edward Thompson - Surf beat modeling.

Naval Postgraduate School:

Edward Thornton - Mean circulation, shear waves, rip currents.

Naval Research Lab:

Dennis Trizna - Radar measurements of waves and currents.

Oregon State University:

Rob Holman - Morphology, runup, shear waves, infragravity waves, video remote sensing.
Peter Howd - Infragravity waves, morphology.
Tom Lippman - Morphology, infragravity waves, video remote sensing.
Todd Holland (also with the U.S. Geological Survey) - Runup, cusp formation.

Scripps Institution of Oceanography:

Robert Guza - Cross-shore and longshore currents, infragravity waves, wave transformation (also SAMSON Principal Investigator).

Northwest Research Associates:

Joan Oltman-Shay - Shear waves, infragravity waves (also SAMSON Principal Investigator)

Washington State University:

Steve Elgar - Incident and reflected directional wave spectra (also SAMSON Principal Investigator).

Experiment plan

The DELILAH array consisted of four subarrays that were interdependent. The primary cross-shore sub-array contained nine current meters and nine pressure wave gauges situated approximately 500 m north of the pier. Two other sub-arrays were positioned longshore, perpendicular to the cross-shore sub-array. Each consisted of one gauge from the cross-shore array where the longshore arrays intersected it. Five additional current meters placed in the trough region, and four placed slightly seaward of the nearshore bar crest, completed these sub-arrays (Figure 2). A final instrument package was positioned between the two longshore arrays forming a secondary cross-shore sub-array approximately 100 meters south of the primary cross-shore sub-array. All of the instruments in the DELILAH array extended across the typical position of the nearshore bar and were designed to sample in conditions generated by incident waves with significant heights up to 1.5 m. Dr. Edward Thornton of the Naval Postgraduate School provided the design and instruments for the primary cross-shore array and, with help from Rob Wyland, Katie Scott, and others, collected all of the data from the DELILAH array. The instruments in the other subarrays were provided by Scripps Institution of Oceanography and by the FRF.

FRF and Oregon State University video cameras were mounted on the FRF's observation tower to record swash and other surf zone processes. Five radar systems operated by the Naval Research Laboratory monitored the waves, currents, and bathymetry. Daily surveys conducted by the FRF's Coastal Research Amphibious Buggy (CRAB) documented changes to the bathymetry in a small 550-m by 375-m gridded area that surrounded the DELILAH array. This region will be referred to as the "minigrid" throughout the remainder of this report. Analysis of the current and bathymetry data collected during the 1986 SUPERDUCK experiment[1] helped in designing the instrument array.

The 8-m,13-m, and DELILAH arrays are shown in Figure 2. As in previous Duck experiments, the minigrid was located north of the FRF pier, open to storm waves from the northeast, and in an area typically characterized by shore-parallel contours. The southern end of the minigrid was within the shadow zone of the FRF pier for waves approaching from the southeast.

DELILAH commenced in the final weeks of September 1990 when the instruments were mounted on pipes (Figures 3 and 4) and deployed from the

[1]Birkemeier, W.A., et. Al (1989). "SUPERDUCK Nearshore Processes Experiment Data Summary: CERC Field Research Facility," Miscellaneous Paper CERC-89-16, U.S. Army Engineer Waterways Experiment Station, Vicksburg, MS.

CRAB (Figure 5). Current meters were positioned so as to be submerged during low tide and to remain above the highest expected bed level (Figure 6).

Stationary instrument measurements were supplemented by a vertical stack of five current meters, an anemometer, and two wave gauges located on the

