Appendix E
Stationary Instrument Data

This appendix includes information about the mounting, positioning, and naming of the DELILAH array instruments. It also provides details on the basic measurements taken at the Field Research Facility (FRF), and a methodology for processing the data. Day-by-day sensor status reports (changes in instrument height, orientation, etc.) were included based on the experiment notes of Dr. Peter Howd and Dr. Edward Thornton. Other factors such as biological growth, bent sensor mounts, or changing local depths have not been included. Potential users of the data should familiarize themselves with the details presented here.

DELILAH Array

Instruments

The 19 instruments of the DELILAH array are shown in Figure E1. Nine instrument packages form the *primary cross-shore array* of the DELILAH array (indicated by squares in Figure E1). These nine gauges were provided by the Naval Postgraduate School. Ten additional current meters, provided by Scripps Institute of Oceanography, were installed to form three subarrays (indicated by circles in Figure E1). One longshore *trough subarray* consisted of six current meters. The second longshore subarray was formed by five current meters seaward of the bar crest, labeled the *crest subarray*. The third subarray was a three-gauge cross-shore array over the bar, between the two longshore subarrays. The cross-shore arrays were aligned to be parallel to the FRF pier and orthogonal to the FRF coordinate system (See Appendix A). However, the cross-shore locations of the longshore instruments was adjusted so that the longshore subarrays were parallel to the shoreline. This resulted in a 3.3 degree rotation of the arrays from the coordinate grid.

Data from the surf zone arrays were collected continuously except for the time required to change tapes. Each primary cross-shore array instrument package included a small ball (Model 512) Marsh-McBirney electromagnetic current meter, a Paro-scientific pressure gauge (except instrument package 80), and a Setra strain-gauge pressure sensor. The Paroscientific gauge was

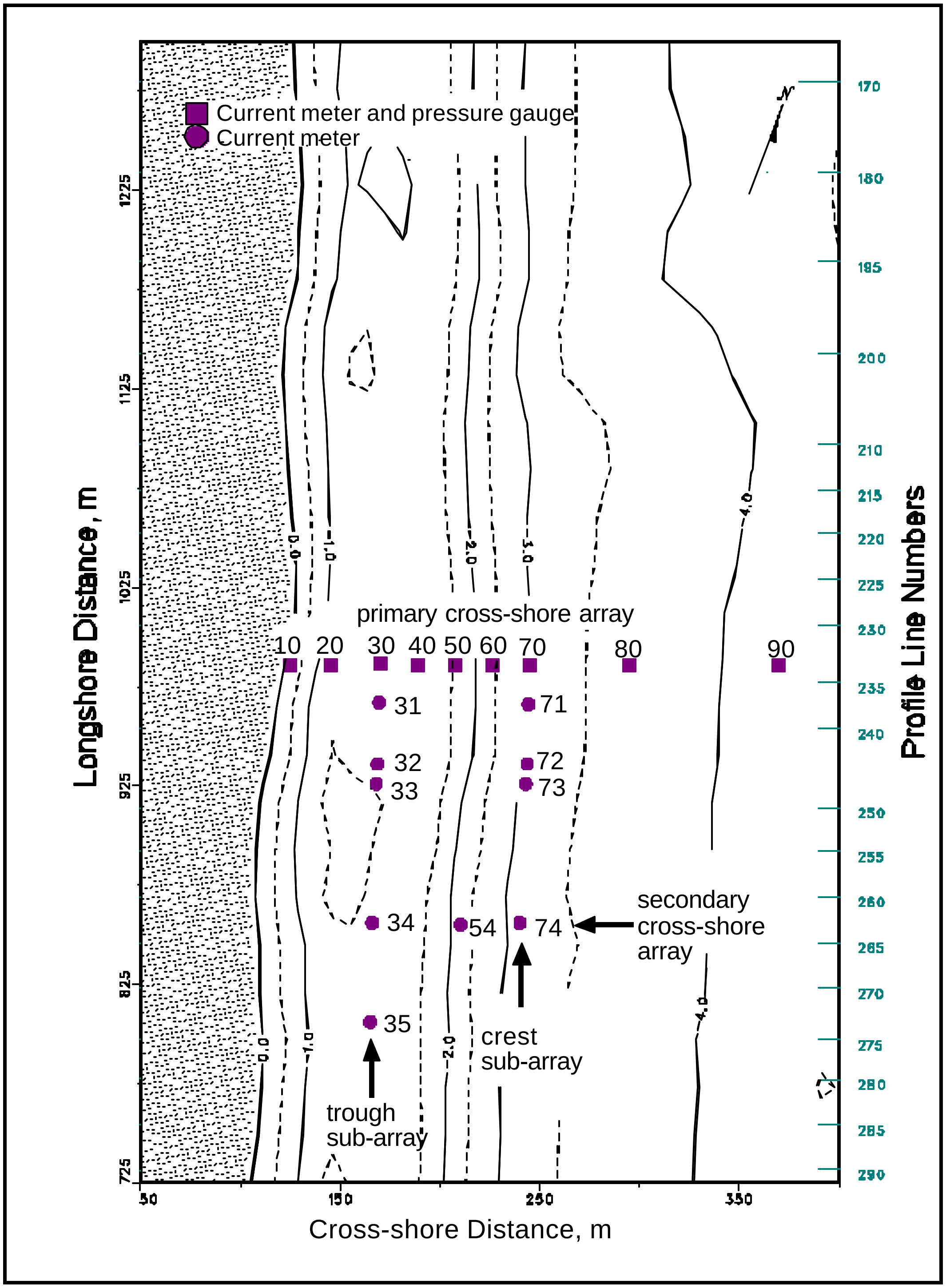

Figure E1. Location and numbering of the DELILAH array connected to a thin copper tube that was buried in the bottom in order to isolate the orifice from the current flow. The Paroscientific gauge was designed to measure wave-induced setup while the strain gauge pressure sensors measured wave energy. After considerable analysis at the Naval Postgraduate School, it was decided that because of the uncertainty in sensor height and other factors, the Paroscientific sensors could not be used to measure setup[1]. Data from all sensors (four channels) were internally converted to a digital signal and transmitted as a serial data stream back to shore. Each instrument package was connected to a data collection system using four-conductor, double armor, lightweight cable. Each electronics package was hose-clamped to the support pipes and connected to the cable with four-pin Brantner® underwater connectors.

Except for the two seawardmost instruments (80 and 90), the current meter probes for the primary cross-shore array were mounted on a separate line of pipes placed 1.5 m northeast of the instrument package/pressure gauge pipe (Figure 6 in the main text). At the five innermost positions (10 to 50), the current meter stinger was mounted downward, 30 cm away from the mounting pipe. All other stingers were mounted upright. Some of the downward-mounted stingers were adjusted during the experiment to keep them either above the sand or in the water.

A second data acquisition system was used to sample the analog output from the 10 current meters in the three subarrays. The five open frame electromagnetic current meters in the crest subarray and the single open frame sensor at position 54 were mounted upward. The five Marsh-McBirney current meter sensors in the trough subarray were mounted downward. Each of these current meters was wired back to the base of the duneline using seven-conductor double armor cable. The cables were wired into watertight "Hoffman" boxes. Power to the Hoffman boxes was isolated through the use of DC-to-DC converters as a preventative measure to reduce potential ground loops.

Figure E2 shows the location of the cross-shore instruments, including the initial position of the current meters relative to the changing bottom and water surface. Note the nearness of some sensors to the water's surface and the initial burial of CM10. This was taken into account when processing the data from these sensors and is discussed in the data analysis section that follows.

Current meter orientations were determined with an underwater digital compass mounted on a long nonmagnetic pipe so that it was not affected by the steel in the sensor mount. For Marsh-McBirney current meters the compass was read with the meters aligned to the direction of -y flow of the sensor ball. For the open frame meters, the compass was read with the meter aligned in the direction

[1] Personal Communication, 29 April 1997, Dr. Edward Thornton, Dept of Oceanography, Naval Postgraduate School, Monterey CA

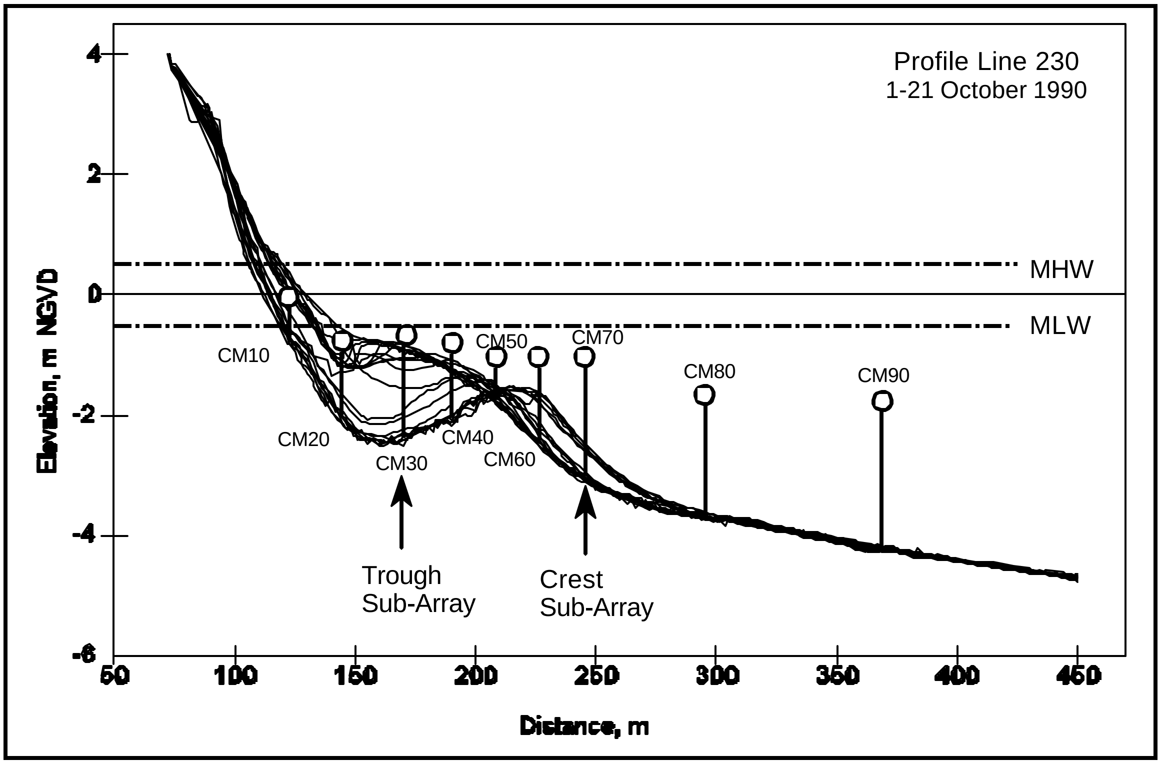

Figure E2. Location of the cross-shore current meters at the start of DELILAH along with the profile changes. Vertical arrows mark the two longshore subarrays

of +x flow. At the time of the DELILAH experiment, it was believed that the pier axis was 70 deg east of true north, and the current meters were aligned relative to the pier. More recent measures have computed the pier orientation at 71.8 deg. Current meter orientations are listed in Table E1.

A Met One anemometer was mounted on the top of the pipe at position 35. The anemometer was hit by high waves and failed on October 13.

DELILAH array gauge numbering

The following tables list the DELILAH instruments by gauge number and name. The gauge number is a four-digit number uniquely identifying the gauge, while the gauge name is a short alphanumeric string that identifies both the type of instrument and the location. Both were required to collect and process data at the FRF.

