NCCCS-89-17

Northern California Coastal Circulation Study

DATA REPORT NO. 2
MAIN MEASUREMENT PROGRAM
MARCH-AUGUST 1988

VOLUME 2:
MOORED INSTRUMENT, METEOROLOGICAL, AND SEA LEVEL OBSERVATIONS

Bruce A. Magnell
John F. Borchardt
J. Bruce Andrews
Joyce M, Federiuk
E. Douglas Kinsella
Clinton D. Winant
EG&G Washington Analytical Services Center, Inc.
Oceanographic Services
77 Rumford Avenue
Waltham, Massachusetts 02154

Published September 1989

Technical Report

Availability: Unlimited Distribution

Prepared for
U.S. Department of the Interior
Minerals Management Service
Pacific OCS Office
1340 West 6th Street
Los Angeles, California 90017

EG&G
WASHINGTON ANALYTICAL SERVICES CENTER, INC.

OCEANOGRAPHIC SE?? VICES

Northern California Coastal Circulation Study

DATA REPORT NO. 2:
MAIN MEASURMENT PROGRAM
MARCH-AUGUST 1988

VOLUME II: MOORED INSTRUMENT, METEOROLOGICAL,
AND SEA-LEVEL OBSERVATIONS

Bruce A. Magnell
John F. Bore-hardt
J. Bruce Andrews
Joyce M, Federiuk
E. Douglas Kinsella
EG&G Washington Analytical Services Center, Inc.
Oceanographic Services Department
77 Rumford Avenue
Waltham, Massachusetts 02154

Clinton D. Winant
Scripps Institution of Oceanography
Shore Processes Laboratory
La Jolla, California 92093

Prepared for:

U.S. Department of the Interior
Minerals Management Service
Pacific OCS Office
1340 West 6th Street
Los Angeles, California 90017

Under Contract No. 14-12-0001-30312

September 1989

TABLE OF CONTENTS

VOLUME I

VOLUME II

TABLE OF CONTENTS

VOLUME II (CONTINUED)

LIST OF FIGURES

VOLUME I

LIST OF FIGURES

VOLUME I (CONTINUED)

VOLUME II

LIST OF FIGURES

VOLUME II (CONTINUED)

LIST OF FIGURES

VOLUME II (CONTINUED)

LIST OF FIGURES

VOLUME II (CONTINUED)

LIST OF TABLES

VOLUME I

VOLUME II

4. MOORED OCEANOGRAPHIC INSTRUMENT OBSERVATIONS
by Bruce A. Magnell and Clinton D. Winant

4.1 INTRODUCTION

The NCCCS moored instrument program is designed to obtain high-quality time series of currents and bottom pressures over the continental shelf and upper slope in the region from San Francisco to the Oregon border. The moored array consists of 21 moorings with 40 current meters and nine bottom pressure gauges. This section of the data report documents moored observations during the first deployment period of the main program, March through August 1988. Overall, the data return rate was very good. Instrumentation and array design are described in subsections 4.2 and 4.3. Data coverage and quality for current observations are described in subsection 4.4, followed by displays of the data in a variety of presentations, including time-series plots, tidal harmonic analyses, progressive vector diagrams, statistical tabulations, and current roses. Subsections 4.5 and 4.6 present time-series plots and statistical summaries of moored temperature and bottom pressure data, respectively. Combined plots of current component, temperature, and bottom pressure spectra are given in subsection 4.7. References are presented in subsection 4.8.

4.2 INSTRUMENTATION

Near-surface current measurements are a central element of the NCCCS. Accurate information on vertical current structure is also important to describe the spatial structure, kinematics, dynamics, and response to forcing of currents over the shelf and slope.

The northern California continental shelf, which is narrow and exposed to the strong winds and waves of the north Pacific Ocean, is a high-energy environment, not conducive to easy current measurements. Wave orbital velocities associated with long Pacific swell can be significant relative to the mean currents at all depths on the shelf. Also, heavy fishing activity in the area poses a threat to moored instruments, particularly those on subsurface moorings. These factors require that the utmost emphasis be placed on measurement quality and mooring survivability. Vector Measuring Current Meters (VMCMs) suspended from large, heavy surface buoys, similar to the design used successfully on the CODE program in 1981-1982 [WHOI, 1983], were used for all current measurements near the surface, and at all depths on the shelf. At depths of 75 m over the slope, NBIS Acoustic Current Meters (ACMs), which are also vector averaging instruments, were used with subsurface flotation to minimize wave and mooring motion contamination of the observations. Only at depths of 150 m or greater were non-vector averaging Aanderaa Recording Current Meters (RCMs) used, and these were used exclusively with subsurface flotation. Figure 4-1 illustrates the mooring design and placement of instrumentation in the water column. SIO-designed pressure/temperature recorders, which incorporate the Paroscientific quartz pressure sensor, were used for high-resolution bottom pressure measurements. The pressure recorders were rigidly mounted on the mooring anchors. Detailed descriptions of all instruments used are given in the pilot program data report [EG&G, 1988] and are not repeated here.

4.2.1 Calibration

Table 4-1 lists the specific instrumentation used in the first deployment period by serial number, including the deployment location for each instrument, and summarizes the calibrations performed prior to the deployment. Calibration procedures and results are described below.

4.2.1.1 Current Meter Calibration

Current meters were calibrated prior to the first main program deployment using the circulating water flume at the S10 hydraulics laboratory. The flume is 1.1 x 1.1 m in cross section, and has an effective length of 12 m. Water is circulated in the flume by impeller pumps whose speed is electrically adjustable. Flow-straightening grids are located at the inlet end of the flume. A VMCM, previously calibrated using the S10 tow tank, is used as a transfer standard to calibrate pump RPM versus water speed. Speed accuracy is estimated to be within about ±1% and is limited primarily by the accuracy of the tow tank tests.

Current meters are always mounted at the same location in the flume (exactly the same location where the transfer standard current meter was located) using standard brackets, VMCMS are mounted vertically in their external support frame, but are only partially immersed in the water. Since the pressure housing is not immersed, the flow field around the sensors is probably slightly different from the fully immersed situation. A similar setup is used for the ACMs. RCMS are fully immersed, using a special bracket attached on the downstream side of the instrument. No vane is used since orientation is irrelevant for calibration of the RCM'S omnidirectional Savonius rotor speed sensor.

The S10 VMCMs were set to normal sampling rates (one average per minute) during the calibrations; EG&G instruments were set to output raw data every 2 seconds. For the SIO VMCMs, general instrument response was checked at 50 cm/sec by rotating the instrument through 360° in 45" steps. A minimum of five samples were obtained per step. A four-point calibration at speeds of 10, 25, 50 and 100 cm/sec was then done at a single 45° orientation to the flow such that the VMCM's propellers were turning at an equal rate. A slightly different procedure was used for the EG&G VMCMs - these were calibrated at speeds of 10, 25, 50, 75 and 100 cm/sec in two separate runs, each run having one sensor oriented into the flow, with the instrument rotated 90° between runs.

Compass calibrations were performed on an S10 fixture located away from magnetic disturbances. Current meters were supported by special brackets on a rotating table. All current meters were swung through a complete circle in 15° increments, and the output direction reading was recorded. Prior to this calibration, the compass mount of each S10 VMCM was first adjusted to read zero when the reference propeller axis was aligned with local True north (at La Jolla, California). EG&G VMCMs are preset at the factory to read zero when aligned with local magnetic (not True) north, and no attempt was made to adjust their zero point.

Current meter calibration data collected during January and February 1988 are shown in Figure 4-2. It is important to note that calibration of current meters is performed primarily as a performance verification measure to ensure that the instrument is functioning correctly over the expected range of current speeds and directions, Calibration data are not generally used to derive or correct the algorithms used to convert the raw data to engineering units, since the relationship between water motion and sensor response is determined by the geometry of the sensor, and should be invariant. Departures of instrument performance from the nominal true value are accepted if minor. If, during calibration, an instrument's performance is found to be outside the manufacturer's accuracy specification using the standard algorithm, the instrument is repaired or adjusted. Also , it must be remembered that the primary source of current measurement errors in the ocean are due to dynamic response problems, not steady-flow calibration errors, and there is no point in using calibration data to derive customized, high-accuracy processing algorithms. The high degree of similarity between speed calibrations for the RCMS results from the unfortunate use of l-minute sampling intervals for calibration. This results in a speed resolution of 2.8 cm/see, which is generally not adequate to resolve differences between instruments, all of which are, however, within specifications.

Compass calibration data for several of the S10 VMCMs show disturbingly large errors. Unfortunately, replacements were not available for these compasses. Although it would have been possible to modify the processing algorithms in these instruments to account for the compass calibration results, this was not done because it was believed at the time that the compass errors were not stable with time and that corrections might result in even larger errors over the course of a deployment (subsequent calibration results indicate that the largest errors are fairly stable). During the March 1988 deployment cruise, instruments with notably poor compasses were placed on a mooring at mid-depth between two instruments with good compasses when ever possible.

4.2.1.2 Temperature Calibration

For temperature and pressure sensors, calibration serves as a primary means of achieving high accuracy. Calibration curves specific to each sensor are used during data processing to convert the raw data to engineering units.

Temperature calibration of S10 VMCMs and pressure sensors is a three-step process. Common to all CCS' temperature measurements is a standard YSI 30 Kohms thermistor with 0.2°C interchangeability (Model #44008). The thermistors are potted into an aluminum bolt for mounting inside the pressure case of the instrument and are then calibrated as a batch using a Solartron 7071 multimeter to measure resistance to the nearest ohm (better than millidegree resolution) over a 5 to 30°C range in 5° increments. Thermistors are then permanently assigned to a specific instrument, but can be removed for later recalibration as necessary.

The actual temperature circuit used in the instruments consists of a voltage-controlled oscillator (VCO) which produces a frequency that varies as a function of the thermistor resistance. The VCO is switched on and counted once every sample interval (typically once a minute). Resolution varies (due to the nonlinearity of the thermistor) between less than 7 millidegrees at 5°C to less than 4 millidegrees at 25°C per count or LSB. Frequent calibration of the temperature circuit is done by substituting a decade resistance box (General Radio Model 1433-X) for the thermistor, setting the mid-range to 10"C (this is only done once prior to a deployment), and recording the temperature channel as the decade box is varied from 25 Kohms to 80 Kohms in 5-Kohms steps (this is done once or twice before and after a deployment).

The final step is a complete temperature calibration of all the instruments in a very stable temperature bath (a few millidegrees accuracy) over the temperature range of interest. This is done immediately prior to and after each deployment.

The SIO/CCS temperature bath has very good short- and long-term stability. A Tronac Model PTC-41 precision temperature controller is used to control the bath temperature. One-minute averages of the measured bath temperature yield a standard deviation from the mean of less than 0.00I°C for several hours. A quartz crystal thermometer and a platinum resistance thermometer are used as the temperature standards. Calibration of the platinum resistance thermometer is traceable to the National Bureau of Standards. Resistance measurements are made on a Solartron Digital Voltmeter Model 7071, having an accuracy of 1.0 ppm, and a sensitivity of 10 micro-ohms.

Temperature calibration data for all S10 VMCMS and bottom pressure units are given in Table 4-2. EG&G and GFE current meters were not calibrated for temperature.

4.2.1.3 Pressure Calibration

Paroscientific Digiquartz Pressure Transducers are used in the S10 pressure sensors. The manufacturer's specifications are (% of full scale instrument range):

Repeatability. 0.005%
Hysteresis 0.005%
Temperature Span Shift . . . 0.047%/°C

To obtain corrections for the error in measured pressure due to changes in temperature, the pressure sensors are calibrated before and after deployment through their entire range of pressure at 5, 10 and 15°C.

A Ruska Digital Direct Reading Pressure Gauge is used as the pressure standard. The accuracy of the Ruska instrument is the sum of all uncertainty inherent to the transducer: repeatability, linearity, hysteresis, and mechanical deviation, plus the uncertainty of the primary calibration standard used to calibrate the transducer. The accuracy is ±0.008%. Based on the system range, the following accuracy can be achieved:

300 psi x 0.006% full-scale	- ±0.018 psi
300 psi x 0.008% reading	- ±0.024 psi
Total at 300 psi	- ±0.042 psi
Accuracy	- 0.014% of reading

Pre-pilot pressure calibration data from the SIO bottom pressure instruments is summarized in Table 4-3.

4.3 MOORED ARRAY DESIGN

Resolution of the principal modes of current variability requires a three-dimensional array of current meters. A key premise underlying the overall NCCCS moored array design is that cross-shelf and vertical gradients are much greater than alongshelf gradients, at least within each major embayment of the coast. This is based on the results of the CODE experiment [Winant et al., 1987], which was conducted in a limited area near Pt. Arena in the southern part of the NCCCS study area, and supported by the results of the NCCCS pilot program [EG&G, 1989]. This premise suggests that a single, fully instrumented current meter transect in each embayment is sufficient to resolve the current patterns and describe the local response to forcing. With transects in several embayments, alongshelf differences in forcing and circulation patterns, and in the ocean's response to forcing, should be observable.

In addition, the NCCCS is concerned with the effects of major topographic features on circulation patterns, since cross-shelf advection in the form of mesoscale jets and eddies is apparently closely linked to topography [Davis, 1985]. Cape Mendocino is the largest topographic feature of the NCCCS study area, if not of the entire California coast. The orientation of the coastline changes from north-south to northwest-southeast around the Cape, and the submarine topography is complex. The shelf is very narrow, and the 1,000-m high Mendocino Escarpment extends westward from the Cape. Due to the mountainous character of the land, the wind field is also expected to be substantially affected by the Cape. Anticipating that Cape Mendocino has a profound influence on the shelf circulation, moored instrumentation north and south of the Cape, at Eureka and Punta Gorda, respectively, is also a part of the NCCCS to provide information on flow continuity and variability in this vicinity. The main program moored array (Figure 4-3) consisted of:

1) a four-mooring transect with ten current meters off Crescent City,
2) a three-mooring transect with eight current meters. off Eureka,
3) a single mooring with three current meters off Punta Gorda on the south side of Cape Mendocino,
4) a four-mooring transect with ten current meters off Cape Vizcano, and
5) a four-mooring transect with ten current meters at Sea Ranch between Pt. Arena and Bodega (the CODE study area).

Mooring locations are detailed in Table 4-4. The moored instrument transects (Figure 4-4) consisted of moorings in standard water depths of 60, 90, 130 and 400 m. These depths were based on the CODE results, which showed maximum amplitude of wind-driven shelf currents at the 90-m isobath, and significant influence of deep ocean motions at the 400-m isobath [Winant et al., 1987). Standard instrument depths of 10, 45, 75, 150 and 300 m were used. Moored instrument records are identified in this report using the station name followed by the instrument depth. For example, K-130/10 refers to the 10-m instrument on the 130-m K-line mooring.

The' K- , V- and C-lines (Figure 4-4) consisted of four moorings in the standard water depths. The 90-m mooring was instrumented at near-surface (lO-m), mid-depth (45-m), and near-bottom (75-m) levels in order to resolve vertical current shear at the energetic mid-shelf location. Moorings with single, near-surface current meters were deployed at 60- and 130-m depths to observe the cross-shelf structure of surface currents. The 400-m mooring was instrumented at 10-, 75-, 150- and 300-m depths to provide information on upper-shelf currents and the influence of deep ocean currents on the shelf circulation. Bottom pressure recorders were installed on the 60- and 130-m moorings. The 60- and 130-m pressure recorders provide a direct measure of cross-shelf pressure gradient centered on the heavily instrumented 90-m mid-shelf isobath, to compare with and supplement the current meter observations there'.

The E-line was similar except that it had no 130-m mooring due to the narrowness of the shelf. The G-line consisted of only one mooring, since the three moorings deployed there during the pilot program showed little cross-shelf variability.

4.4 MOORED CURRENT OBSERVATIONS

This subsection presents the moored current observations from the first deployment period. Moored temperature and bottom pressure observations are described separately in subsections 4.5 and 4.6, respectively.

4.4.1 Moored Current Data Coverage and Quality

Two moorings were lost early in the first deployment period: the V-400 subsurface mooring and the C-400 surface mooring; both moorings were replaced in early May. Other data losses which resulted from instrument failures were: E-90/45 (no good data); V-90/45 (no good data); and C-400/75 (80%). Aside from these losses, which fortunately did not significantly compromise the data set for scientific analysis, there were virtually no gaps in the current records, and the data were judged to be of excellent quality. Current meter data coverage, as a function of time, is shown in Figure 4-5.

4.4.2 Time Series of Currents and Winds

Figure 4-6 presents the current data in time series form, both unfiltered (hourly averages) and low-pass filtered using the PL-33 filter [Flagg, 1977], The data are plotted in several formats, and wind data are included in the plots where appropriate to facilitate comparison and interpretation.

A single alongshelf direction is defined for each mooring transect, based on the average orientation of mid-shelf isobaths, and current vectors are resolved into alongshelf and cross-shelf components. The alongshelf and cross-shelf directions thus defined do not necessarily coincide with the principal axis of variance at each instrument location. However, since the mooring transects were deliberately located in regions of smooth, shore-parallel topography, the use of a topographically defined coordinate system is physically consistent and avoids data-dependent coordinate orientations. The positive alongshelf (upcoast, y coordinate) directions are:

K-line: 355° True
E-line: 027" True
G-line: 317" True
V-line: 354° True
C-line: 317" True

The positive cross-shelf (onshore, x coordinate) directions are 90° to the right of these directions. These coordinate definitions are used throughout the moored instrument sections of this report.

Unfiltered data are shown as alongshelf and cross-shelf components. Low-pass-filtered data are shown as vectors as well as components; vector directions are plotted relative to the alongshelf direction, which is straight up on the page. The time axis is Pacific Standard Time (PST), which is used throughout this report unless otherwise noted,

Wind Stress Vectors

Figure 4-6a shows vector plots of low-passed wind stress at all offshore NDBC buoy locations and coastal meteorology stations in the NCCCS study area and nearby; these wind data are shown in this section to facilitate comparison with current data (winds are described in more detail in Section 5). Wind stress is calculated from wind speed and direction using the method of Large and Pond [1981]. The mean wind direction was generally southward with an onshore tendency, except at the three buoys far offshore (Washington, Oregon, and Papa) where winds were highly variable with a westerly tendency, North of Cape Mendocino, winds were quite variable during the first half of the deployment period, while winds in the south were more uniformly northerly. Wind stress variations were generally correlated over the northern half of the array and over the southern half, but the magnitude of events was quite variable from one wind station to another, Coastal stations had noticeably weaker wind stress than offshore buoys only a few kilometers away, suggesting significant cross-shelf variability in the wind field. As found in the pilot program, Shelter Cove was again unusual in that the mean wind direction was northward in contrast to southward at most other stations.

Low-Frequency Current Vectors

Near-surface (lO-m) current vectors from all stations are plotted in Figure 4-6b, together with wind stress vectors from principal offshore buoys. Currents were generally well correlated within each mooring transect. As found in the pilot program, K- and E-line currents looked similar and major differences between E- and G-line currents were observed. Currents in the C-line were predominantly southward, while the V-line by comparison exhibited weaker and more variable current velocities.

The vertical structure of currents is illustrated in vector stickplots of current at each station (K-line is shown in Figure 4-6c, E- and G-lines in Figure 4-6d, V-line in Figure 4-6e, and C-line in Figure 4-6f). Significant vertical shear is observed at all these stations, with deeper currents having a marked tendency toward upcoast flow. The upcoast flow was strongest and most steady in direction at the G-and V-lines, south of Cape Mendocino.

Low-Frequency Alongshelf Currents

Time-series plots of low-passed alongshelf near-surface current components (Figure 4-6g) illustrate clearly the high correlation of 5- to 15-day fluctuations among records from the same mooring transect. Alongshelf currents at each mooring location (Figures 4-6h through 4-6k) were correlated in the vertical, although the magnitude of the fluctuations decreased with depth.

Low-Frequency Cross-Shelf Currents

By contrast with the alongshelf currents, the cross-shelf currents appear disorganized. Near-surface (10-m) low-passed cross-shelf components (Figure 4-6l) exhibit moderate correlation among stations within each transect north of Cape Mendocino, but exhibit great variability on the V- and C-lines, There is no evident correlation between cross-shelf currents and wind stress. Cross-shelf components were in general not well correlated in the vertical (Figures 4-6m through 4-6p).

Unfiltered Current Components

Hourly averages of current components and local wind stress are shown in Figures 4-6q through 4-6z. These are similar in most respects to the corresponding low-pass-filtered plots, but they illustrate the relative magnitude of the tidal components compared to the low-frequency currents. Tidal currents on the E- and K-lines were about 25-30 cm/sec peak-to-peak. On the V- and C-lines, tidal currents were slightly lower, about 15-25 cm/s peak-to-peak. However, on the G-line, there were very strong near-surface tidal currents of over 1 knot (50 cm/see) especially during March and early May (Figure 4-6q). These strong oscillations were also seen during the pilot program and are probably indicative of the presence of internal tides at this location. This is implied by the high vertical shear of tidal current amplitude at the G-line moorings (Figure 4-6s) and the erratic variability of current amplitude.

4.4.3 Tidal Harmonic Analysis of Currents

Current components are analyzed using the response method [Munk and Cartwright, 1966], which can be applied co records of arbitrary length. The results are summarized in Table 4-5, which shows the amplitude and phase (relative to Greenwich) of tidal harmonic constituents for both current components at each current meter location. The table also shows tidal ellipses for each instrument, giving the major and minor axis amplitudes, major axis orientation, and major axis phase for each significant constituent.

It should be noted that tidal currents are not as stable and predictable as tide heights. Vertical shear in the water column, particularly that associated with internal (baroclinic) tides, can change with time as the stratification changes. This causes apparent variability in tidal current amplitude and phase, and results in energy leakage into nontidal frequency bands. These effects are especially evident in the G-line data. The time-series plots of the preceding subsection show high tidal current amplitudes, particularly in April and May, but the phase of these tidal oscillations is not stable, and the average amplitude calculated by the tidal analysis procedure (Table 4-5) is lower than the peak amplitude observed.

The phase-stable tidal constituents account for a large fraction of the total current variance. However, in terms of particle displacement, the tidal oscillation is minor compared to the net displacement due to low-frequency motions. Tidal current displacement is less than ± 2 km at the G-line, and is less than ± 1 km at most other stations.

4.4.4 Progressive Vector Diagrams (PVDs)

PVDS (Figure 4-7) display the virtual displacement resulting from the flow measured at each instrument location. Although PVDS appear similar to drifter tracks, they are fundamentally different, being the time integral of Eulerian current velocity measured at a point in space. Drifter tracks are true Lagrangian measures of water motion, and they include the effects of spatial current variability, which PVDS do not.

For clarity of presentation, the current data are low-pass filtered before integration and plotting. If this were not done, the tidal current ellipses would obscure the low-frequency motions, particularly at times of low net flow. However, tidal displacements ($<\pm 2$ km) are small compared to the low-frequency displacements shown (typically 1,000 km over 4.5 months),

4.4.5 Mean and Low-Frequency Current Patterns

Figure 4-8 shows the average current at each measurement location over the entire 5-month duration of the pilot program, together with low-pass-filtered current ellipses. These ellipses are dominated by the wind-driven current variance, which occurs on 5- to 10-day time scales (see subsection 4.7). Table 4-6 summarizes statistics of currents observed during the pilot program.

4.4.6 Current Roses

As a final form of statistical presentation, the current data are summarized as current roses in Figure 4-9, based on hourly averages. This type of presentation emphasizes the dominant direction and typical speed of flow at each measurement location.

4.5 MOORED TEMPERATURE OBSERVATIONS

4.5.1 Moored Temperature Data Coverage and Quality

All but three of the current meters, and all of the bottom pressure recorders, were equipped with temperature sensors. Data return from the temperature sensors was excellent (Figure 4-10). The mechanical problem that occurred in a few current meters did not necessarily affect the temperature data, so the overall data return rate for temperature (about 90%) was higher than for currents.

4.5.2 Time Series of Temperature Data

Time-series plots of temperature from all moorings are shown in unfiltered and low-pass-filtered form in Figure 4-11. The unfiltered data (Figure 4-ha) contain a great deal of high-frequency variability, particularly near the surface. Advection of thermal gradients and the effects of diurnal heating combine to produce these fluctuations.

Temperature fluctuations associated with wind forcing are evident in the low-pass-filtered temperature data (Figure 4-11b). Strong downcoast wind events, causing rapid decreases in temperature and reduced stratification, occurred at different times in the northern and southern regions. Such events occurred in mid-May and early June at the K-, E- and G-lines, and in late April and again in early June at the V- and C-lines. Wind relaxations or upcoast wind events were associated with rapid increases in surface temperature and water column stratification. Qualitatively, these observations are consistent with the concept of wind-driven upwelling and poleward relaxation as observed in CODE [Winant et al, , 1987] . However, in contrast to the CODE results, and consistent with the pilot program results, the stratification remained significant throughout most of the first main deployment period. Also, the coldest water temperatures were found at the G-1ine, south of Cape Mendocino, where the current was flowing generally northward, opposite to the usual upwelling direction. Highest mean temperatures were found at E-90 and C-400.

4.5.3 Temperature Statistics

The mean, standard deviation, and range of temperatures observed at all moored instrument stations during the pilot program are summarized in Table 4-7.

4.6 BOTTOM PRESSURE OBSERVATIONS

4.6.1 Moored Bottom Pressure Data Coverage and Quality

The bottom pressure array also gave good data return (Figure 4-12). Data recording at K-60 and C-60 was cut short due to excessive power consumption of the pressure sensor, and the instrument at V-130 returned a blank tape. Aside from these, the bottom pressure data were judged to be of excellent quality, and there were no gaps in the records.

4.6.2 Time Series of Bottom Pressure Data

Unfiltered Pressures

To illustrate the range of bottom pressure variations due to tides, Figure 4-13a shows hourly pressure averages plotted relative to the record mean. The magnitude of the tidal pressure signal is typically ±150 mb. The spring/neap cycle is clearly evident, and the tides appear to be highly coherent over the entire array.

The abrupt 100 mb increase in pressure observed at the E-90 mooring around 28 March and at C-130 around 27 March is believed to be due to a disturbance of the surface mooring anchor to which the bottom pressure sensor was attached (the anchor probably tipped over).

Low-Frequency Pressure Field

Low-frequency fluctuations in bottom pressure, although obscured by tides in the unfiltered plots, are dynamically important. Bottom pressure fluctuations are due to the combined effects of sea-level fluctuations and changes in the depth-averaged density of the water column (steric effects). At short periods and in shallow water, density-related bottom pressure fluctuations are expected to be relatively unimportant. In deeper water, the effect of density changes may be significant, especially if the thermohaline stratification is subject to major changes on time scales of interest.

Figure 4-13b shows low-pass-filtered bottom pressures, together with wind stress vectors at selected points along the coast. Fluctuations on typically 5- to 10-day periods can be seen, with peak-to-peak amplitudes of 10 mb. Also apparent is a very low-frequency (about 90-day period) oscillation beginning in early July. This variability is highly correlated over the pressure array, although the magnitude of the fluctuations was slightly greater inshore than offshore. Thus, to a first approximation, the bottom pressure (and presumably the sea surface) rose and fell uniformly over the study area.

4.6.3 Tidal Harmonic Analysis of Bottom Pressures

Table 4-8 lists the results of tidal harmonic analysis applied to the eight bottom pressure records of the main program. Amplitudes and phases were similar at all locations, with the M2 constituent (12.42-hour period) being largest (67 rob), followed by the K_1 (23.93 hours, 39 rob), and the O_1 (25.82 hours, 25 rob). Both amplitude and phase of major constituents increased from south to north (C-line to K-1ine) over the array.

4.7 SPECTRAL ANALYSIS AND COMPARISON

The distribution of water velocity, pressure, and temperature variance as a function of frequency is of interest because the driving forces and the ocean's response are frequency dependent, Figure 4-14 presents autospectra of each record, with the moorings from each transect grouped for comparison, and with spectra from all instruments on each mooring overplotted. Current vectors are resolved into alongshelf and cross-shelf components, using the nominal alongshelf orientation for each mooring transect described earlier, Coincident time intervals were used in the spectral analysis wherever possible; small quantities of data at the beginning and end of certain records were discarded in the interest of ensuring exact overlap.

Procedure and Presentation

Spectra are plotted on a logarithmic frequency scale in variance-conserving form. The area under each spectrum, or part of a spectrum, is proportional to the variance in that frequency band. The variance-conserving presentation differs from the standard log-log energy density (ED) spectrum by having a linear ordinate scale proportional to the product of ED and frequency. This form of presentation emphasizes the energetic constituents of the data and permits direct comparison of kinetic energy levels among various records.

Spectra are computed using an ensemble averaging technique. Each record is first checked for gaps, and any gaps less than 3 hours are filled by linear interpolation. Larger gaps are left unfilled. Then the data are broken into month-long gap-free segments that are overlapped by about 50%, The mean and trend of each segment are removed by least-squares fitting of a linear function. Each segment is tapered with a Harming (cosine) window prior to Fourier transformation, Spectra are averaged in the frequency domain across the ensemble of segments, and are further smoothed with the application of a geometric-progression band-averaging technique that provides maximum smoothing at high frequencies. The segmenting/ensemble averaging method permits spectral analysis even when large gaps are present in the data, and it also ensures a common frequency resolution regardless of the length of the record. It does not resolve fluctuations at periods longer than the segment length (30 days here).

Details of the spectral analysis procedure are summarized in Table 4-9. This table also lists the 90% confidence limits for each record; it would be impractical to show these on the figures, since the confidence limit varies with both spectral amplitude and frequency in the variance-conserving presentation.

Current Spectra

All current spectra in Figure 4-14 are similar in the distribution of variance as a function of frequency. Tidal energy is concentrated in narrow spectral peaks, with the M_2 being the sharpest. At the diurnal frequency, the spectral peaks are broader and there is considerable variability from record to record. Tides are generally smaller at the V- and C-lines, as was seen in the unfiltered current records (Figure 4-6q through 4-6z).

Low-frequency variance is concentrated in a broad period band from 3 days to 30 days, with the spectral peak occurring at about 7 or 8 days (0.005 cph). In general, low-frequency currents were polarized in the alongshelf direction and kinetic energy levels decreased toward the bottom. Energy levels were similar at near-shore and offshore moorings. Near-surface currents were more isotropic at the C-line offshore moorings than anywhere else.

Bottom Pressure Spectra

Pressure spectra show essentially the same frequency distribution of energy as the current component spectra, except that the tidal peaks were much stronger relative to the low-frequency energy. There was a marked amplitude decrease of the low-frequency energy in the offshore direction -- the 130-m spectra had only half the variance of the 60-m spectra on the C-line. This is consistent with the concept of a cross-shelf sea-surface slope in geostrophic balance with alongshelf currents.

Temperature Spectra

Temperature changes in the water column occur mainly as a result of advection of thermal gradients, and consequently do not have an unambiguous interpretation. The temperature spectra shown in Figure 4-14 generally resemble the alongshelf current spectra, in that the energy is divided into distinct tidal and low-frequency bands. The low-frequency energy peaks are generally at 7 to 8 days, coincident with those of the currents. This suggests that temperature variations are closely coupled to current variations.

4.8 REFERENCES

Beardsley, R.C. 1987. A Comparison of the Vector Averaging Current Meter and new Edgerton, Germeshausen, and Grier, Inc., Vector Measuring Current Meter on a Surface Mooring in Coastal Ocean Dynamics Experiment 1. JGR, Vol. 92, No. C2, pp. 1845-1860. February.

Beardsley, R.C., W. Boicourt, L.C. Huff, and J. Scott. 1977. CMICE 76: A current meter intercomparison conducted off Long Island in February-March 1976. Tech. Report. WHOI-77-62, Woods Hole Oceanographic Institution, Woods Hole, MA 02543. 123 pp. October.

Davis, R.E. 1985. Drifter Observations of Coastal Surface Currents during CODE: The Method and Descriptive View. JGR, Vol. 90, No. C3, pp. 4741-4755. May.

EG&G, 1989. The Northern California Coastal Circulation Study: Results of the Pilot Program. OCS Study MMS 89-0008. Progress Report, August 1989. Prepared by EG&G Washington Analytical Services Center, Inc., for U.S. Department of the Interior, Minerals Management Service, Los Angeles, California. 270 pp.

EG&G . 1988. Northern California Coastal Circulation Study Data Report No. 1: Pilot Measurement Program, March-August 1987. Prepared for Department of Interior, Minerals Management Service, EG&G WASC Oceanographic Services Report No. NCCCS-88-9, Waltham, Massachusetts, 268 pp. September.

Flagg, C.N. 1977. The kinematics and dynamics of the New England continental shelf and shelf/slope front. Ph. D. Thesis, Department of Meteorology, MIT, Cambridge, MA, and Woods Hole Oceanographic Institution, Woods Hole, MA.

Large, W.G. and S. Pond. 1981. Open Ocean Momentum Flux Measurements in Moderately Strong Winds. JPO, 11, pp. 324-336.

Magnell, B.A. and D. Dillon. 1981. Dynamic performance of an acoustic current meter - kinematic model prediction and laboratory dynamic tests. EG&G Washington Analytical Services Center, Inc., Tech. Report No. TR E930-0002. Prepared for NOAA, Office of Ocean Technology and Engineering Services, Engineering Support Office, Rockville, MD 20852. 2 Vols. September.

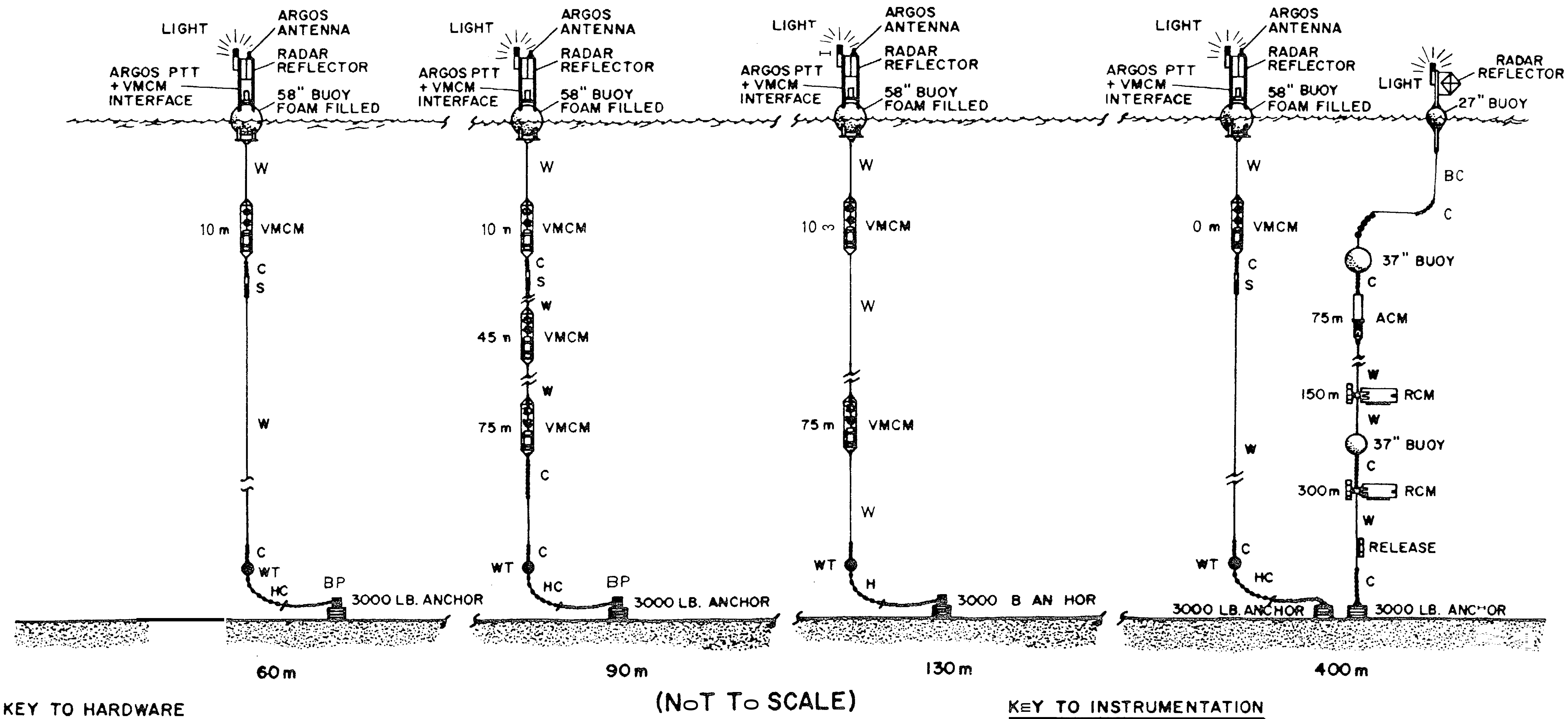
McCullough, J.R. 1978. Near-Surface Ocean Current Sensors: Problems and Performance. In: Proceedings of a Working Conference on Current Measurement, W. Woodward, C. Mooers, and K. Jensen (eds.). Tech. Report DEL-SG-3-78, College of Marine Studies, University of Delaware, Newark, DE 19711, 372 pp. June.

Munk, W.H. and D.E. Cartwright. 1966. Tidal Spectroscopy and Prediction. Phil. Trans. Royal Sot. London, Series A, No. 1105, Vol. 259, pp. 533-581. May.

Shureman, P. 1941. Manual of Harmonic Analysis and Prediction of Tides, Special Publication No. 98, Coast and Geodetic Survey, U.S. Dept. of Commerce.

WHOI . 1983. CODE-1: Moored Array and Large-Scale Data Report, CODE Tech. Report No. 21. L.K. Rosenfeld (cd.). Tech. Report WHOI 82-23, Woods Hole Oceanographic Institution, Woods Hole, MA 02543, 186 pp. August .

Winant, C.D., R.C. Beardsley, and R.E. Davis. 1987. Moored Wind, Temperature, and Current Observations made During Coastal Ocean Dynamics Experiments 1 and 2 over the Northern California Continental Shelf and Upper Slope. JGR, Vol. 92, No. C2, Paper 6C0539, pp. 1569-1604. February.



KEY TO HARDWARE

W = 7/16" GALVANIZED, TORQUE-BALANCED. JACKETED WIRE ROPE
C = 1/2" ALLOY CHAIN
S = SWIVEL
HC = HEAVY CHAIN
WT = CLUMPWEIGHT
BC = BUNGY CORD

KEY TO INSTRUMENTATION

VMCM = EG&G VECTOR MEASURING CURRENT METER, MODEL 630
ACM = NBIS ACOUSTIC CURRENT METER, MODEL ACM-II
RCM = AANDERAA RECORDING CURRENT METER, MODEL RCM-4/5
BP = SCRIPPS BOTTOM PRESSURE/TEMPERATURE RECORDER

Figure 4-1. Current meter/bottom pressure mooring design details

Table 4-1. Moored instrument utilization and calibration summary.