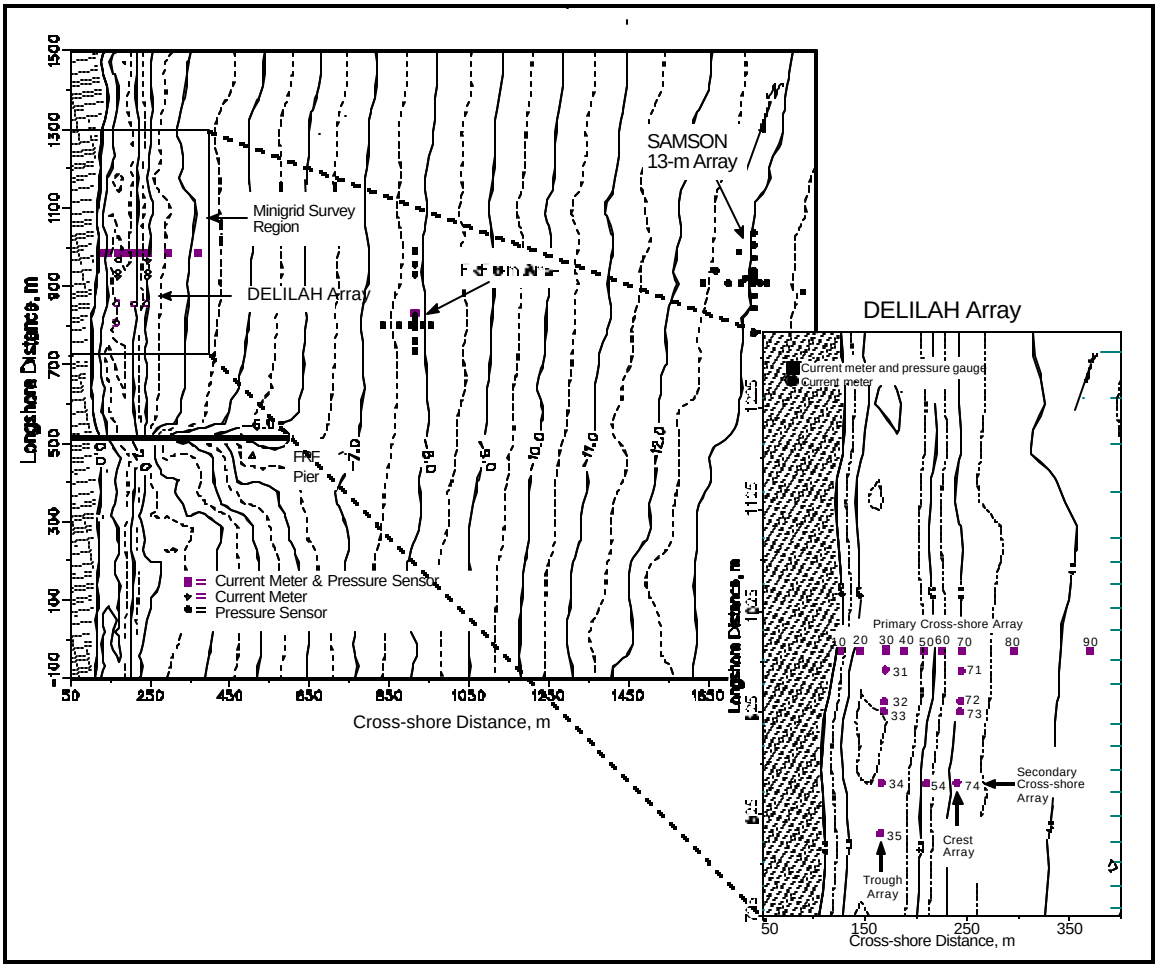

Figure 2. DELILAH and SAMSON instrument locations

instrumented sled (Figures 7 and 8). This sled was towed out by the CRAB and retrieved toward shore, stopping at the same inshore distance as the stationary instruments.