Included in both labels is the location numbering scheme (Figure E1) which uses a two digit-number to locate every surf zone instrument. The first digit (1-

9) refers to the cross-shore locations starting at the shoreline and moving offshore. The second digit numbers the longshore location starting with 0 at the primary cross-shore array and increasing to 5 at the southernmost gauge location.

The gauge number is stored in the header of the FRF's time series data (along with other information such as the gauge depth, gain, and bias). It is composed of four digits. The first digit, always a 2, identifies the gauge as a DELILAH instrument. The middle two digits refer to the location code described above. The last digit identifies the sensor (or channel) at that particular location. The sensors used were:

a. Current speed in the X direction.
b. Current speed in the Y direction.
c. Paroscientific pressure gauge.
d. Strain gauge pressure sensor.

Thus, a gauge number of 2503 is a DELILAH instrument, located at the 50 position, the fifth offshore gauge on the primary cross shore subarray, and is the Paroscientific pressure gauge (type 3).

The Gauge Name is used only to describe the particular gauge. It is not stored with either the raw time series or the FRF's summary statistics file. The following conventions are used:

CM	-	Current meter (Either open-frame or Marsh-McBirney).
PD	-	Pressure gauge to measure water Depth. This refers to the buried Paroscientific pressure sensors designed to measure setup.
PW	-	Pressure gauge to measure Waves. Refers to the strain gauge pressure sensors to be placed on the cross-shore array.
Y	-	Current measurement, positive to the south (also known as U).
X	-	Current measurement, positive offshore (also known as V).
SLED	-	This word precedes the names of instruments mounted on the sled.

Current meters and pressure gauges used in DELILAH are listed in Tables E1 and E2, respectively. The tables include gauge name, gauge number, serial number plots, gain, bias, and coordinates relative to the FRF coordinate system. The signs of the gains may differ from those listed in Appendix D. The signs have been adjusted to compensate for instruments being mounted downward. A negative gain flips the data of the channel so that they correspond to the conventions of:

+Y - a southward-moving longshore current.
+X - an offshore-moving cross-shore current.

Table E1
DELILAH Array Current Meter Locations and Gauge Numbering

Gauge Name	Gauge Number	Serial Number	FRF Coordinate System[1] Longsho	Cross-	Depth[2]	Gauge Depth[2] m	Direction from true N deg
CM10 X Y	2101 2102	90990/S1083	985.95	125.06	-0.28	0.07	162.3
CM20 X Y	2201 2202	9089/S1082	985.94	144.99	-1.39	-0.77	162.3
CM30 X Y	2301 2302	90988/S1081	985.61	169.97	-0.87	-0.66	162.3
CM40 X Y	2401 2402	81161/S9721	985.95	188.94	-1.32	-0.82	162.3
CM50 X Y	2501 2502	81455/S1013	985.88	207.41	-1.88	-0.98	160.9 163.7
CM60 X Y	2601 2602	81453/S1011	986.08	226.25	-2.33	-1.02	162.3
CM70 X Y	2701 2702	81454/S1012	985.91	245.00	-3.03	-1.05	162.3
CM80 X Y	2801 2802	81456/S1015	985.97	295.21	-3.68	-1.66	162.3
CM90 X Y	2901 2902	90991/S1084	986.11	370.12	-4.25	-1.68	162.3
CM31 X Y	2311 2312	MM S892	967.22	169.57	-0.94	-0.82	160.9 163.7
CM32 X Y	2321 2322	MM S385	936.44	168.68	-1.86	-0.78	162.3
CM33 X Y	2331 2332	MM S476	926.17	168.21	-1.88	-1.67	162.3
CM34 X Y	2341 2342	MM S760	856.09	166.06	-1.60	-0.82	161.6
CM35 X Y	2351 2352	MM S761	806.37	164.87	-1.58	-0.92	160.9
X Y	2351 2352	MM S762	Replaced MM S761 at 1251, 3 Oct 91				
CM54 X Y	2541 2542	Open Frame 6	855.87	210.37	-2.09	-1.02	252.3
CM71 X Y	2711 2712	Open Frame 7	966.04	244.36	-3.02	-0.93	252.3
CM72 X Y	2721 2722	Open Frame 10	936.08	243.65	-3.07	-1.01	252.3
CM73 X Y	2731 2732	Open Frame 16	926.06	243.16	-3.11	-1.04	252.3
CM74 X Y	2741 2742	Open Frame 9	856.05	240.88	-3.21	-1.27	252.3

TABLE E2
DELILAH Array Pressure Gauge Locations and Numbering

Gauge Name	Gauge Number	Serial Number	Gain[3] (m/s)/V	Bias[3] V	FRF Coordinate System[1] Longshore m	Cross-shore m	Depth[3] m	Gauge Depth[3] m
Paroscientific Pressure Gauges (Water Depth Measurement)								
PD10	2103	32089	1.0	0	984.41	124.86	-0.28	-0.07
PD20	2203	29439	1.0	0	984.75	145.03	-1.39	-0.69
PD30	2303	32088	1.0	0	984.99	169.78	-0.87	-0.55
PD40	2403	30735	1.0	0	985.01	188.60	-1.32	-0.67
PD50	2503	30566	1.0	0	984.88	207.54	-1.88	-0.78
PD60	2603	30344	1.0	0	985.29	226.46	-2.33	-0.81
PD70	2703	30564	1.0	0	985.07	245.02	-3.03	-1.00
PD90	2903	30565	1.0	0	986.11	370.12	-4.25	-3.26
Strain Gauges (Wave Measurement)								
PW10	2104	#2	1.0	0	984.41	124.86	-0.28	-0.65
PW20	2204	#3	1.0	0	984.75	145.03	-1.39	-0.86
PW30	2304	#4	1.0	0	984.99	169.78	-0.87	-0.75
PW40	2404	#5	1.0	0	985.01	188.60	-1.32	-0.86
PW50	2504	#6	1.0	0	984.88	207.54	-1.88	-0.98
PW60	2604	#7	1.0	0	985.29	226.46	-2.33	-1.22
PW70	2704	#8	1.0	0	985.07	245.02	-3.03	-1.20
PW80	2804	#9	1.0	0	985.97	295.21	-3.68	-3.04
PW90	2904	#1	1.0	0	986.11	370.12	-4.25	-3.06

[1]Coordinates are relative to the FRF coordinate system which is orthogonal to the research pier. The origin of this system is on the southern property line, behind the dune crest.
[2] The gain and bias values for these sensors were already adjusted for prior to the data being written.
[3] Depths relative to NGVD at start of DELILAH

DELILAH array data collection

Data were sampled at 8 Hz except for the Paroscientific sensors, which were sampled at 1 Hz. The primary cross-shore array had an unanticipated 4 to 8-sec gap in the data which occurred approximately every 20 min as a result of the microprocessors used. The 10 current meters in the three subarrays did not have these data gaps. These gaps in the time series were filled with values of -9999 so they are easily identified. There was no way to eliminate these gaps.

Gains and biases applied can be found in the data file headers of each time series. Several of the gauges (CM73 at 0939 on 20 October, CM71 at 1030 on 20 October, and CM50 at 1358 on 4 October) were rotated 180Eduring the experiment, noted as a change in the sign of the gains, in order to conform to other Marsh McBirney current meter orientations. Other orientation changes that occurred and must be noted include: gauge CM31 rotated 20E clockwise (visually estimated) at 1330 on 15 October, gauge CM10 rotated 2E clockwise between the beginning of collection at 0834 and end of collection at 1455 on 11 October and also re-aligned 17.6E clockwise between 0624 and 1330 on 18 October, and a re-alignment of gauge CM20 rotated 28.1E counter-clockwise between 0624 and 1330 on 18 October. In addition, a 10E landward bend from vertical in Gauge CM73 was corrected at 0939 on 20 October. These rotations were noted in the time series headers.

Throughout the experiment, two current meters, CM10 and CM20, were in a zone that experienced large bathymetric change. This necessitated moving the gauges up and down in order to ensure that they remained submerged in the water but were sufficiently far above the sediment surface. Gauge CM10 was moved up on 7 and 8 October and down on 9,11, and 18 October. Gauge CM20 was moved up on 7 and 8 October. Measurements of how far up or down these gauges were moved were not always recorded. The time series headers were modified to reflect recorded elevation changes.

The electronics package at position 60 (Figure E1) was lost during the high waves of Hurricane Lili at approximately 0700 on October 11. The sensors at position 30 stopped functioning a few days later.

DELILAH array data analysis

Summary statistics of the instrument data were computed based on the 8 min records samples at 8 Hz. More robust statistics could be computed by recombining the data into 17 or 34 min records. This would require that a suitable technique be used to fill the occasional 8-sec gap.

Although several of the current meters were vertically adjusted to maintain submergence and to remain above the bottom, several of the shallower gauges would occasionally became exposed in the wave troughs, particulary during low tide. A technique for determining when the current meters were exposed is presented, and was used to mark time series headers with a data quality parameter for exposed sensors. Several methods for estimating gauge exposure could be envisioned, the one presented here was used since it was fairly simple to employ. This technique finds the lowest trough elevation in each pressure gauge record (Setra gauges), then determines if the position of the corresponding current meter is above the lowest trough. This was a reasonable approach, particularly for the primary cross-shore array, since the current meters and pressure sensors were only separated by 1.5 m. The 10 current meters in the sub-arrays did not have co-located pressure gauges, so comparisons were made with primary cross-shore array pressure gages at the same cross-shore coordinate. Longshore homogeneity of the wave field was assumed.

DELILAH array pressure gauges recorded offsets and daily variations which were corrected by comparison to the Paroscientific pressure gauge LA33 (gauge number 231) in the FRF's permanent 8-m array. Gaps sometimes occurred in the data from gauge 231. If the gaps were less than 30 minutes in length, interpolation was used to attain water levels for those times. On 20 October, 1990 gauge 231 stopped functioning, from that time forward, the tide gauge located at the end of the pier was used for water level comparisons (Gauge 1, Figure E3). The tide gauge was not used for correcting water levels through the entire experiment because the signal from this gauge is typically not as accurate as the signal from the Paroscientific gauge. It samples a single point every six minutes which results in a noisier signal. This method does not take into account any potential wave setup between the 8-m array and the nearshore DELILAH array. The changes in the water levels for the current meters resulting from this analysis are presented in Figure E4.