Instrument Type	S/N	Owner	Deployment Location	Predeployment Calibration Speed	Dir	Temp	Pres
VMCM	1501	EG&G	K-130/75	X	X	NA	NA
VMCM	2804	EG&G	c-90/45	X	X	NA	NA
VMCM	003004	EG&G	v-130/75	X	X	NA	NA
VMCM	200503	EG&G	C-400/10	X			NA
VMCM	201104	EG&G	E-400/10	X			NA
VMCM	202903	EG&G	V-400/10				NA
VMCM	301010	EG&G	K-400/10	X			NA
VMCM	50	SIO	V-60/10			X	NA
VMCM	51	S10	K-130/10			X	NA
VMCM	53	S10	G-90/75			X	NA
VMCM	54	S10	v-90/75			X	NA
VMCM	55	S10	v-90/lo			X	NA
VMCM	56	S10	G-90/10			X	NA
VMCM	57	SIO	E-90/45			X	NA
VMCM	58	S10	K-90/75			X	NA
VMCM	59	S10	E-90/75			X	NA
VMCM	60	S10	K- 60/10			X	NA
VMCM	61	S10	v-130/lo			X	NA
VMCM	62	S10	c-130/lo			X	NA
VMCM	63	S10	E-60/lo			ND	NA
VMCM	64	S10	E-90/10			X	NA
VMCM	65	SIO	c-60/10			X	NA
VMCM	67	S10	v-90/45	ND	ND	X	NA
VMCM	68	S10	c-90/75			X	NA
VMCM	69	SIO	c-90/lo			X	NA
VMCM	70	S10	K-90/45			X	NA
VMCM	71	S10	K-90/45			X	NA
VMCM	72	S10	K- 90/10			X	NA
VMCM	73	S10	G-90/45			X	NA
ACM	080	EGG	E-400/75	X			NA
ACM	106	EGG	K-400/75	X			NA
ACM	1172	EGG	V-400/75	·	-	-	NA
ACM	1174	EGG	C-400/75	X			NA
RCM	7105	MMs	C-400/300	X	X		NA
RCM	7106	MMs	C-400/150	X	X		NA
RCM	7169	MMs	V-400/300	X	X		NA
RCM	7170	MMs	K-400/150	X	X		NA
RCM	7171	MMs	E-400/300	X	X		NA
RCM	7173	MMS	V-400/300	X	X		NA
RCM	7175	MMs	K-400/300	X	X		NA
RCM	7178	MMs	E-400/150	X	X		NA
RCM	7262	MMs	v-4oo/150	X		-	NA
BP/TR	02	SIO	c-130/130	NA	NA	X	X
BP/TR	07	S10	E-90/90	NA	NA	X	X
BP/TR	09	S10	G-90/90	NA	NA	X	X
BP/TR	10	S10	K-130/130	NA	NA	X	X
BP/TR	11	S10	v-60/60	NA	NA	X	X
BP/TR	13	S10	K- 60/60	NA	NA	ND	X
BP/TR	14	S10	c-60/60	NA	NA	X	X
BP/TR	15	S IO	se-lo/lo	NA	NA	X	X

NA - Not applicable
ND - No data
NG - No good
VMCM - Vector Measuring Current Meter
ACM - Acoustic Current Meter, NBIS ACM-II
RCM - Recording Current Meter, Aanderaa RCM-4/5
BP/TR = Bottom Pressure/Temperature Recorder

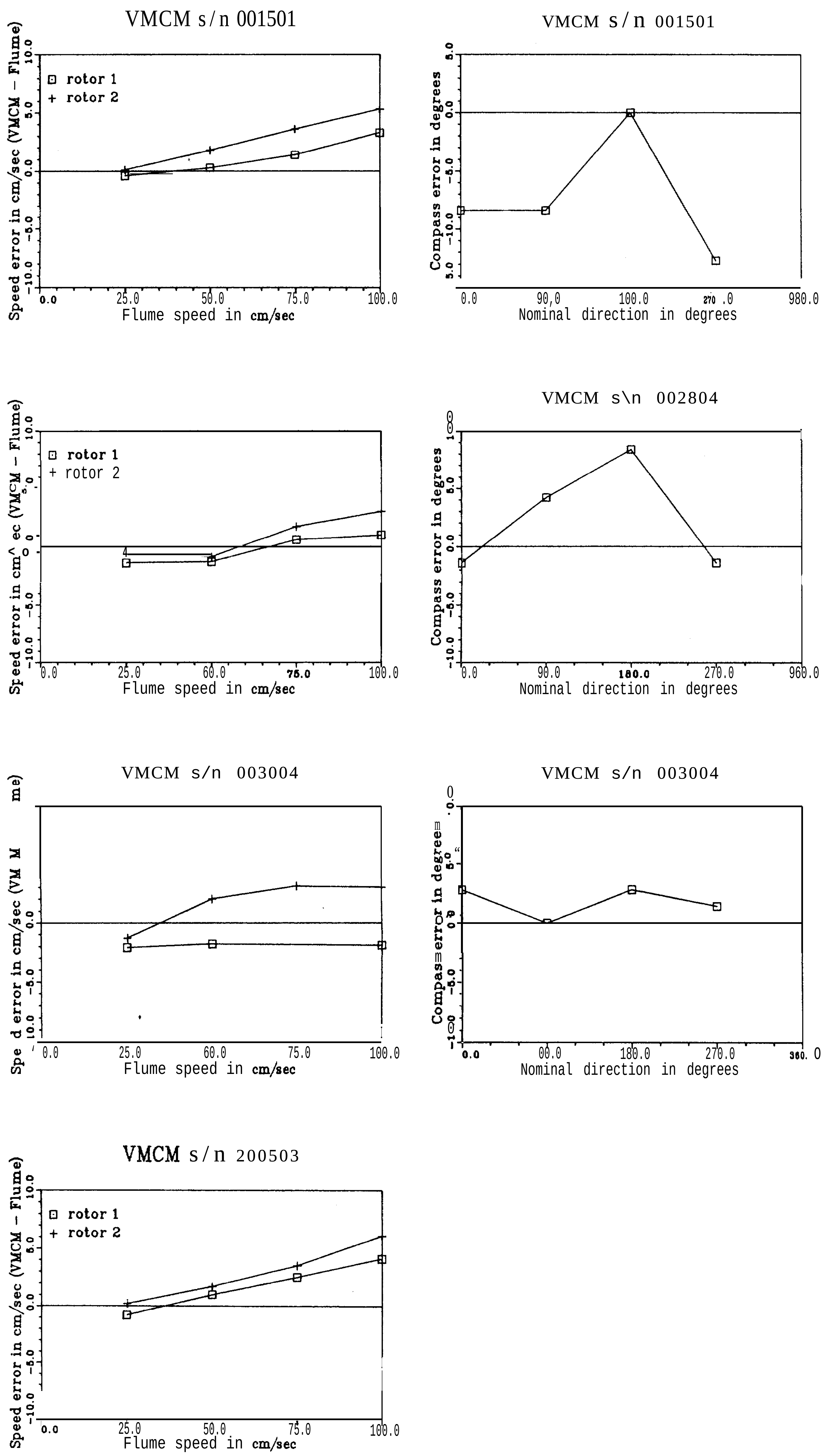


Figure 4-2a. Predeployment current meter calibration, S10 flume : VMCMs .

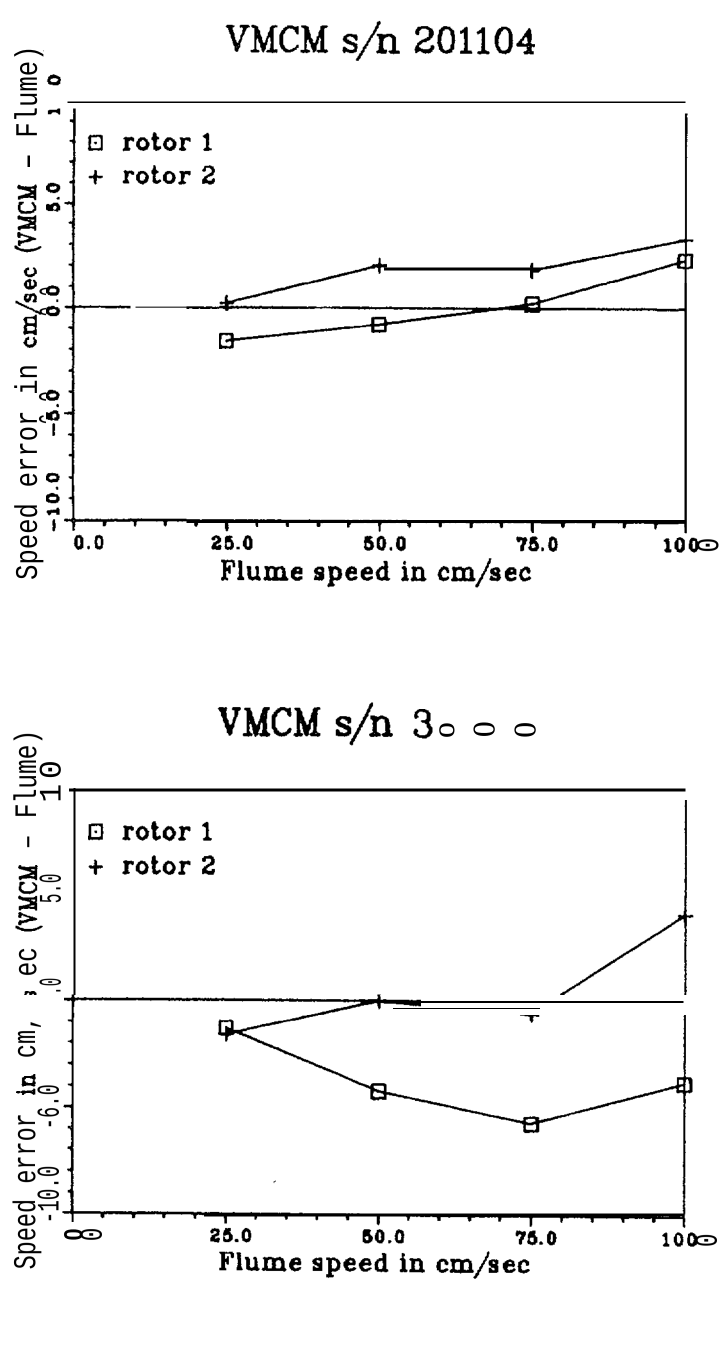


Figure 4-2a. Continued

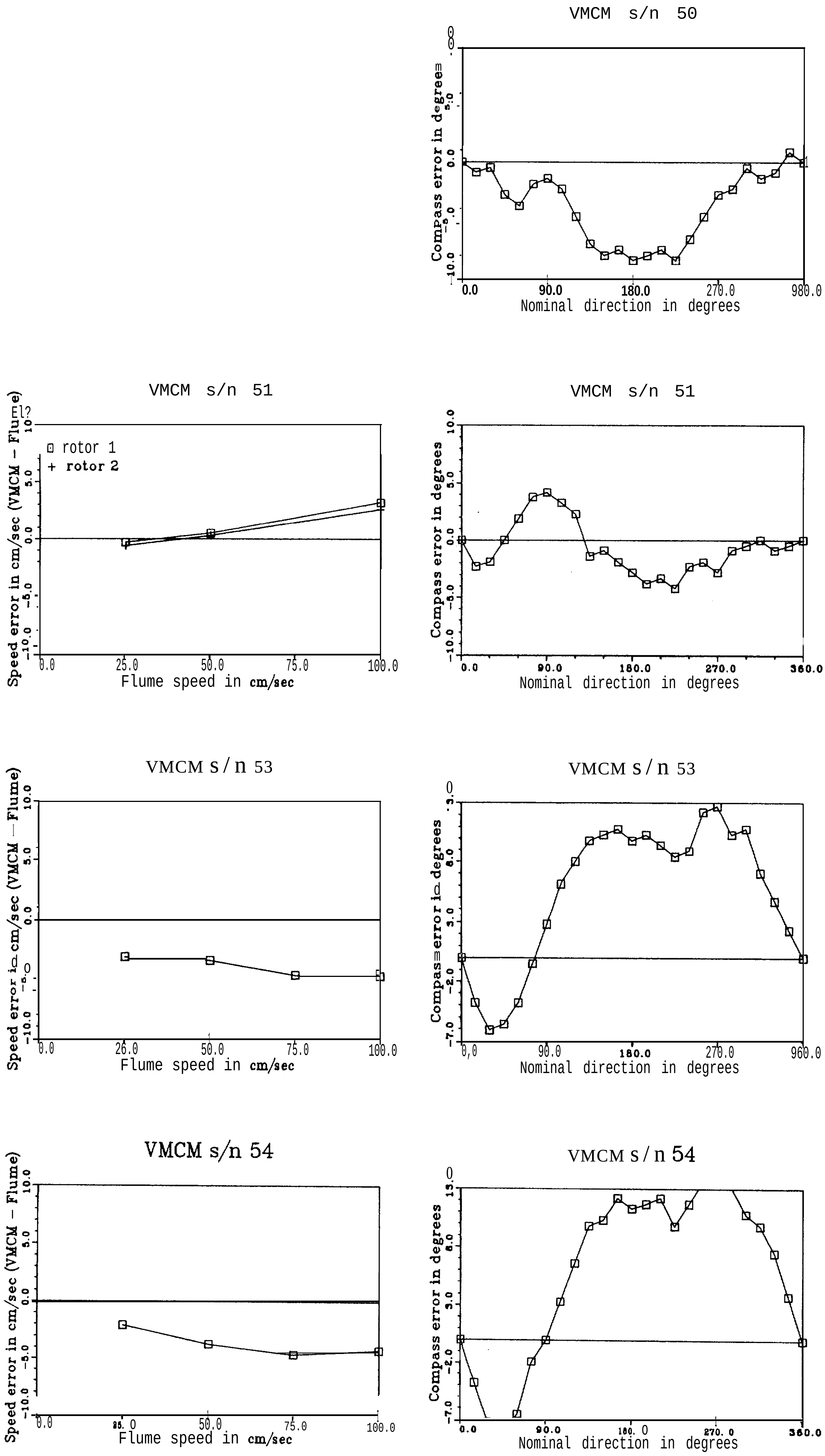


Figure 4-2a. Continued.

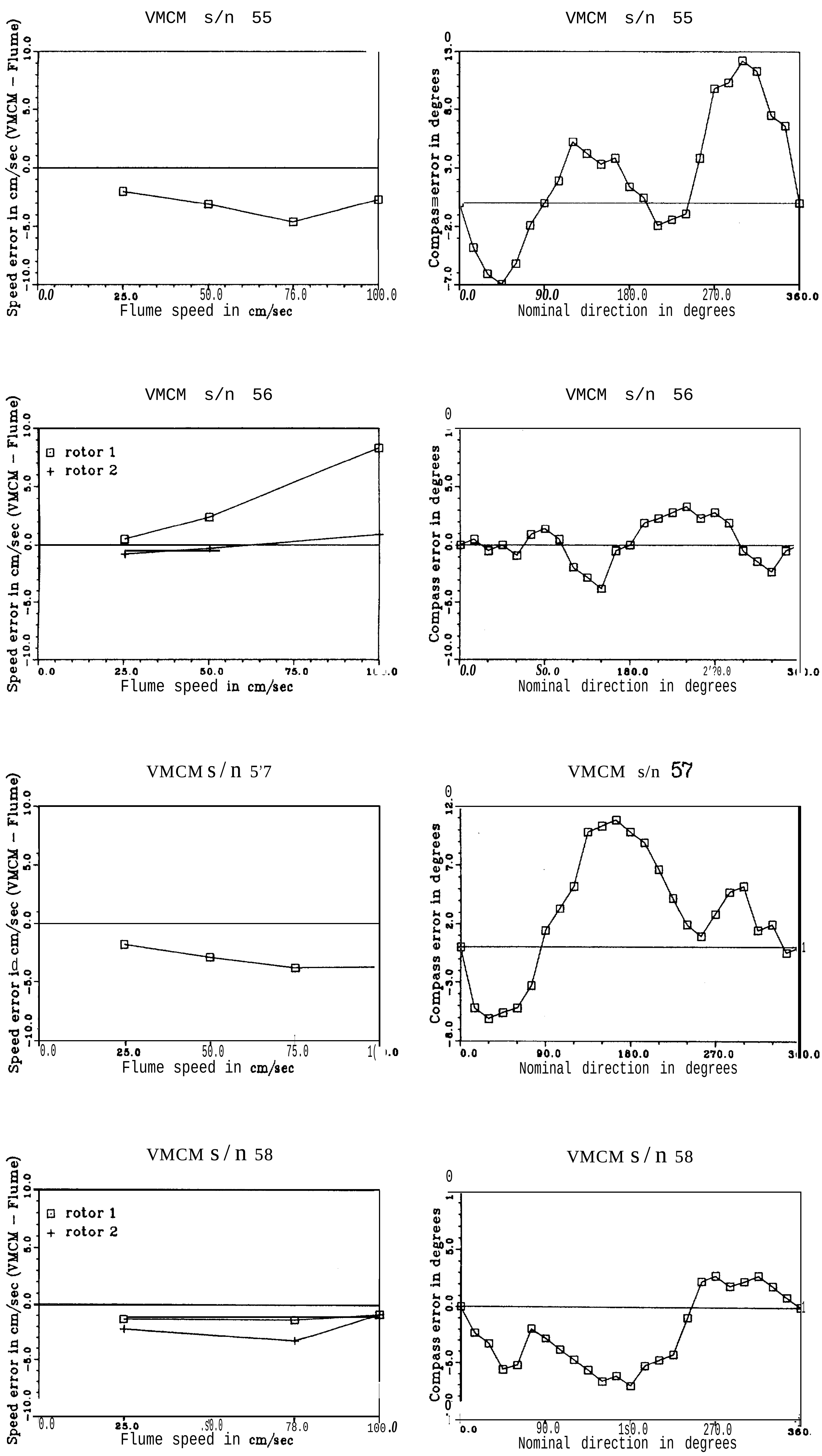


Figure 4-2a. Continued.

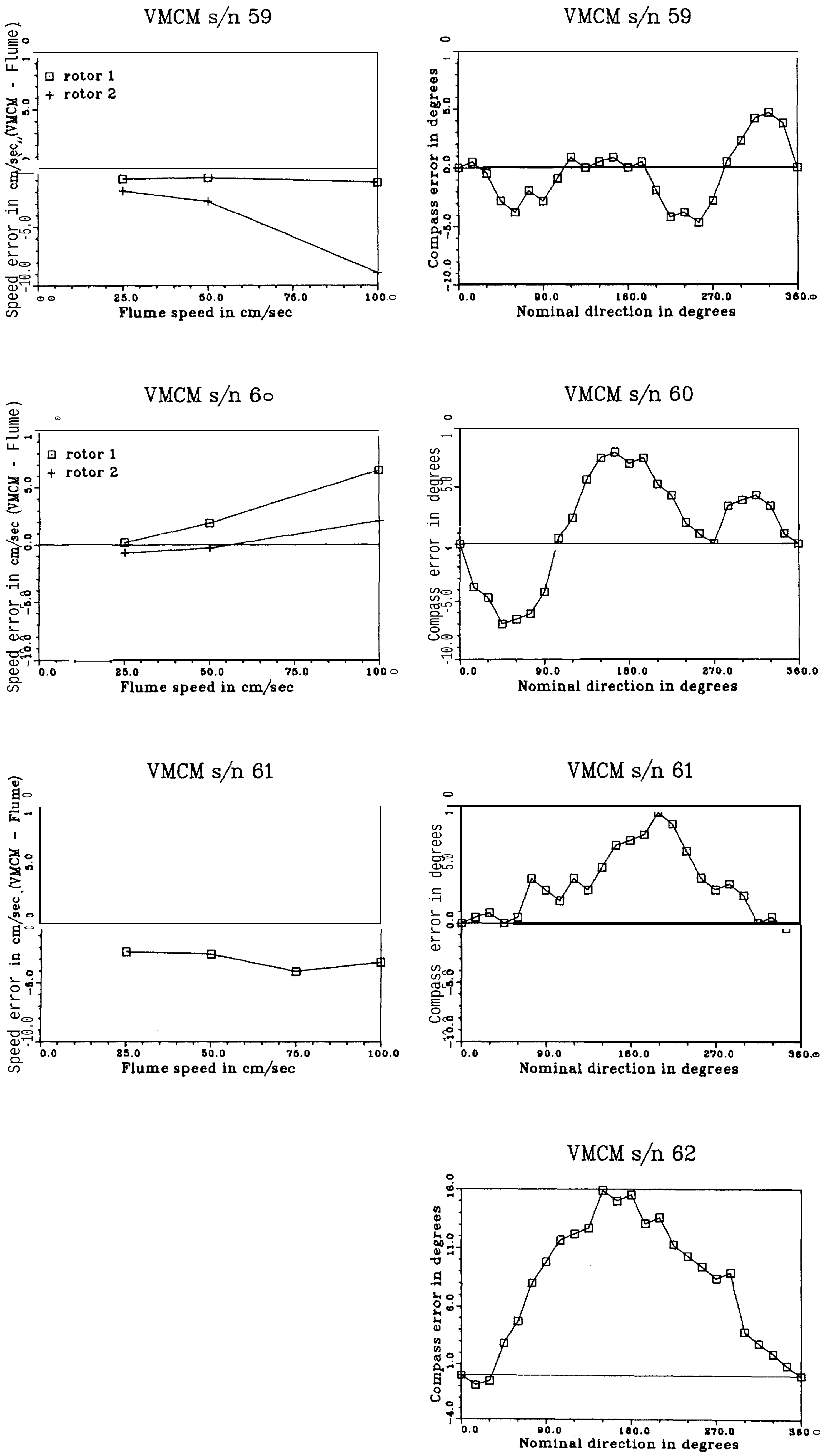


Figure 4-2a. Continued

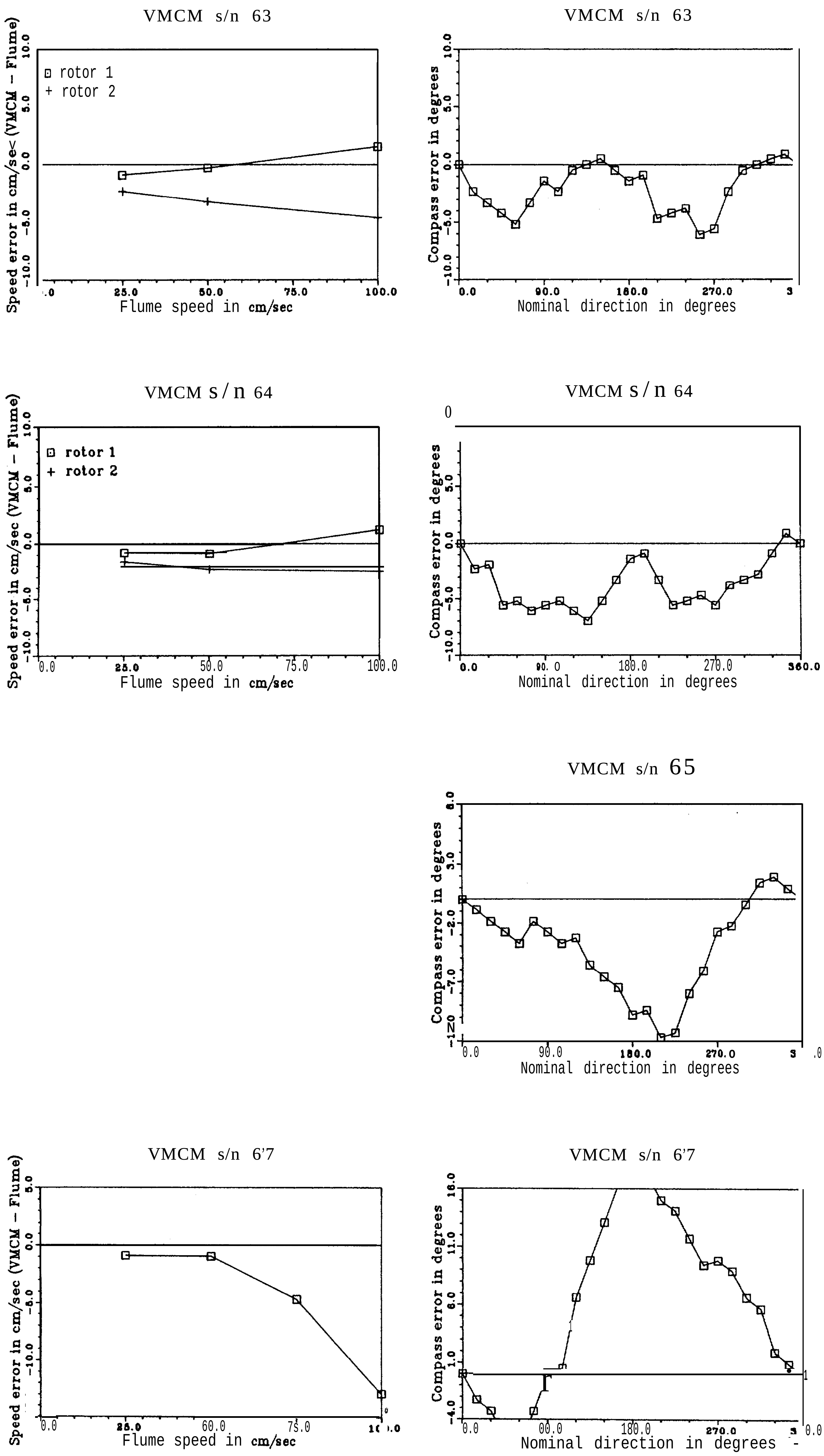


Figure 4- 2a. Continued.

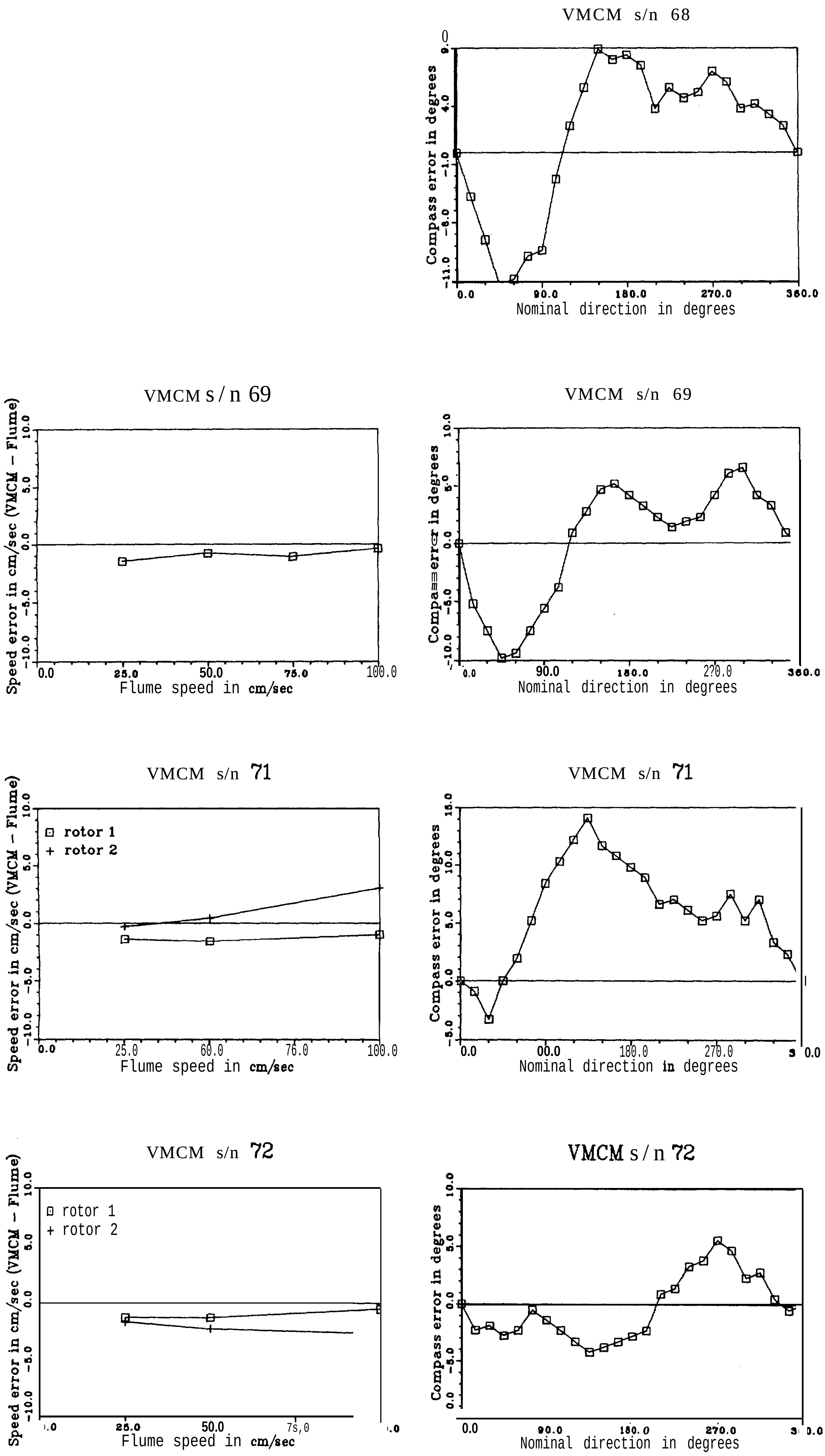


Figure 4-2a. Continued.

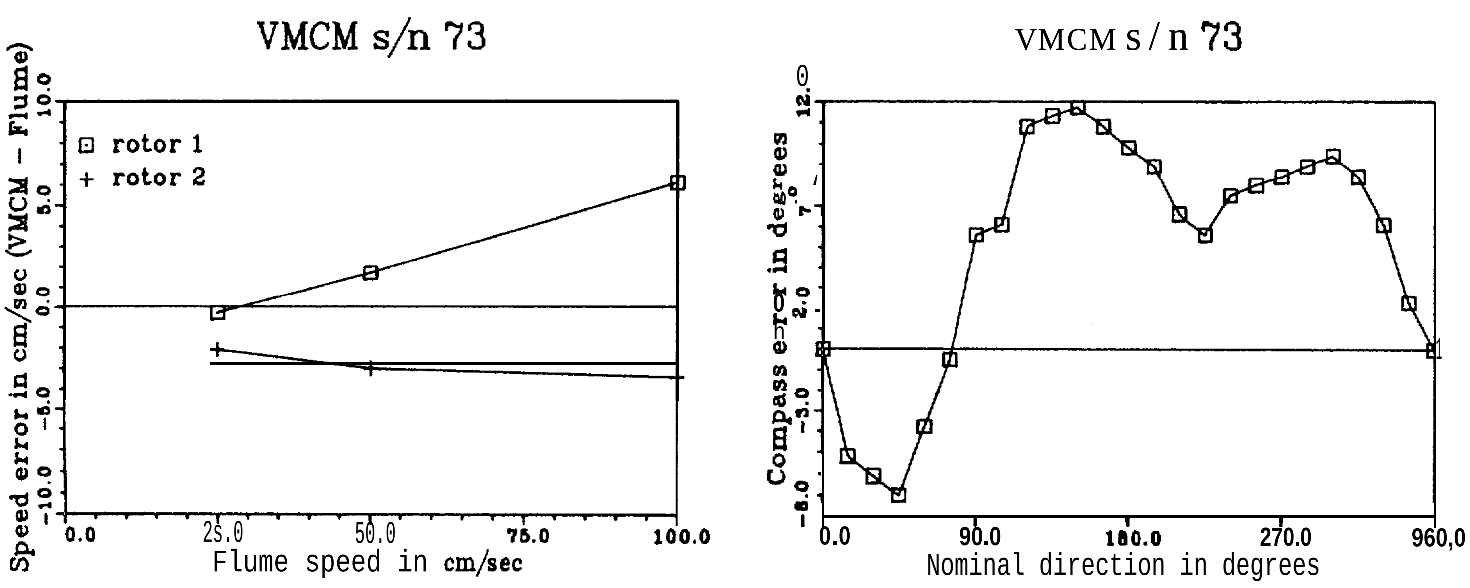


Figure 4-2a. Continued.

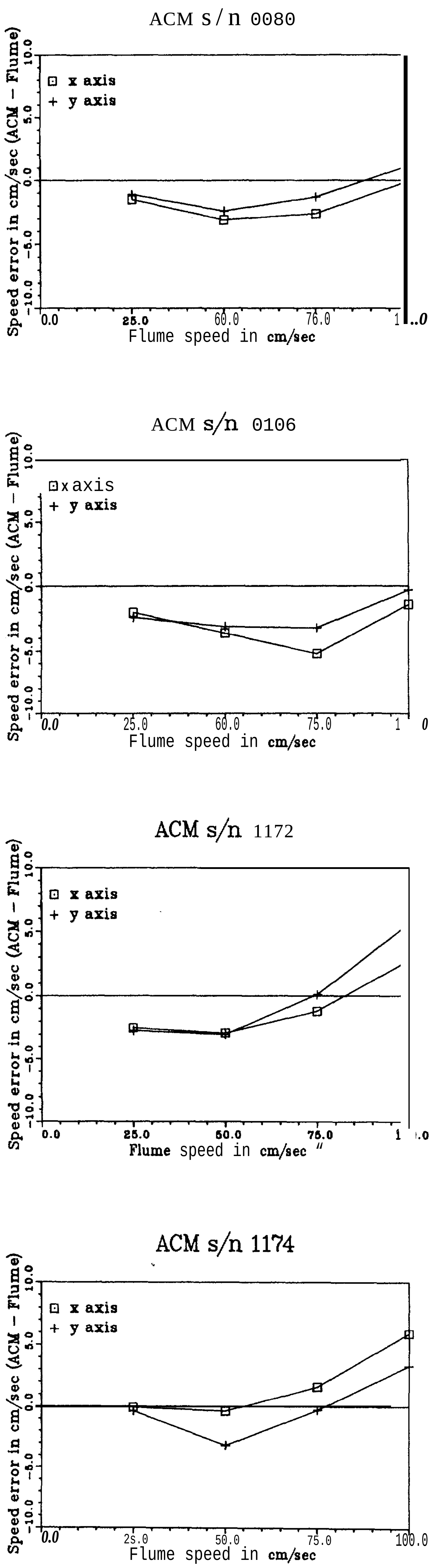


Figure 4- 2b. Predeployment current meter calibration, S10 flume: ACMS.

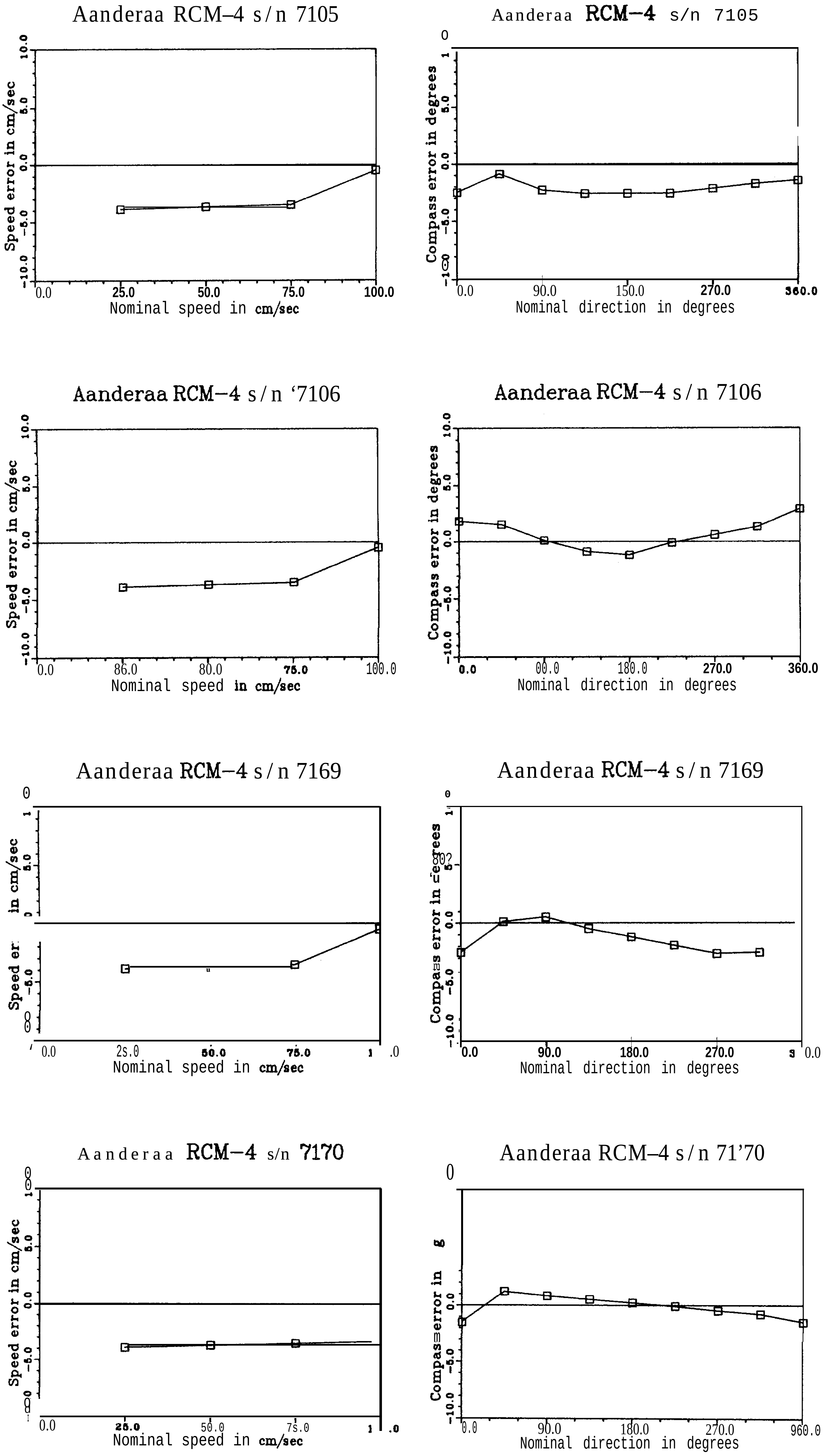


Figure 4-2c. Predeployment current meter calibration, S10 flume: RCMS.

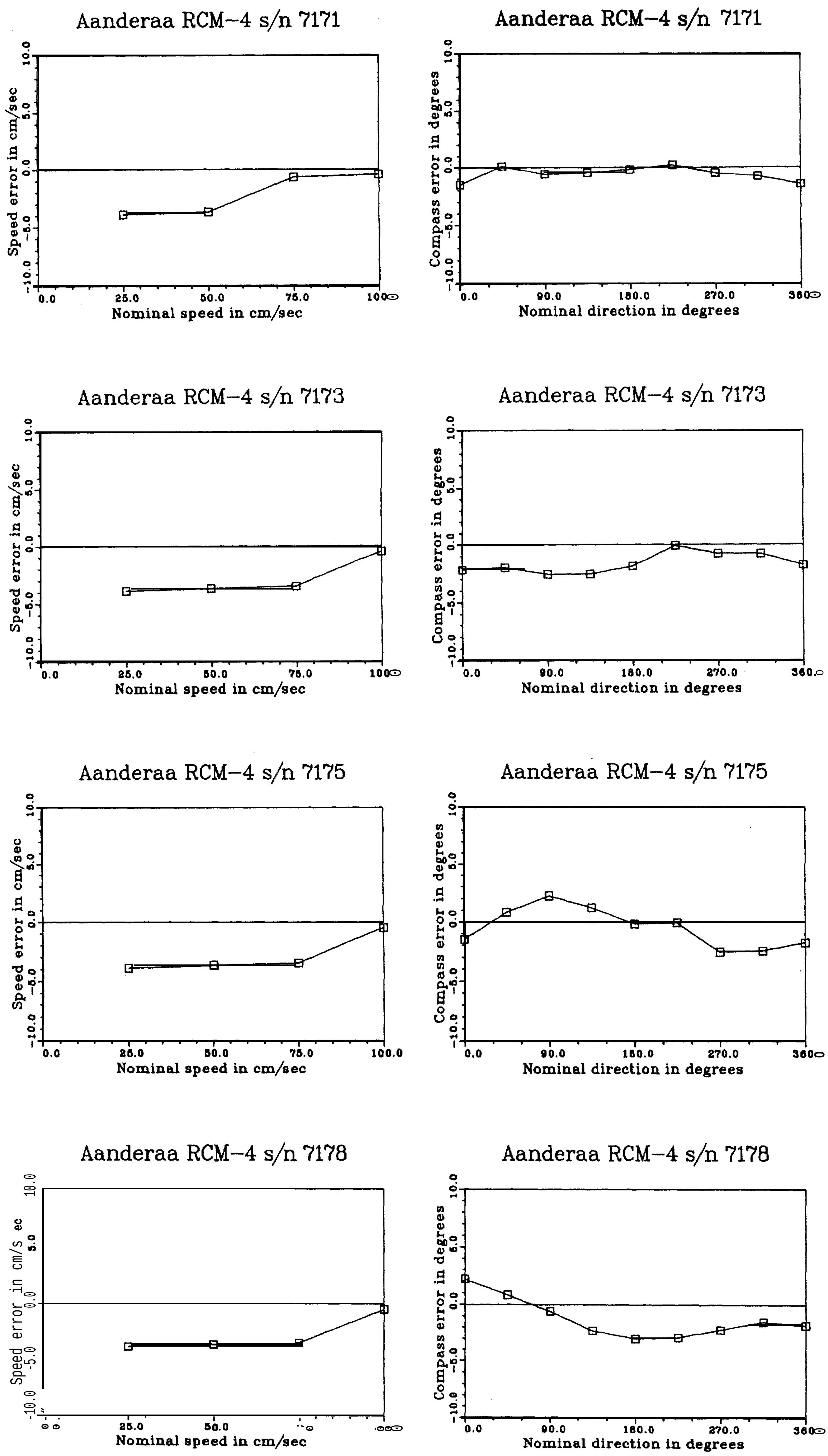


Figure 4 2c Continued

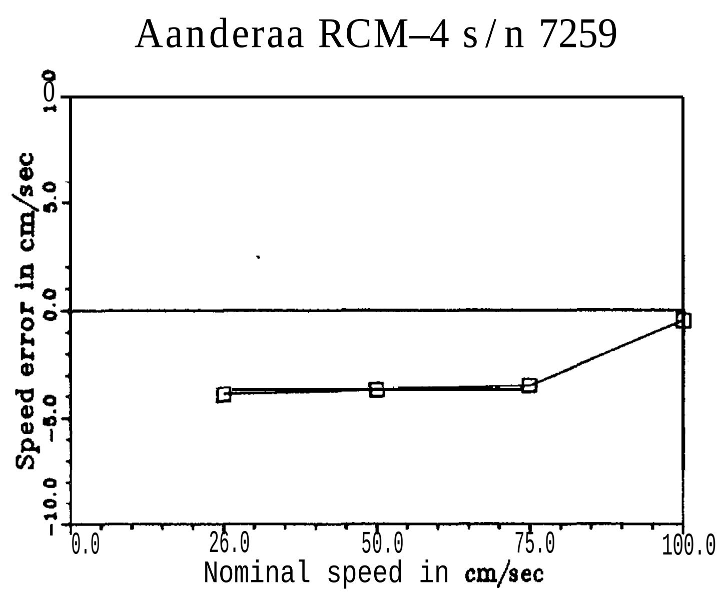


Figure 4-2c. Continued.