Figure 3. Mr. Rob Wyland assembling the instrument pipes in the FRF parking lot

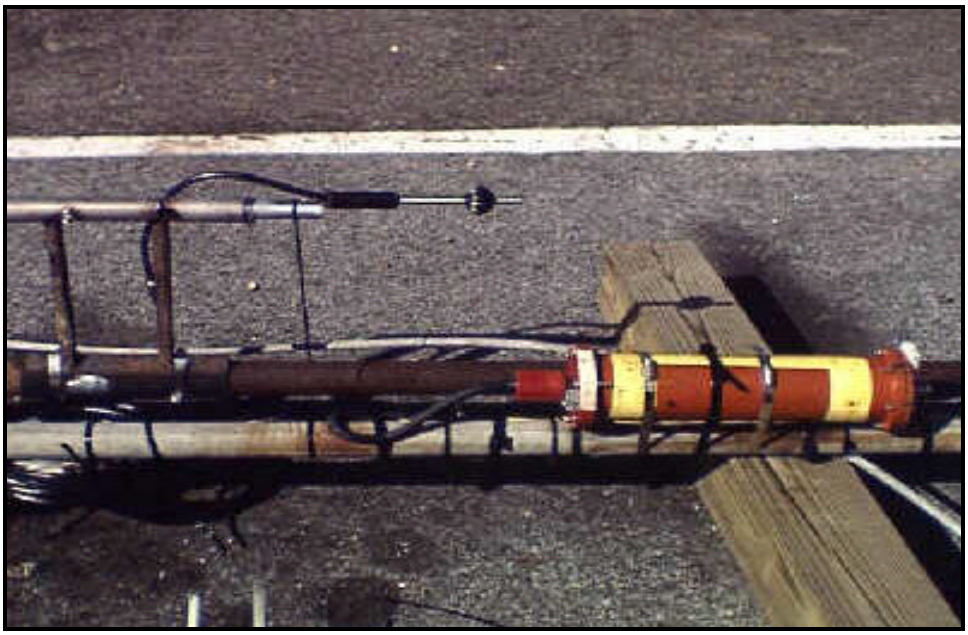

Figure 4. Closeup of assembled electronic package and sensor pipes. The Marsh-McBirney electromagnetic current meter is the small bar at the top center of the photograph

Figure 5. Instrument pipe being deployed from the CRAB

Figure 6. Cross-shore array after deployment. Current meter sensors were mounted on the left pipes, electronics and pressure gauges on the right pipes.

Figure 7. The instrumented sled prior to deployment. In this configuration it has five current meters, two wave gauges, and an anemometer

Figure 8. The sled being towed seaward by the CRAB

Experiment Conditions

During the 21 days of data collection, from 1 to 21 October 1990, a variety of conditions were encountered, as shown in Figure 9. This graph shows the wind, as measured at the end of the FRF pier (gauge 3932); the significant wave height, wave period, and wave direction measured in 8 m of water (gauge 3111); the longshore current in the inner bar trough (gauge 2342); and water level from gauge 1, relative to the National Geodetic Vertical Datum. After a short-duration wave event on 1-2 October, there was an extended period of low waves (<1 m) until 9 October, when a "Southeaster" occurred, causing the wave height to build to nearly 2 m. There was initial concern that Hurricane Lili might interrupt the experiment, but Lili's passage brought only windless, long-period swell approximately 2.5 m in height on 13 October. Energetic waves (H_{mO}>1 m) and longshore currents (>1 m/s) continued until the end of the experiment.

As in each previous Duck experiment, significant changes occurred in the nearshore profile. Figure 10 illustrates four of the minigrid surveys with the current meter locations indicated by vertical lines. The topography was rhythmic in the longshore dimension through 9 October, when it began to become more linear. The topography was linear on 11 October and remained so until the end of the experiment. High longshore flows occurred frequently during the experiment; an example of one of the more energetic periods is given in Figure 11, which shows longshore currents greater than 1.5 m/sec concentrated along the nearshore trough, inshore of the longshore bar crest. A plot of the cross-shore currents from the sled (Figure 12) shows onshore flow only near the surface in the region of the bar crest and weak offshore flow elsewhere.

Instrument retrieval and cleanup began on 22 October. All pipes and cables were removed, with the last being recovered on 25 October.

The remainder of this report consists of a series of appendices which include details about specific DELILAH data sets. Appendix A contains the survey data; Appendix B tabulates the video and runup data; Appendix C provides summary information about the bottom sediments; Appendix D presents pre- and post-experiment current meter calibrations; Appendix E summarizes the locations of and data from the stationary instruments; Appendix F summarizes the data collected from the instrumented sled; and Appendix G provides addresses for the participants and lists publications which use DELILAH and SAMSON data.