An additional data quality analysis was performed on each current meter

Table E3
Depth Variation at DELILAH Surf Zone Instrument Locations (in cm, NGVD)

	Sensor Location																		
Date	10	20	30	40	50	60	70	80	90	31	32	33	34	35	54	71	72	73	74
901001	27	123	106	112	150	241	306	367	419	106	132	146	147	141	223	302	309	312	317
901002	16	118	116	108	160	237	302	368	423	86	109	126	153	145	222	302	311	314	318
901003	4	124	84	123	170	242	306	370	423	87	117	132	158	147	226	306	313	314	322
901004	8	127	91	131	179	249	309	371	427	93	117	132	158	147	227	308	315	319	321
901005	8	124	94	127	181	249	309	371	427	95	118	132	154	142	228	308	314	318	320
901006	5	123	94	129	180	249	309	369	427	96	118	132	146	131	230	307	313	317	322
901007	8	117	93	122	174	249	307	369	424	98	123	137	140	112	236	308	315	318	321
901008	23	63	99	130	160	255	309	370	425	110	142	149	116	112	241	308	318	322	320
901009	33	86	131	138	163	249	312	371	424	147	139	127	122	124	252	312	318	322	327
901010	24	123	152	146	163	247	315	370	425	141	131	130	130	129	251	314	315	316	328
901011	63	173	191	150	162	225	303	372	425	186	192	194	186	183	173	304	310	314	315
901012	82	187	200	165	157	222	301	371	425	198	209	214	199	199	184	301	302	302	315
901013	95	203	221	185						216	220	221	221	186			279	279	
901014	98	222	238	206	171	178	267	374	428	233	227	226	219	186	174	264	269	273	264
901015	97	220	244	219	168	183	264	371	427	239	242	232	226	188	172	270	278	280	273
901016	86	228	230	229	161	186	268	372	427	229	227	222	224	188	163	273	282	284	278
901017	92	221	228	226	170	181	266	372	429	230	227	223	222	189	171	272	281	284	279
901018	101	221	224	218	158	186	264	371	427	216	221	220	214	186	180	269	279	283	283
901019	114	226	219	240	156	192	269	370	426	215	221	221	218	202	179	272	274	274	282
901020	114	226	219	240	156	192	269	370	426	215	221	221	218	202	179	272	274	274	282

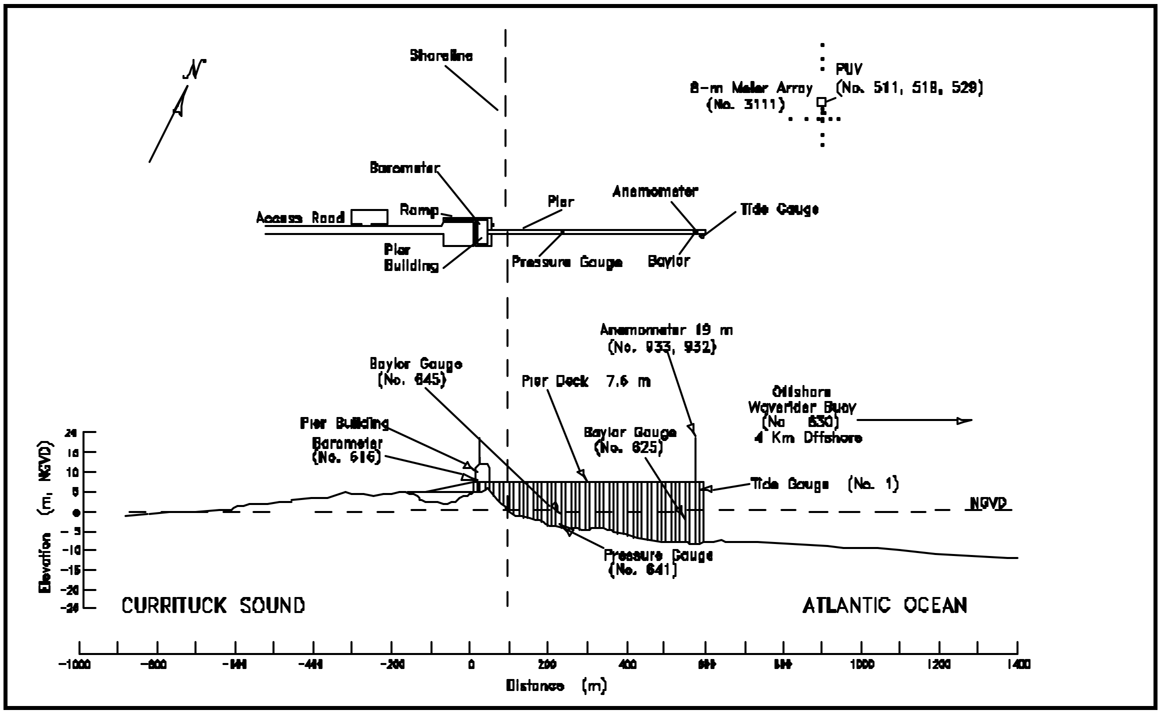

Figure E3. Schematic showing position of FRF's stationary instrumentation

record to determine the effect of biofouling on signal attenuation. This procedure, referred to as the *PUV-test*, Z(σ), used a ratio of surface wave H_{mo} computed from pressure gauges and current meters, to estimate a gain correction for the current meters. The method to calculate the PUV-test follows.

Pressure gauge data (in units of meters of sea water) were surface normal ized by the pressure response function $K(z,d,k) = \cosh k(z+d)/\cosh kd$, where z is gauge depth from (ensemble) mean sea level, d is total water depth, and k is radian wavenumber (related to radian frequency σ by the dispersion relation $\sigma^2 = gk \tanh kd$) immediately after Fourier transformation, by dividing the complex Fourier coefficients at frequencies σ by $K(z,d,k)$. Current meter data were surface normalized in a similar fashion except that the Fourier coefficients were divided by $\frac{gk}{\sigma}K(z,d,k)$. In linearized wave theory, the auto-spectrum from surface normalized pressure $C_{pp}(\sigma)$ is equal to the sum of the auto-spectra from the two surface normalized velocity compo

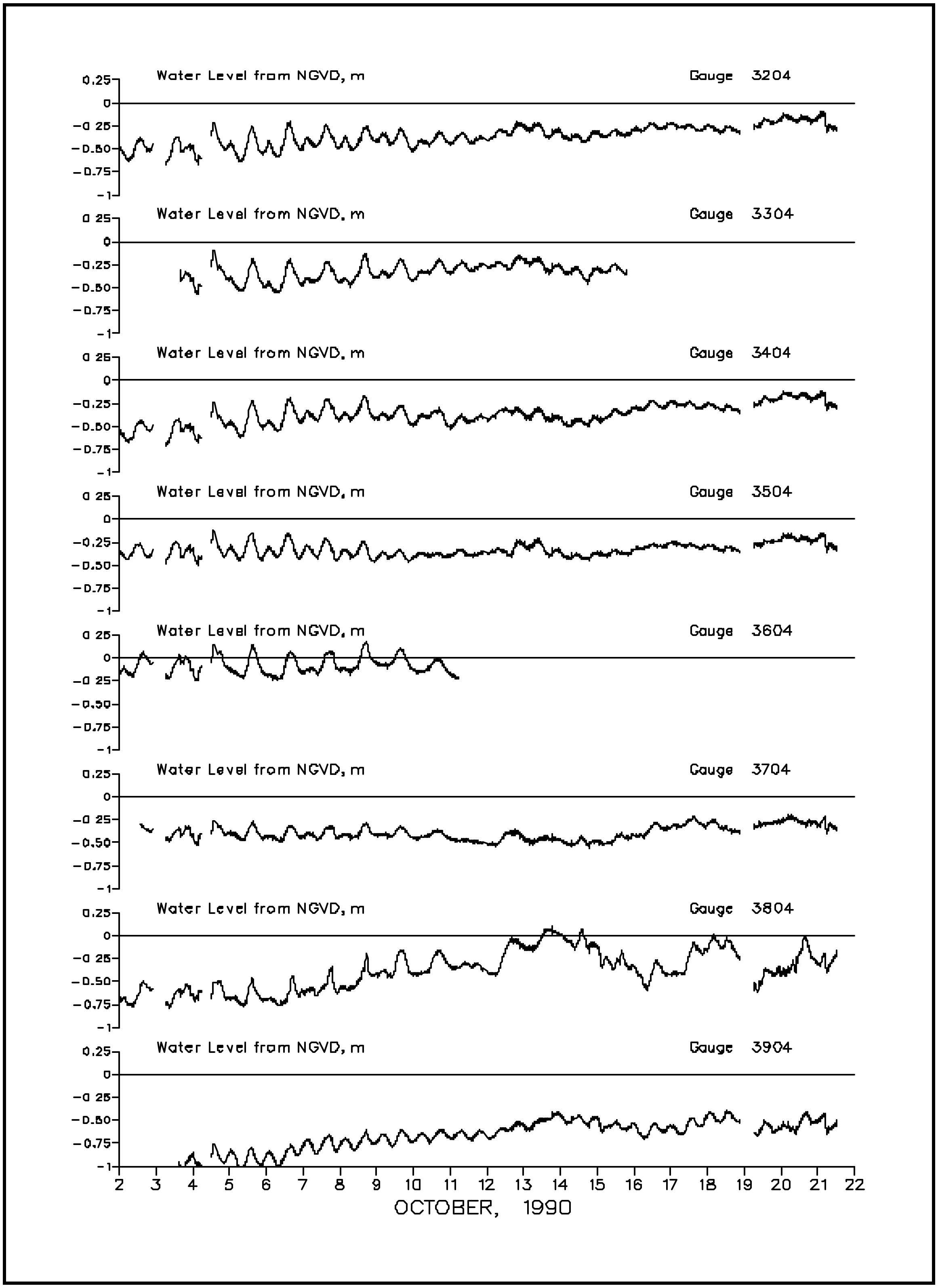

Figure E4. Changes in water levels for current meters resulting from comparison to 8-m array Paroscientific pressure gauge 231 nents $C_{uu}(ó)$ and $C_{vv}(ó)$ for u and v, respectively. A routine check on data quality for co-located pressure and current meter data , the $PUV\text{-}test$, is to compute the function, $Z^2(\sigma)=C_{pp}(ó)/[C_{uu}(ó)+C_{vv}(ó)]$,which was expected to be unity in the wind-wave pass band of frequencies in regions where linear theory applies.

The PUV-test analysis used the same gauge pairs as the exposed current meter analysis, current meters without colocated pressure gauges were matched with primary array pressure gauges at the same cross-shore coordinate. Again, longshore homogeneity was assumed. An average PUV-test is calculated for ach current meter record over a select frequency range of the $Z(\sigma)$. This PUV-test is averaged over the half-power bandwidth in the pressure gauge energy spectra, for the spectral peak that lies in the wind-wave band (0.4 to 0.05 Hz). These PUV-test values are used as a multiplier to adjust the mean current amplitudes. Inherent in this treatment is the assumption of uniform fouling between both axes of each current meter. Corrected and uncorrected current velocities, and PUV-test values are recorded in the DELILAH statistics database. Plots of the PUV-test values are presented in Figures E5 and E6. These data are noisy because averages are taken over short time segments. PUV-test plots for current meters that are not colocated to pressure gauges are especially noisy. The noisiness increases with the distance between current meter and pressure gauge. Plots CM71, CM72, CM73 and CM74 demonstrate this spatial inhomogeneity. The consistent PUV-test value of less than one for gauge CM90 indicates the pressure gauge was either lower in the water than believed or the current meter was higher.