Table 4-2. S10 predeployment temperature calibration data, first deployment of NCCCS main program.

Computed value - $a_0 + a_1(\text{count}) + a_2(\text{count})^2 + a_3(\text{count})^3$,

where a_0, a_1, a2 and a3 are calibration constants. D - double precision.

Applied Temperature ("C)	Instrument Output (count)	Computed Temperature ("C)	
	μP 02 27 Feb 1988		
6.0453067	-11092	6.7035460	
7.9390216	-8951	8.2096195	
10.0104132	-6795	10.2630558	
12.0861311	-4847	12.3367863	
Calibration Constants: 3.15108e+003	-8.63051e+002	7.86380e+001	-2.38795e+000
Variance: 1.582897e-001 °C^2			
	μP 07 19 Feb 1988		
6.1449490	-10967	6.1700072	
8.1583748	-8708	8.1682987	
10.1031923	-6706	10.1117496	
12.1470261	-4795	12.1548405	
Calibration Constants: -1.30126e+002	3.27168e+001	-2.87626e+000	8.46168e-002
Variance: 2.151735e-004 "C^2			
	μP 09 19 Feb 1988		
6.1449490	-10924	6.1620116	
8.1583748	-8672	8.1679020	
10.1031923	-6682	10.1130924	
12.1470261	-4782	12.1581059	
Calibration Constants: -1.78091e+002	4.57387e+001	-4.05473e+000	1.20168e-001
Variance: 1.506689e-004 "C^2			
	PS 10 27 Feb 1988		
6.0453067	-14678	6.0443053	
7.9390216	-10405	7.9388671	
10.0104132	-6130	10.0101871	
12.0861311	-2256	12.0858707	
Calibration Constants: -2.24581e+001	4.39769e+000	-3.89754e-001	1.17205e-002
Variance: 2.863640e-007 °C^2			
	Ps 11 16 Feb 1988		
6.0034475	-14659	6.0062194	
8.1992483	-9760	8.2003727	
10.1012020	-5873	10,1018925	
12.0941162	-2175	12.0955448	
Calibration Constants: -3.28759e+001	7.24421e+000	-6.49006e-001	1.95910e-002
Variance: 2.866264e-006 °C^2			
	PS 12 27 Feb 1988		
6.0453067	-14917	6.0308471	
7.9390216	-10636	7.9338012	
10.0104132	-6340	10.0050602	
12.0861311	-2453	12.0815372	
Calibration Constants: -4.31470e+001	1.00395e+001	-9.02592e-001	2.72591e-002
Variance: 7.152270e-005 °C^2			

Table 4-2. Continued.

Applied Temperature (“C)	Instrument Output (count)	Computed Temperature (“C)
	Ps 14 11 Ott 1988	
5.9815240	-15269	5.9809203
8.1972589	-10237	8.1955509
10.0732803	-6353	10.0750065
12.0621738	-2605	12.0603275
14.1401968	961	14,1400700

Calibration Constants: -9.62177e+000 9.03992e-001 -7.28000e-002 2.13543e-003
Variance: 1.937270e-006 °C²

	PS 15 2 Mar 1988	
6.2246585	-14268	6.2244811
8.1862803	-9896	8.1865482
10.0004435	-6198	10.0003300
12.0601826	-2355	12.0603275
14.0712729	1069	14.0714664

Calibration Constants: -2.38692e+000 -1.06965e+000 1.06620e-001 -3.29963e-003
Variance: 3.493023e-008 “C²

	CM 50 23 Feb 1988	
7.3658156	-12049	7.3656554
8.1354418	-10351	8.1363773
10.0912304	-6308	10.0905399
12.0312290	-2639	12.0317631
14.0912390	908	14.0911808

Calibration Constants: -7.57062e+000 3.48055e-001 -2.25716e-002 6.22685e-004
Variance: 3.332538e-007 °C²

	CM 51 23 Feb 1988	
7.3658156	-11810	7.3658080
8.1354418	-10127	8.1362553
10.0912304	-6115	10.0906620
12.0312290	-2470	12.0317631
14.0912390	1061	14.0913029

Calibration Constants: -5.98258e+000 -8.10522e-002 1.60596e-002 -5.35756e-004
Variance: 2.548364e-007 °C²

	CM 53 26 Feb 1988	
6.4468780	-13630	6.4491820
8.0606594	-10072	8.0602055
10.0632906	-6011	10.0651493
12,0631704	-2317	12.0626163
14.0602942	1069	14.0610294

Calibration Constants: 2.04369e+000 -2.28275e+000 2.17291e-001 -6.66365e-003
Variance: 1.963460e-006 °C²

	CM 54 26 Feb 1988	
6.4468780	-13695	6.4462523
8.0606594	-10125	8.0598087
10.0632906	-6047	10.0634098
12.0631704	-2330	12.0623417
14.0602942	1068	14.0600834

Calibration Constants: -3.48938e+000 -7.62976e-001 7.81810e-002 -2.42041e-003
Variance: 3.720974e-007 °C²

Table 4-2. Continued.

Applied Temperature (“C)	Instrument Output (count)	Computed Temperature (“C)
	CM 55 23 Feb 1988	
6.0592599	-14737	6.0590758
8.0596647	-10183	8.0594120
10.0632906	-6031	10.0631351
12.0671730	-2245	12.0671024
14.0812559	1231	14.0811710

Calibration Constants: -3.13487e+000 -8.57364e-001 8.66750e-002 -2.67889e-003
Variance: 2.681918e-008 $^{\circ}C^2$

Applied Temperature (“C)	Instrument Output (count)	Computed Temperature (“C)
	CM 56 23 Feb 1988	
7.3668103	-11857	7.3659301
8.1354418	-10165	8.1363773
10.0912304	-6142	10.0899906
12.0312290	-2490	12.0314884
14.0912390	1051	14.0909061

Calibration Constants: -9.68531e-001 -1.45735e+000 1.41992e-001 -4.37700e-003
Variance: 6.730397e-007 $^{\circ}C^2$

Applied Temperature (“C)	Instrument Output (count)	Computed Temperature (“C)
	CM 57 2 Mar 1988	
6.2246585	-14154	6.2228942
8.1862803	-9769	8.1844120
10.0004435	-6059	10.0012760
12.0601826	-2207	12.0585575
14.0712729	1250	14.0707645

Calibration Constants: 4.35019e+000 -2.89989e+000 2.72394e-001 -8.30553e-003
Variance: 2.039090e-006 ‘C^2

Applied Temperature (“C)	Instrument Output (count)	Computed Temperature (“C)
	CM 58 24 Feb 1988	
6.3711400	-14262	6.3711791
8.0686350	-10448	8.0677128
10.0852404	-6290	10.0859623
12.0931196	-2524	12.0924015
14,0752583	876	14,0751591

Calibration Constants: -3.66425e+000 -7.20951e-001 7.49042e-002 -2.33886e-003
Variance: 3.797402e-007 “C^2

Applied Temperature (“C)	Instrument Output (count)	Computed Temperature (“C)
	CM 59 24 Feb 1988	
6.3711400	-14045	6.3718505
8.0686350	-10261	8.0681095
10.0852404	-6134	10.0869083
12.0931196	-2392	12.0924015
14.0752583	1001	14.0757084

Calibration Constants: 9.47544e-001 -1.97529e+000 1.88601e-001 -5.77317e-003
Variance: 8.562747e-007 “C^2

Applied Temperature (“C)	Instrument Output (count)	Computed Temperature (“C)
	CM 60 2 Mar 1988	
6.2246585	-14034	6.2303405
8.1862803	-9694	8.1862736
10.0004435	-6024	10.0024967
12.0601826	-2214	12.0604496
14.0712729	1221	14.0729618

Calibration Constants: 1.51406e+001 -5.85607e+000 5.42275e-001 -1.65159e-002
Variance: 7.884966e-006 $^{\circ}C^2$

Table 4-2. Continued.

Applied Temperature (°C)	Instrument Output (count)	Computed Temperature (“C)
	CM 61 29 Feb 1988	
6.2396064	-14345	6.2416625
8.0576754	-10259	8.0568485
10.0583143	-6135	10.0605717
12.0691643	-2366	12.0683537
14.0562887	1049	14.0569401

Calibration Constants: -1.44505e+000 -1.32222e+000 1.29230e-001 -3.97551e-003
Variance: 2.217658e-006 °C^2

Applied Temperature (°C)	Instrument Output (count)	Computed Temperature (“C)
	CM 62 24 Feb 1988	
6.3711400	-14190	6.3713317
8.0686350	-10349	8.0685368
10.0852404	-6162	10.0854130
12.0931196	-2366	12.0929508
14.0752583	1052	14.0751591

Calibration Constants: -6.47819e+000 5.26257e-002 4.09887e-003 -1.80890e-004
Variance: 2.290399e-008 “C^2

Applied Temperature (°C)	Instrument Output (count)	Computed Temperature (“C)
	CM 63 2 Mar 1988	
6.2246585	-14460	6.2238097
8.1862803	-10064	8.1861515
10.0004435	-6344	10.0000553
12.0601826	-2480	12.0599003
14.0712729	961	14.0710392

Calibration Constants: -3.59818e+000 -7.37649e-001 7.62990e-002 -2.37713e-003
Variance: 2.043844e-007 °C^2

Applied Temperature (°C)	Instrument Output (count)	Computed Temperature (“C)
	CM 64 27 Feb 1988	
6.0453067	-14805	9.7073612
7.9390216	-10507	7.8257689
10.0104132	-6215	9.2036381
12.0861311	-2329	12.2632999
14.0413046	-15363	10.2007694

Calibration Constants: 1.75388e+003 -4.84864e+002 4.45256e+001 -1.36260e+000
Variance: 5.771091e+000 “C^2

Applied Temperature (°C)	Instrument Output (count)	Computed Temperature (“C)
	CM 65 23 Feb 1988	
6.0592599	-15258	6.0590758
8.0596647	-10692	8.0598087
10.0632906	-6529	10.0632572
12.0671730	-2734	12.0672550
14.0812559	744	14.0813236

Calibration Constants: -5.31426e+000 -2.69068e-001 3.36702e-002 -1.08547e-003
Variance: 1.340814e-008 ‘C^2

Applied Temperature (°C)	Instrument Output (count)	Computed Temperature (“C)
	CM 66 23 Feb 1988	
6.0592599	-14937	6.0589538
8.0596647	-10411	8.0599308
10.0632906	-6285	10.0625858
12.0671730	-2521	12.0673771
14.0812559	926	14.0811710

Calibration Constants: -5.94666e+000 -9.78703e-002 1.82112e-002 -6.19503e-004
Variance: 1.420121e-007 “C^2

Table 4-2. Continued.

Applied Temperature (“C)	Instrument Output (count)	Computed Temperature (“C)
	CM 67 24 Feb 1988	
6.3711400	-14204	6.3713317
8.0686350	-10360	8.0679874
10.0852404	-6172	10.0858097
12.0931196	-2382	12.0925541
14.0752583	1030	14.0754337

Calibration Constants: -6.32332e+000 5.03305e-003 8.90769e-003 -3.41096e-004
Variance: 2.261651e-007 °C²

	CM 68 29 Feb 1988	
6.2396064	-14406	6.2405944
8.0576754	-10312	8.0567265
10.0583143	-6183	10.0601444
12.0691643	-2410	12.0684757"
14.0562887	1001	14.0565128

Calibration Constants: -3.76622e+000 -6.91146e-001 7.20413e-002 -2.24809e-003
Variance: 1.150036e-006 °C²

	CM 69 29 Feb 1988	
6.2396064	-14338	6.2399230
8.0576754	-10265	8.0560551
10.0583143	-6157	10.0602970
12.0691643	-2402	12.0676517
14.0562887	1007	14.0566654

Calibration Constants: 5.05193e-001 -1.85454e+000 1.77631e-001 -5.44148e-003
Variance: 1.817259e-006 °C²

	CM 70 26 Feb 1988	
6,4468780	-13951	6.4470458
8.0606594	-10323	8.0608768
10.0632906	-6178	10.0631351
12.0631704	-2402	12.0633183
14.0602942	1034	14.0603580

Calibration Constants: -8.69618e+000 6.60866e-001 -5.15151e-002 1.51460e-003
Variance: 2.510988e-008 °C²

	CM 71 23 Feb 1988	
7.3658156	-11965	7.3649840
8.1354418	-10273	8.1366520
10.0912304	-6244	10.0899906
12.0312290	-2584	12.0316105
14.0912390	945	14.0909061

Calibration Constants: -1.35504e+001 1.98295e+000 -1.71570e-001 5.14927e-003
Standard Deviation 7.899045e-007 °C²

	CM 72 26 Feb 1988	
6.4468780	-13933	6.4453063
8.0606594	-10312	8.0607548
10.0632906	-6177	10.0615177
12.0631704	-2405	12.0631657
14.0602942	1018	14.0594120

Calibration Constants: -1.19695e+001 1.55411e+000 -1.32776e-001 3.97904e-003
Variance: 1.280102e-006 “C²

Table 4-2. Continued.

Applied Temperature (“C)	Instrument Output (count)	Computed Temperature (°C)
	CM 73 29 Feb 1988	
6.2396064	-14434	6.2403197
8.0576754	-10366	8.0563297
10.0583143	-6252	10,0609684
12.0691643	-2491	12.0678043
14.0562887	919	14,0567875

Calibration Constants: -3.70263e+000 -7.02445e-001 7.24786e-002 -2.24234e-003
Variance: 2.292385e-006 “C^2

Table 4-3. S10 predeployment bottom pressure calibration data, first deployment of NCCCS main program.

Computed value - $a_0 + a_1(\text{count}) + a_2(\text{count})^2$,

where a_0, a_1 and a_2 are calibration constants. D - double precision.

UP 02

first calibration 27 February 1988 T - 6°C Patm - 10148 dPa

Applied Pressure	Measured Pressure (dPa)-	Computed pressure
10148.0	10033.0	10155.8
30832.4	30682,0	30820.1
51516.8	51365.0	51518.0
72201.2	72037.0	72204.5
92885.6	92703.0	92884.5
113570.0	113377.0	113572.0
134254.4	134042.0	134250.2
154938.8	154722.0	154942.8
175623.2	175387.0	175620.0
196307.6	196070.0	196314.8
216992.0	216731.0	216987.2

Calibration Constants: 1.15195e+002 1.00076e+000 -5.21650e-010
Variance: 3.175424e+001 dPa^2

second calibration 27 February 1988 T - 8°C Patm - 10155 dPa

Applied pressure	Measured Pressure (dPa)	Computed Pressure
10155.0	10012.0	10160.5
30839.4	30670.0	30829.8
51523.8	51355.0	51526.5
72208.2	72025.0	72208.4
92892.6	92698.0	92893.5
113577.0	113373.0	113581.0
134261.4	134037.0	134257.7
154945.8	154710.0	154943.6
175630.2	175382.0	175628.8
196314.6	196063.0	196323.3
216999.0	216720.0	216994.1

Calibration Constants: 1.43088e+002 1.00054e+000 3.12197e-010
Variance: 2.422258e+00l dPa^2

third calibration 28 February 1988 T - 10"C Patm - 10180 dPa

Applied Pressure	Measured Pressure (dPa)	Computed Pressure
10180.0	10038.0	10186.8
30864.4	30691.0	30853.2
51548.8	51373.0	51547.8
72233.2	72051.0	72237.8
92917.6	92722.0	92920.0
113602.0	113394.0	113602.5
134286.4	134066.0	134284.3
154970.8	154746,0	154973.5
175655.2	175413.0	175648.9
196339.6	196101.0	196344.6
217024.0	216772.0	217022.6

Calibration Constants: 1.42093e+002 1.00068e+000 -8.22963e-010
Variance: 2.536806e+001 dPa^2

Table 4-3. Continued.

μP 02

fourth calibration 28 February 1988 T = 12°c Patm - 10168 dPa

Applied Pressure	Measured Pressure (dPa)	Computed Pressure
10168.0	10013.0	10169.2
30852.4	30670.0	30841.1
51536.8	51356.0	51541.4
72221.2	72031.0	72230.2
92905.6	92697.0	92909.4
113590.0	113368.0	113593.0
134274.4	134031.0	134268.1
154958.8	154711.0	154959.6
175643.2	175372.0	175631.5
196327.6	196057.0	196326.9
217012.0	216740.0	217019.7

Calibration Constants: 1.48726e+002 1.00075e+000 -6.67970e-010
Variance: 4.473313e+001 dPa^2

JMzz-

first calibration 19 February 1988 T = 6°C Patm = 10164 dPa

Applied Pressure	Measured Pressure (dPa)	Computed Pressure
10164.0	10100,0	10175.7
.23953.6	23857.0	23939.5
37743.2	37649.0	37737.7
51532.8	51439.0	51533.2
65322.4	65227.0	65326.0
79112.0	79010.0	79113.2
92901.6	92804.0	92910.7
106691.2	106583.0	106692.5
120480.8	120367.0	120478.6
134270.4	134144.0	134257.0
148060.0	147954.0	148067.8

Calibration Constants: 7.02814e+001 1.00056e+000 -1.77244e-009
Variance: 6.437354e+001 dPa^2

second calibration 19 February 1989 T = 8°C Patm = 10164 dPa

Applied Pressure	Measured Pressure (dPa)	Computed Pressure
10164.0	10109.0	10173.9
23953.6	23866.0	23939.1
37743.2	37661.0	37741.7
51532.8	51445.0	51532.5
65322.4	65237.0	65330.6
79112.0	79013.0	79112.0
92901.6	92798.0	92901.7
106691.2	106583.0	106690.6
120480.8	120371.0	120481.9
134270.4	134152.0	134265.5
148060.0	147947.0	148062.4

Calibration Constants: 5.84376e+001 1.00066e+000 -1.85965e-009
Variance: 3.713594e+001 dPa^2

third calibration 21 February 1988 T - 10"C Patm = 10182 dPa

Applied Pressure	Measured Pressure (dPa)	Computed Pressure
10182.0	10124.0	10196.7
23971.6	23876.0	23954.1
37761.2	37670.0	37753.5
51550.8	51455.0	51543.9
65340.4	65258.0	65352.3
79130.0	79048.0	79147.6
92919.6	92814.0	92918.9
106709.2	106596.0	106706.2
120498.8	120373.0	120488.4
134288.4	134162.0	134282.7
148078.0	147960.0	148085,9

Calibration Constants: 6.86821e+001 1.00040e+000 -6.55255e-011
Variance: 1.173434e+002 dPa^2

Table 4-3 Continued

μP 07

fourth calibration 21 February 1988 T - 12°C Patm - 10158 dPa

Applied Pressure	Measured Pressure (dPa)	Computed Pressure
10158.0	10091.0	10170.2
23947.6	23844.0	23931.8
37737.2	37637.0	37732.2
51526.8	51427.0	51528.3
65316.4	65216.0	65322.0
79106.0	79000.0	79109.5
92895.6	92787.0	92898.6
106685.2	106570.0	106682.4
120474.8	120362.0	120473.9
134264.4	134151.0	134261.1
148054.0	147949.0	148056.0

Calibration Constants: 7.19988e+001 1.00075e+000 -3.44514e-009
Variance: 4.543491e+001 dPa^2

UP 09

first calibration 19 February 1988 T = 6°C Patm - 10164 dPa

Applied Pressure	Measured Pressure (dPa)	Computed Pressure
10164.0	10132.0	10174.9
23953.6	23904.0	23941.0
37743.2	37706.0	37736.8
51532.8	51509.0	51533.0
65322.4	65311.0	65327.9
79112.0	79108.0	79117.4
92901.6	92901.0	92902.4
106691.2	106700.0	106693.0
120480.8	120488.0	120472.2
134270.4	134298.0	134273.0
148060.0	148095.0	148060.3

Calibration Constants: 4.69150e+001 9.99613e-001 -1.10688e-009
Variance: 4.196316e+001 dPa^2

second calibration 19 February 1988 T = 8°C Patm - 10164 dPa

Applied Pressure	Measured Pressure (dPa)	Computed Pressure
10164.0	10140.0	10174.8
23953.6	23911.0	23940.1
37743.2	37715.0	37738.1
51532.8	51520.0	51536.7
65322.4	65315.0	65324.9
79112.0	79110.0	79112.7
92901.6	92908.0	92903.2
106691.2	106705.0	106692.3
120480.8	120501.0	120480.1
134270.4	134299.0	134269.5
148060.0	148098.0	148059.5

Calibration Constants: 3.87620e+001 9.99620e-001 -9.60694e-010
Variance: 3.195444e+001 dPa^2

third calibration 21 February 1988 T - 10"C Patm - 10182 dPa

Applied Pressure	Measured Pressure (dPa)	Computed Pressure
10182.0	10151.0	10190.9
23971.6	23921.0	23956.0
37761.2	37735.0	37764.5
51550.8	51528.0	51551.6
65340.4	65326.0	65343.2
79130.0	79120.0	79130.4
92919.6	92917.0	92920.0
106709.2	106715.0	106710.2
120498.8	120510.0	120496.9
134288.4	134309.0 .	134287.2
148078.0	148110.0	148078.9

Calibration Constants: 4.32553e+001 9.99684e-001 -1.25317e-009
Variance: 3.189687e+001 dPa^2

Table 4-3. Continued.

UP 09

fourth calibration 21 February 1988 T = 12*C Patm = 10158 dPa

Applied Pressure	Measured Pressure (dPa)	Computed Pressure
10158.0	10121.0	10171.2
23947.6	23890.0	23934.3
37737.2	37691.0	37729.0
51526.8	51495.0	51526,1
65316.4	65298.0	65321.8
79106.0	79094.0	79110.0
92895.6	92891.0	92898.7
106685.2	106683.0	106681.9
120474.8	120487.0	120476.6
134264.4	134285.0	134264.9
148054,0	148082.0	148051.6

Calibration Constants: 5.41887e+001 9.99617e-001 -1.27033e-009
Variance: 4.479962e+001 dPa^2

Ps 10

first calibration 27 February 1988 T = 6°C Patm = 10148 dPa

Applied Pressure	Measured Pressure (dPa)	Computed pressure
10148.0	9966.0	10152.5
30832.4	30586.0	30805.6
51516.8	51266.0	51516.0
72201.2	71938.0	72215.6
92885.6	92611.0	92913.4
113570.0	113267.0	113591.5
134254.4	133937.0	134280.9
154938.8	154473.0	154833.3
175623.2	175259.0	175633.3
196307.6	195941.0	196326.3
216992.0	216608.0	217001.6

Calibration Constants: 1.69563e+002 1.00173e+000 -3.22733e-009
Variance: 1.322991e+003 dPa^2

second calibration 27 February 1988 T = 8°C Patm - 10155 dPa

Applied Pressure	Measured Pressure (dPa)	Computed Pressure
10155.0	9951.0	10169.6
30839.4	30582.0	30819.4
51523.8	51259.0	51514.9
72208.2	71950.0	72224.1
92892,6	92597.0	92888.9
113577.0	113267.0	113576.3
134261.4	133948.0	134274.3
154945.8	154591.0	154934.0
175630.2	175272.0	175631.3
196314.6	195941.0	196316.3
216999.0	216607,0	216997.9

Calibration Constants: 2.09369e+002 1.00093e+000 -4.25009e-010
Variance: 1.153842e+002 dPa^2

third calibration 28 February 1988 T = 10"C Patm = 10180 dPa

Applied Pressure	Measured Pressure (dPa)	Computed Pressure
10180.0	9976.0	10193.0
30864.4	30613.0	30848.1
51548.8	51286.0	51538.5
72233.2	71968.0	72237.4
92917.6	92642.0	92927.7
113602.0	113308.0	113609,5
134286.4	133973.0	134289.6
154970.8	154627.0	154958.2
175655.2	175305.0	175650.1
196339.6	195988.0	196346.5
217024.0	216652.0	217023.4

Calibration Constants 2.08106e+002 1.00090e+000 -6.81644e-010
Variance: 8.757446e+00l dPa^2

Table 4-3. Continued.

Ps 10

fourth calibration 28 February 1988 T = 12°C Patm - 10168 dPa

Applied pressure	Measured Pressure (dPa)	Computed Pressure
10168.0	9953.0	10130.9
30852.4	30598.0	30829.0
51536.8	51273.0	51551.0
72221.2	71956.0	72274.5
92905.6	92610.0	92962.6
113590.0	113282.0	113662.5
134274.4	133942.0	134343.9
154958.8	154197.0	154613.7
175643.2	175268.0	175693.7
196327.6	195953.0	196381.1
217012.0	216623.0	217047.1

Calibration Constants: 1.49949e+002 1.00288e+000 -7.44469e-009
Variance: 1.309188e+004 dPa^2

Ps 11

first calibration 16 February 1988 T - 6°C Patm = 10100 dPa

Applied Pressure	Measured Pressure (dPa)	Computed Pressure
10100.0	9888.0	10138.2
23889.6	23572.0	23849.7
37679.2	37357.0	37659.7
51468.8	51140.0	51465.0
65258.4	64930.0	65274.6
79048.0	78698.0	79059.5
92837.6	92454.0	92829.6
106627.2	106250.0	106637.0
120416.8	120026.0	120421.8
134206.4	133802.0	134203.8
147996.0	147584.0	147989.1

Calibration Constants: 2.28603e+002 1.00225e+000 -7.15276e-009
Variance: 3.707272e+002 dPa^2

second calibration 16 February 1988 T - 8°C Patm - 10088 dPa

Applied Pressure	Measured Pressure (dPa)	Computed Pressure
10088.0	9889.0	10110.2
23877.6	23591,0	23845.4
37667.2	37394.0	37679.0
51456.8	51131.0	51443.6
65246.4	64918.0	65255.5
79036.0	78671.0	79030.4
92825.6	92445.0	92823.5
106615.2	106230.0	106624.7
120404.8	120006.0	120414.0
134194.4	133776.0	134194.5
147984.0	147549.0	147975.1

Calibration Coefficients: 1.95437e+002 1.00268e+000 -7.56058e-009
Variance: 2.012322e+002 dPa^2

third calibration 18 February 1988 T - 10″C Patm = 10124 dPa

Applied Pressure	Measured Pressure (dPa)	Computed pressure
10124.0	9896.0	10146.0
23913.6	23635.0	23900.8
37703.2	37408.0	37690.5
51492.8	51181.0	51481.0
65282.4	64962.0	65280.3
79072.0	78740.0	79077.3
92861.6	92505.0	92862.2
106651.2	106287.0	106664.8
120440.8	120052.0	120451.3
134230.4	133811.0	134232.5
148020.0	147561.0	148005.5

Calibration Constants: 2.39056e+002 1.00108e+000 2.09460e-009
Variance: 1.355647e+002 dPa^2

Table 4-3. Continued.

PS 11

fourth calibration 18 February 1988 T - 12°C Patm - 10100 dPa

Applied Pressure	Measured Pressure (dPa)	Computed Pressure'
10100.0	9857.0	10118.9
23889.6	23596.0	23870.8
37679.2	37384.0	37672.7
51468.8	51164.0	51467.4
65258.4	64940.0	65259,0
79048.0	78713.0	79048.5
92837.6	92481.0	92833.9
106627.2	106269.0	106640.3
120416.8	120034,0	120424,4
134206.4	133792.0	134202.5
147996.0	147558.0	147989.5

Calibration Constants: 2.53164e+002 1.00086e+000 2.35159e-009
Variance: 9.598655e+001 dPa^2

Ps 12

first calibration 27 February 1988 T - 6°C Patm - 10148 dPa

Applied Pressure	Measured Pressure (dPa)	Computed Pressure
10148.0	34573.0	10164.4
30832.4	106191.0	30805.8
51516.8	178536.0	51513.2
72201.2	251324.0	72201.9
92885.6	324687.0	92906.2
113570.0	398446.0	113572.8
134254.4	472811.0	134257.3
154938.8	547689.0	154930.6
175623.2	623153.0	175609.3
196307.6	699289.0	196313.1
216992.0	775941.0	216995.8

Calibration Constants: 1.49284e+002 2.90155e-001 -1.37802e-008
Variance: 1.578352e+002 dPa^2

second calibration 27 February 1988 T - 8°C Patm - 10155 dPa

Applied pressure	Measured Pressure (dPa)	Computed Pressure
10155.0	34473.0	10166.7
30839.4	106139.0	30817.7
51523.8	178480.0	51520.3
72208.2	251324.0	72221.8
92892.6	324587.0	92895.6
113577.0	398406.0	113577.3
134261.4	472811.0	134271.9
154945.8	547649.0	154933.8
175630.2	623149.0	175622.7
196314.6	699241.0	196315.7
216999.0	775905.0	217003.6

Calibration Constants: 1.82914e+002 2.90085e-001 -1.37162e-008
Variance: 1.042560e+002 dPa^2

third calibration 28 February 1988 T - 10"C Patm - 10180 dPa

Applied pressure	Measured Pressure (dPa)	Computed pressure
10180.0	34505.0	10191.9
30864.4	106.195.0	30848.4
51548.8	178508.0	51541.5
72233.2	251316.0	72231.1
92917.6	324683.0	92932.2
113602.0	398506.0	113612.8
134286.4	472843.0	134286.2
154970.8	547733.0	154959.9
175655.2	623253.0	175651.5
196339.6	699329.0	196337.1
217024.0	776021.0	217029.4

Calibration Constants: 1.99462e+002 2.90069e-001 -1.37319e-008
Variance: 8.664185e+001 dPa^2

Table 4-3. Continued.

Ps 12

fourth calibration 28 February 1988 T = 12°C Patm = 10168 dPa

Applied pressure	Measured Pressure (dPa)	Computed pressure
10168.0	34365.0	10171.5
30852.4	106083.0	30837.7
51536.8	178420.0	51539.2
72221.2	251220.0	72228.1
92905.6	324531.0	92915.0
113590.0	398350.0	113596.1
134274.4	472691.0	134272.2
154958.8	547593.0	154950.7
175643.2	623065.0	175630.7
196327.6	699177.0	196327.5
217012.0	775869.0	217021.1

Calibration Constants: 2.18774e+002 2.90089e-001 -1.37366e-008
Variance: 6.530627e+001 dPa^2

Ps 13

first calibration 16 February 1988 T = 6°C Patm = 10100 dPa

Applied Pressure	Measured Pressure (dPa)	Computed Pressure
10100.0	9995.0	10111.8
23889.6	23746.0	23874.6
37679.2	37538.0	37676.6
51468.8	51323.0	51469.9
65258.4	65106.0	65259.5
79048.0	78894.0	79052.3
92837.6	92675.0	92836.3
106627.2	106468.0	106630.5
120416.8	120254.0	120416.0
134206.4	134046.0	134205.8
147996.0	147839.0	147994.8

Calibration Constants: 1.07113e+002 1.00101e+000 -4.63009e-009
Variance: 3.701811e+001 dPa^2

second calibration 16 February 1988 T = 8°C Patm = 10088 dPa

Applied Pressure	Measured Pressure (dPa)	Computed Pressure
10088.0	9987.0	10100.1
23877.6	23736.0	23860.0
37667.2	37532.0	37665.3
51456.8	51318.0	51459.1
65246.4	65101.0	65248.3
79036.0	78891.0	79043.0
92825.6	92671.0	92826,2
106615.2	106457,0	106613.8
120404.8	120244.0	120400.8
134194.4	134039.0	134194.3
147984.0	147833.0	147985.2

Calibration Constants: 1.04243e+002 1.00093e+000 -4.08339e-009
Variance: 4.904608e+001 dPa^2

third calibration 18 February 1988 T = 10°C Patm = 10124 dPa

Applied Pressure	Measured Pressure (dPa)	Computed Pressure
10124.0	10023.0	10136.2
23913.6	23773.0	23898.5
37703.2	37564.0	37700,2
51492.8	51345.0	51490.4
65282.4	65135.0	65287,9
79072.0	78918.0	79076.8
92861.6	92699.0	92862.1
106651.2	106486.0	106651.8
120440.8	120271.0	120437.8
134230.4	134065.0	134231.3
148020.0	147855,0	148019.1

Calibration Constants: 1.03197e+002 1.00104e+000 -4.23748e-009
Variance: 4.137179e+001 dPa^2

Table 4-3. Continued.

Ps 13

fourth calibration 18 February 1988 T = 12°C Patm - 10100 dPa

Applied Pressure	Measured Pressure (dPa)	Computed Pressure
10100.0	9999.0	10111.7
23889.6	23750.0	23873.9
37679.2	37543.0	37676.4
51468.8	51329.0	51470.3
65258.4	65113.0	65260.6
79048.0	78901.0	79053.1
92837.6	92683.0	92838.1
106627.2	106472.0	106628.4
120416.8	120257.0	120413.0
134206.4	134052,0	134206.0
147996.0	147846.0	147996.4

Calibration Constants: 1.03557e+002 1.00096e+000 -4.33628e-009
Variance: 4.016178e+001 dPa^2

Ps 14

first calibration 11 October 1988 T = 6°C Patm = 10138 dPa

Applied Pressure	Measured Pressure (dPa)	Computed Pressure
10138.0	10035.0	10144.0
23927.6	23806,0	23922.1
30822.4	30698.0	30817.5
44612.0	44487.0	44613.0
61849.0	61719.0	61852.5
79086.0	78945.0	79085..5
96323.0	96177.0	96323.8
113560.0	113409.0	113561.6
130797.0	130637.0	130794.7
148034.0	147872.0	148034.3

Calibration Constants: 1.03645e+002 1.00055e+000 -1.01773e-009
Variance: 1.130702e+001 dPa^2

second calibration 11 October 1988 T - 8°c Patm = 10121 dPa

Applied pressure	Measured Pressure (dPa)	Computed Pressure
10121.0	10024.0	10122.9
23910.6	23803.0	23909.6
30805.4	30693.0	30803.3
44595,0	44478,0	44595,4
61832.0	61706.0	61831.5
79069.0	78937.0	79069.8
96306.0	96168.0	96307.3
113543.0	113398.0	113543.0
130780.0	130629.0	130779.0
148017.0	147863.0	148017.2

Calibration Constants: 9.28701e+001 1.00061e+000 -1.32176e-009
Variance: 1.235160e+000 dPa^2

third calibration 12 October 1988 T - 10″C Patm = 10154 dPa

Applied preSSUre	Measured Pressure (dPa)	Computed pressure
10154,0	10051,0	10145.5
23943.6	23853.0	23949.2
30838.4	30743.0	30840.2
44628.0	44534.0	44633.6
61865.0	61764.0	61867.4
79102.0	78990.0	79097.9
96339.0	96225.0	96338.3
113576.0	113452.0	113571.4
130813.0	130684.0	130810.4
148050.0	147921.0	148055.1

Calibration Constants: 9.36632e+001 1.00007e+000 1.35202e-009
Variance: 2.146666e+001 dPa^2

Table 4-3. Continued

Ps 14

fourth calibration 12 October 1988 T = 12°C Patm - 10140 dPa

Applied Pressure	Measured Pressure (dPa)	Computed Pressure
10140.0	10041.0	10130.7
23929.6	23842.0	23936.1
30824.4	30731.0	30827.3
44614.0	44517.0	44617.7
61851.0	61749.0	61855.1
79088.0	78972.0	79083.4
96325.0	96205.0	96321.6
113562.0	113438.0	113559.7
130799.0	130670.0	130796.7
148036.0	147909.0	148040.6

Calibration Constants: 8.63638e+001 1.00033e+000 -1.62317e-010
Variance: 2.341239e+001 dPa^2

Ps 15

first calibration 12 March 1988 T = 6°C Patm = 10110 dPa

Applied Pressure	Measured Pressure (dPa)	Computed Pressure
10110.0	5031.0	10121.2
13557.4	6726.0	13537.4
17004.8	8452.0	17006.2
20452.2	10174.0	20457.1
23899.6	11902.0	23910.0
27347.0	13623.0	27339.1

Calibration Constants: -7.48167e+001 2.03502e+000 -1.66554e-006
Variance: 1.205115e+002 dPa^2

second calibration 2 March 1988 T = 8°C Patm - 10126 dPa

Applied Pressure	Measured Pressure (dPa)	Computed Pressure
10126.0	5040.0	10141.7
13573.4	6736.0	13550.6
17020.8	8463.0	17016,9
20468.2	10186.0	20470.3
23915.6	11913.0	23926.7
27363.0	13636.0	27370.3
30810.4	15355,0	30800.9

Calibration Constants: -1.64700e+001 2.01968e+000 -8.25761e-007
Variance: 1.503985e+002 dPa^2

third calibration 2 March 1988 T - 10″C Patm = 10125 dPa

Applied Pressure	Measured Pressure (dPa)	Computed pressure
10125.0	5036.0	10139.4
13572,4	6732.0	13549.7
17019,8	8460.0	17018,3
20467.2	10183.0	20470.8
23914.6	11910,0	23925.2
27362.0	13632.0	27363.4
30809.4	15358.0	30803.6

Calibration Constants: -2.17607e+001 2.02287e+000 -1.02527e-006
Variance: 1.262736e+002 dPa^2

fourth calibration 2 March 1988 T = 12°C Patm = 10116 dPa

Applied pressure	Measured Pressure (dPa)	Computed Pressure
10116.0	5241.0	10248.0
13563.4	6723.0	13379.0
17010.8	8449.0	16971.4
20458.2	10173,0	20501.3
23905.6	11899.0	23977.1
27353.0	13621.0	27386.6
30800,4	15346.0	30743.9

Calibration Constants: -1.16982e+003 2.22987e+000 -9.79158e-006
Variance: 9.179211e+003 dPa^2

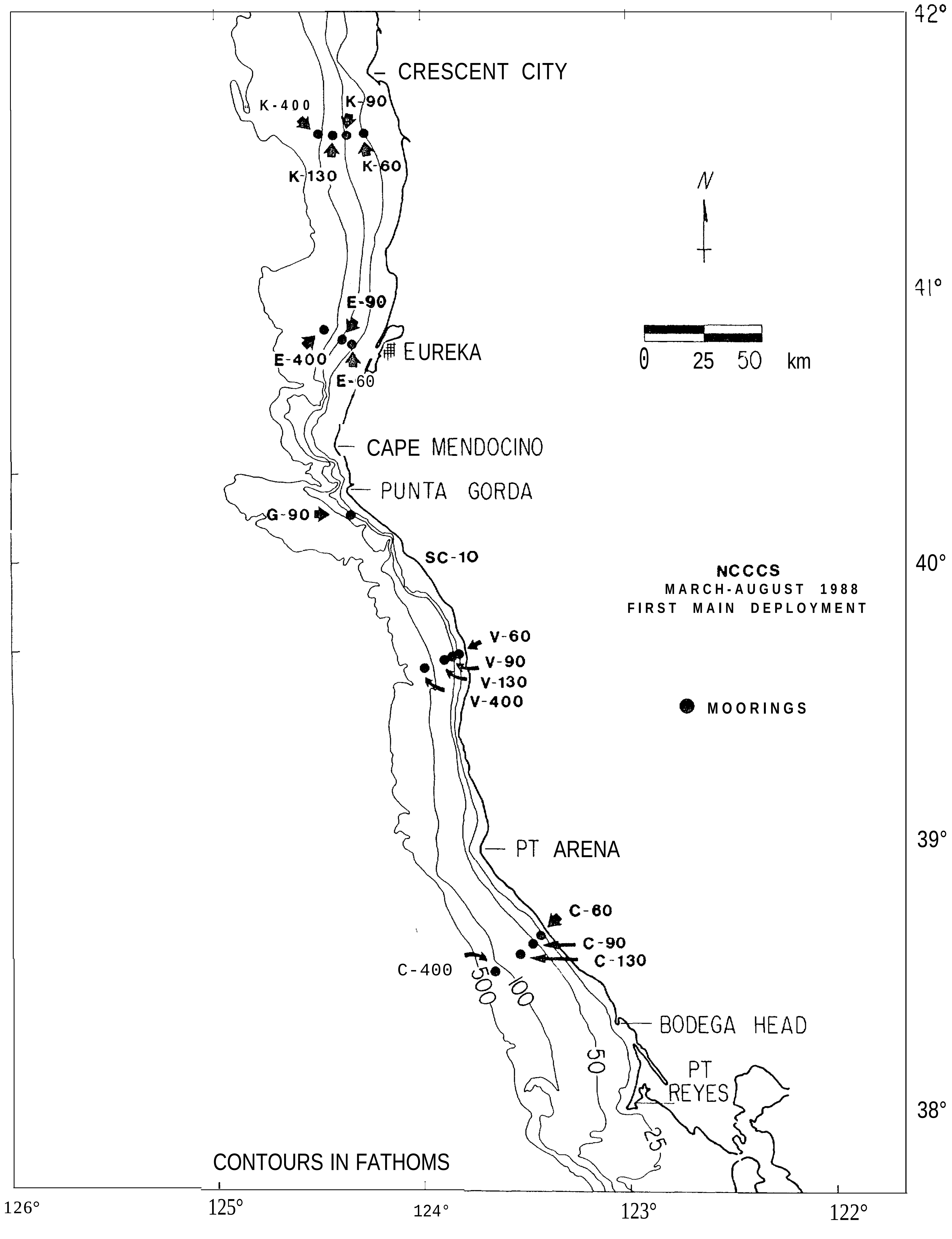


Figure 4-3. Main program mooring locations, March-August 1988.