This report summarizes the collected data. The actual data are available via electronic media including online access and CD-ROM. Connect through the World Wide Web to http://frf.usace.army.mil. Since this address may change, contact the US Army Engineer Waterways Experiment Station, Coastal and Hydraulics Laboratory at 3909 Halls Ferry Road, Vicksburg, MS 39180.

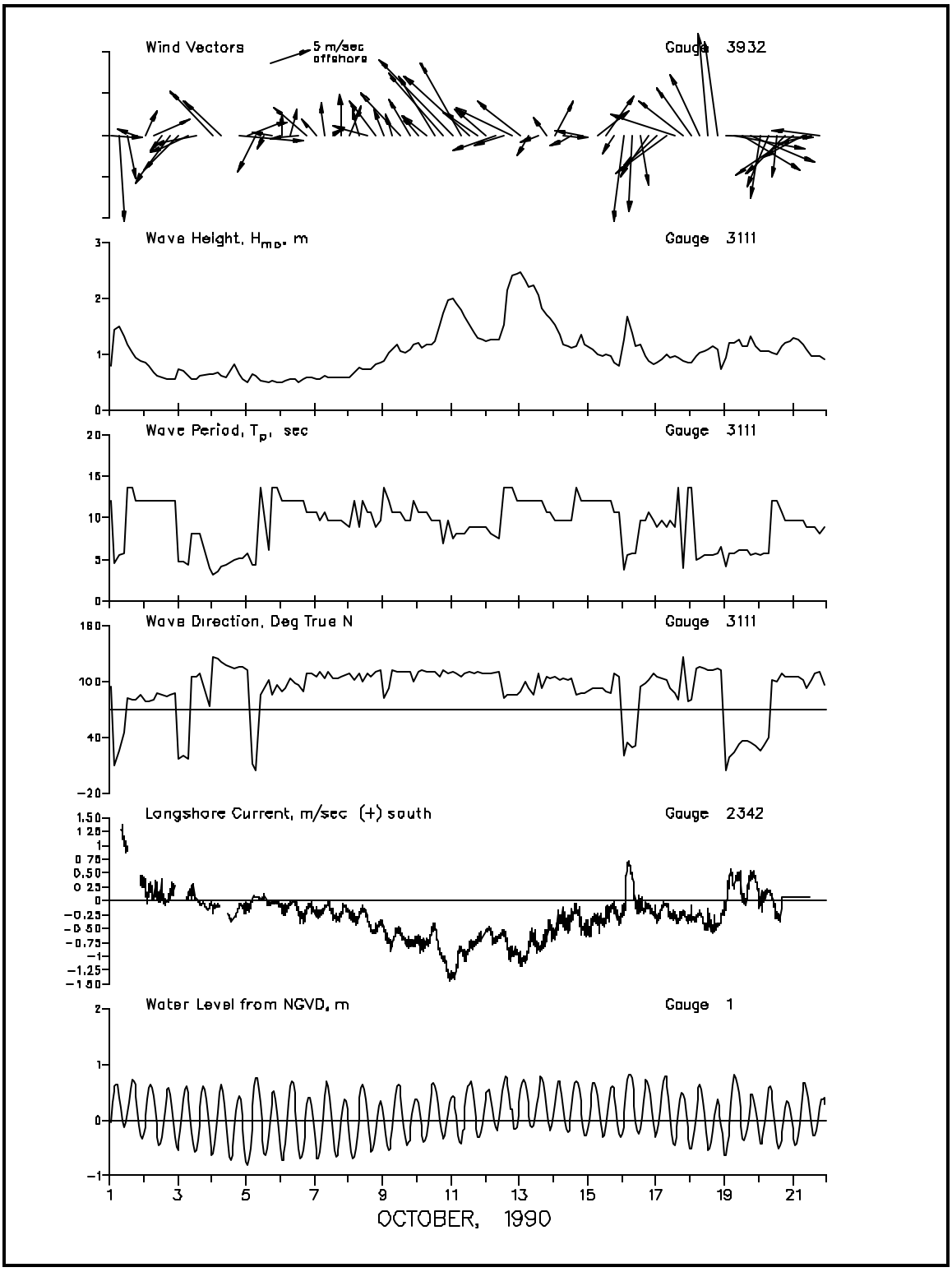

Figure 9. Conditions during the DELILAH experiment

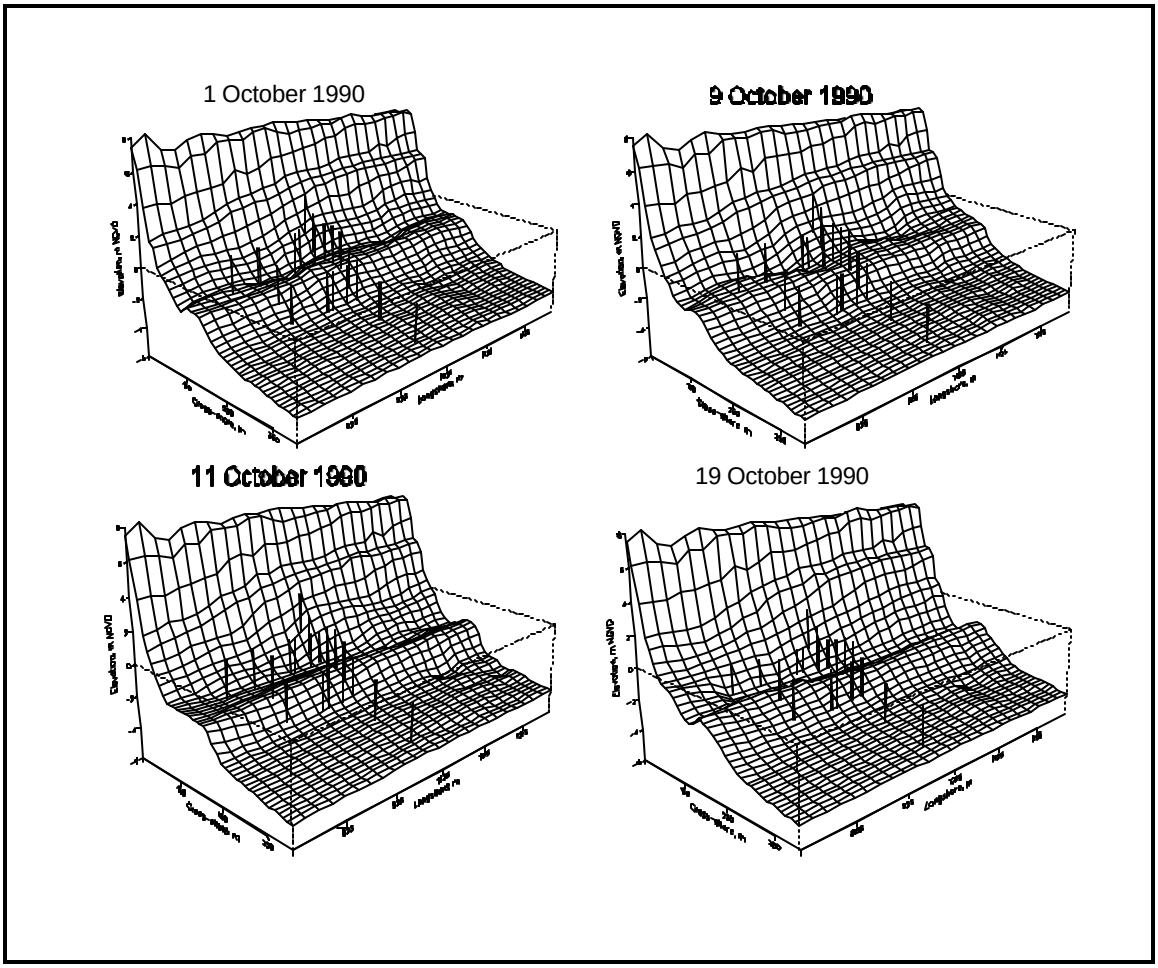