Data from each instrument in the primary cross-shore subarray, the trough array, and crest array are plotted in Figures E7 through E12. Gauge 1231 on these plots the water level measured by the Paroscientific sensor as described on the bottom of page E8. These plots have been processed to handle data gaps, establish gauge depths relative to mean sea surface, and eliminate gauges that became exposed at low tide. Analysis has indicated the data set is of highest quality between 6 and 16 October. In the first few days of the experiment problems existed in the collection system and gauge elevations and orientations were being adjusted. After 16 October biofouling of current meters had significantly attenuated the sensor response, this was especially true for the Scripps Open Frame gauges. For these Open Frame gauges, there appears to be three identifiable portions of the experiment where three separate gains can appropriately be applied to each Open Frame current meter. The PUV-test values remained fairly constant during the first portion of the experiment, from 1 October through 8 October, then increased from 9 October through 13 October, and stabilized again from 14 October through 19 October. When these PUV-test multipliers are applied to the data, differences in the current velocity as great as 0.24 m/sec (27.5 % change in velocity) can result. For these reasons DATA COLLECTED USING OPEN FRAME SENSORS SHOULD BE USED WITH

CAUTION.**FRF Permanent Instrumentation**

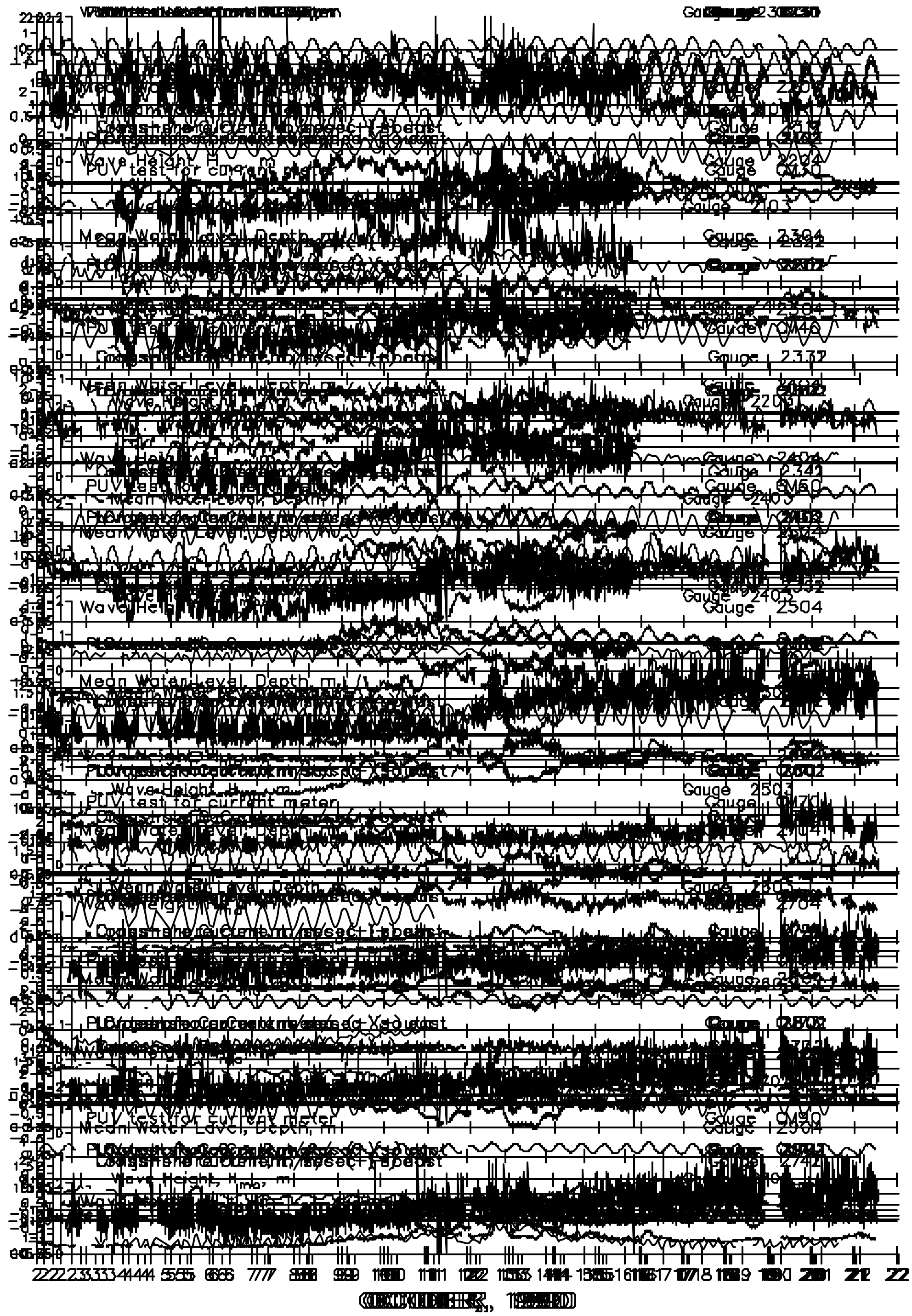

Figure E5. PUV-test values for gauges in the primary cross-shore subarray

[illegible]

A group of instruments that is permanently installed at the FRF allows for the continuous collection of oceanographic and meteorologic data. During large cooperative experiments, such as DELILAH, these instruments not only provide researchers with information on conditions during the experiment, but also with an invaluable archive of data from which to compare and interpret trends. The permanent instrumentation includes the 8-m array; Baylor wave gauges; waverider buoy; and gauges for wind speed, wind direction, tide, atmospheric pressure, and temperature. Table E4 lists the FRF permanent instruments by name and number and includes gain, bias, coordinates relative to the FRF coordinate system, and gauge depth. Figure E3 is a schematic depicting the location of these instruments.

An additional numbering convention for FRF permanent instrumentation is used to refer to combinations of gauges. This is a four digit gauge number that associates a name with the results of a multi-sensor data analysis. Among these four-digit combination gauges are 3111, which is the pressure sensors in the 8-m array; 3519, which is the vector averaged currents of the PUV gauge in the 8-m array; and 3932, which is the vector averaged wind speed and direction. Statistics from these and other gauges show the basic climatology during DELILAH in Figure E13.

8-m Array

The 8-m array is composed of a linear longshore array of ten pressure sensors (Nos. 101-191), a cross-shore array of five pressure sensors (Nos. 211-251), and a combination pressure/current meter (PUV) (Nos. 511, 519, and 529) within the array. The fifteen pressure gauges are mounted approximately 0.5 m off the bottom in the vicinity of the 8-m isobath. The array employs pressure sensors, manufactured by Senso-Metrics Inc., with a range of 0-25 psir (pounds per square inch relative to 1 atm). Each sensor was statically calibrated prior to deployment and mounted on a 2-in.-diam pipe jetted into the ocean bottom. A complete analysis of the data results in a three-dimensional directional spectra as illustrated in Figures E14 through E24. Characteristic wave heights from spectral observation are most frequently given as H_{mo}, which is four times the standard deviation of sea-surface displacement. It can be determined from the volume under the frequency-direction spectrum by the equation:

$$H_{mo}^2 = 16 \sum_{n=1}^{N} \sum_{m=1}^{M} S(f_n, \theta_m)\, df\, d\theta \qquad (1)$$

It can also be found from the integrated frequency spectrum by:

$$H_{mo}^2 = 16 \sum_{n=1}^{N} S(f_n)\, df \qquad (2)$$

which is its more conventional definition, or from the integrated direction spectrum (Equation 3) by:

$$H_{mo}^2 = 16 \sum_{m=1}^{M} S(\theta_m)\, d\theta \qquad (3)$$

Peak wave period (T_p) and peak direction (θ_p), can be determined by integrating the data in both direction and frequency as shown by the graphs on the vertical panels in Figures E12-E22. Note that as defined, the peak direction does not necessarily correspond to the waves which occurred at the peak period (i.e. peak energy). The PUV directional wave gauge consists of a Marsh-McBirney electromagnetic current meter and a Senso-Metrics Co., Inc. pressure sensor. It is mounted on a tripod located within the linear array. Wave direction is measured in degrees relative to true North and indicates the direction the waves are coming from. A detailed discussion of the data processing required to transform measured time series to estimates of frequency-direction spectra may be found in Long and Atmadja (1994)[1].

Surface Wave Gauges

The Baylor gauges and the waverider buoy are two different types of gauges used to collect wave information. The Baylor gauges (nos. 625 and 645) are surface piercing inductance staff gauges mounted on the pier at the locations indicated in TableE4 and Figure E3. The waverider (no. 630) is an accelerometer buoy located four kilometer offshore. Data analysis is similar for the two gauge types. Data were collected in 34 min records, which consisted of 4,096 data values (representing the voltage output of the sensor) sampled at 2 Hz. After the voltages were converted to engineering units using the sensor calibration factors, the time series were edited to eliminate erroneous jumps and spikes.

Wind Gauge

Measurements of the wind speed (no. 933) and direction (no. 932) were made at the seaward end of the research pier using a Qualimetrics Corporation

---

[1] Long, Charles E., and Atmadja, Juliana. (1994). “Index and Bulk Parameters for Frequency-Direction Spectra Measured at CERC Field Research Facility, September 1990 to August 1991,” Miscellaneous Paper CERC-94-5, U.S. Army Engineer Waterways Experiment Station, Vicksburg, MS.

Skyvane Model 2101 anemometer. Wind directions are reported relative to true North with onshore winds having a direction of 71.8º. Summary statistics

TABLE E4
FRF Permanent Instrumentation

Gauge Name	Gauge Number	Serial Number	Gain (m/s)/V	Bias V	FRF Coordinate System[1] Longshore m	Cross-shore m	Depth[2] m	Gauge Depth[2] m
Linear Array of Pressure Sensors								
LA09	191	7B273	3.476	0.061	990.43	914.64	-7.87	-7.87
LA08	181	5H308	3.407	0.175	955.79	914.28	-7.87	-7.84
LA07	171	5H264	3.419	0.131	930.45	914.01	-7.87	-7.76
LA01	111	4H263	3.419	0.289	825.52	914.43	-7.87	-7.76
LA02	121	7B272	3.453	-0.002	815.80	914.37	-7.87	-7.78
LA10	101	2F143	3.480	0.161	815.68	919.28	-7.82	-7.27
LA03	131	5H306	3.464	0.085	800.55	914.52	-7.87	-7.77
LA04	141	2F146	3.464	0.025	795.62	914.00	-7.87	-7.86
LA05	151	4H623	3.374	0.352	760.60	914.31	-8.09	-7.82
LA06	161	9B182	3.440	0.123	735.63	914.19	-7.87	-7.81
Cross-shore Array of Pressure Sensors								
LA31	211	0F380	3.445	0.057	800.44	834.64	-7.32	-6.58
LA32	221	0F381	3.447	0.127	800.62	874.67	-7.64	-6.86
LA33	231	PAROS[3]	1.158	-6.164	801.05	904.12	-7.81	-7.09
LA34	241	0F383	3.461	0.071	800.69	934.76	-7.95	-7.17
LA35	251	7B269	3.447	0.056	800.62	954.72	-8.14	-7.46
PUV Meter within the Linear Array								
Pressure	511	4H622	3.453	0.091	800.46	914.36	-7.93	-6.92
Current X	519	B989	0.600	0.000	830.46	914.36	-7.93	-5.68
Current Y	529	B989	0.600	0.000	830.46	914.36	-7.93	-5.68
Other FRF Instruments								
Waverider® wave buoy	630	67715-7	2.000	2.500	830	6100	-18.8	0.0
Baylor Wave	625	465	2.804	0.000	516.64	568.00	-8.35	-6.93
Baylor Wave	645	460	1.706	0.000	516.64	239.11	-4.75	-1.50
Wind Speed	933	1392	108.00	0.000	515.11	597.41	19.00	19.00
Wind Direction	932	1392	9.401	-0.036	515.11	597.41	19.00	19.00
Atm. Press.	616	16726	0.800	-0.038	569.00	11.60		

[1]Coordinates are relative to the FRF coordinate system which is orthogonal to the research pier. The origin of this system is on the southern property line, behind the dune crest.
[2]Depths relative to NGVD at start of DELILAH
[3]Calibration for period beginning 4 October 1990.

of 34 minute mean values of these data are presented as the wind vector plot in Figure E11.

Tide Gauge

Water level data were collected by a National Oceanic and Atmospheric Administration (NOAA) tide gage located at the seaward end of the research pier (Gage 1). A 6 minute mean value from the tide gauge, computed once per hour, is plotted as water level from NGVD in Figures E7 through E13.