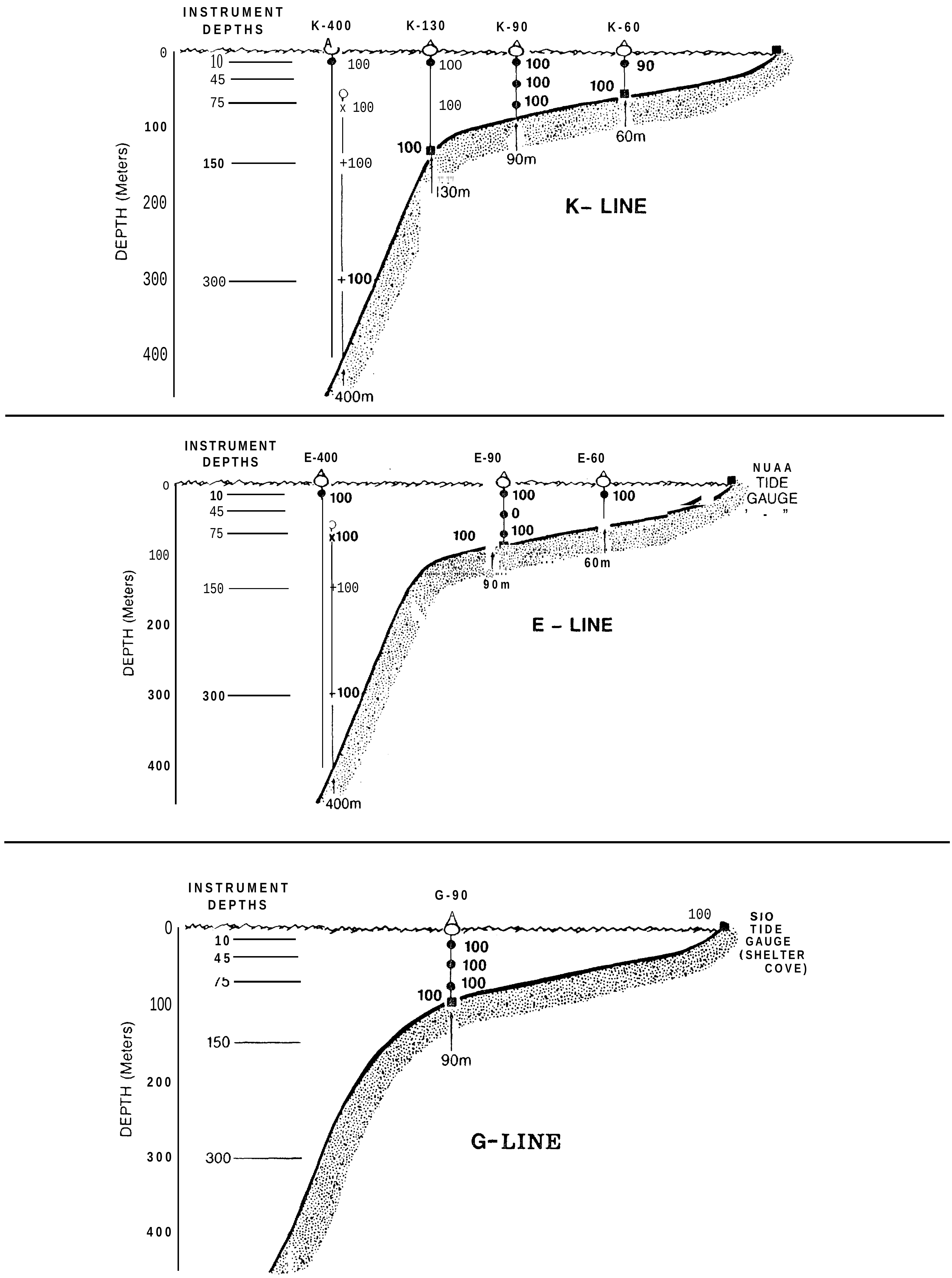
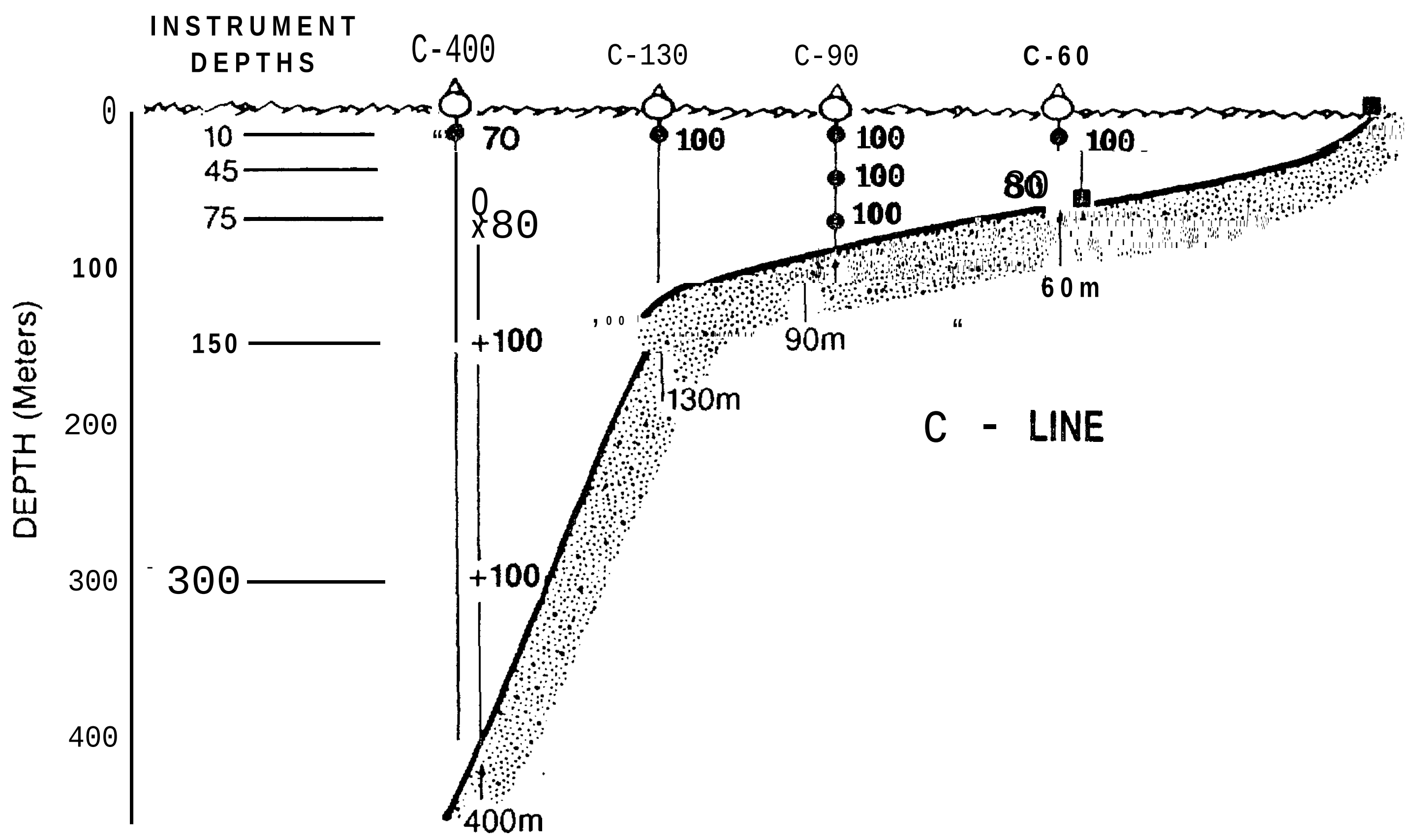


Figure 4-4. Main program moored instrumentation and data return (first deployment period) for currents and pressures (shown as percentage next to each instrument) .



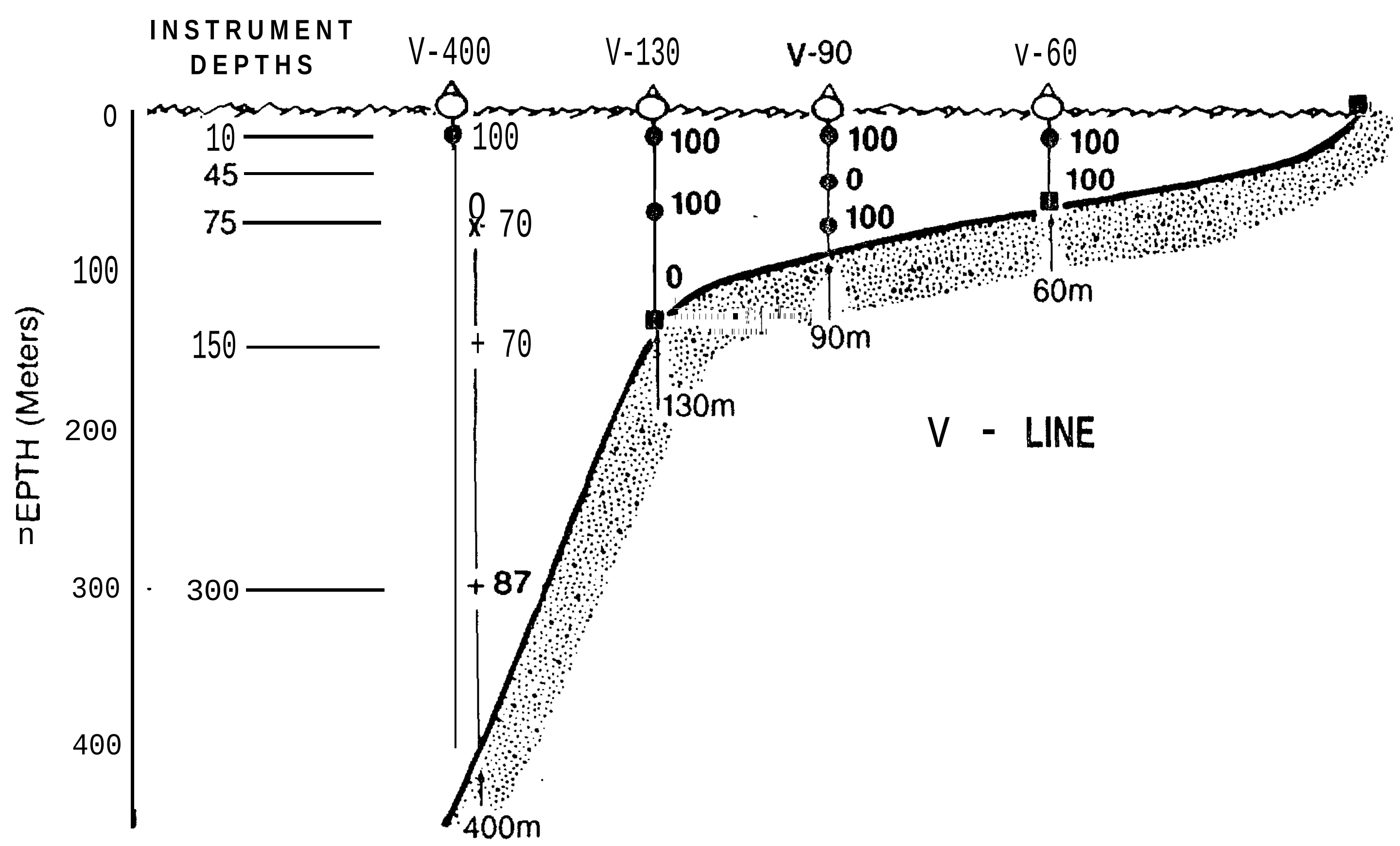


Figure 4-4. Continued.

Table 4-4 Main program moored array location and deployment data,

	Latitude	Longitude	Loran TDs (Microseconds)	Time of Deployment/ Anchor-Buoy Hook Time (GMT)	Date	Depth (m)	Owner	Type	S/N
K-400	41 33.309	124 31.413	W: 14431.2	23:32	5/4/88		GFE	PTT	8155
			X: 27499.4	08:45	8/29/88	10	EG&G	VMCM	301010
			Y: 43848.4						
K-400SS	41 33.151	124 31.503	W: 14432.2	01.17	3/13/88	75	EG&G	ACM	106
			X: 27498.9	20:55	8/28/88	150	GFE	RCM-4	7170
			Y: 43859.4			300	GFE	RCM-4	7175
						400	EG&G	AR722A	902502
K-130	41 34,130	124 26.230	W: 14434.8	21:45	3/12/88		GFE	PTT	8156
			X: 27512.3	11:09	8/29/88	10	S10	VMCM	51
			Y: 43863.1			75	EG&G	VMCM	1501
						130	S10	BP	10
K-90	41 34.592	124 21.485	w: 14440.4	04:11	3/13/88		GFE	PTT	8158
			X: 27523.5	06:20	8/29/88	10	S10	VMCM	72
			Y: 43914.5			45	SIO	VMCM	71
						75	S10	VMCM	58
K-60	41 34.914	124 16.847	w: 14447.1	06:15	3/13/88		GFE	PTT	8153
			X: 27534.2	13:52	8/29/88	10	S10	VMCM	60
			Y: 43919.7			60	S10	BP	13
E-400	40 50.832	124 28.379	w: 14753,3	01:02	3/15/88		GFE	PTT	8154
			X: 27370.8	20:06	8/31/88	10	EG&G	VMCM	201104
			Y: 43786.9						
E-400SS	40 50.684	124 28.331	W: 14754.6	03:11	3/15/88	75	&G	ACM	080
			X: 27370.3	~22:30	8/31/88	150	GFE	RCM	7178
			Y: 43786.5	Release		300	GFE	RCM	7171
				Triggered		400	EG&G	AR722A	902402
E-90	40 48.605	124 23.820	W: 14782.2	05:23	3/15/88		GFE	PTT	8159
			X: 27372.4	18:29	8/30/88	10	S10	VMCM	64
			Y: 43785.5			45	SIO	VMCM	57
						75	S I0	VMCM	59
						90	S I0	BP	7
E-60	40 47.477	124 19.487	W: 14798.8	09:17	3/15/88		GFE	PTT	8157
			X: 27375.0	~20:30	8/30/88	10	S10	VMCM	63
			Y: 43786.7	(20:19-20:45					
				VMCM on deck)					
G-90	40 10.907	124 26.301	w: 15155.5	22:43	3/17/88		GFE	PTT	8161
			X: 27225.6	02:24	8/21/88	10	S10	VMCM	56
			Y: 43693.1			45	S10	VMCM	73
						75	S I0	VMCM	53
						90	S10	BP	9
Se-lo	40 01.012	124 03.688	W: 15152.8	17:45	3/17/88	10	S10	BP	15
			X: 27229.6	18:32	8/21/88	10	EG&G	AR743A	000103
			Y: 43695.4						
V-400	39 37.078	123 59.516	W: 15307.6	08:26	3/18/88		GFE	PTT	8150
			X: 27144.1	~07:13	8/16/88	10	EG&G	VMCM	202903
			Y: 43632.0	VMCM on deck					
V-400SS	39 36.816	123 59.619	W: 15308.9	05:03	5/2/888	75	EG&G	ACM	1172
			X: 27144.0	18:15	8/15/88	150	EG&G	RCM	7262
			Y: 43631.9	Release		300	EG&G	RCM	7173
				Triggered		400	S10	AR	204203
V-130	39 37.675	123 53.885	W: 15321.8	05:57	3/18/88		GFE	PTT	8164
			X: 27151,4	06:10	8/16/88	10	S10	VMCM	61
			Y: 43637.0			75	EG&G	VMCM	003004
						130	S10	BP	12
V-90	39 38.564	123 50.506	W: 15327.0	18:07	3/18/88		GFE	PTT	8163
			X: 27158.2	04:35	8/16/88	10	S10	VMCM	55
			Y: 43641.7			45	S10	VMCM	67
						75	S10	VMCM	54
V-60	39 38.804	123 49.202	W: 15326.6	11:25	3/18/88		GFE	PTT	8160
			X: 27160.7	02:40	8/16/88	10	S10	VMCM	50
			Y: 43643.1			60	S10	BP	11

Table 4-4. Continued.

	Latitude	Longitude	Loran TDs (Microseconds)	Time of Deployment/ Anchor-Buoy Hook Time (GMT)	Date	Depth (m)	Owner	Type	S/N
C-400	38 29.795	123 38.486	W :	16:27	5/1/88		GFE	PTT	8151
			X:	22:47	8/19/88	10	EG&G	VMCM	200503
			Y:						
C400SS	38 30.013	123 38.957	W: 15700.8	03:58	3/20/88	75	EG&G	ACM	1174
			X: 26998.2			150	GFE	RCM	7106
			Y: 43403.1			300	GFE	RCM	7105
						400	EG&G	AR743	000303
C-130	38 33.606	123 30.778	W: 15712.7	08:05	3/19/88		GFE	PTT	8152
			X: 26998.1			10	S10	VMCM	62
			Y: 43418.9			130	S10	BP	10
C-90	'38 36.772	123 26,968	w: 15711.1	07:31	3/20/88		GFE	PTT	8165
			X: 26998.5			10	S IO	VMCM	69
			Y: 43432.4			45	EG&G	VMCM	2804
						75	S10	VMCM	68
C-60	38 38.369	123 24.613	W: 15712.5	09:08	3/20/88		GFE	PTT	8162
			X: 26999.0			10	S10	VMCM	65
			Y: 43439.4			60	S10	BP	14

Key:

VMCM	Vector Measuring Current Meter	AR	Acoustic Releases
ACM	Neil Brown Acoustic Current Meter	PTT	Platform Transmitter Terminal
RCM -4	Aanderaa Recording Current Meter	BP	Bottom Pressure Sensor

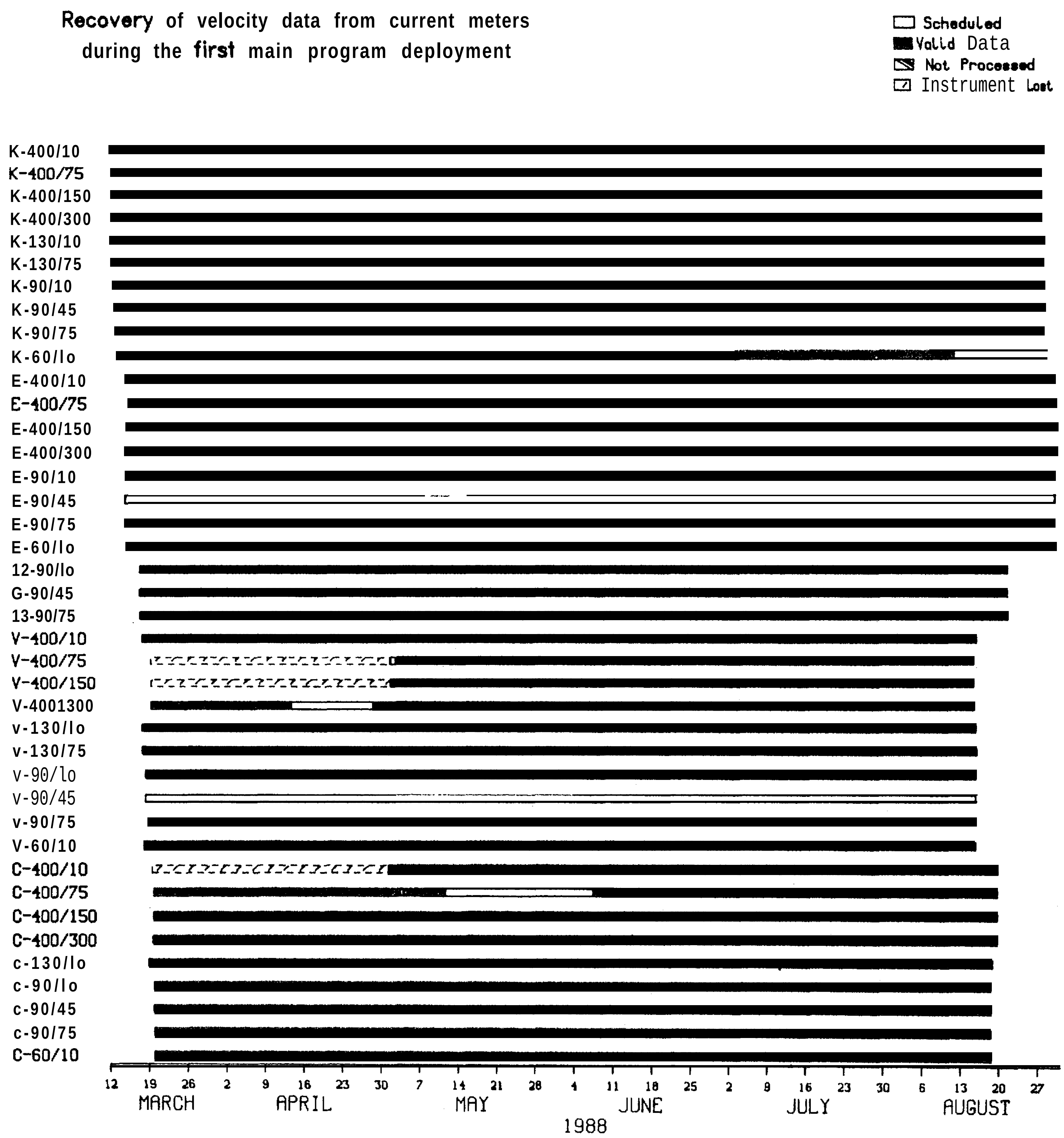


Figure 4-5. First deployment interval data coverage: velocity data from moored current meters.

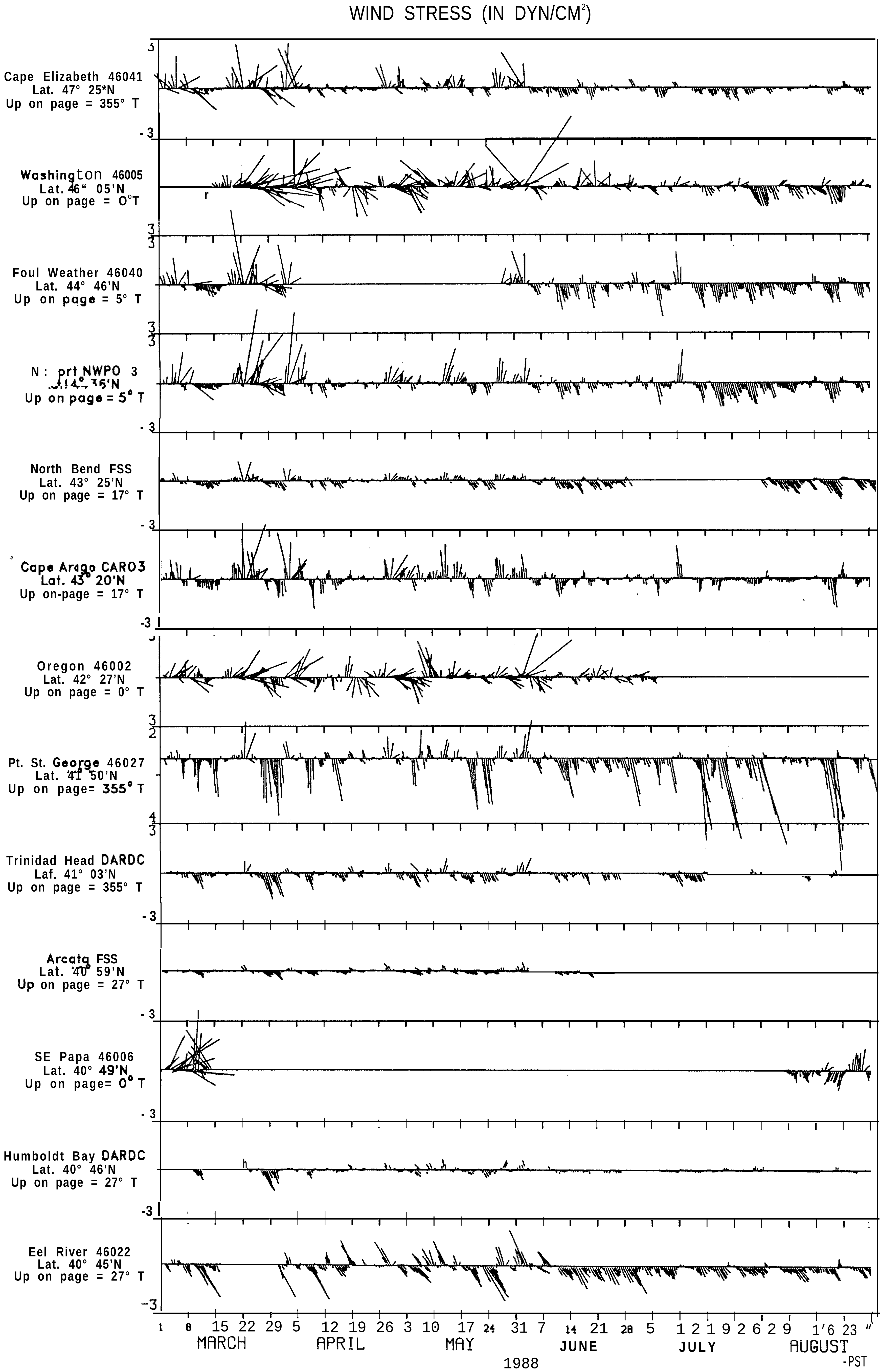


Figure 4-6a, Time series of currents and winds, NCCCS first deployment of the main program, March-August 1988: low-passed vectors of wind stress at offshore and coastal locations in study area.

WIND STRESS (IN DYN/CM²)

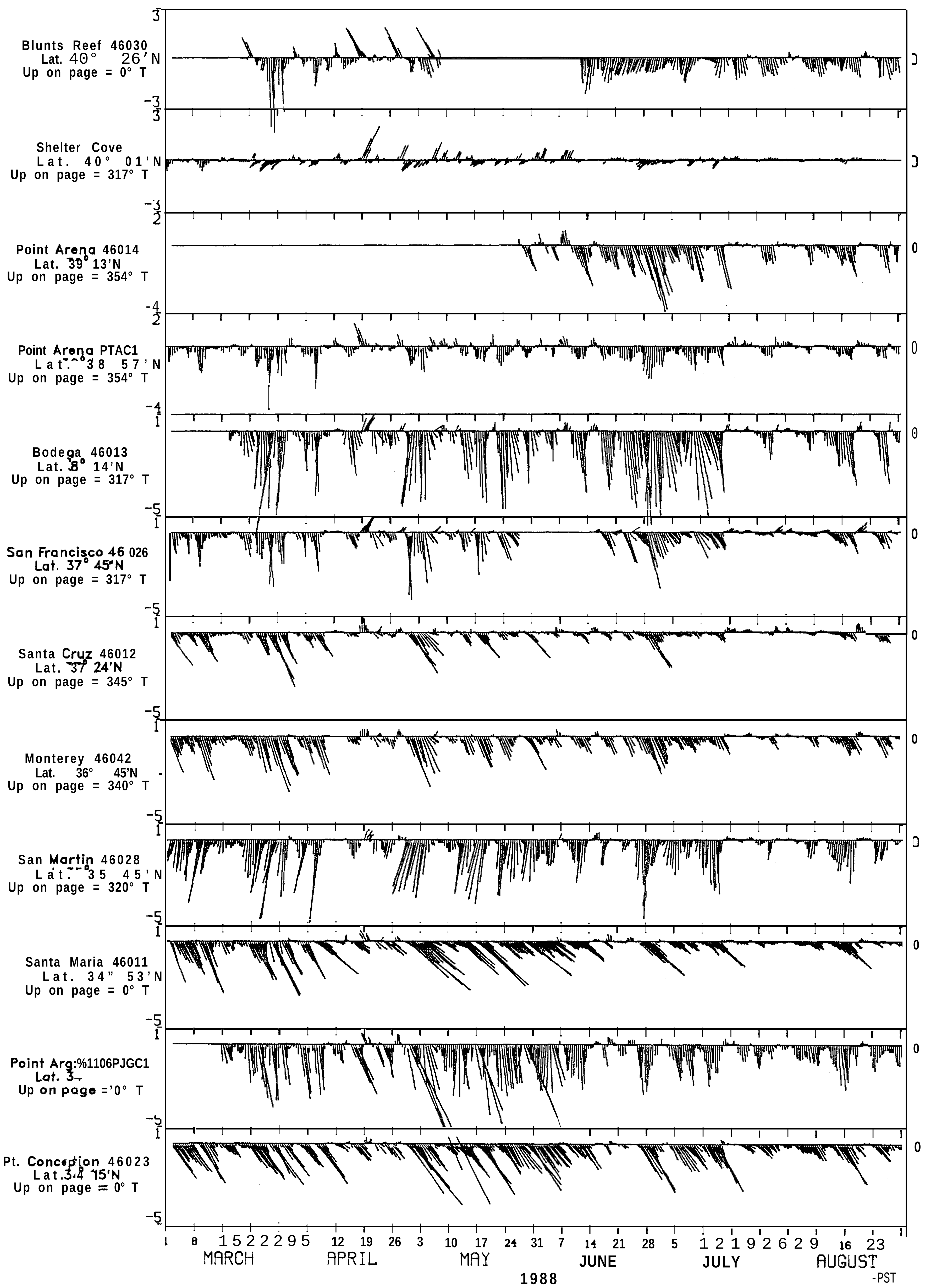


Figure 4- 6a. Continued,

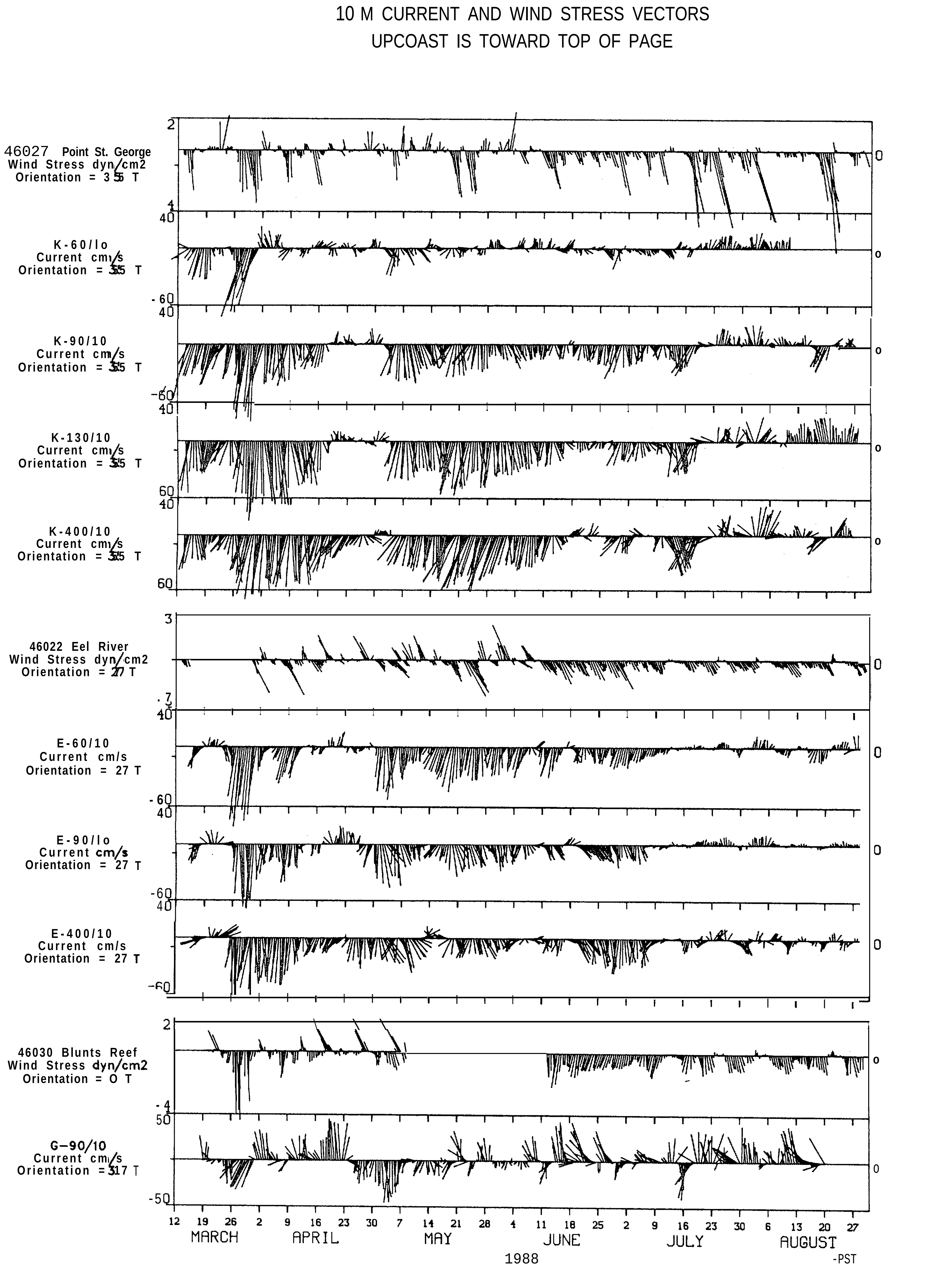


Figure 4-6b. Time series of currents and winds, NCCCS first deployment of the main program, March-August 1988: low-passed vectors, 10-m currents and selected wind stress.

10 M CURRENT AND WIND STRESS VECTORS
UPCOAST IS TOWARD TOP OF PAGE

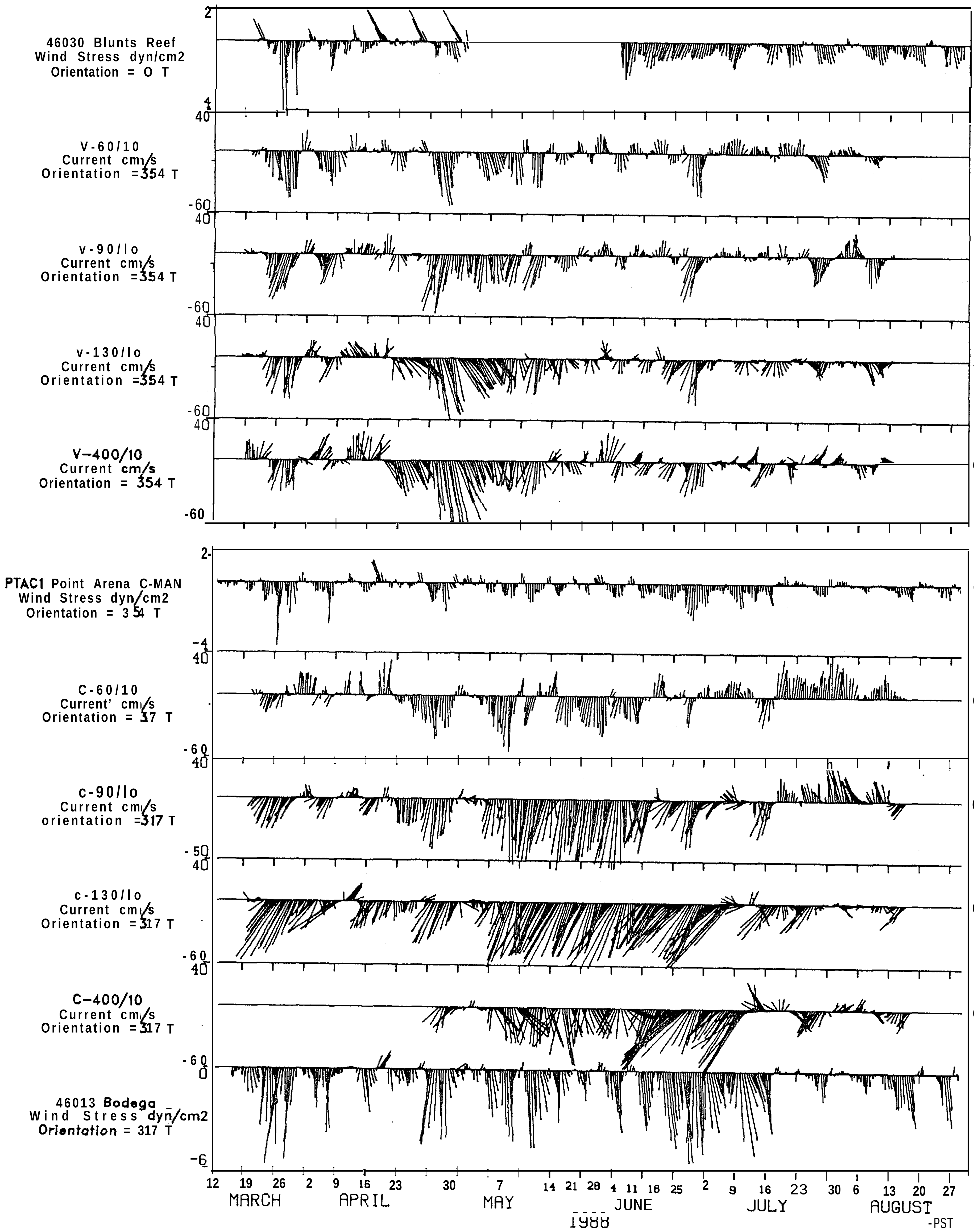


Figure 4-6b. Continued.