Figure 10. Four of the minigrid surveys showing bathymetric change over time

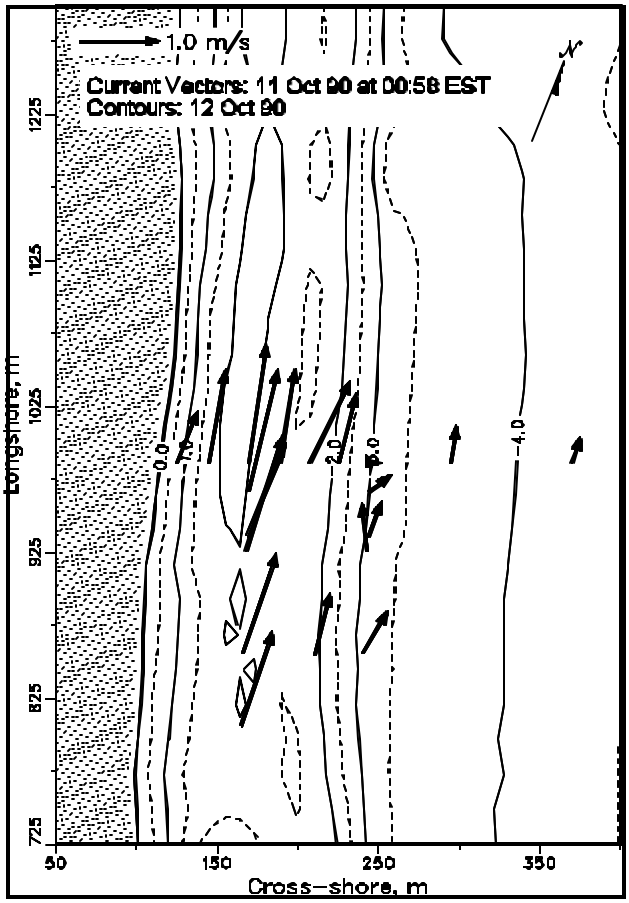

Figure 11. Current vectors during one of the energetic periods

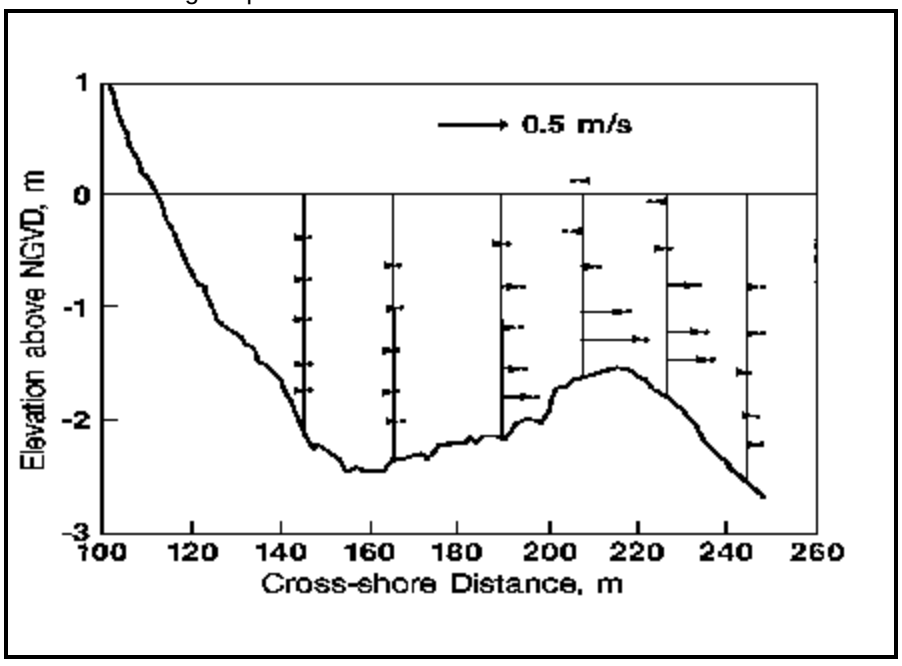

Figure 12. Sample instrumented sled cross-shore current data