Barometer and Thermometer

Atmospheric pressure (gauge 616) and air temperature (gauge 624) were measured by Yellow Springs Instrument Co. sensors installed at the FRF building. Summary statistics of 34 minute mean values of atmospheric pressure is included in Figure E13.

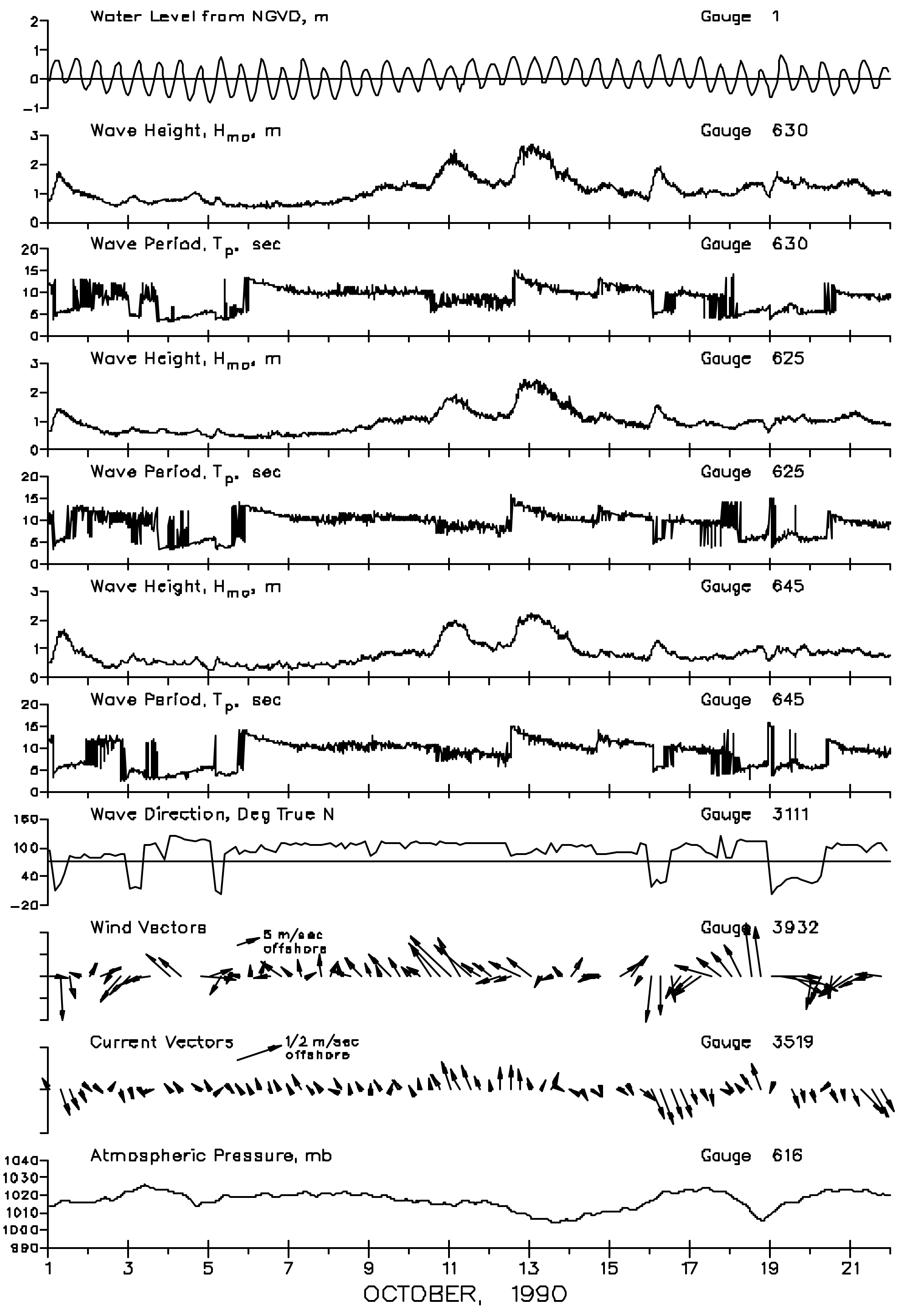

Figure E13. FRF instrumentation

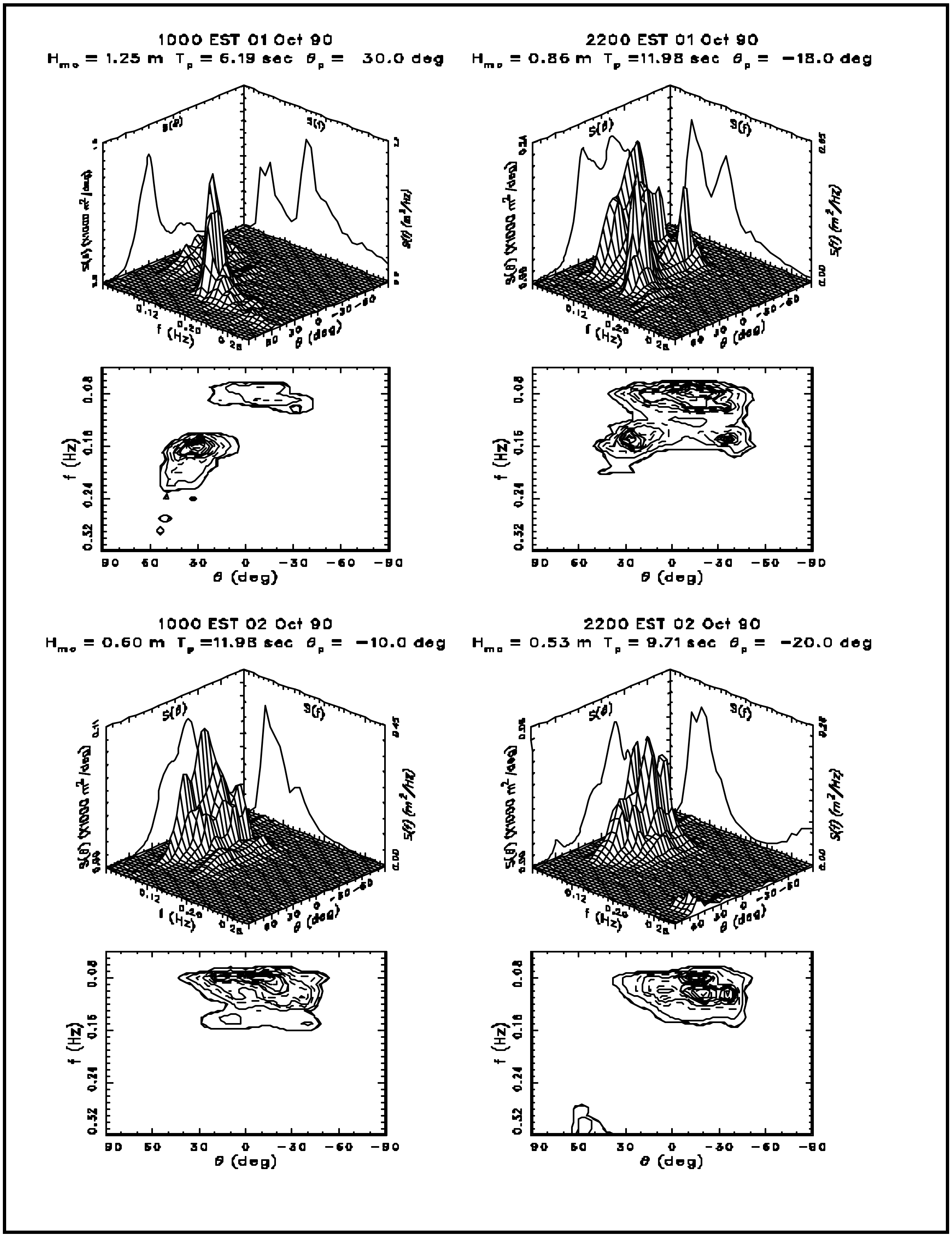

Figure E14. Representative frequency-direction spectra from 8-m array for 1 and 2 October 1990

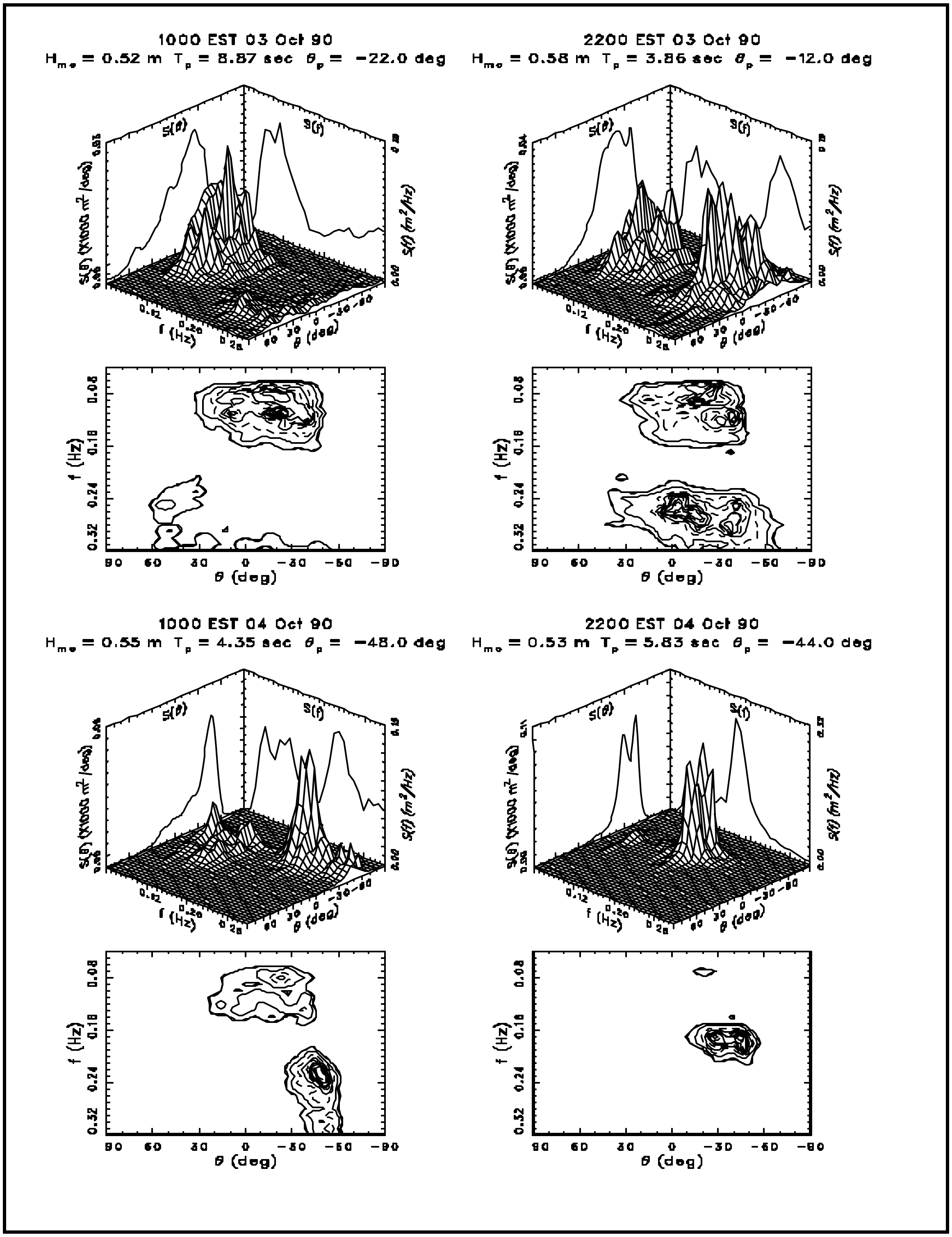

Figure E15. Representative frequency-direction spectra from 8-m array for 3 and 4 October 1990