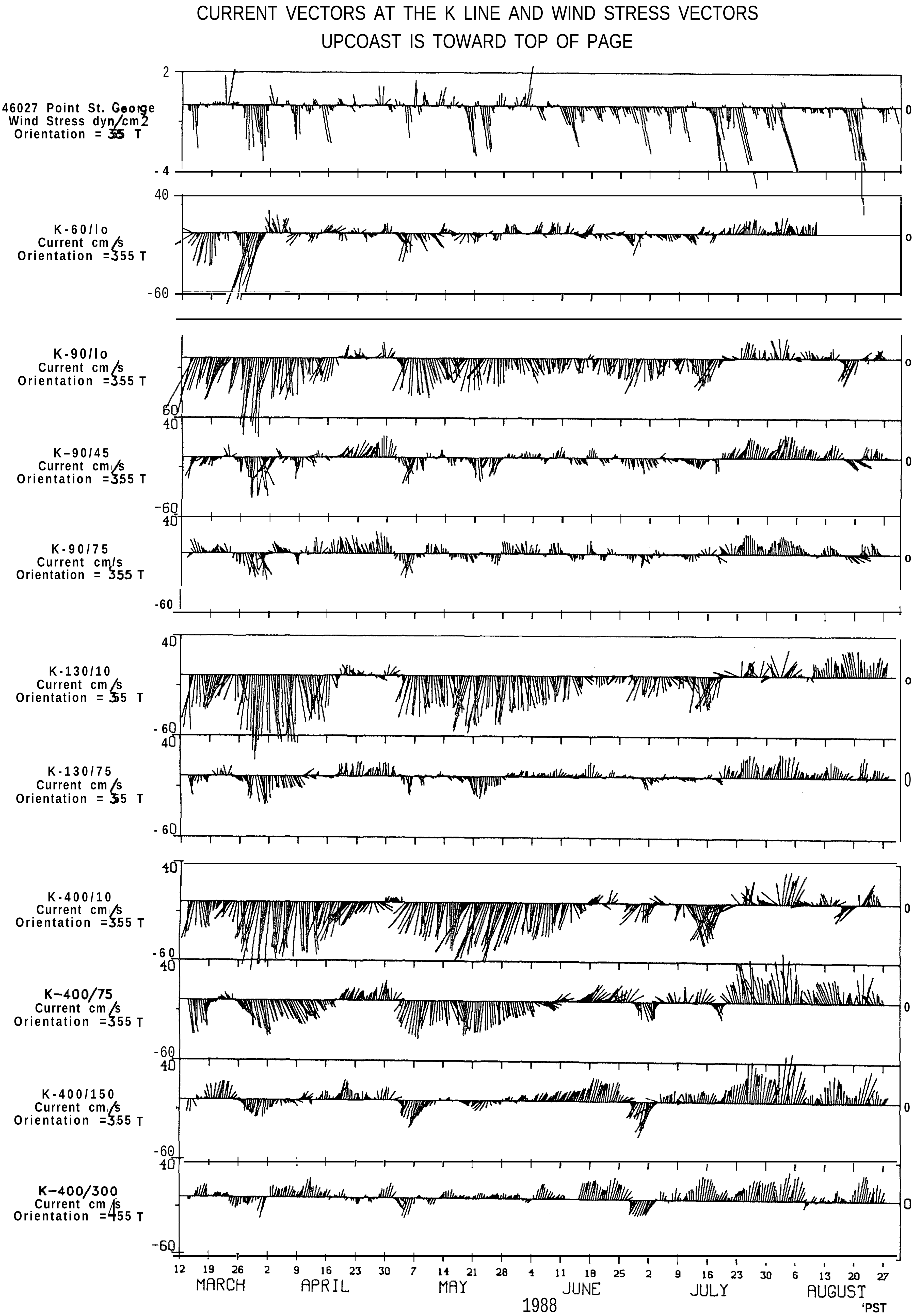


Figure 4- 6c. Time series of currents and winds , NCCCS first deployment of the main program, March-August 1988: low-passed vectors, K- line currents and nearby wind stress .

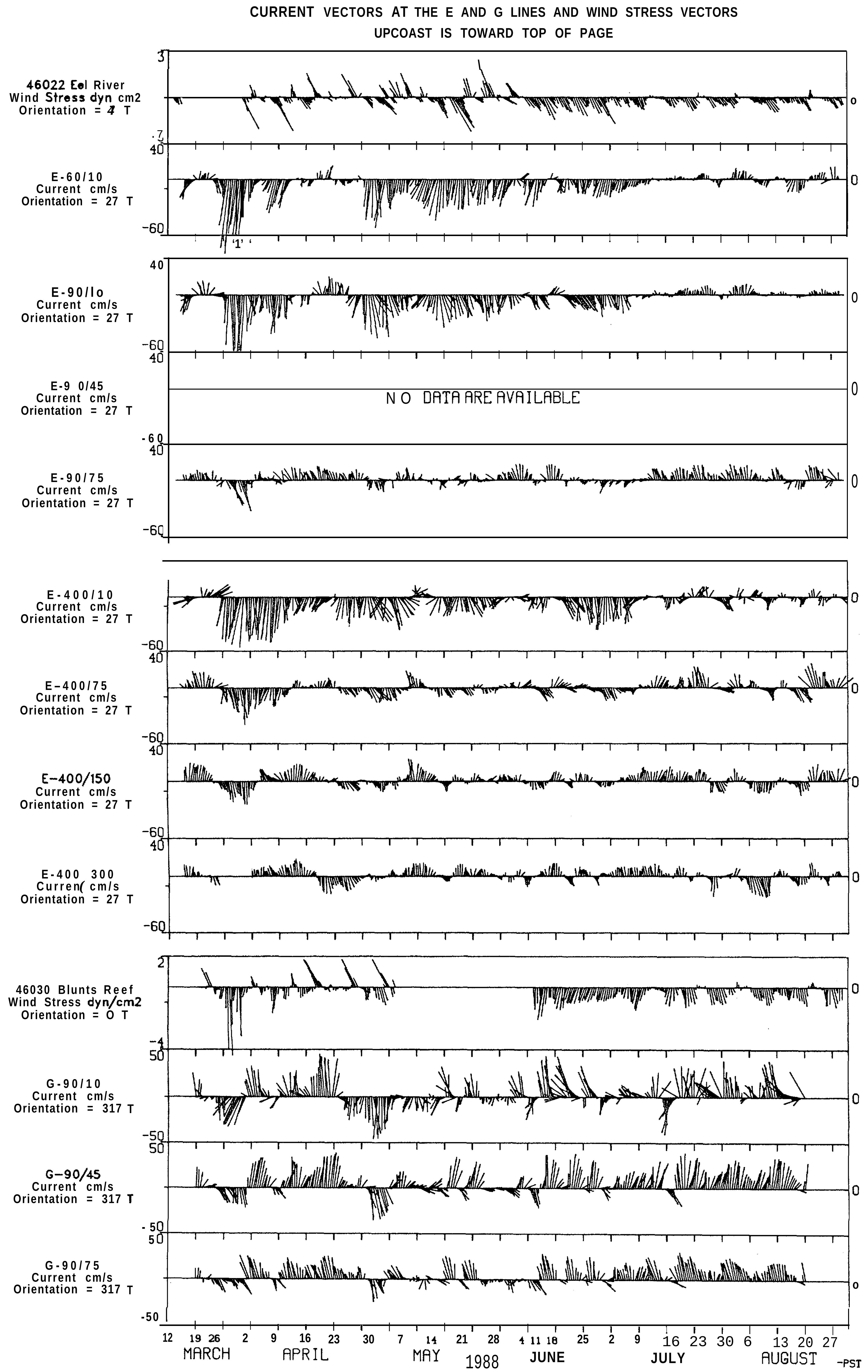


Figure 4-6d. Time series of currents and winds, NCCCS first deployment of the main program, March-August 1988: low-passed vectors, E- and G-line currents and nearby wind stress.

CURRENT VECTORS AT THE V LINE AND WIND STRESS VECTORS
UPCOAST IS TOWARD TOP OF PAGE

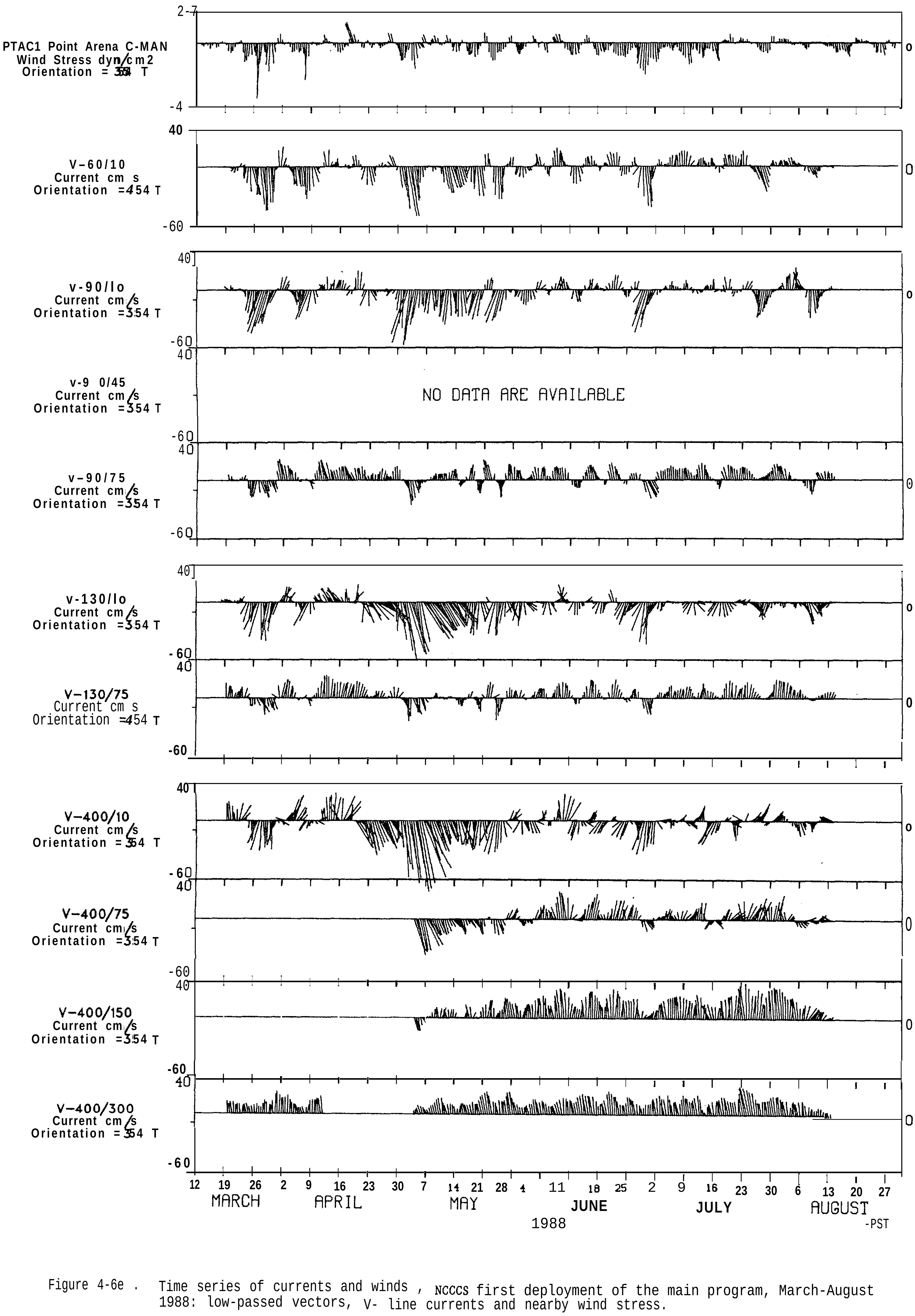


Figure 4-6e . Time series of currents and winds , NCCCS first deployment of the main program, March-August 1988: low-passed vectors, V- line currents and nearby wind stress.

CURRENT VECTORS AT THE C LINE AND WIND STRESS VECTORS
UPCOAST IS TOWARD TOP OF PAGE

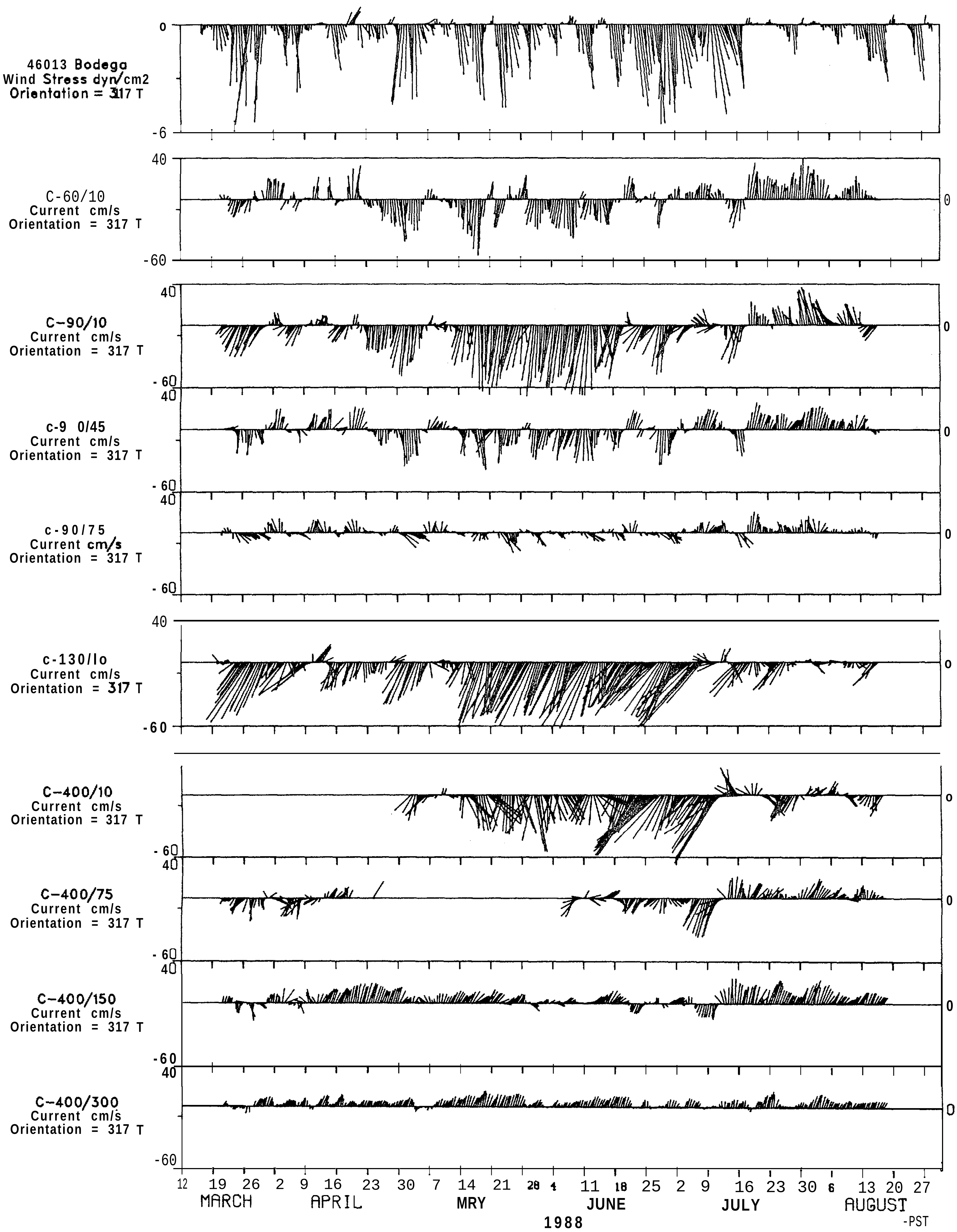


Figure 4-6f. Time series of currents and winds , NCCCS first deployment of the main program, March-August 1988: low-passed vectors, C-line currents and nearby wind stress.

ALONGSHORE 10 M CURRENTS AND ALONGSHORE WIND STRESS
UPCOAST IS TOWARD TOP OF PAGE

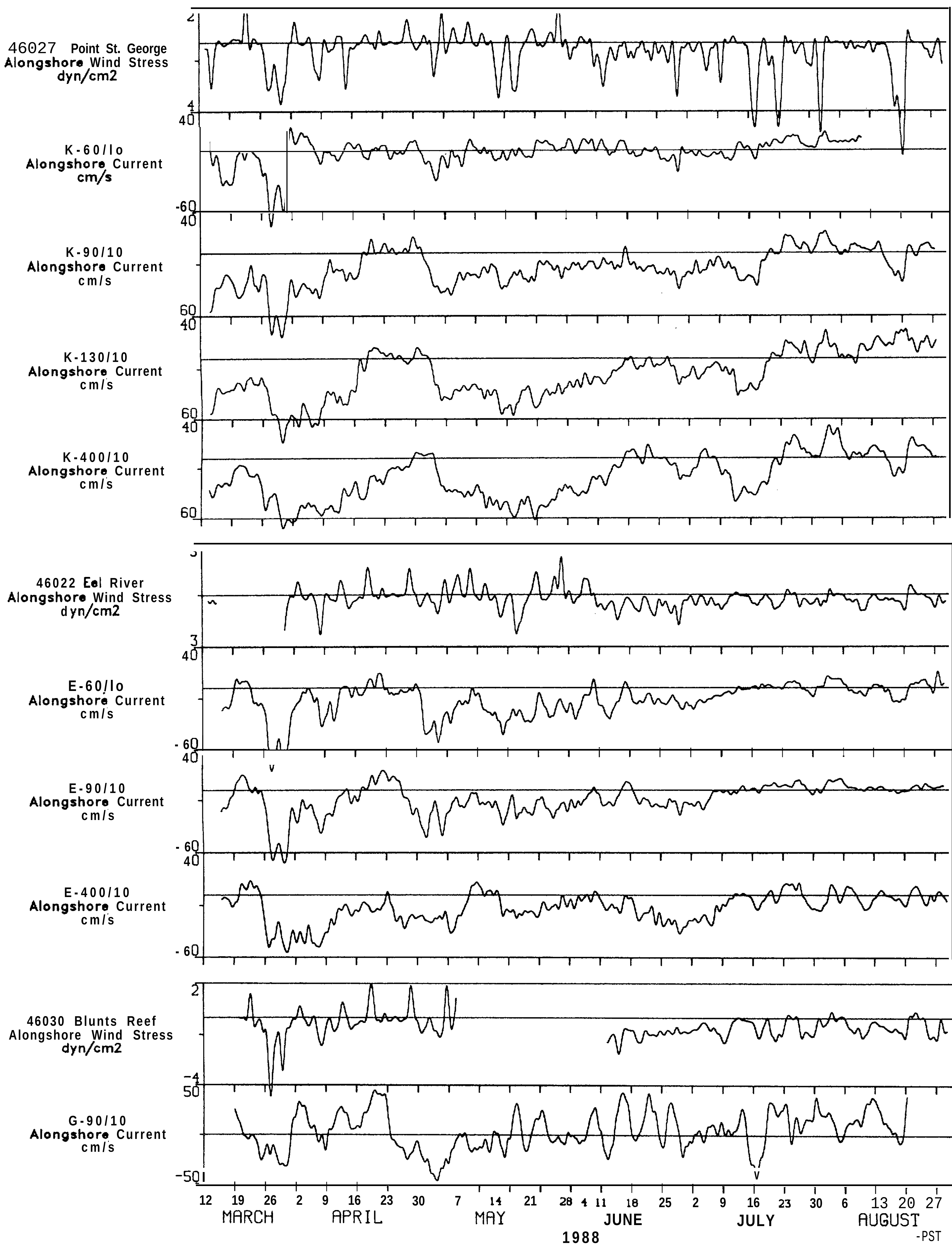


Figure 4-6g. Time series of currents and winds, NCCCS first deployment of the main program, March-August 1988: low-passed alongshelf component, 10-m currents and nearby wind stress.

ALONGSHORE 10 M CURRENTS AND ALONGSHORE WIND STRESS
UPCOAST IS TOWARD TOP OF PAGE

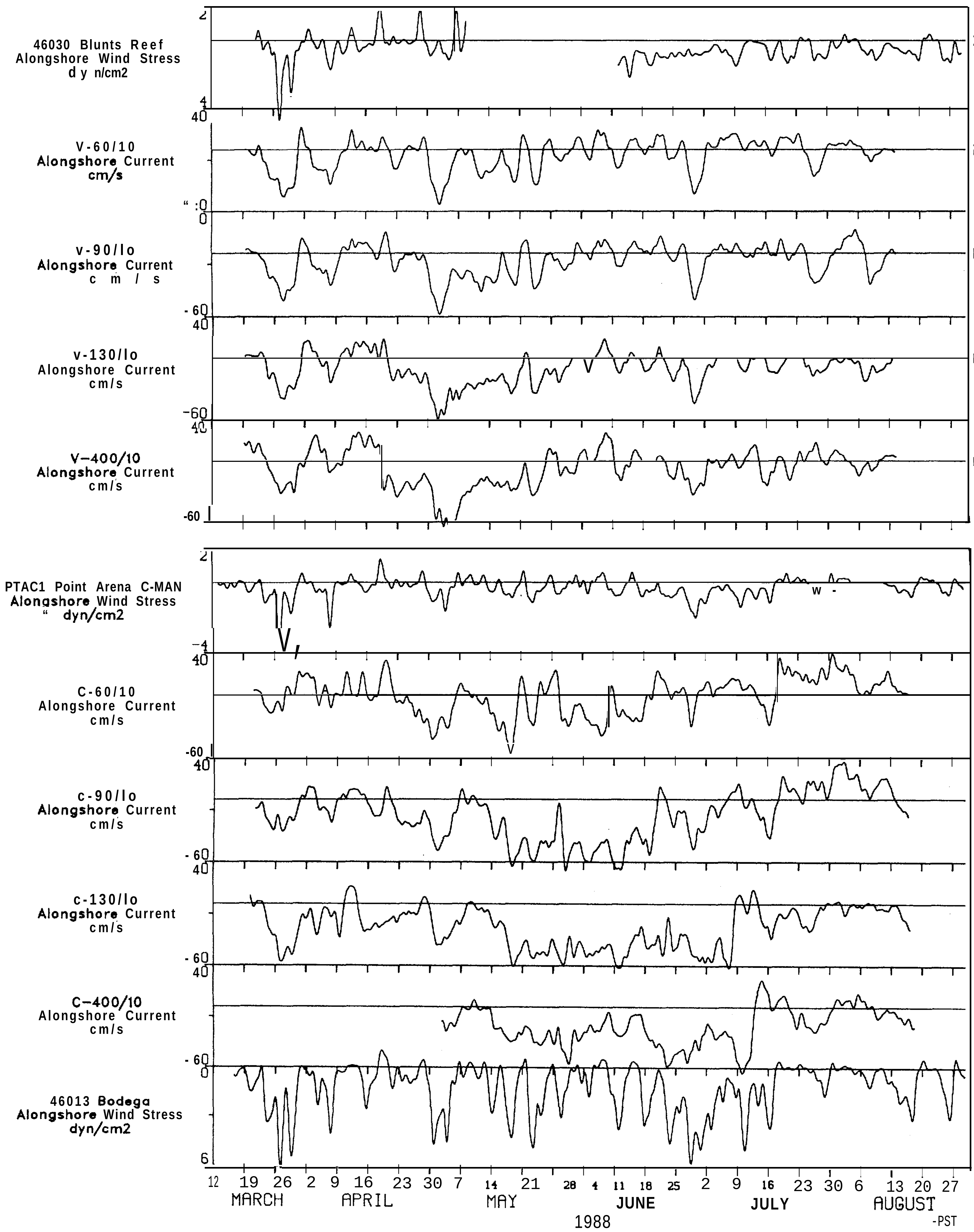


Figure 4-6g. Continued.

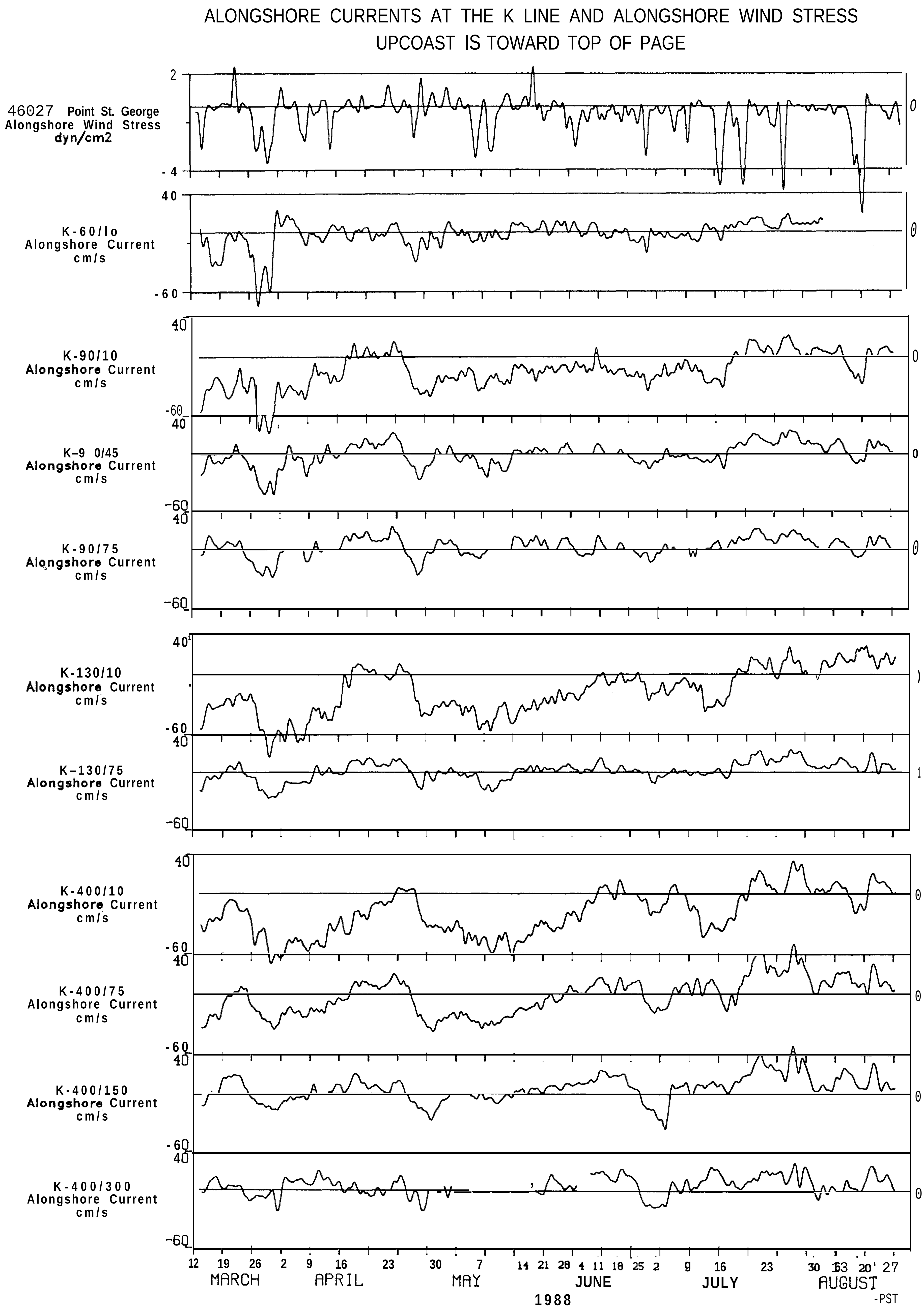


Figure 4-6h. Time series of currents and winds, NCCCS first deployment of the main program, March-August 1988: low-passed alongshelf component, K-line currents and nearby wind stress.

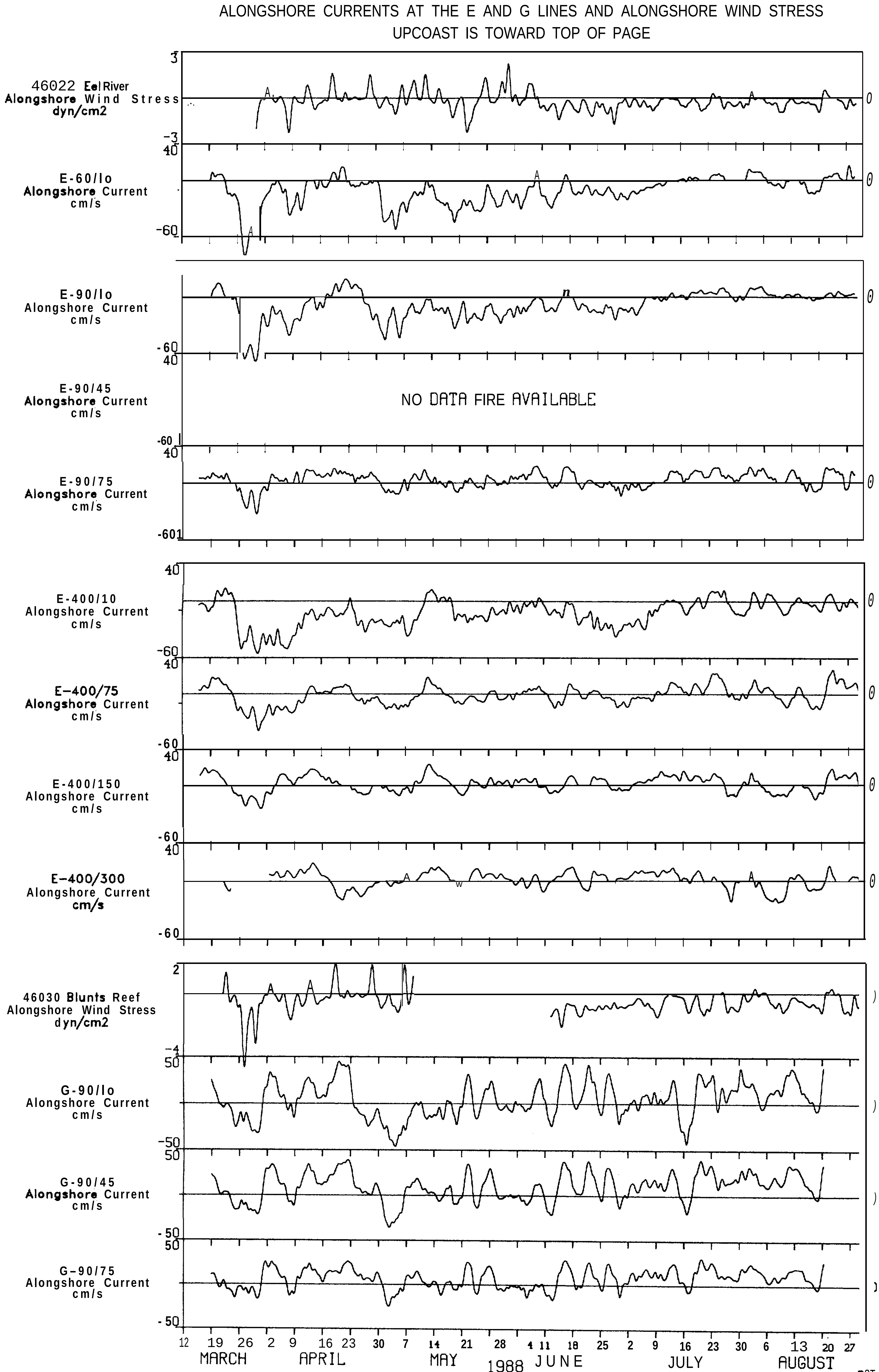


Figure 4-6i. Time series of currents and winds, NCCCS first deployment of the main program, March-August 1988: low-passed alongshelf component, E- and G-line currents and nearby wind stress.

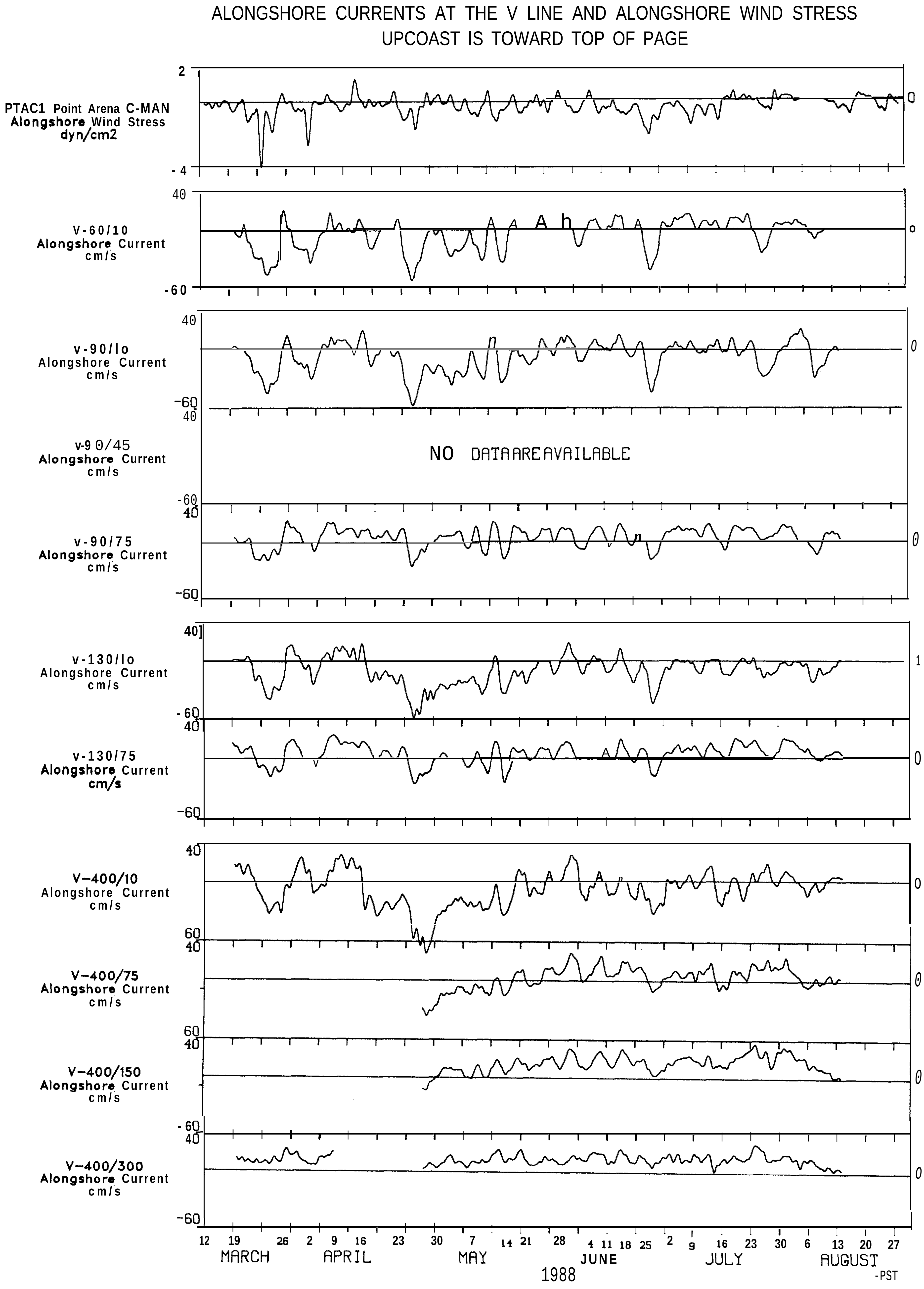


Figure 4-6j. Time series of currents and winds, NCCCS first deployment of the main program, March-August 1988: low-passed alongshelf component, V-line currents and nearby wind stress.

ALONGSHORE CURRENTS AT THE C LINE AND ALONGSHORE WIND STRESS
UPCOAST IS TOWARD TOP OF PAGE

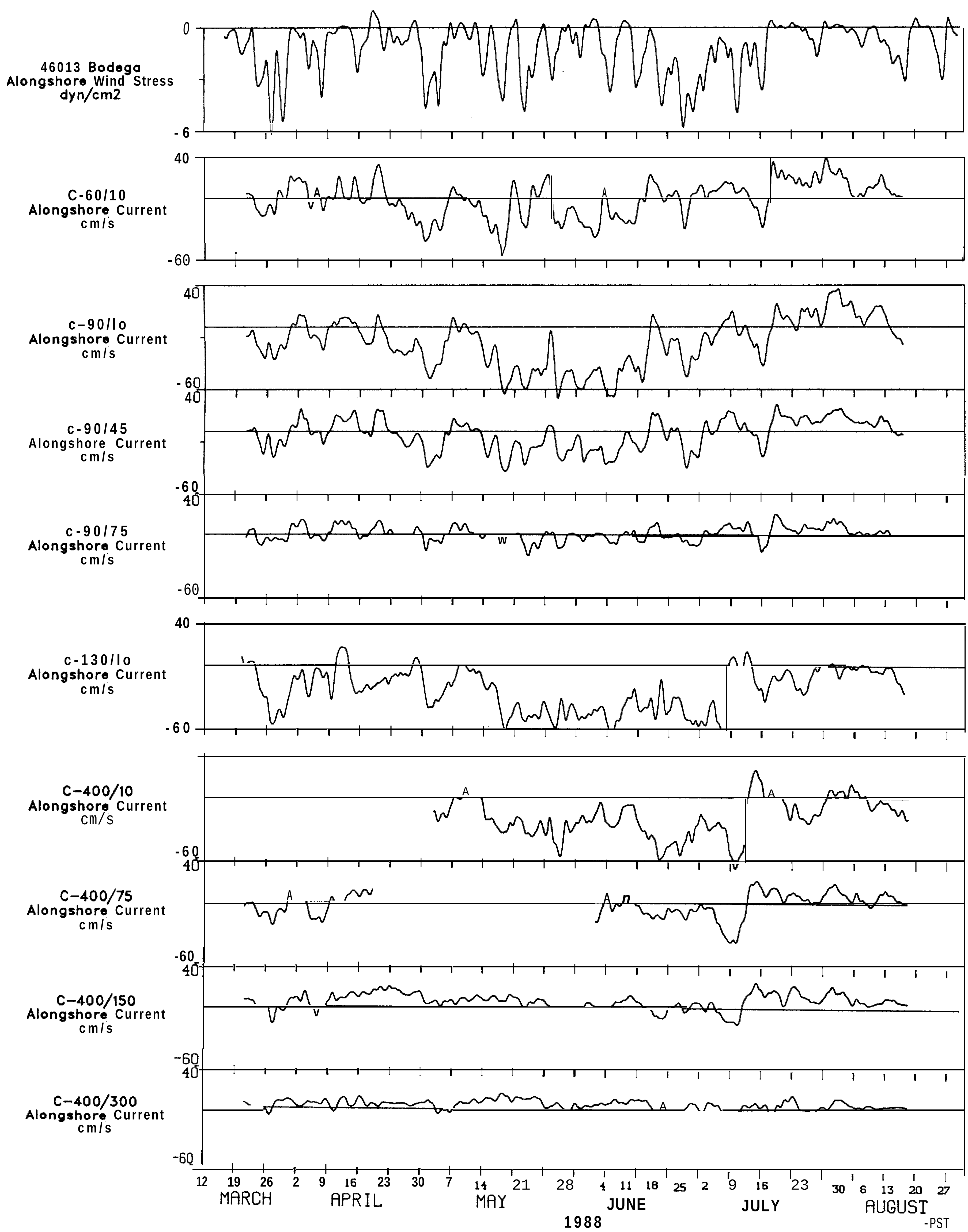


Figure 4-6k. Time series of currents and winds, NCCCS first deployment of the main program, March-August 1988: low-passed alongshelf component, C-line currents and nearby wind stress.

CROSS–SHORE 10 M CURRENTS AND CROSS–SHORE WIND STRESS
ONSHORE IS TOWARD TOP OF PAGE

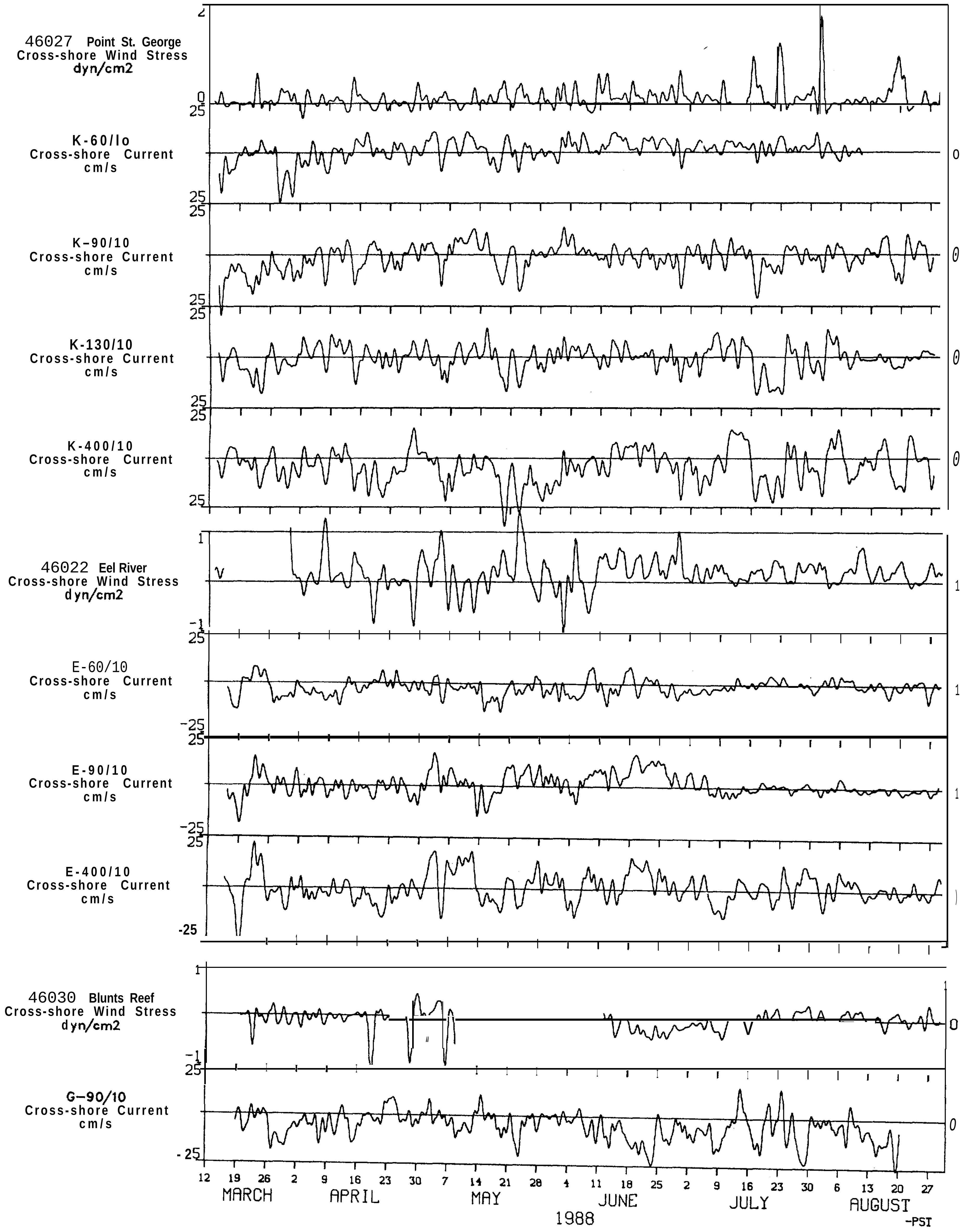


Figure 4-61. Time series of currents and winds, NCCCS first deployment of the main program, March-August 1988: low-passed cross-shelf component, 10-m currents and nearby wind stress.

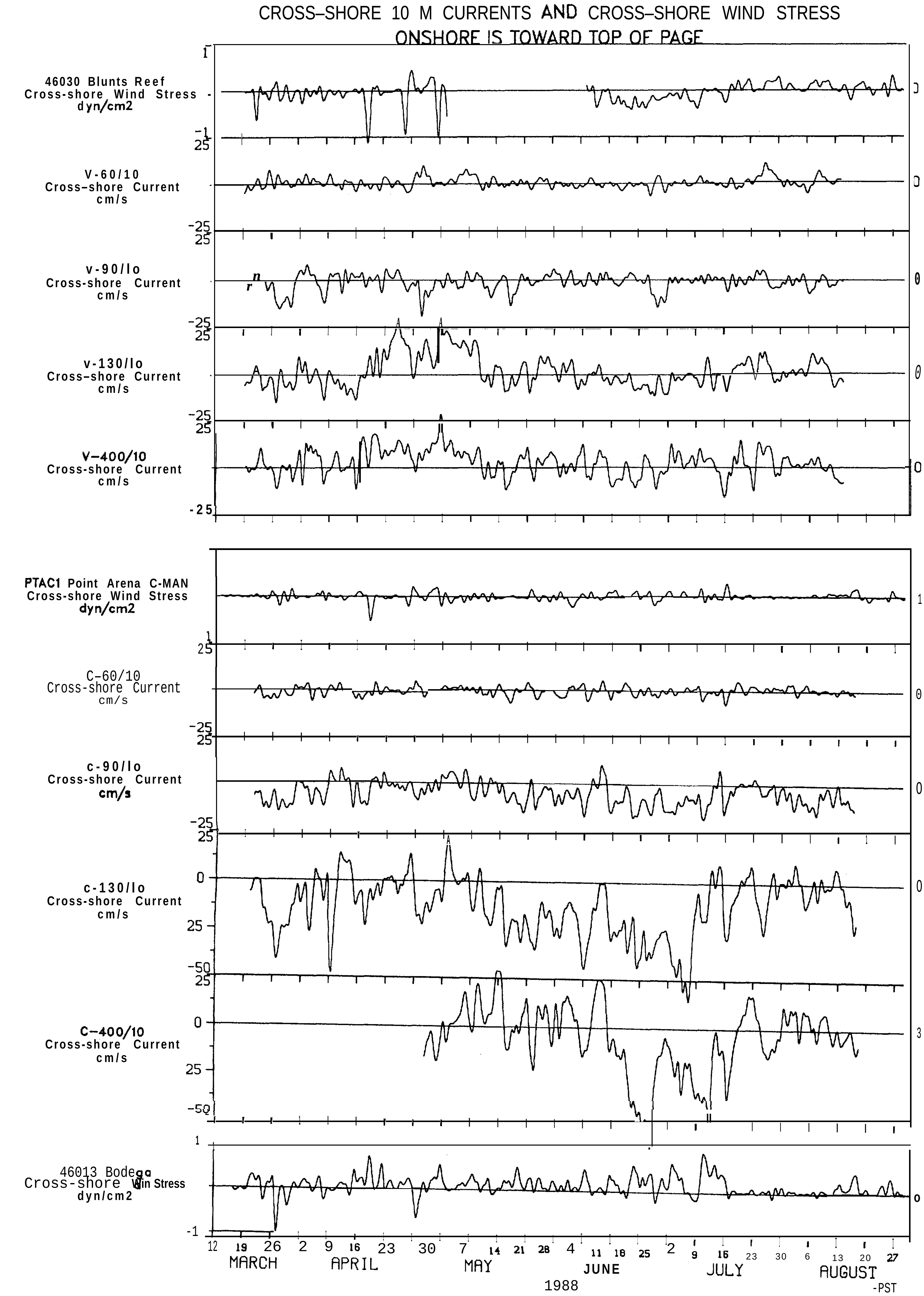


Figure 4-61. Cent inued.

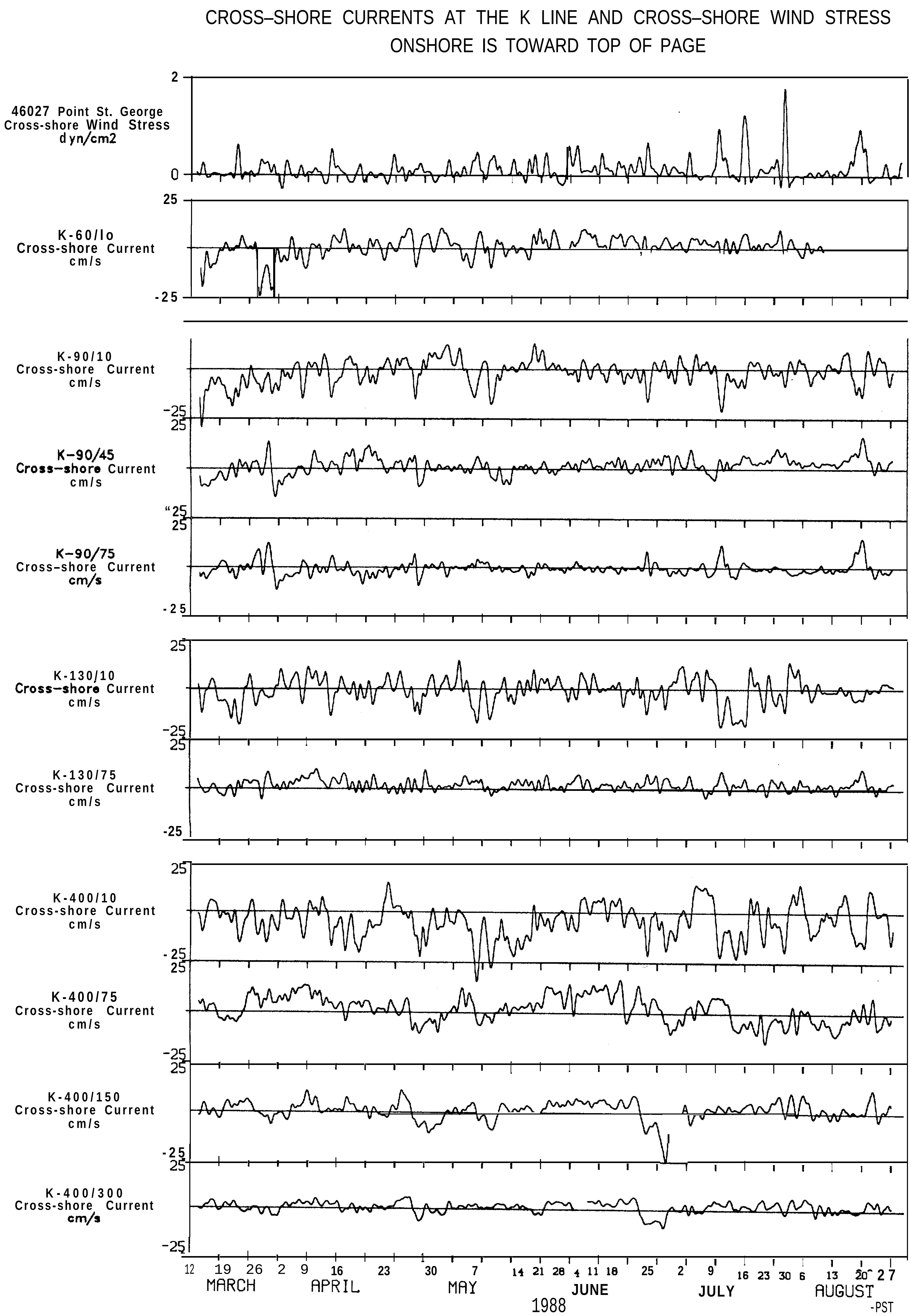


Figure 4-6m. Time series of currents and winds, NCCCS first deployment of the main program, March-August 1988: low-passed cross-shelf component, K-line currents and nearby wind stress.

CROSS–SHORE CURRENTS AT THE E AND G LINES AND CROSS–SHORE WIND STRESS
ONSHORE IS TOWARD TOP OF PAGE

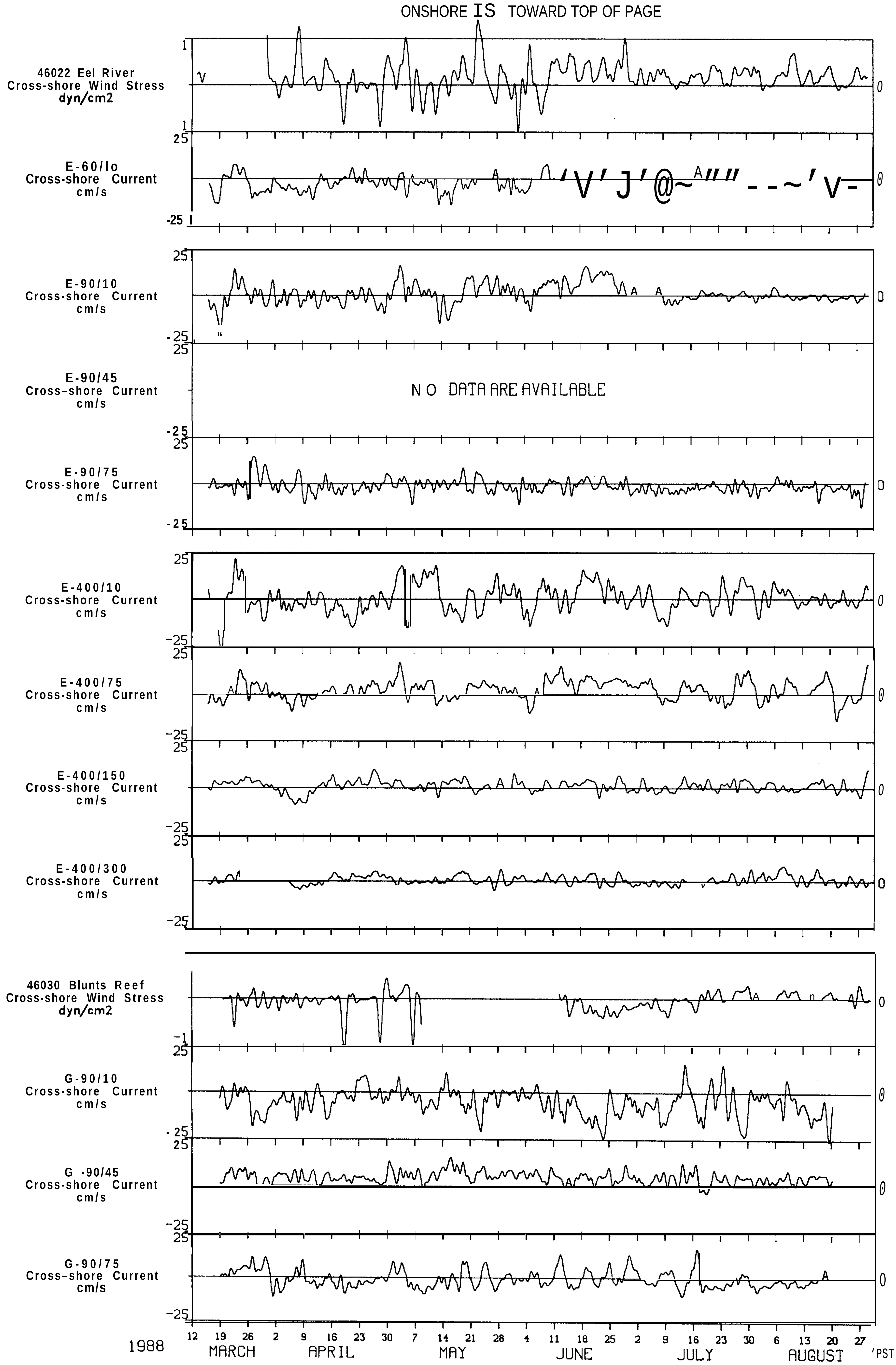


Figure 4-6n. Time series of currents and winds, NCCCS first deployment of the main program, March-August 1988: low-passed cross-shelf component, E- and G-line currents and nearby wind stress.

CROSS–SHORE CURRENTS AT THE V LINE **AND CROSS-SHORE WIND STRESS**
ONSHORE IS **TOWARD TOP OF PAGE**

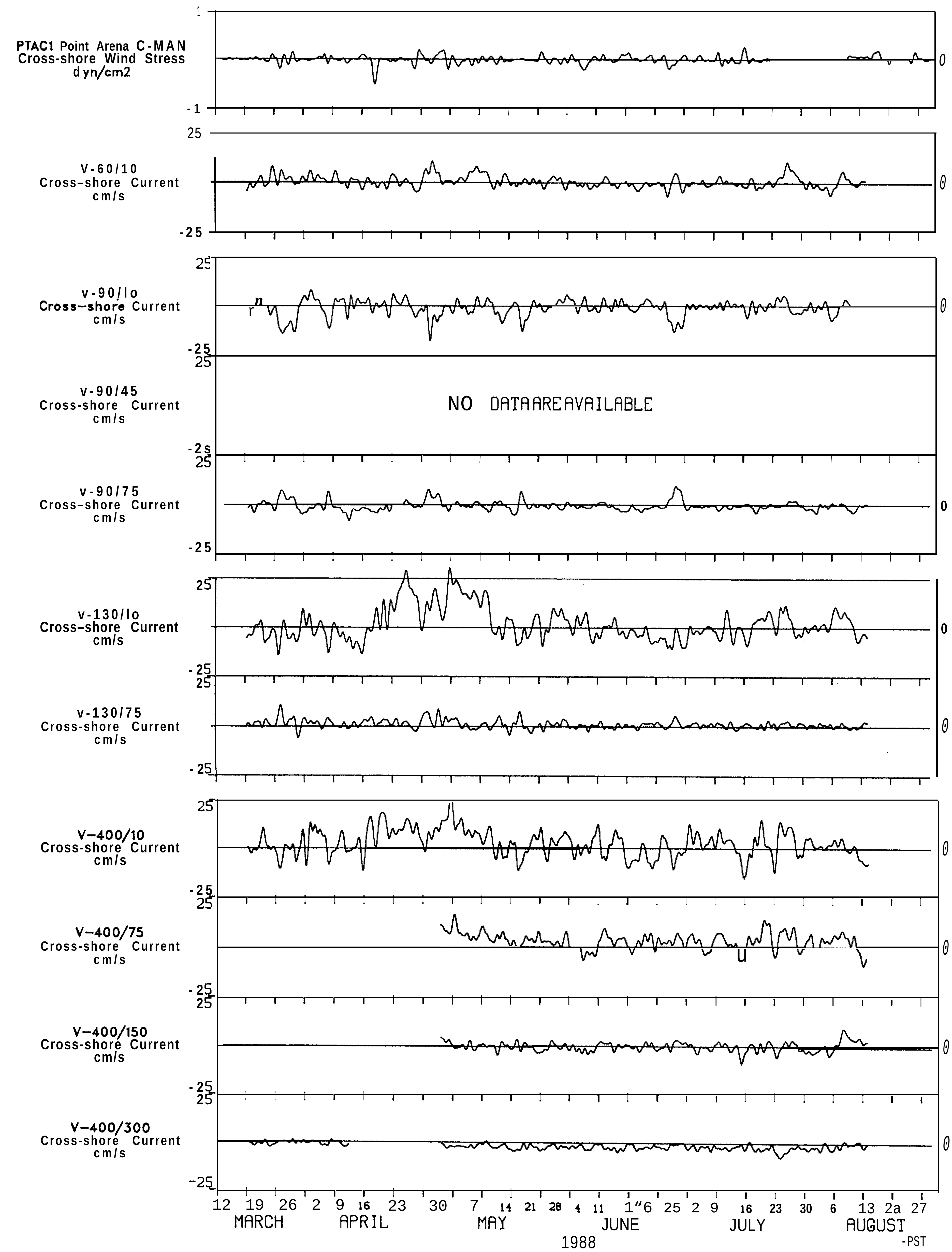


Figure 4-60. Time series of currents and winds, NCCCS first deployment of the main program, March-August 1988: low-passed cross-shelf component, V-line currents and nearby wind stress.

CROSS–SHORE CURRENTS AT THE C LINE AND CROSS–SHORE WIND STRESS
ONSHORE IS TOWARD TOP OF PAGE

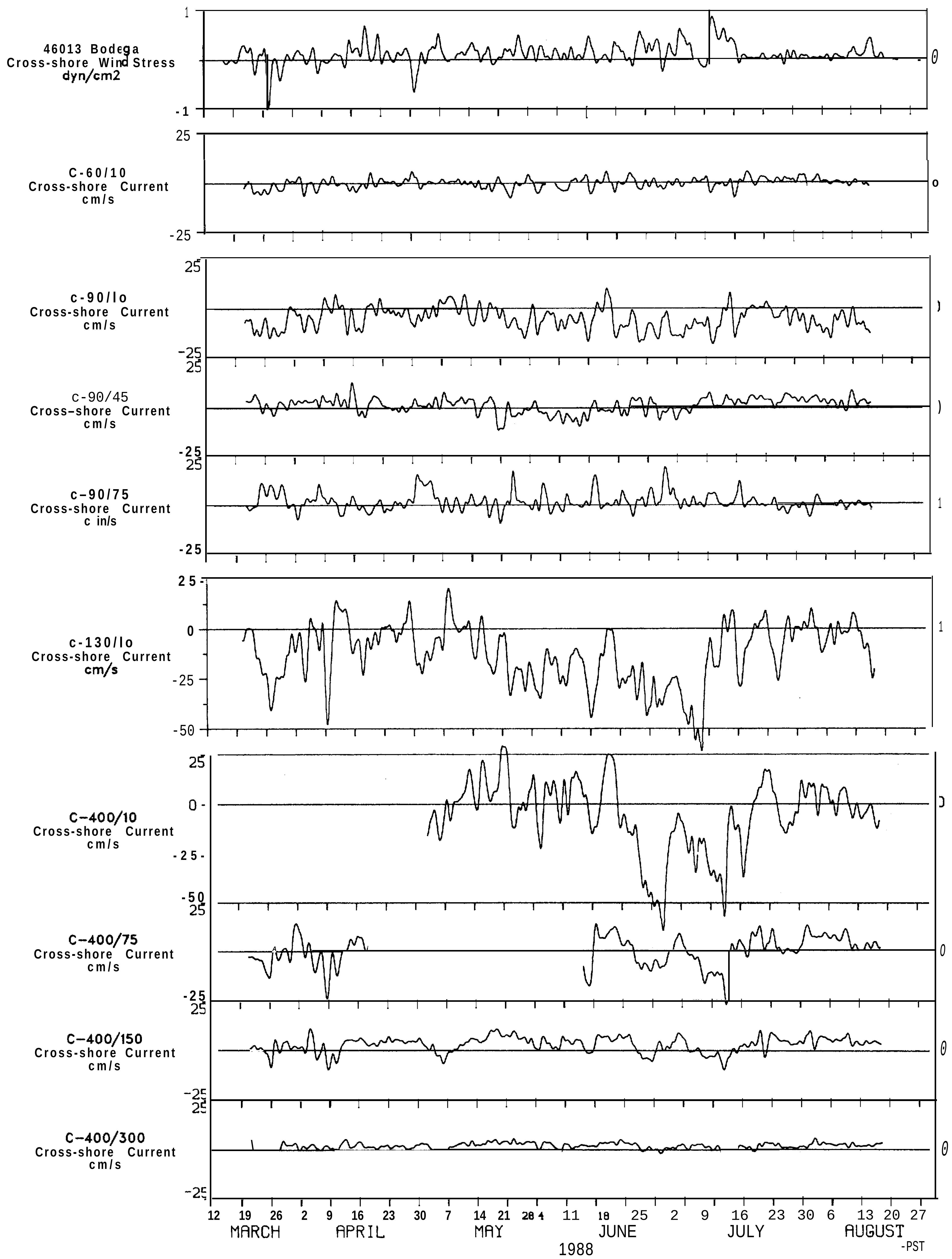


Figure 4-6p. Time series of currents and winds, NCCCS first deployment of the main program, March-August 1988: low-passed cross-shelf component, C-line currents and nearby wind stress.

ALONGSHORE 10 M CURRENTS AND ALONGSHORE WIND STRESS
UPCOAST IS TOWARD TOP OF PAGE

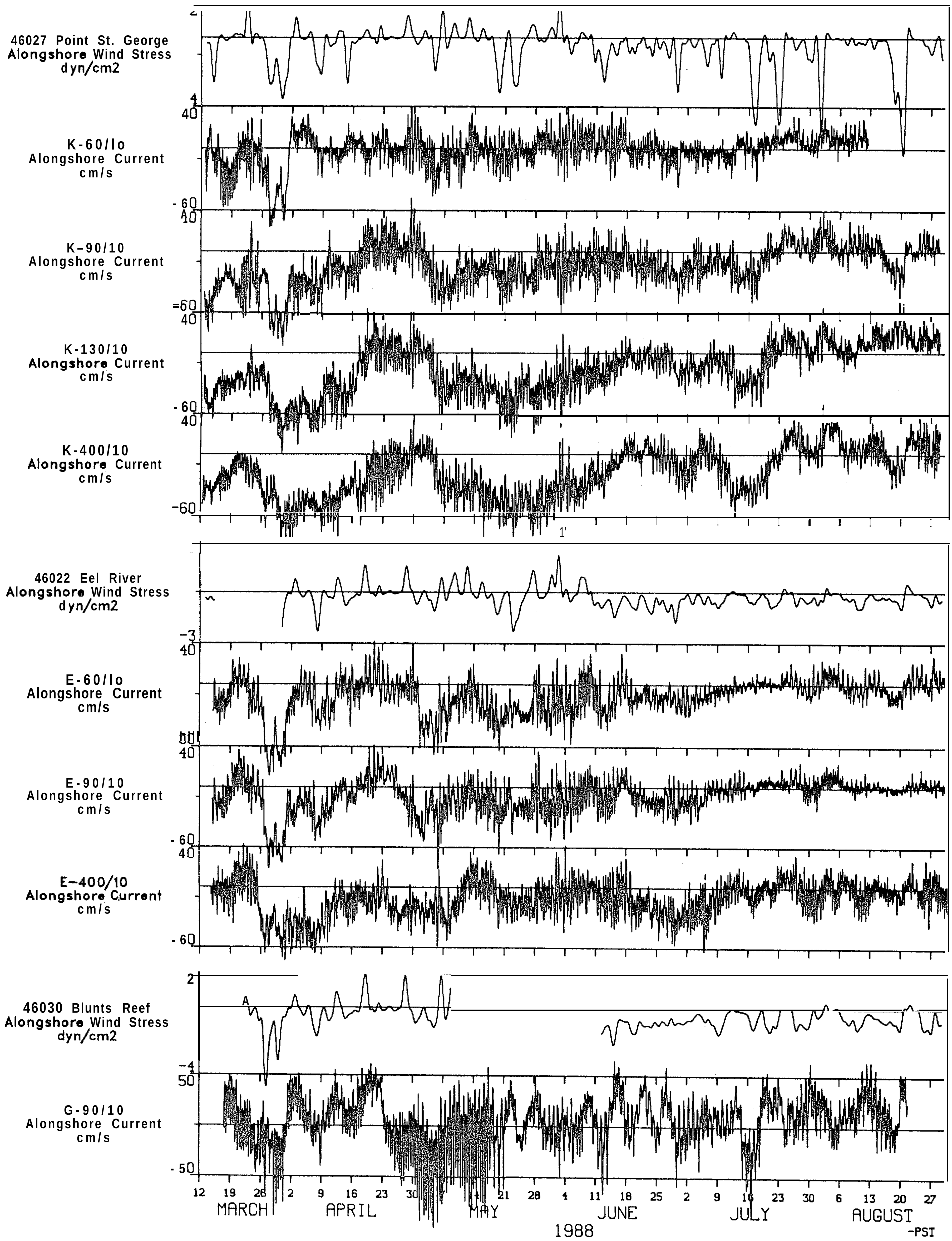


Figure 4- 6q. Time series of currents and winds, NCCCS first deployment of the main program, March-August 1988: hourly alongshelf component, 10-m currents and nearby wind stress.

ALONGSHORE 10 M CURRENTS AND ALONGSHORE WIND STRESS
UPCOAST IS TOWARD TOP OF PAGE

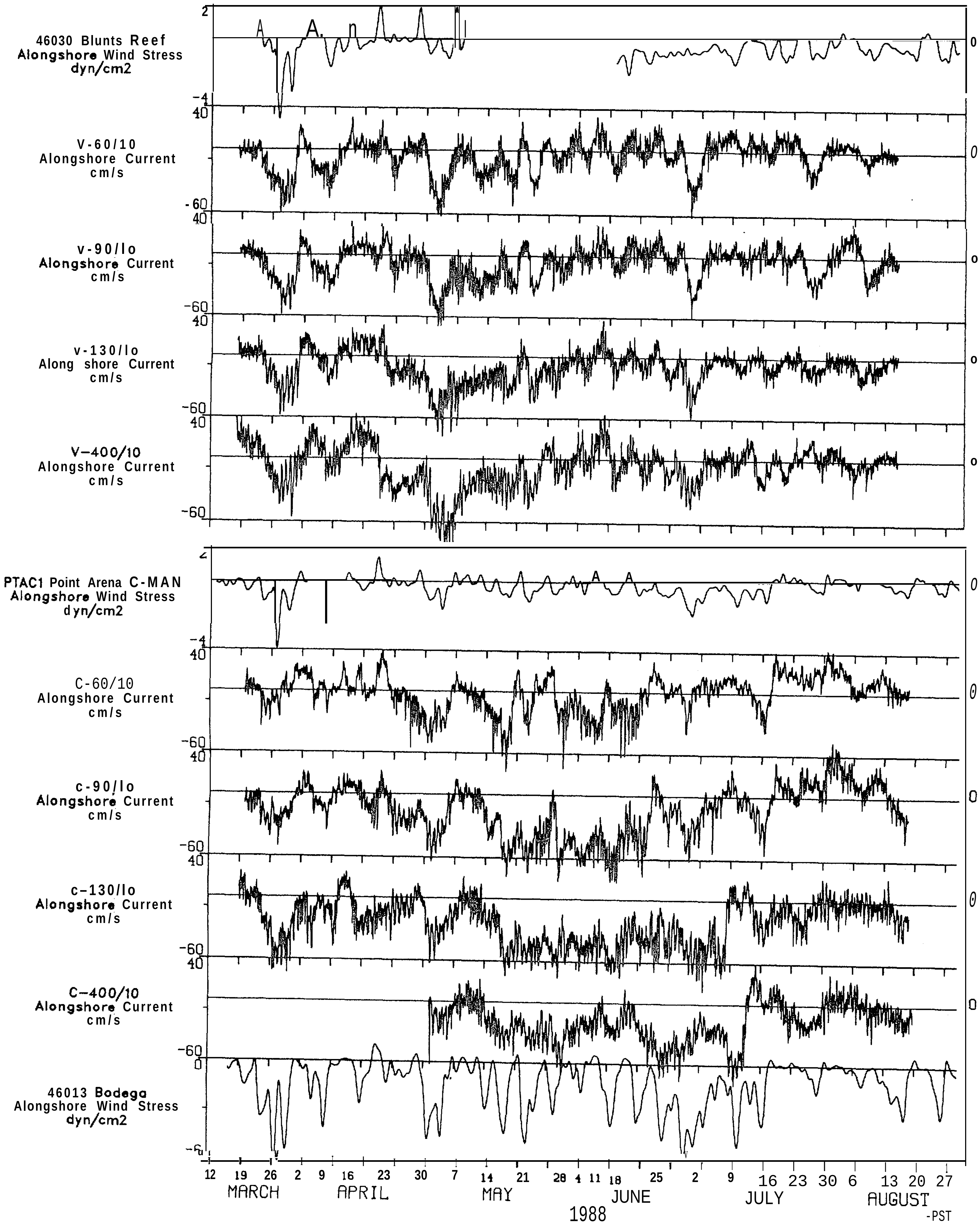


Figure 4-6q. Continued.

- - - n -

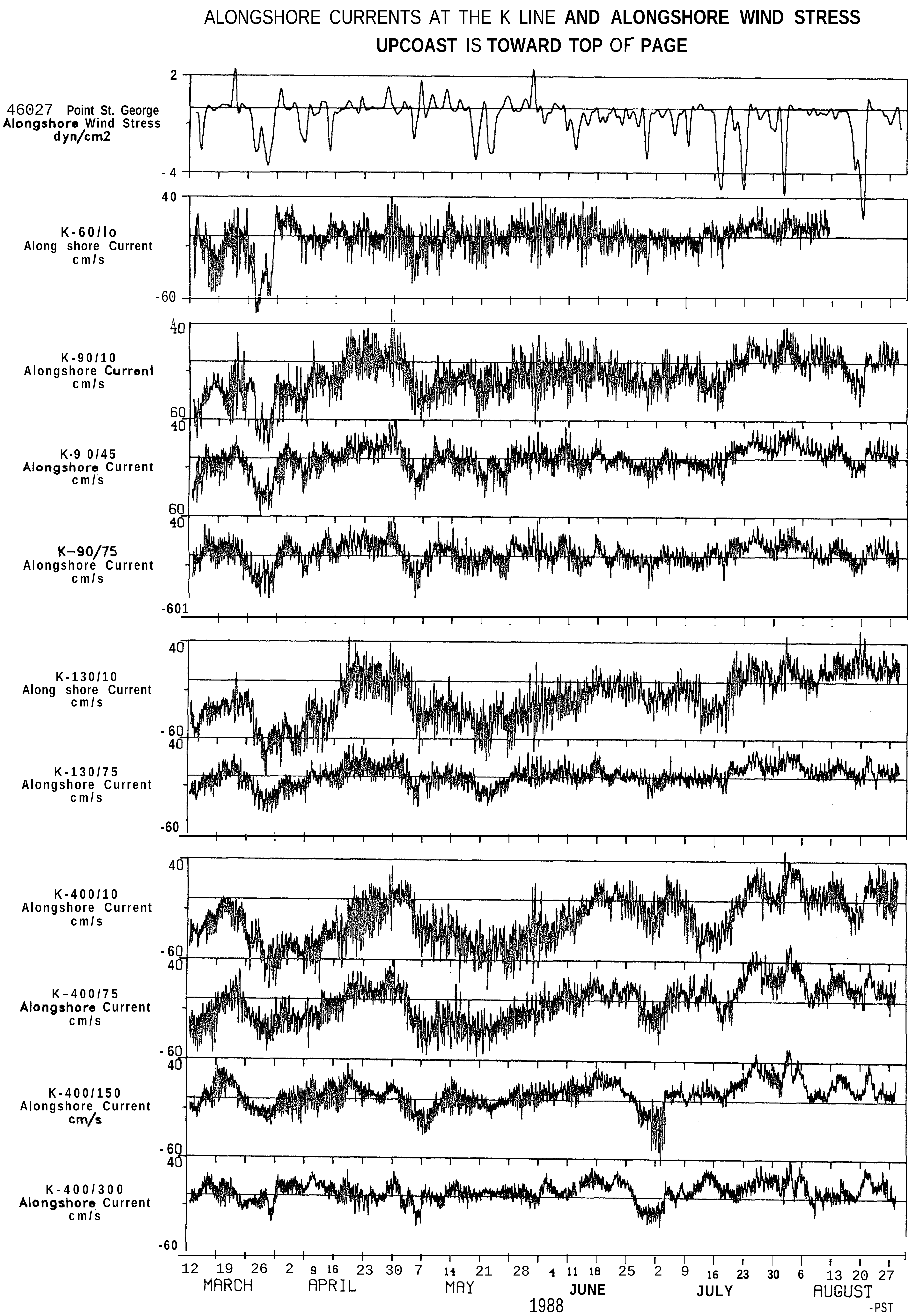


Figure 4-6r. Time series of currents and winds, NCCCS first deployment of the main program, March-August 1988: hourly alongshelf component, K-line currents and nearby wind stress.

ALONGSHORE CURRENTS AT THE E AND G LINES AND ALONGSHORE WIND STRESS
UPCOAST IS TOWARD TOP OF PAGE

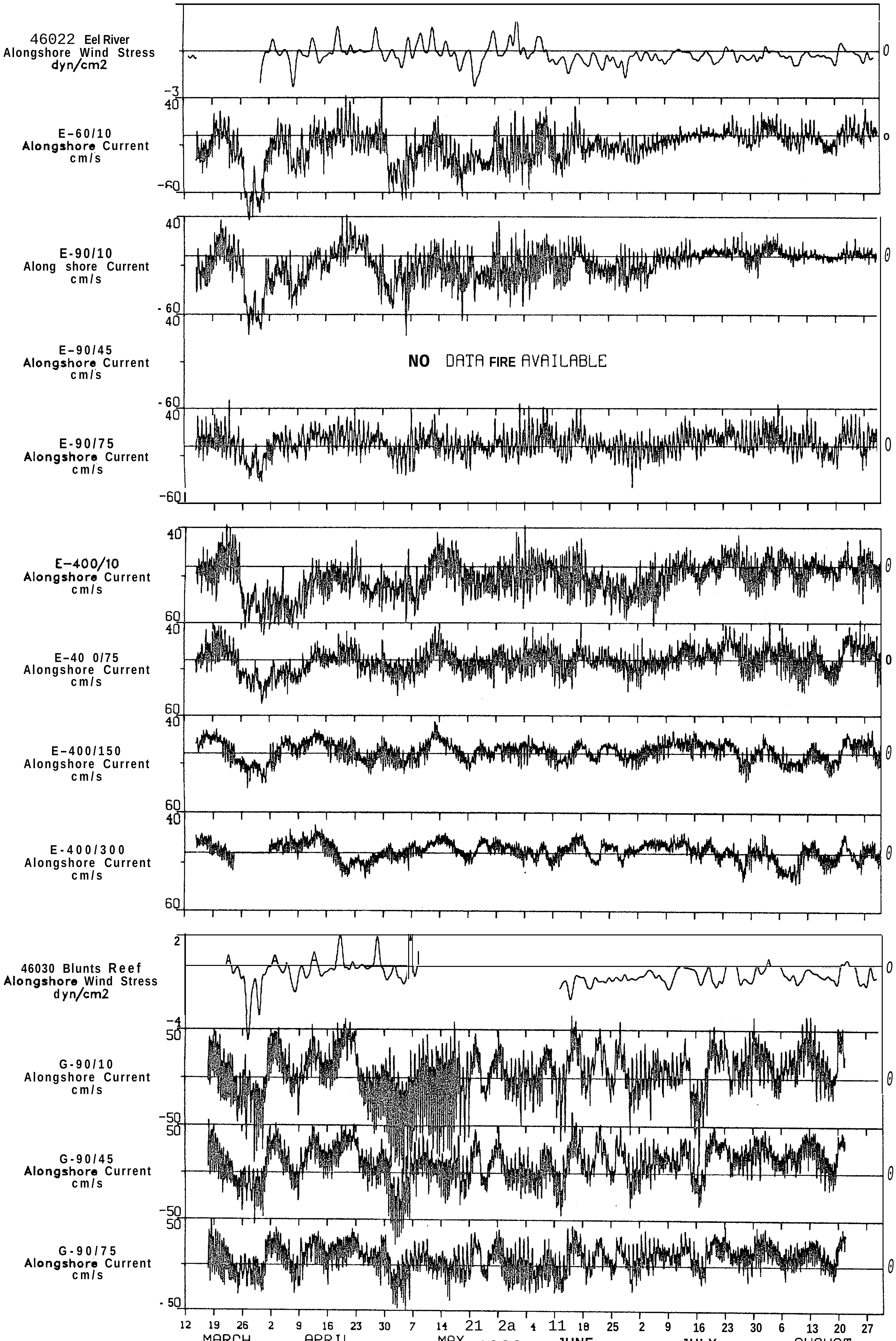


Figure 4-6s. Time series of currents and winds , NCCCS first deployment of the main program, March-August 1988: hourly alongshelf component, E- and G-line currents and nearby wind stress.