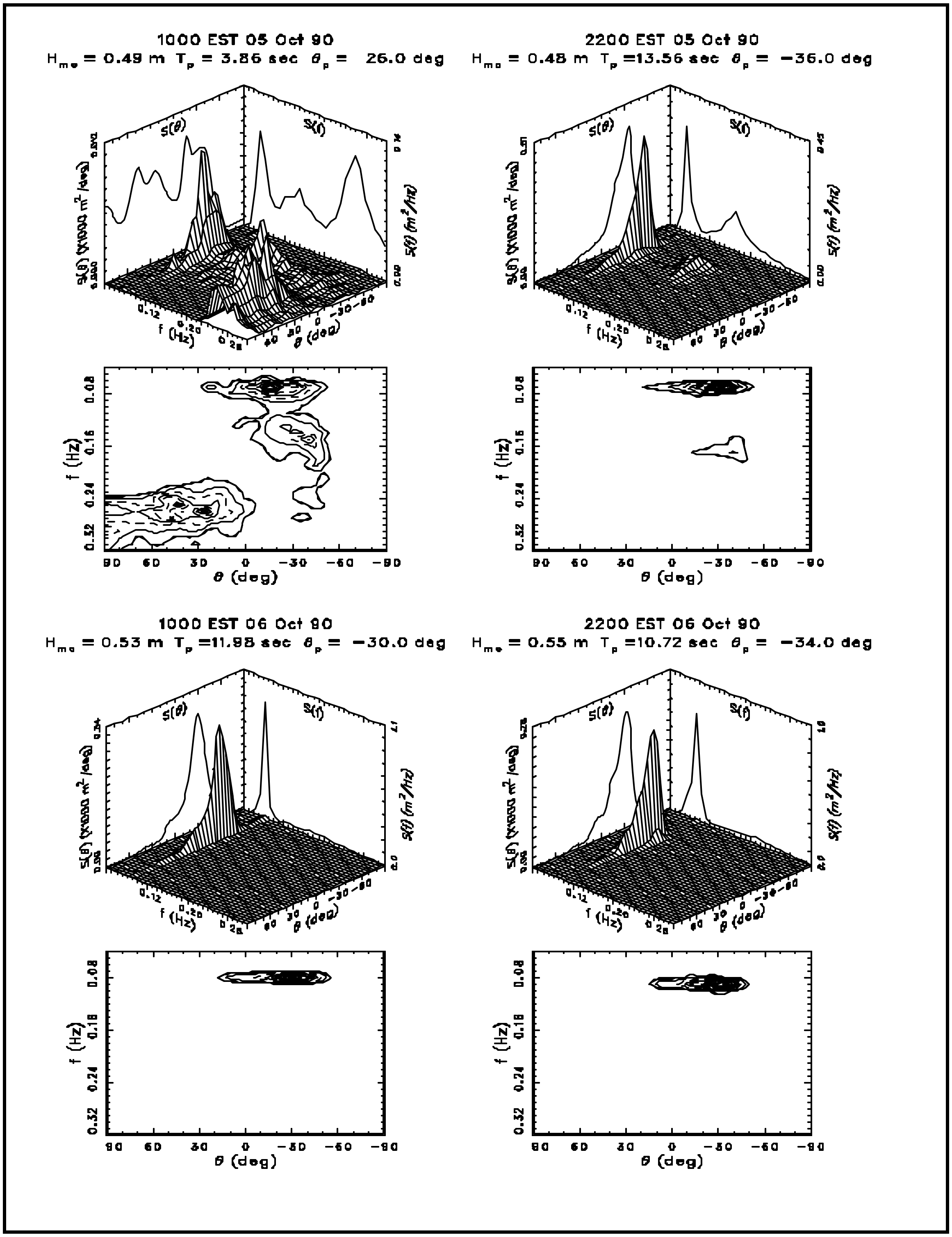

Figure E16. Representative frequency-direction spectra from 8-m array for 5 and 6 October 1990

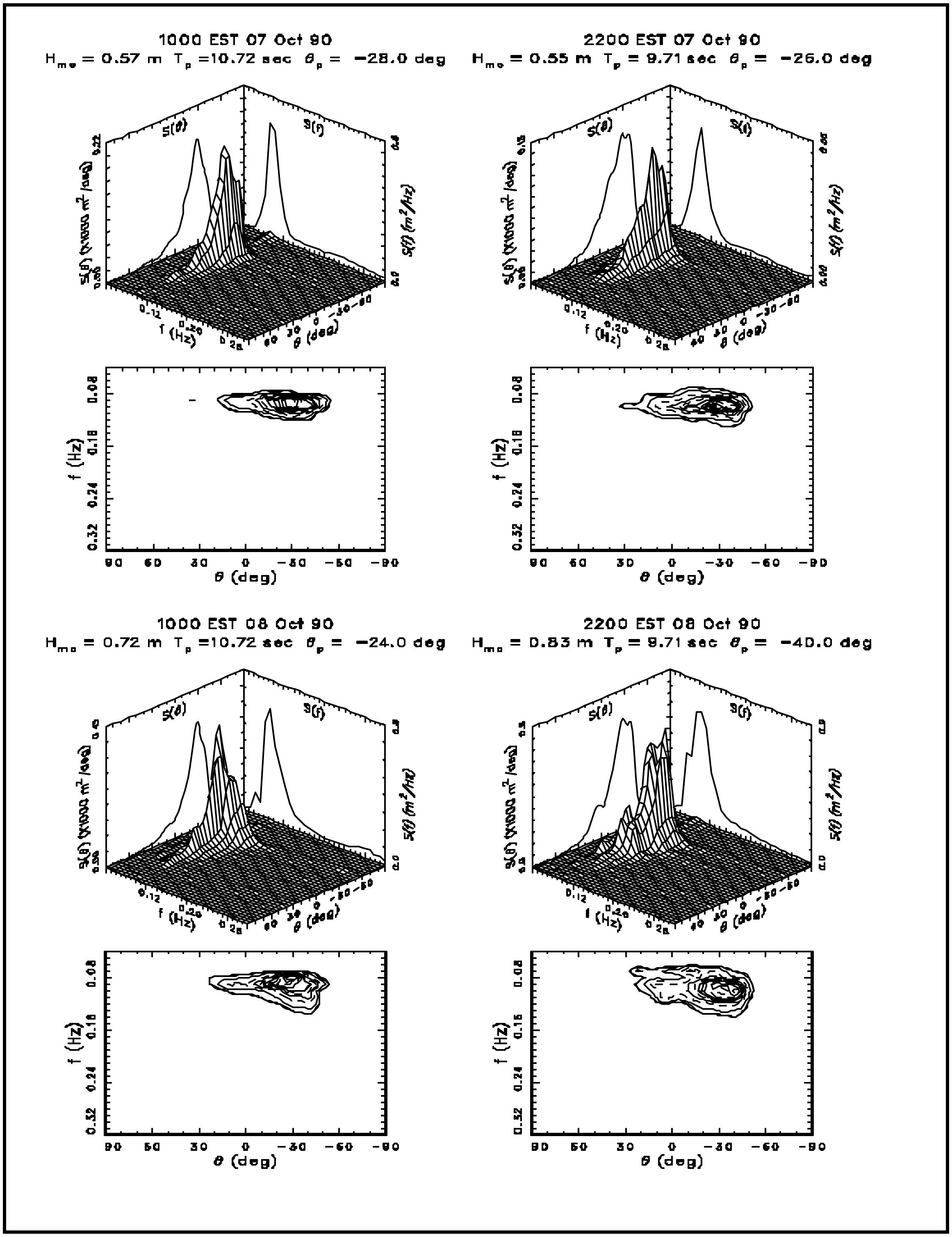

Figure E17. Representative frequency-direction spectra from 8-m array for 7 and 8 October 1990

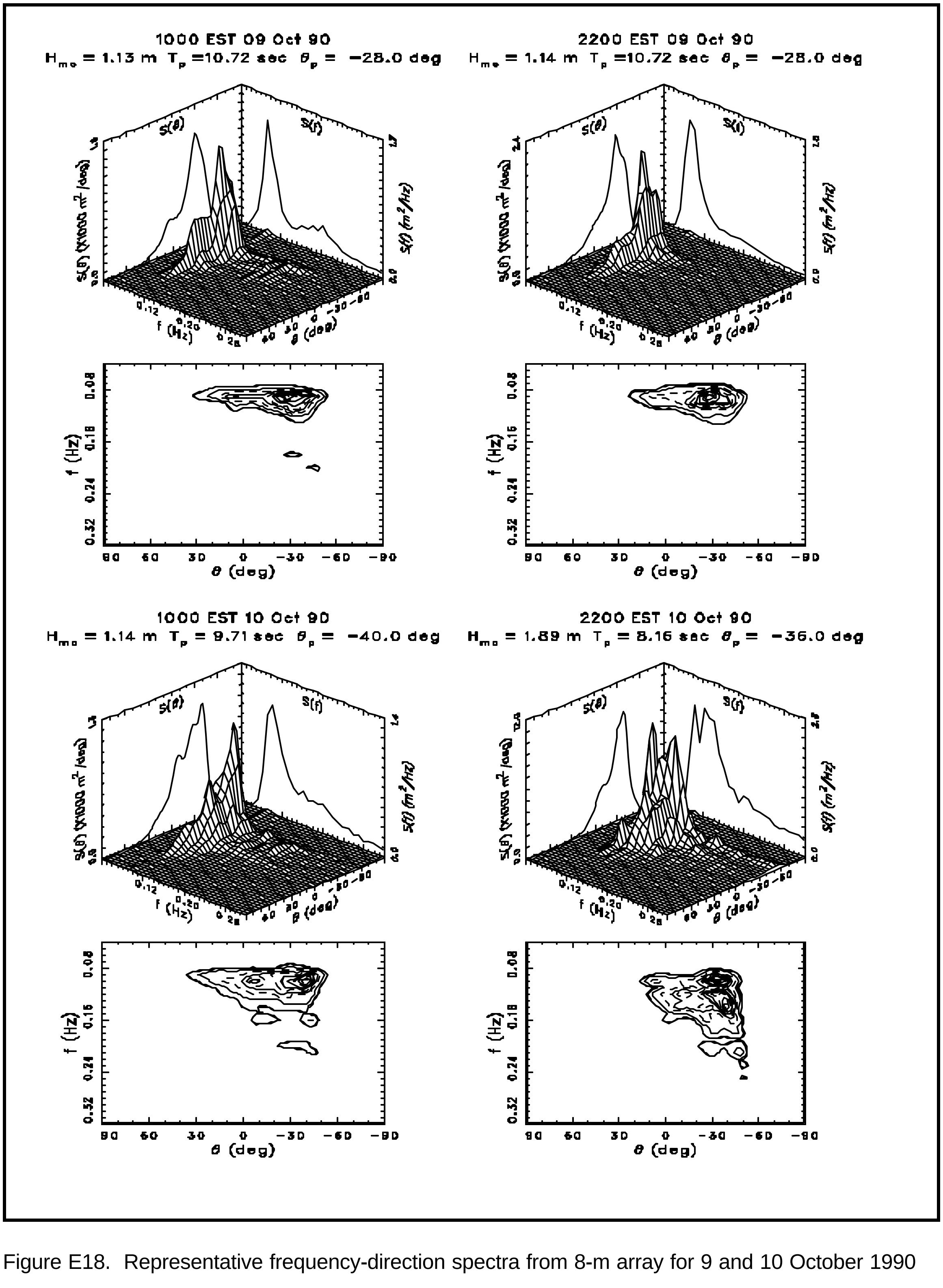

Figure E18. Representative frequency-direction spectra from 8-m array for 9 and 10 October 1990