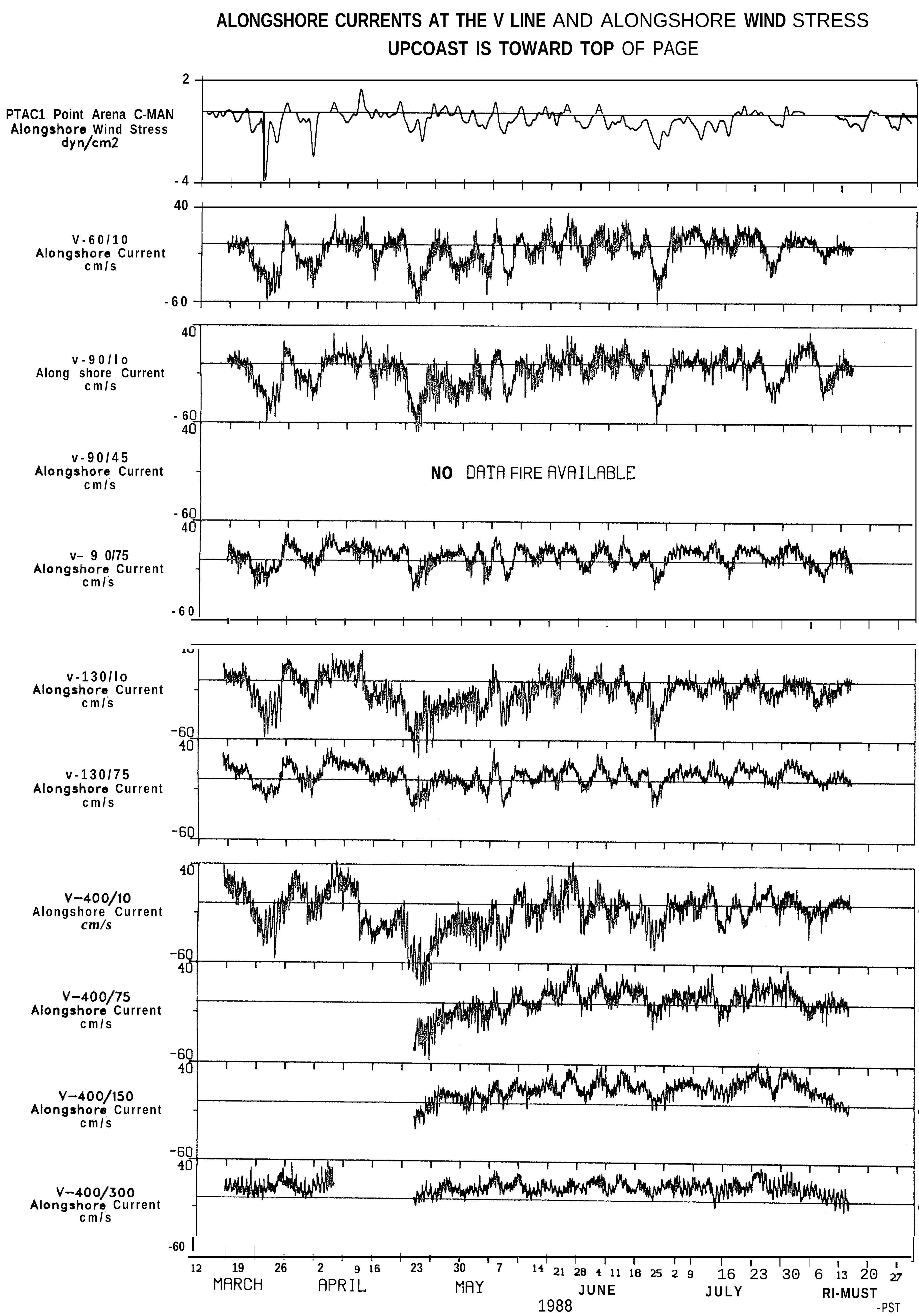


Figure 4-6t. Time series of currents and winds, NCCCS first deployment of the main program, March-August 1988: hourly alongshelf component, V-line currents and nearby wind stress.

ALONGSHORE CURRENTS AT THE C LINE AND ALONGSHORE WIND STRESS
UPCOAST IS TOWARD TOP OF PAGE

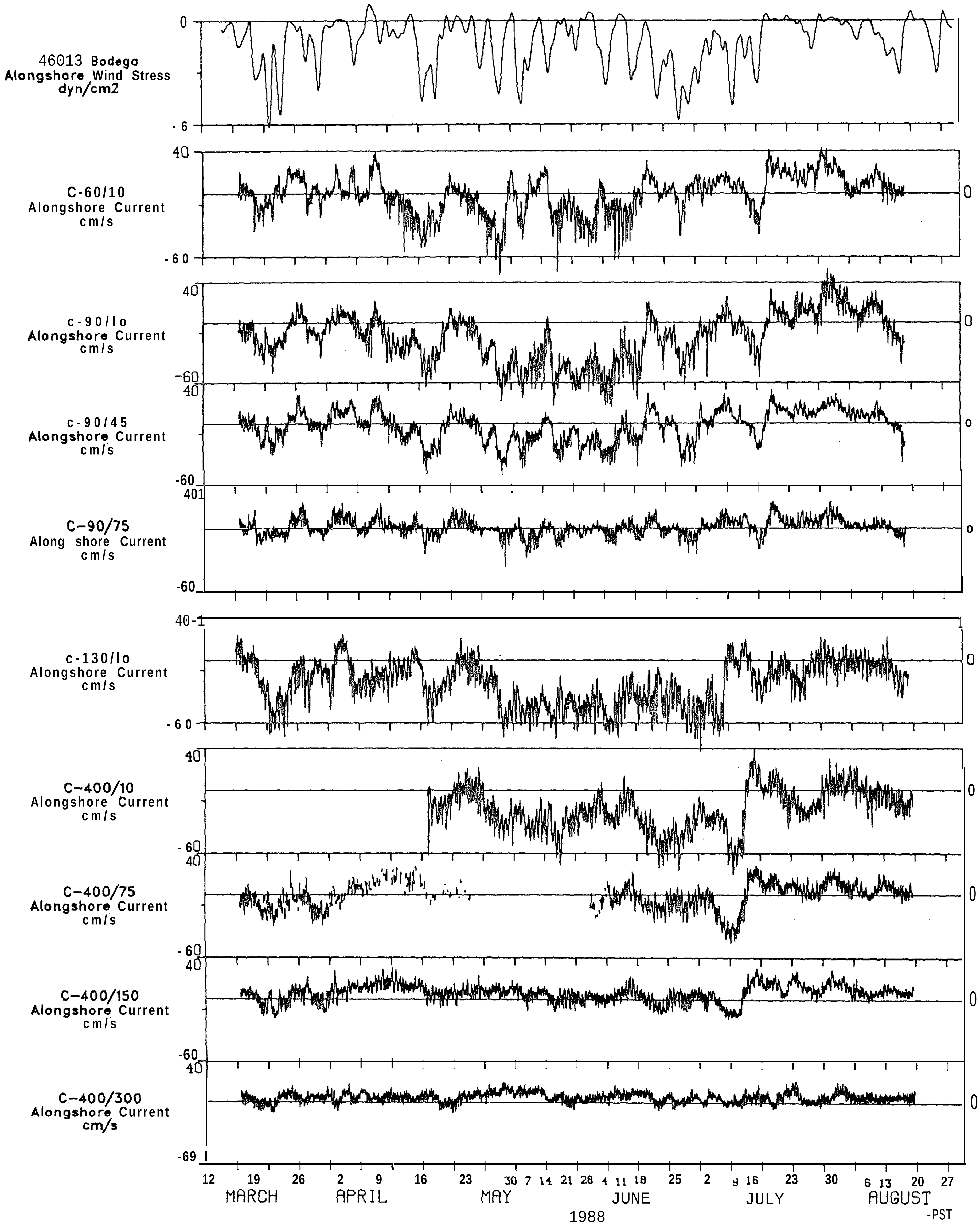


Figure 4- 6U. Time series of currents and winds, NCCCS first deployment of the main program, March-August 1988: hourly alongshelf component, C-line currents and nearby wind stress.

CROSS-SHORE 10 M CURRENTS AND CROSS–SHORE WIND STRESS
ONSHORE IS TOWARD TOP OF PAGE

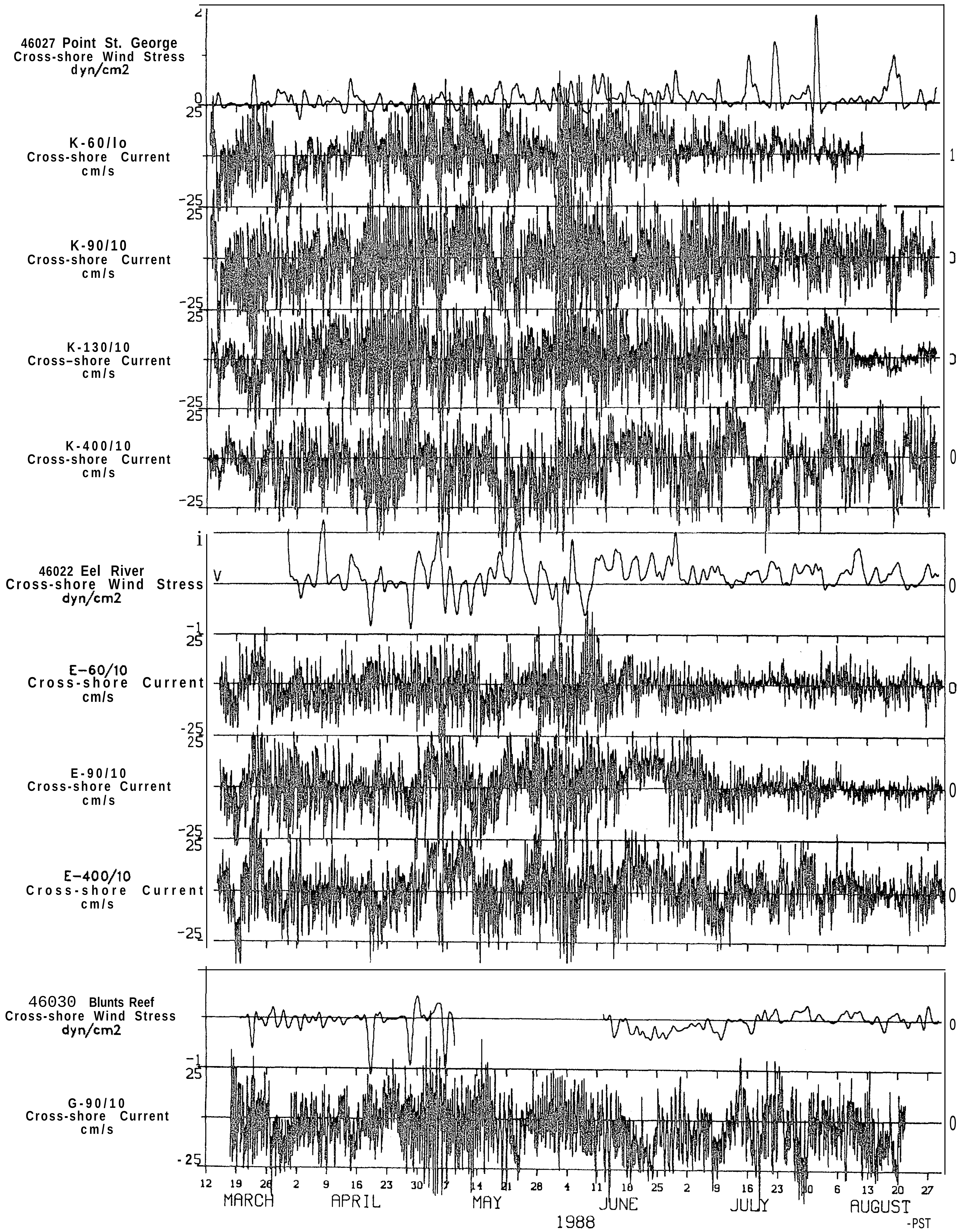


Figure 4- 6v. Time series of currents and winds, NCCCS first deployment of the main program, March-August 1988: hourly cross-shelf component, 10-m currents and nearby wind stress.

CROSS–SHORE 10 M CURRENTS AND CROSS–SHORE WIND STRESS
ONSHORE IS TOWARD TOP OF PAGE

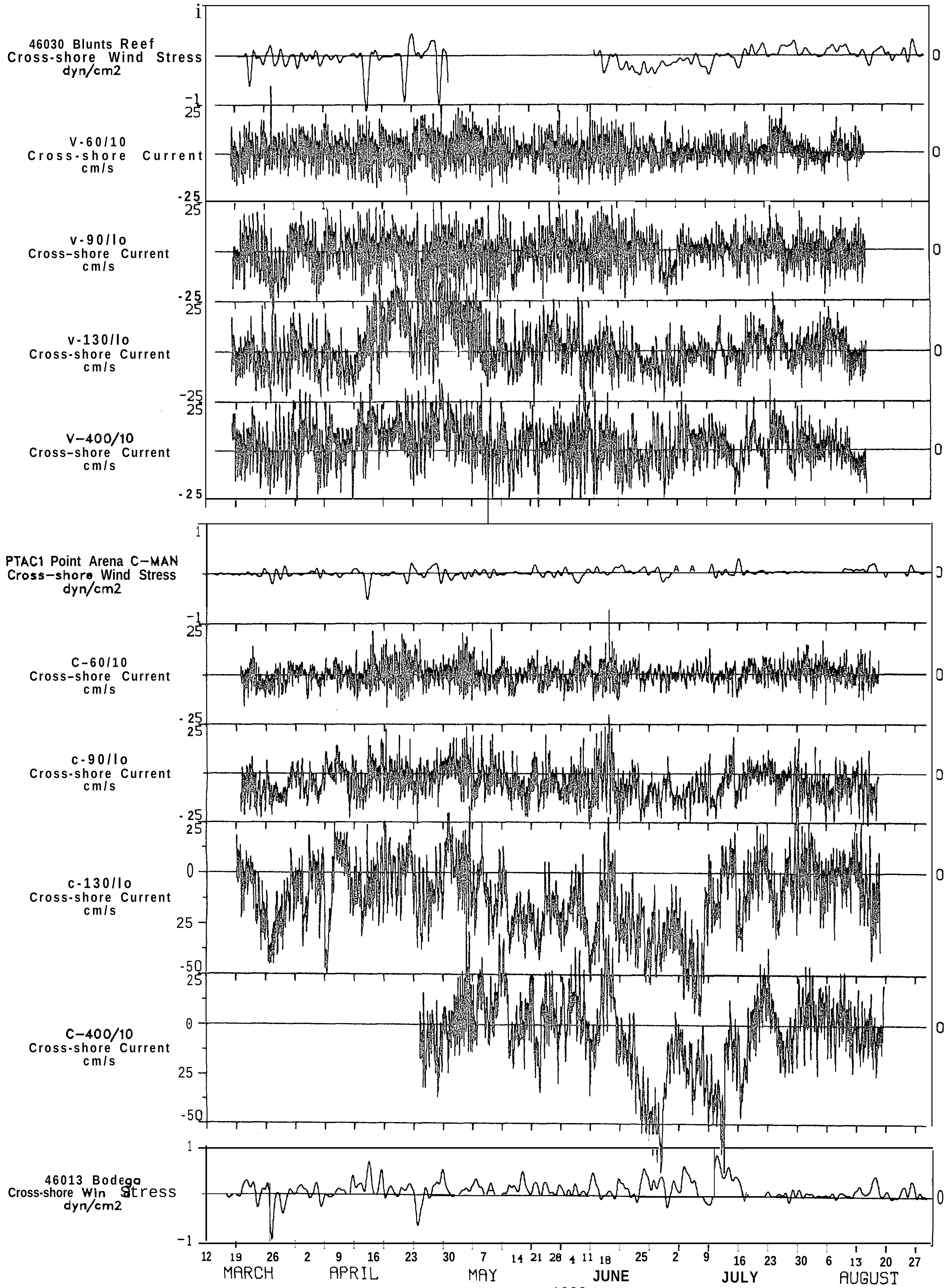


Figure 4-6v. Continued.

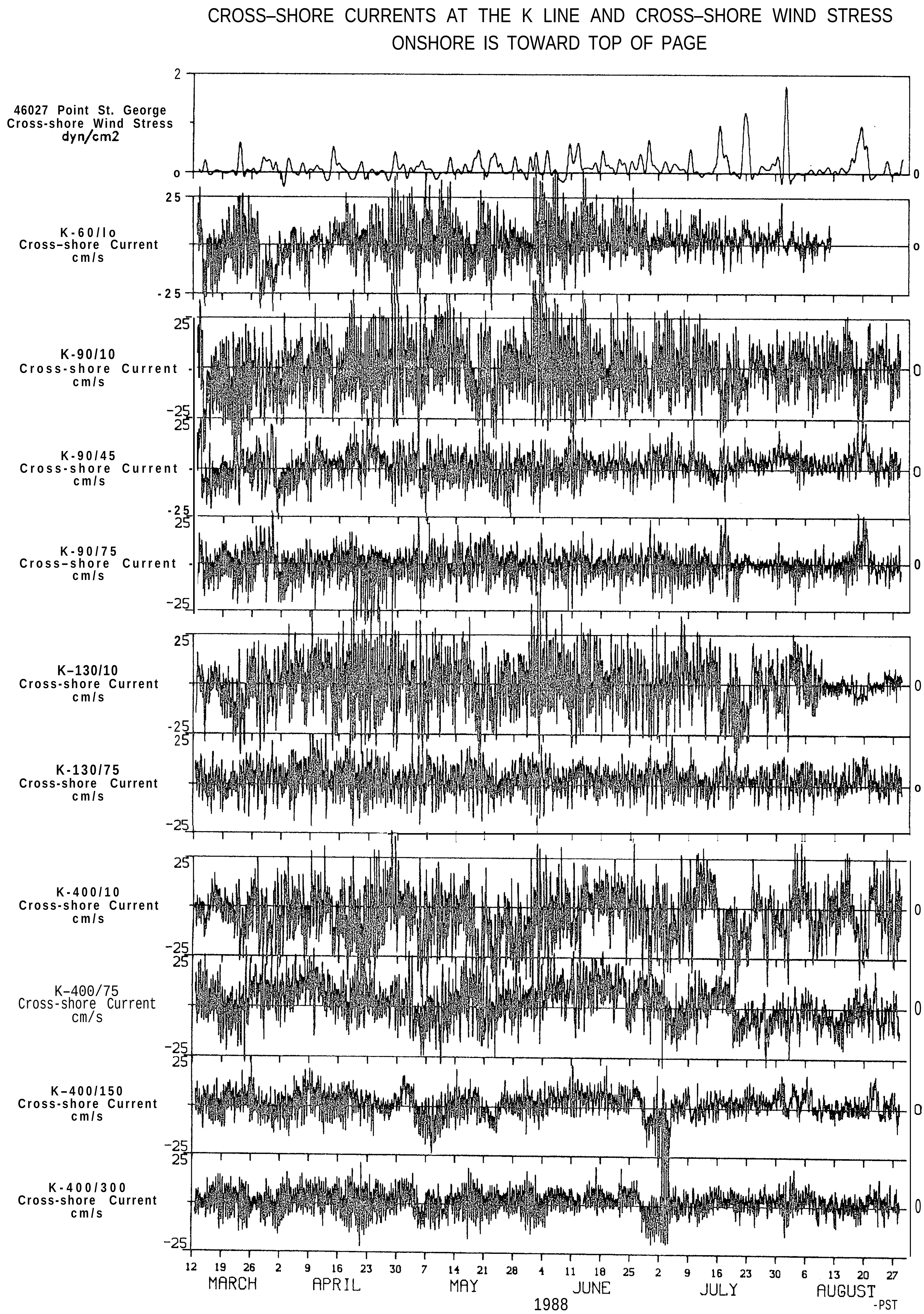


Figure 4-6w. Time series of currents and winds, NCCCS first deployment of the main program, March-August 1988: hourly cross-shelf component, K-line currents and nearby wind stress.

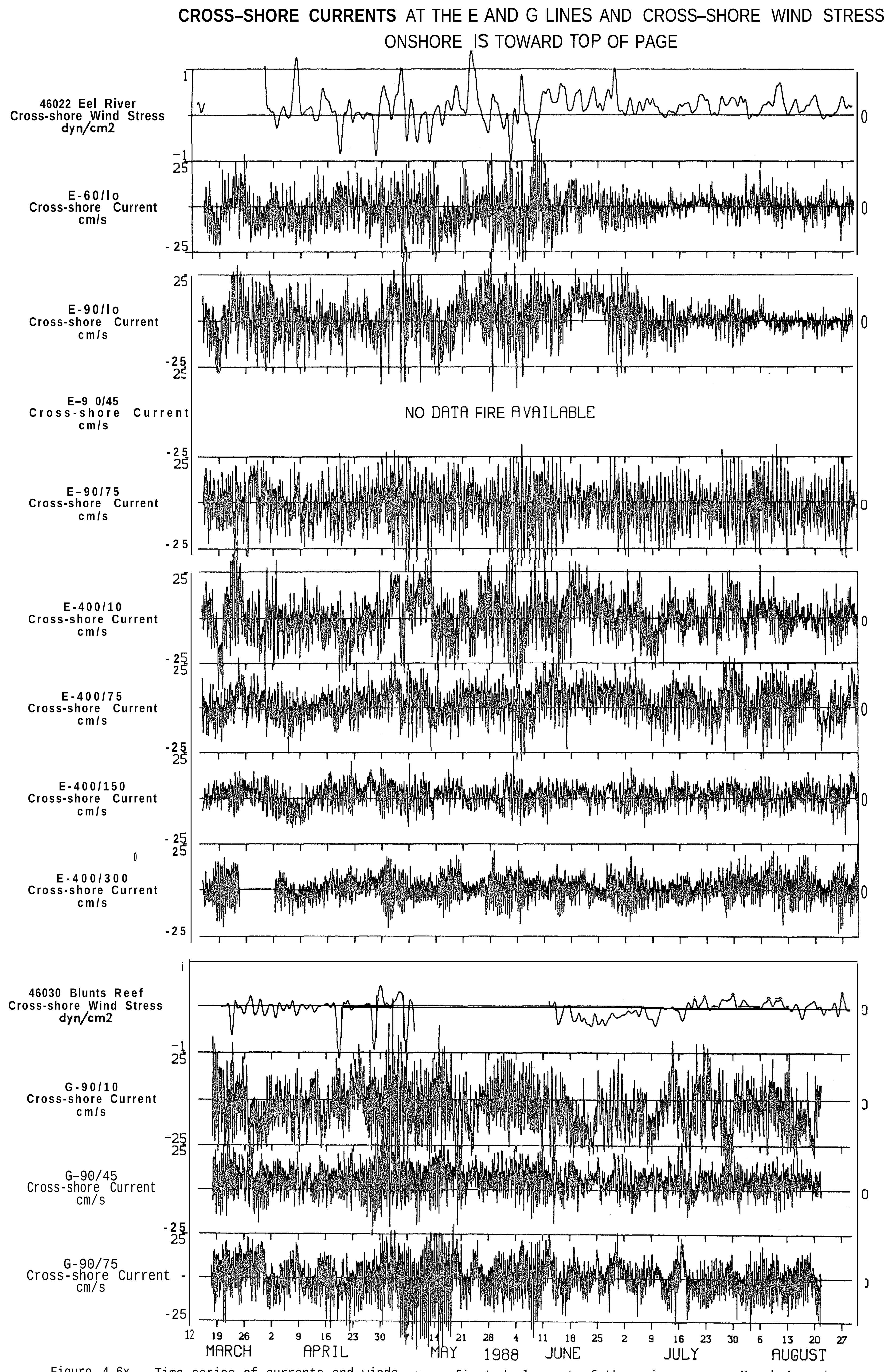


Figure 4-6x. Time series of currents and winds, NCCCS first deployment of the main program, March-August 1988: hourly cross-shelf component, E- and G-line currents and nearby wind stress.

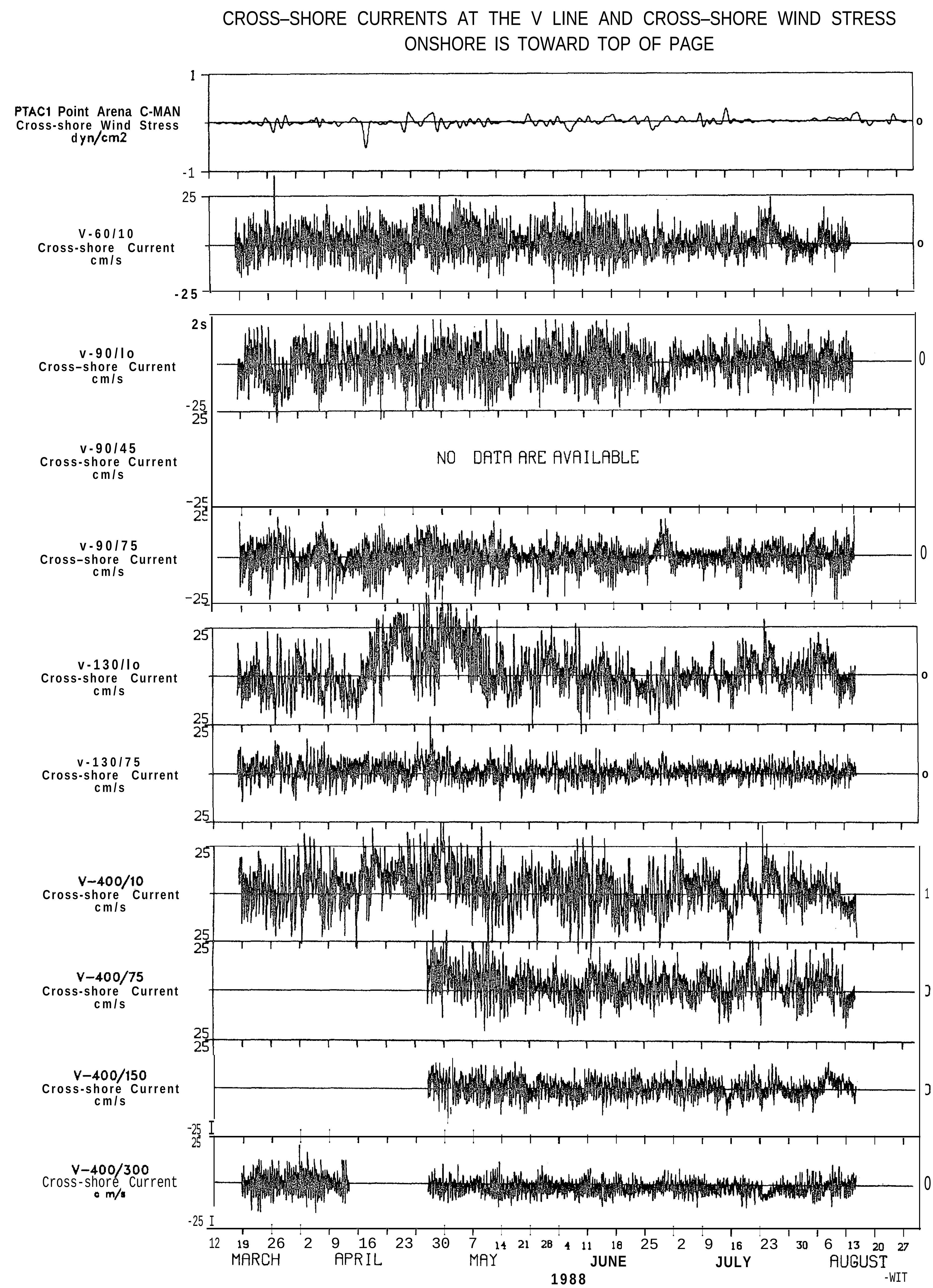


Figure 4-6y. Time series of currents and winds, NCCCS first deployment of the main program, March-August 1988: hourly cross-shelf component, V-line currents and nearby wind stress.

CROSS–SHORE CURRENTS AT THE C LINE AND CROSS–SHORE WIND STRESS
ONSHORE IS TOWARD TOP OF PAGE

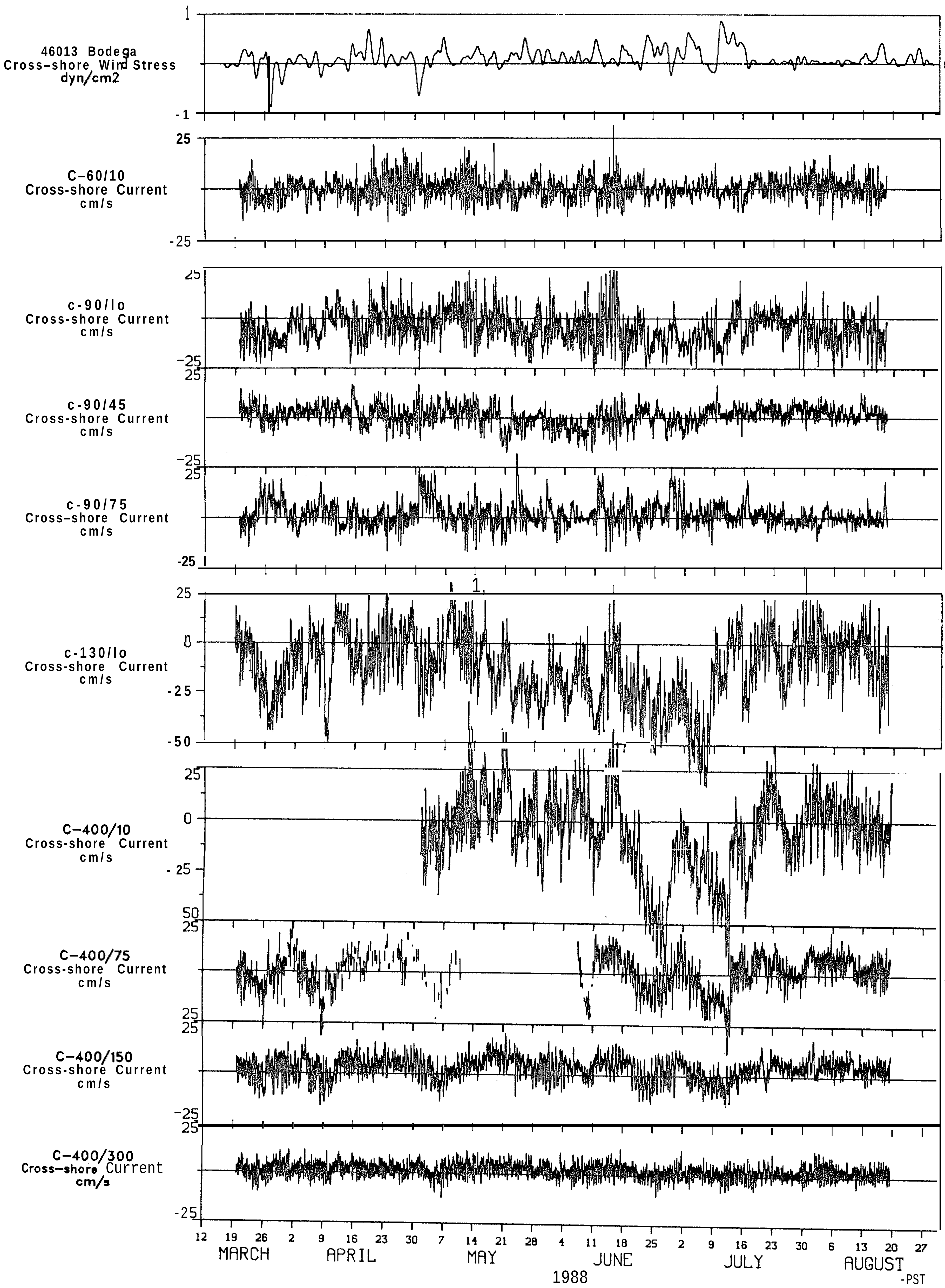


Figure 4-6z. Time series of currents and winds, NCCCS first deployment of the main program, March-August 1988: hourly cross-shelf component, C-line currents and nearby wind stress.

PROGRESSIVE VECTOR DIAGRAMS (LOW PASS FILTERED)

NCCCS MAIN PROGRAM, MARCH – AUGUST 1988

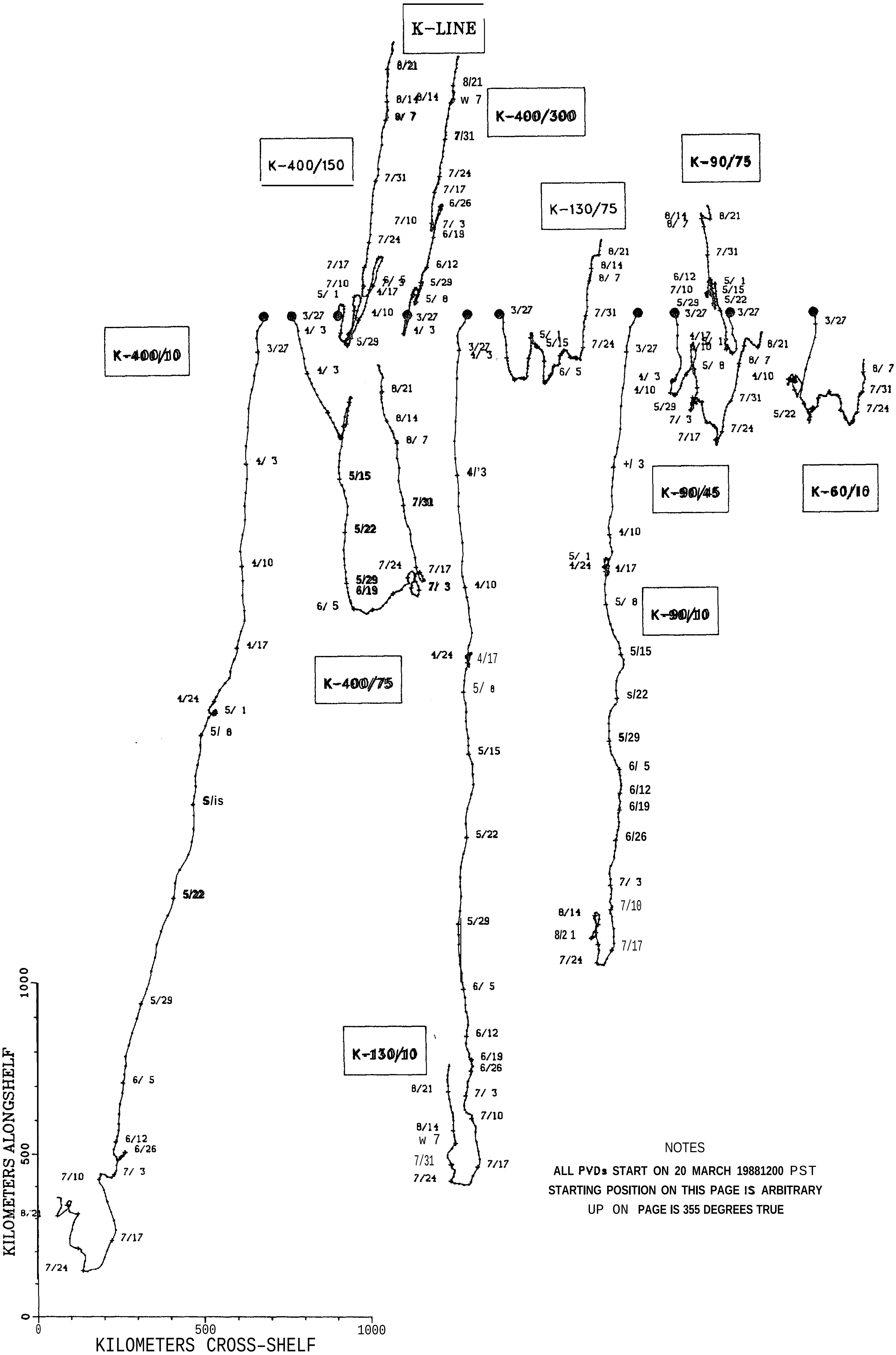


Figure 4- 7a. Progressive vector diagrams (PVDs) of low-passed currents: K-line low-passed PVDs.

PROGRESSIVE VECTOR DIAGRAMS (LOW PASS FILTERED)

NCCCS MAIN PROGRAM, MARCH – AUGUST 1988

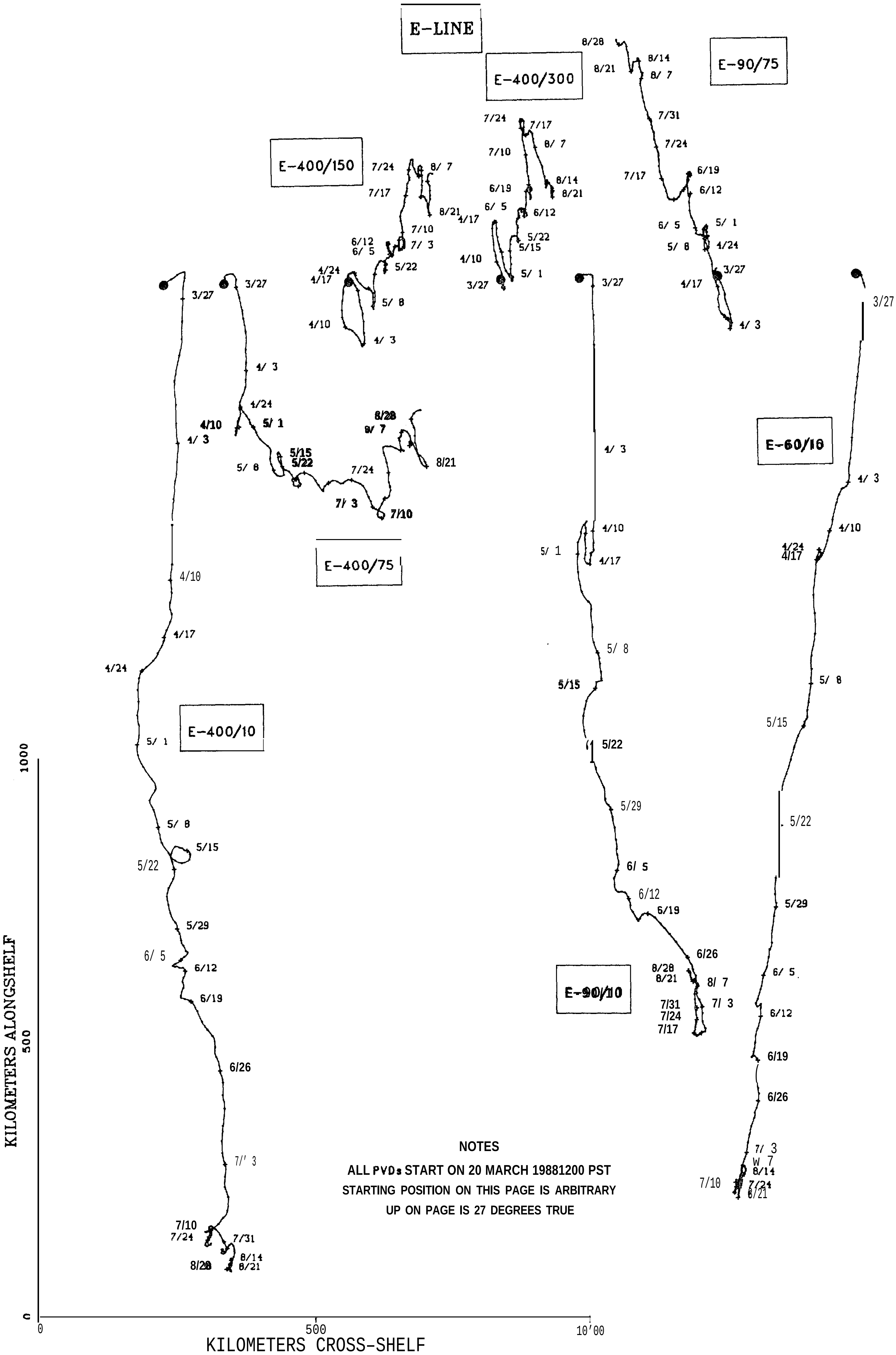


Figure 4- 7b. Progressive vector diagrams (PVDs) of low-passed currents: E-1ine low-passed PVDS.