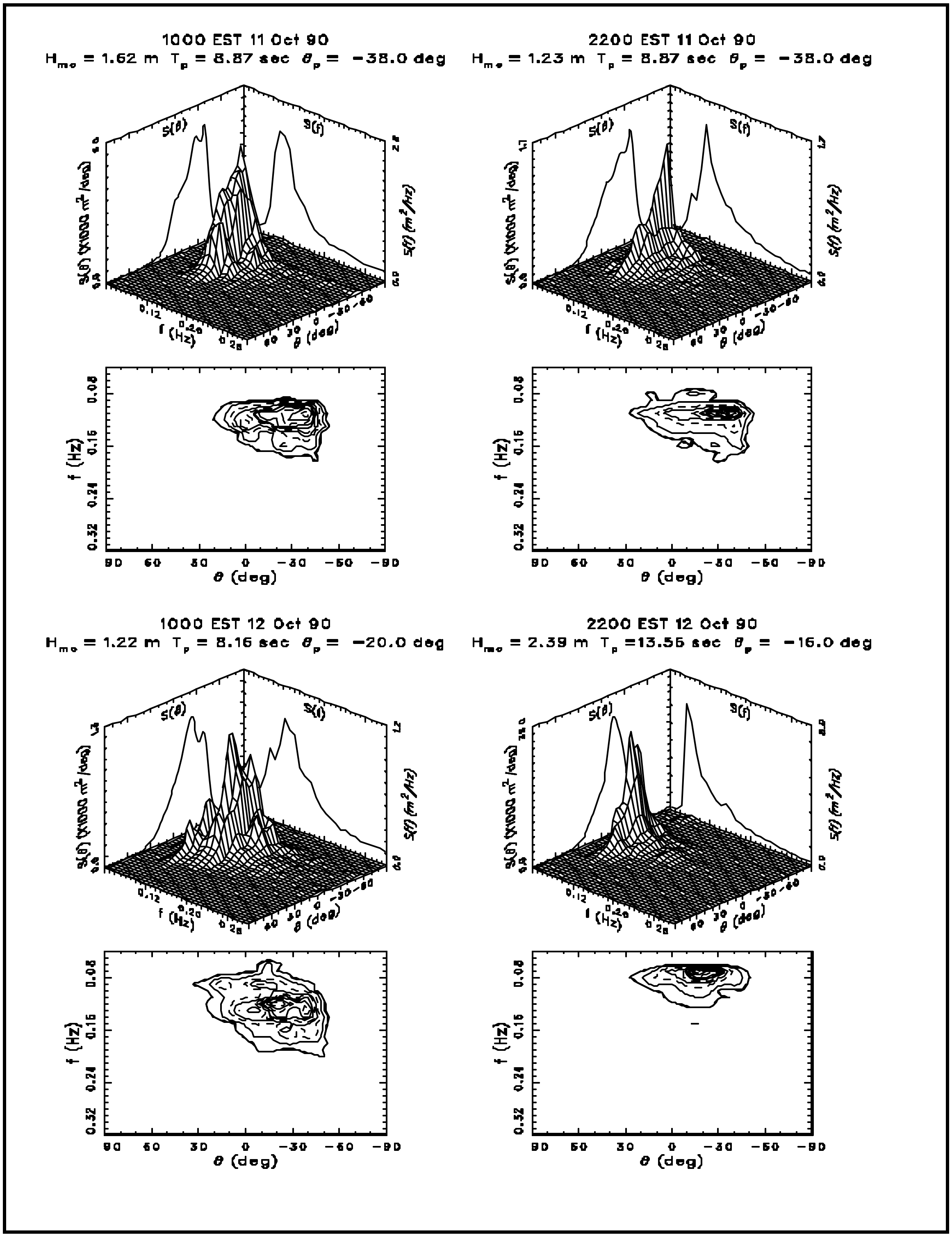

Figure E19. Representative frequency-direction spectra from 8-m array for 11 and 12 October 1990

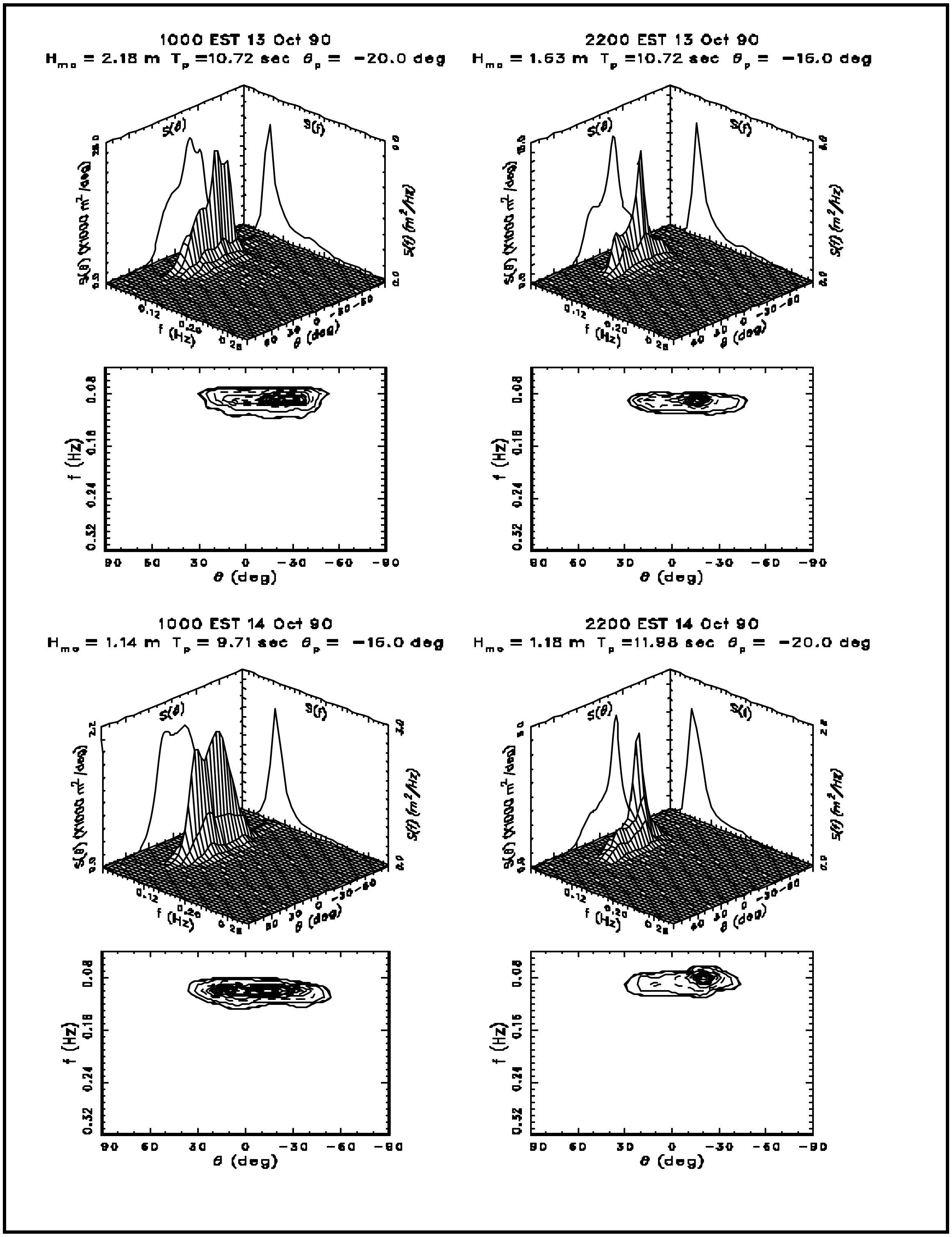

Figure E20. Representative frequency-direction spectra from 8-m array for 13 and 14 October 1990

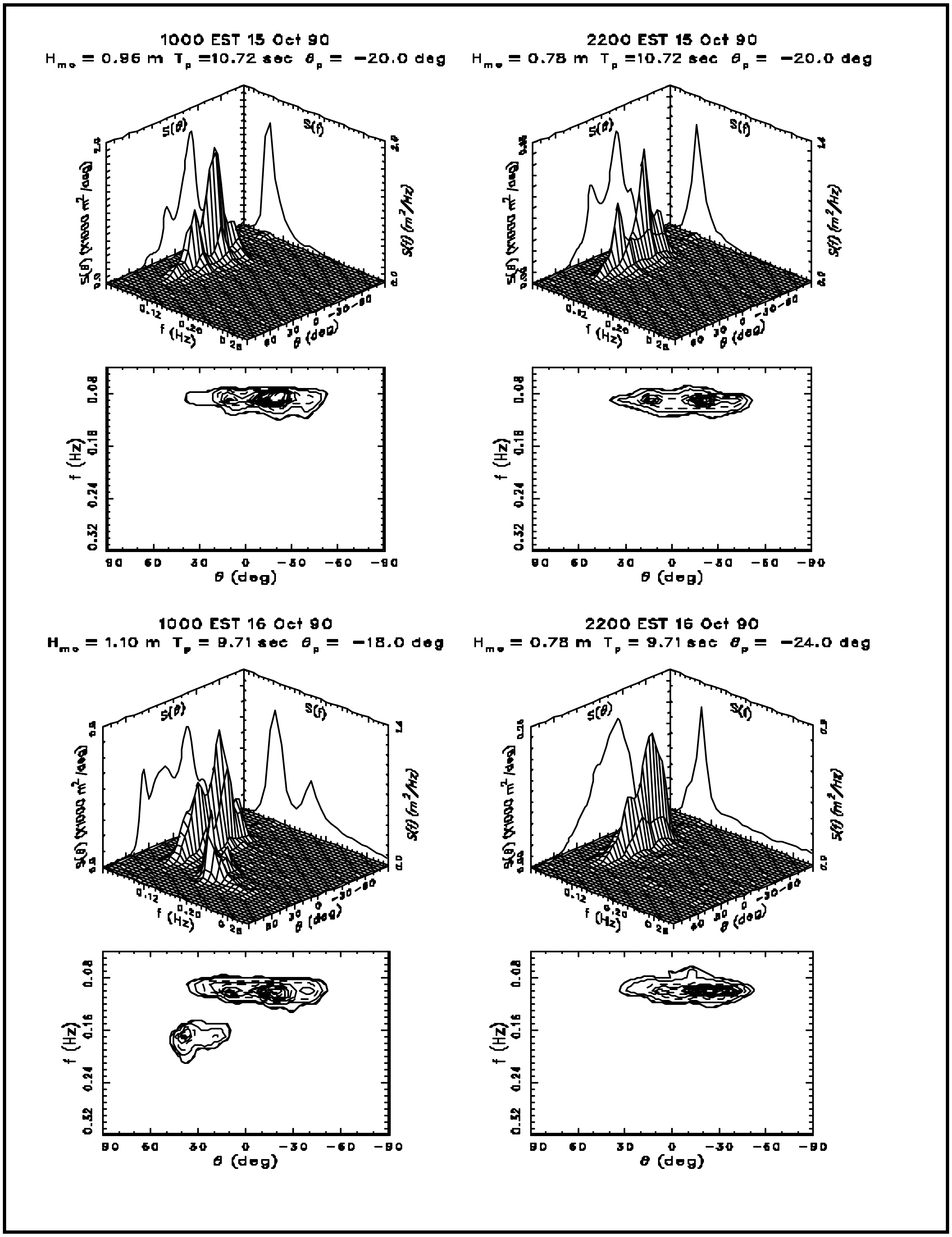

Figure E21. Representative frequency-direction spectra from 8-m array for 15 and 16 October 1990

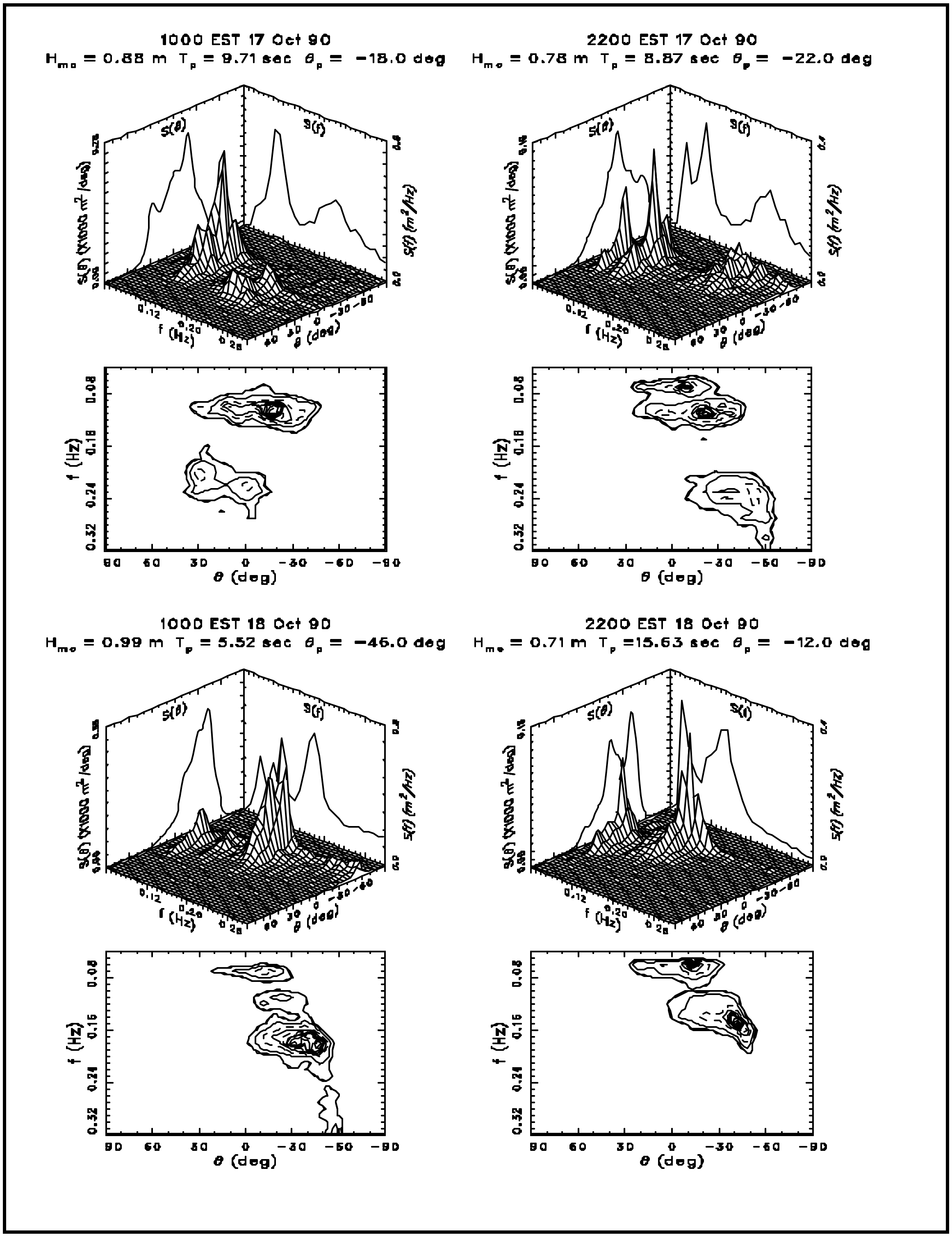

Figure E22. Representative frequency-direction spectra from 8-m array for 17 and 18 October 1990

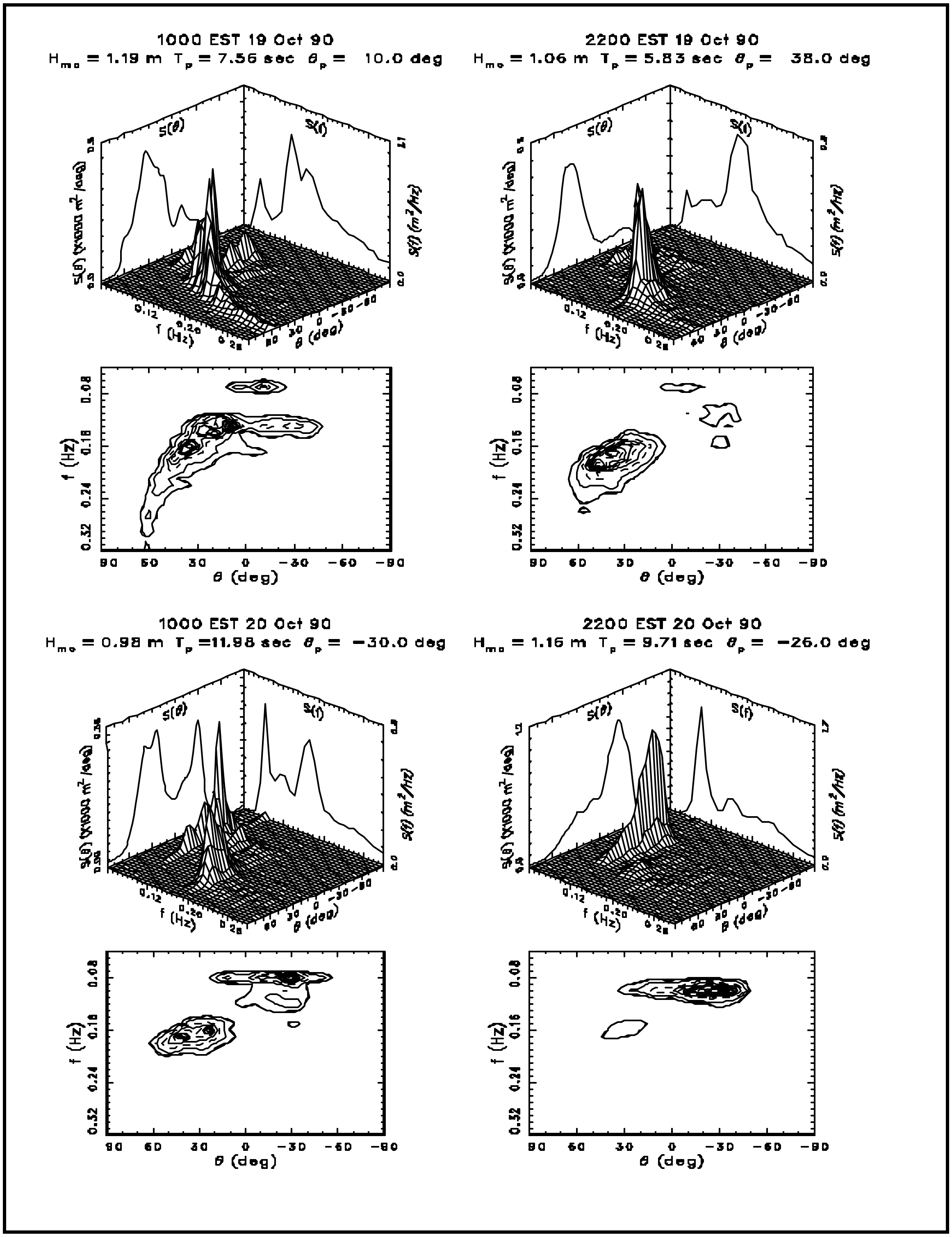

Figure E23. Representative frequency-direction spectra from 8-m array for 19 and 20 October 1990

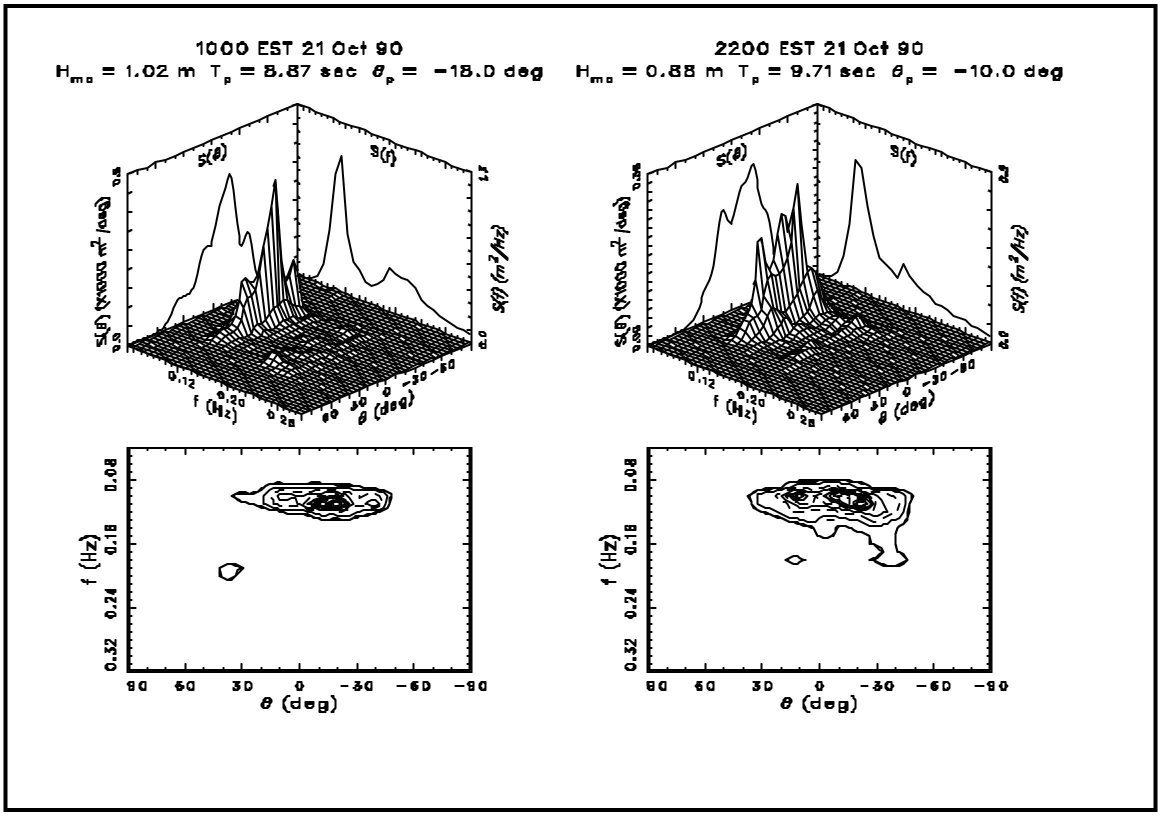

Figure E24. Representative frequency-direction spectra from 8-m array for 21 October, 1990