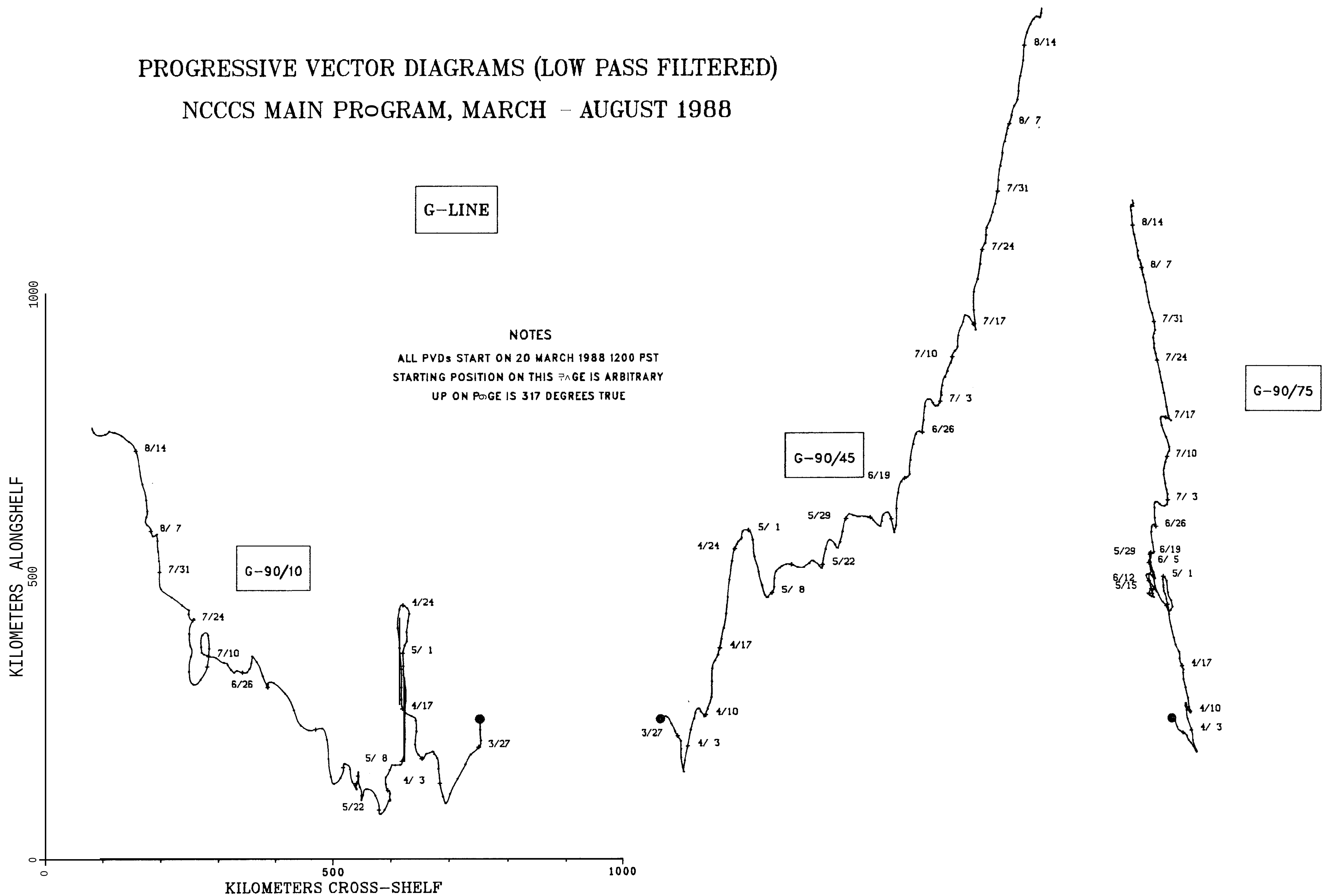


Figure 4-7c. Progressive vector diagrams PVDs) of low-passed currents: G-line low-passed PVDs

PROGRESSIVE VECTOR DIAGRAMS (LOW PASS FILTERED)

NCCCS MAIN PROGRAM, MARCH – AUGUST 1988

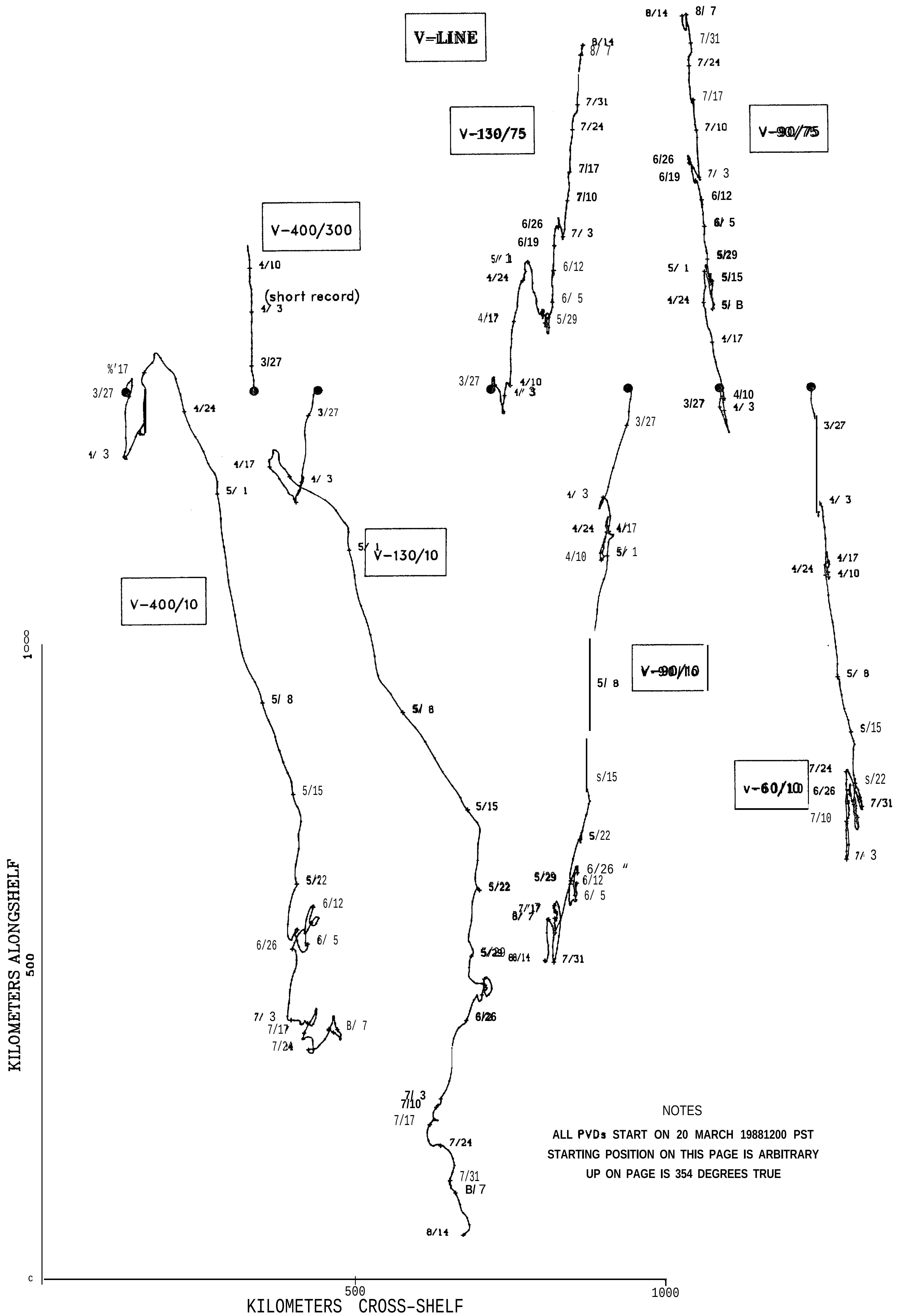


Figure 4-7d. Progressive vector diagrams (PVDs) of low-passed currents: V-line low-passed PVDS.

PROGRESSIVE VECTOR DIAGRAMS (LOW PASS FILTERED)

NCCCS MAIN PROGRAM, MARCH – AUGUST 1988

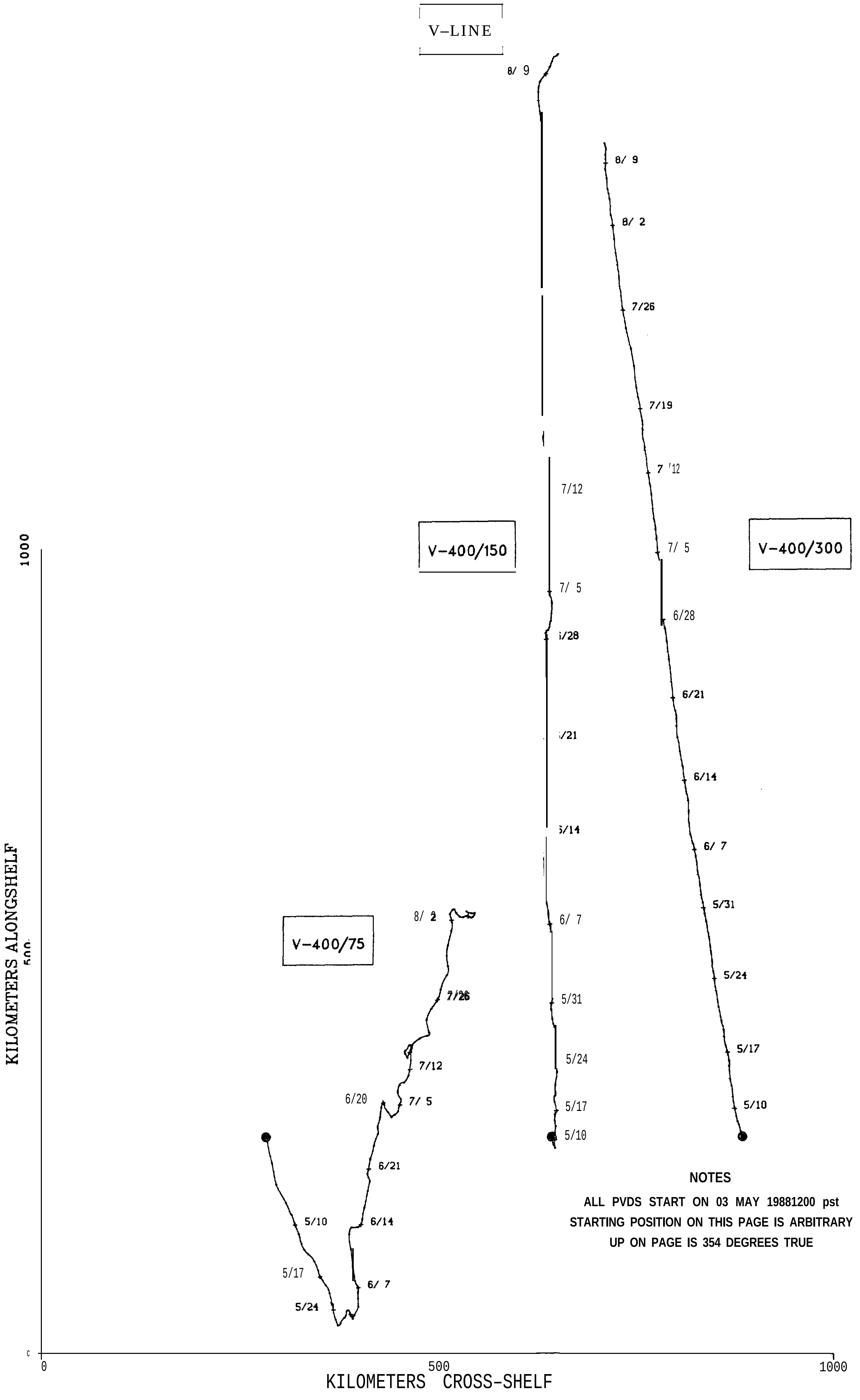


Figure 4-7e. Progressive vector diagrams (PVDs) of low-passed currents: V-line redeployed 400-m mooring low-passed PVDS.

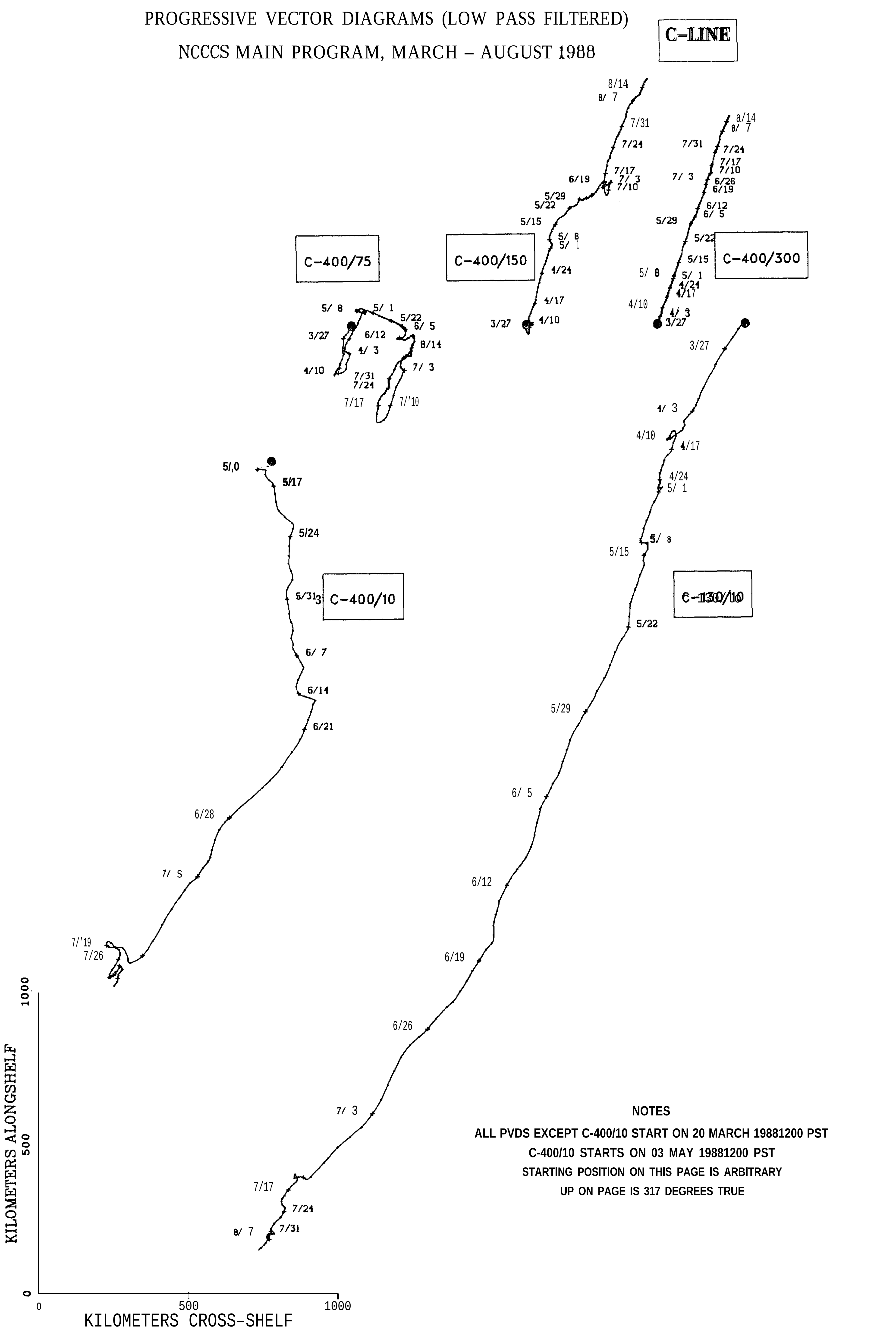


Figure 4-7f. Progressive vector diagrams (PVDs) of low-passed currents : C-400 and c-130 low-passed PVDs.

PROGRESSIVE VECTOR DIAGRAMS (LOW PASS FILTERED)

NCCCS MAIN PROGRAM, MARCH – AUGUST 1988

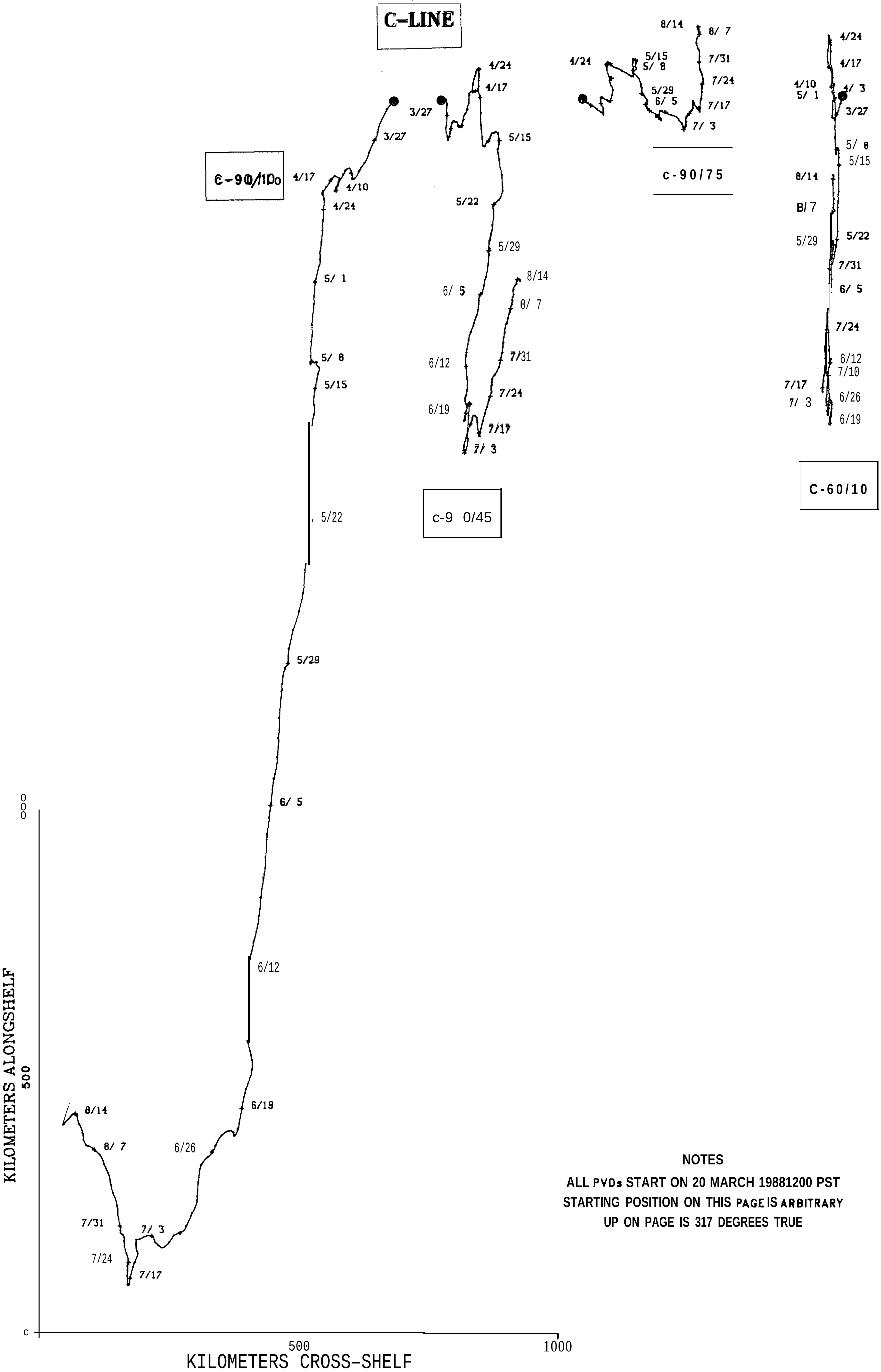


Figure 4-7g. Progressive vector diagrams (PVDs) of low-passed currents: C-90 and c-60 low-passed PVDs.

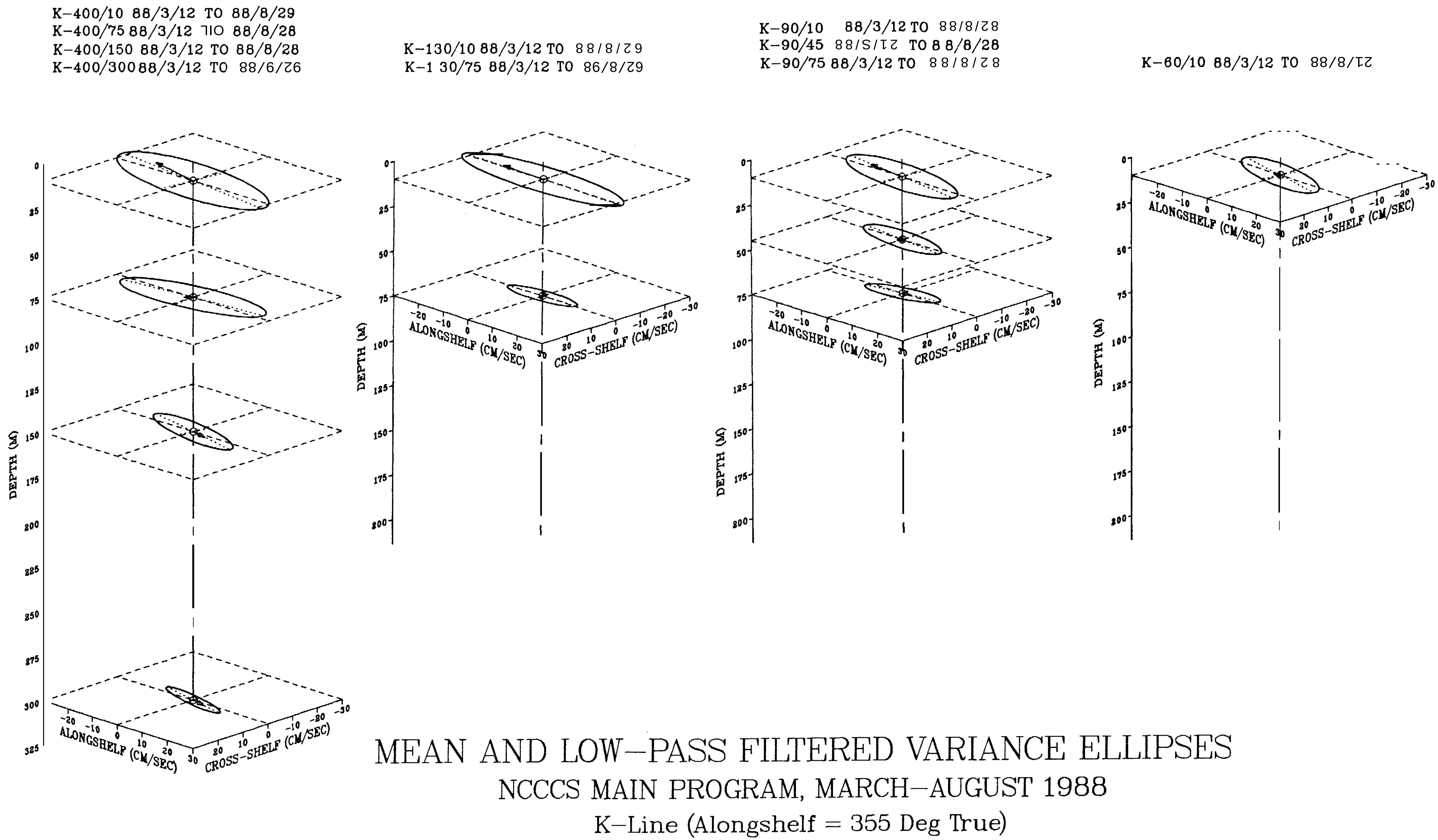
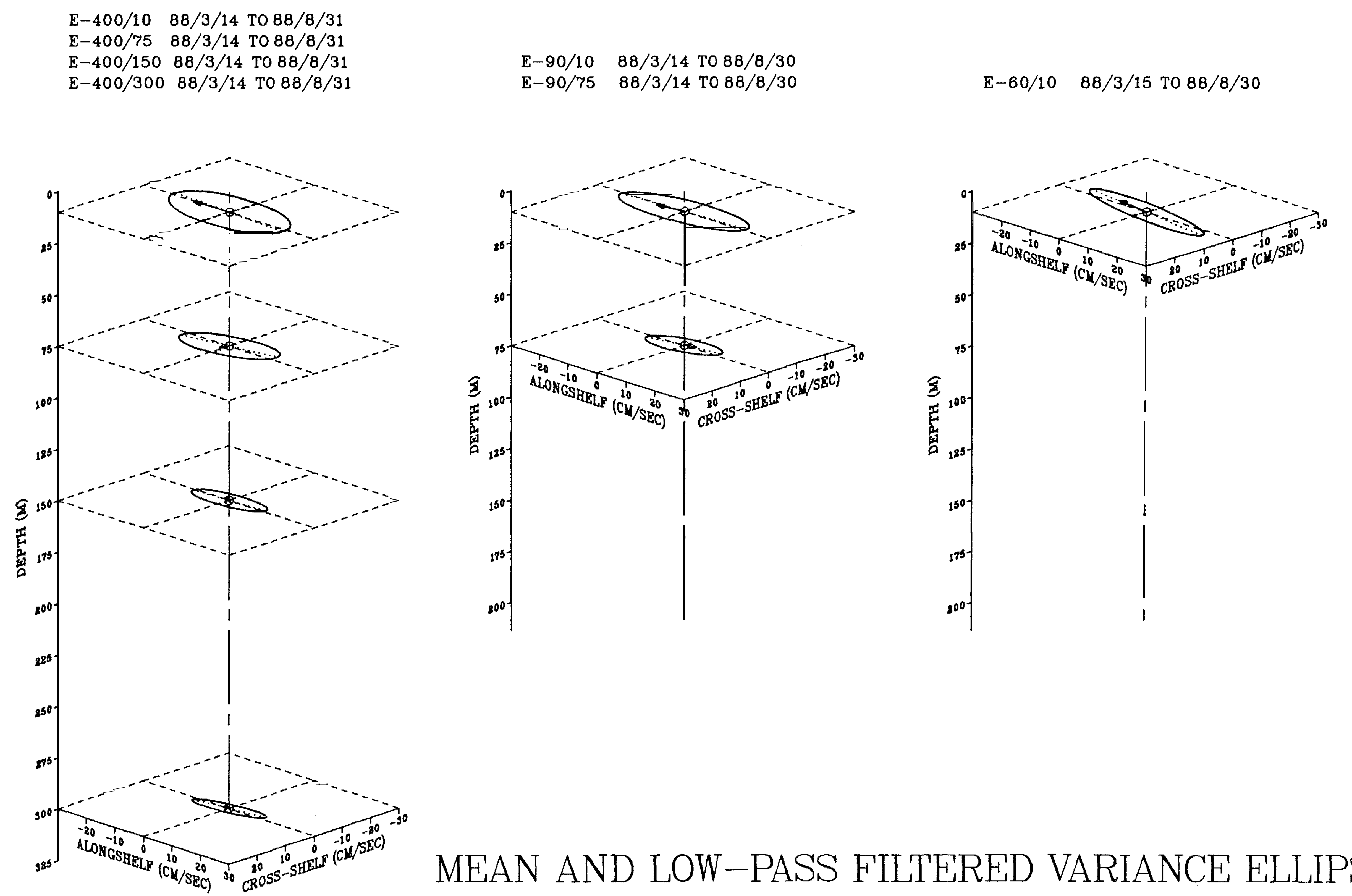


Figure 4-8a. Mean and low-pass-filtered variance ellipses: K-line.

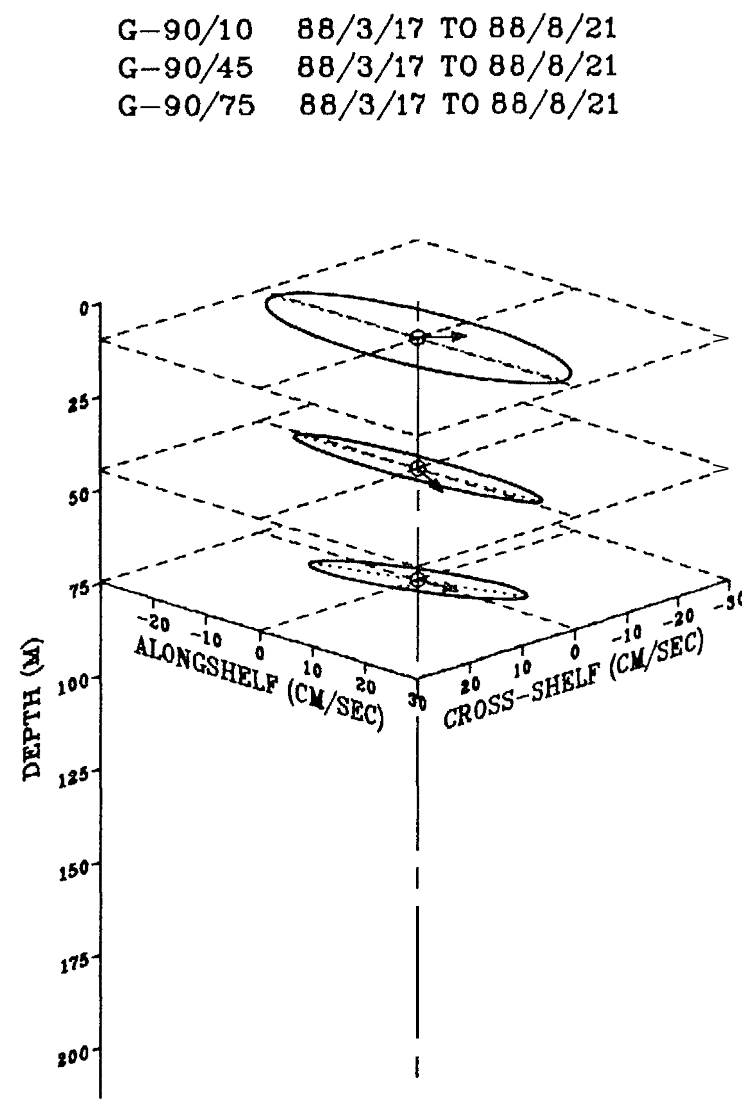


MEAN AND LOW-PASS FILTERED VARIANCE ELLIPSES

NCCCS MAIN PROGRAM, MARCH-AUGUST 1988

E-Line (Alongshelf = 027 Deg True)

Figure 4-8b. Mean and low-pass-filtered variance ellipses: E-line.



MEAN AND LOW-PASS FILTERED VARIANCE ELLIPSES

NCCCS MAIN PROGRAM, MARCH-AUGUST 1988

G-Line (Alongshelf = 317 Deg True)

Figure 4-8c. Mean and low-pass-filtered variance ellipses: G-line

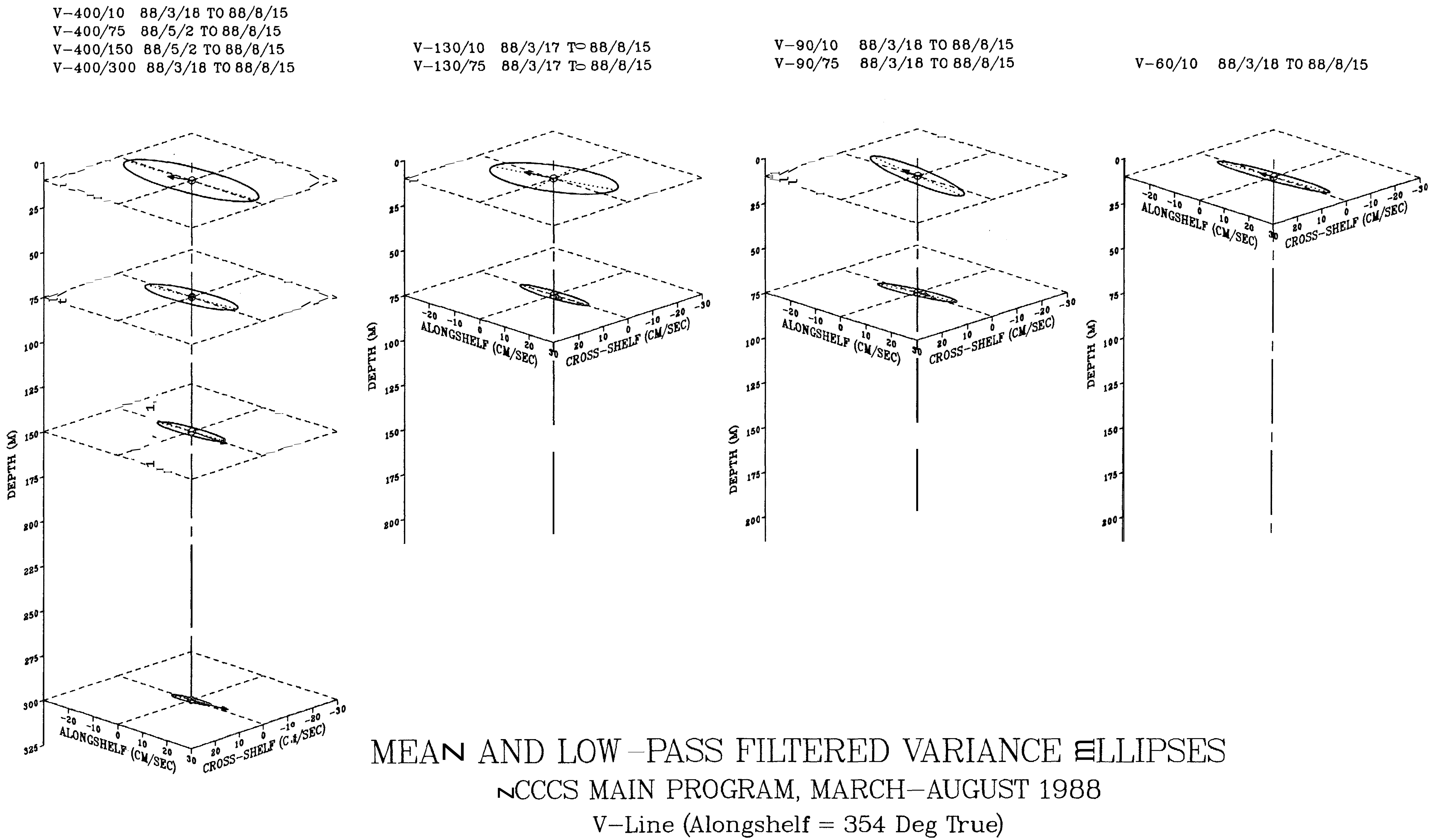
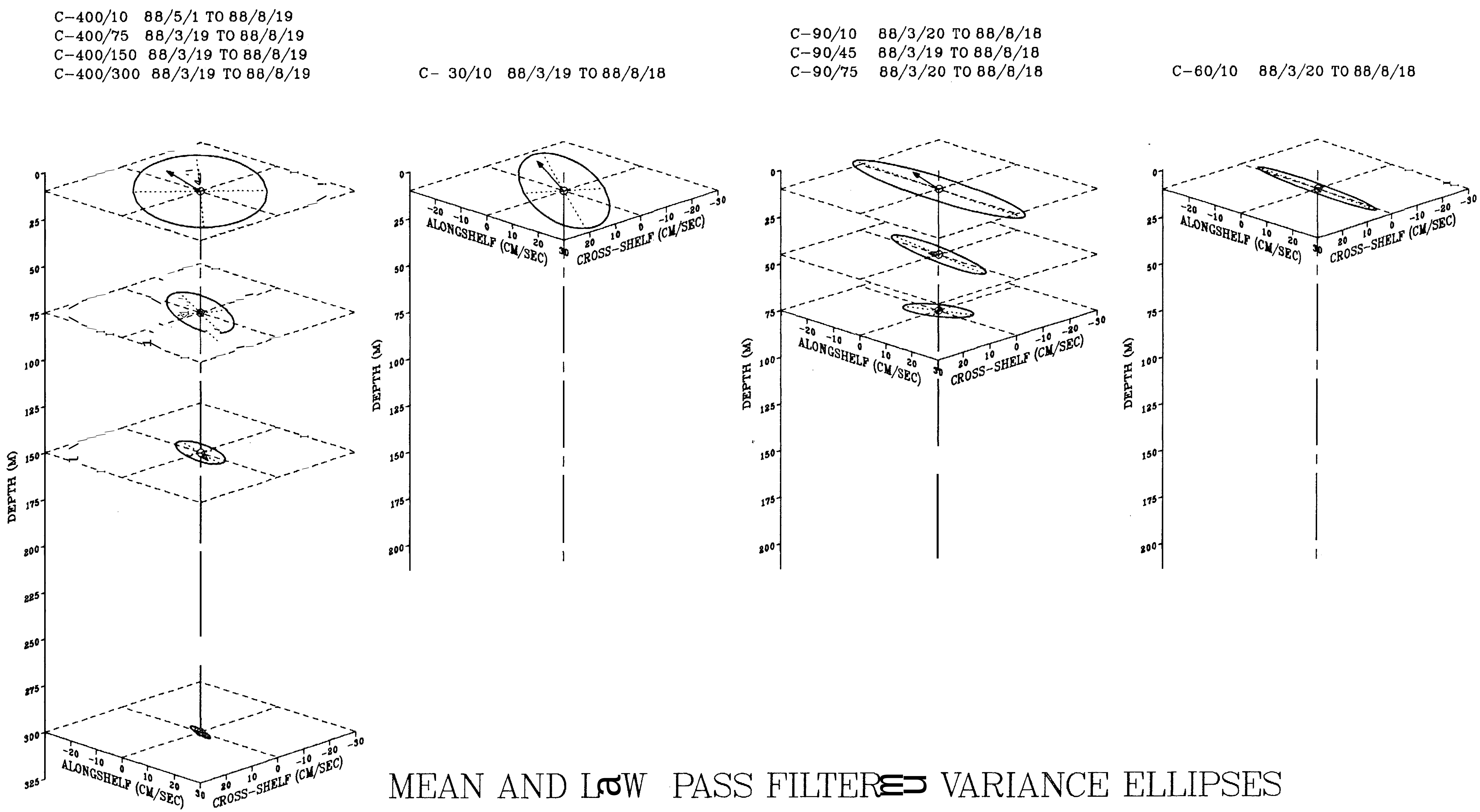


Figure 4-8d Mean and low-pass-filtered variance ellipses: V-line.



MEAN AND LOW PASS FILTERED VARIANCE ELLIPSES

NCCCS MAIN PROGRAM MARCH–AUGUST 1988

C–Line (Alongshelf = 317 Deg True)

Figure 4-8e Mean and low-pass-filtered variance ellipses: C-line

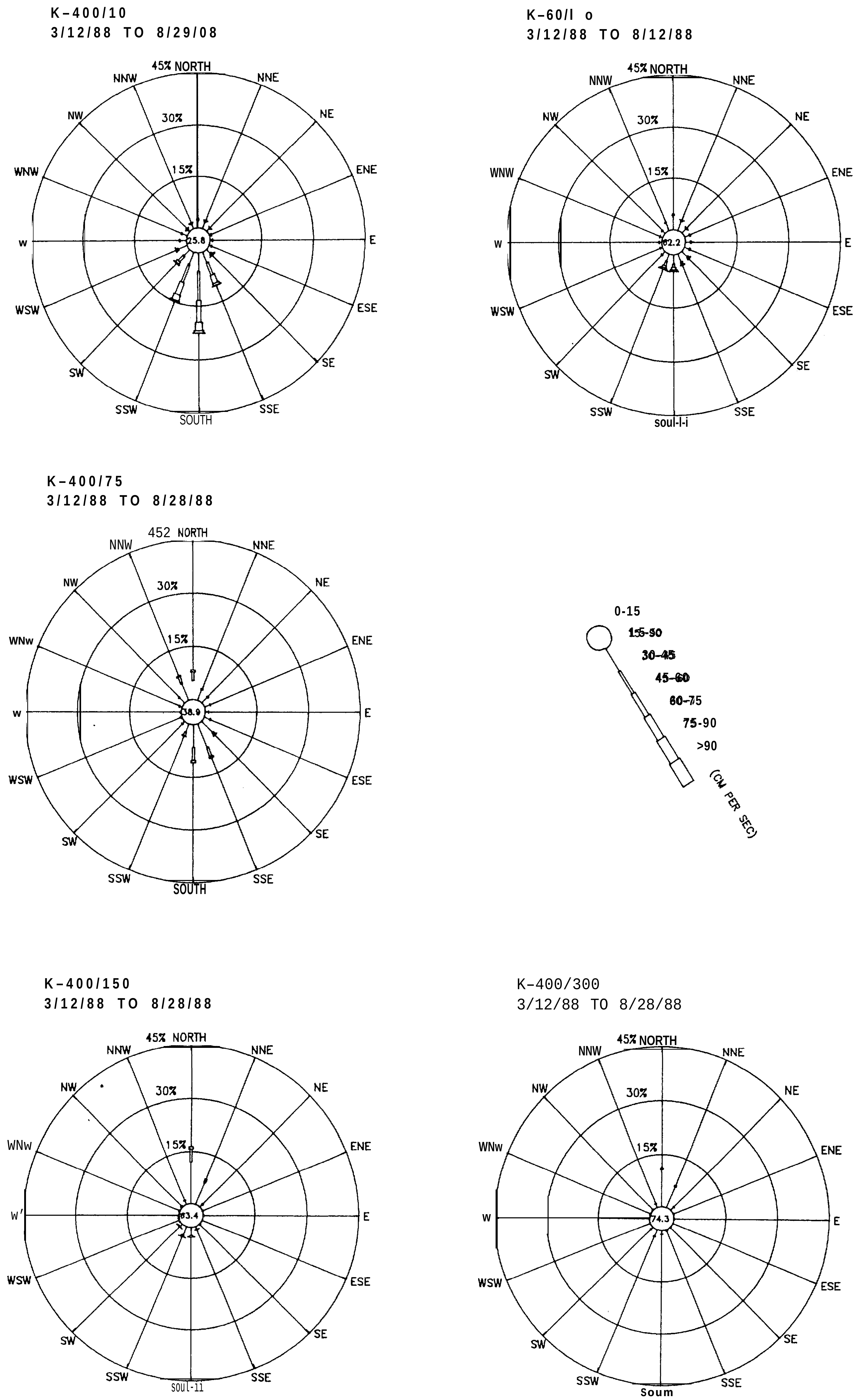


Figure 4-9a. Current roses based on hourly values: K-400 and K-60.

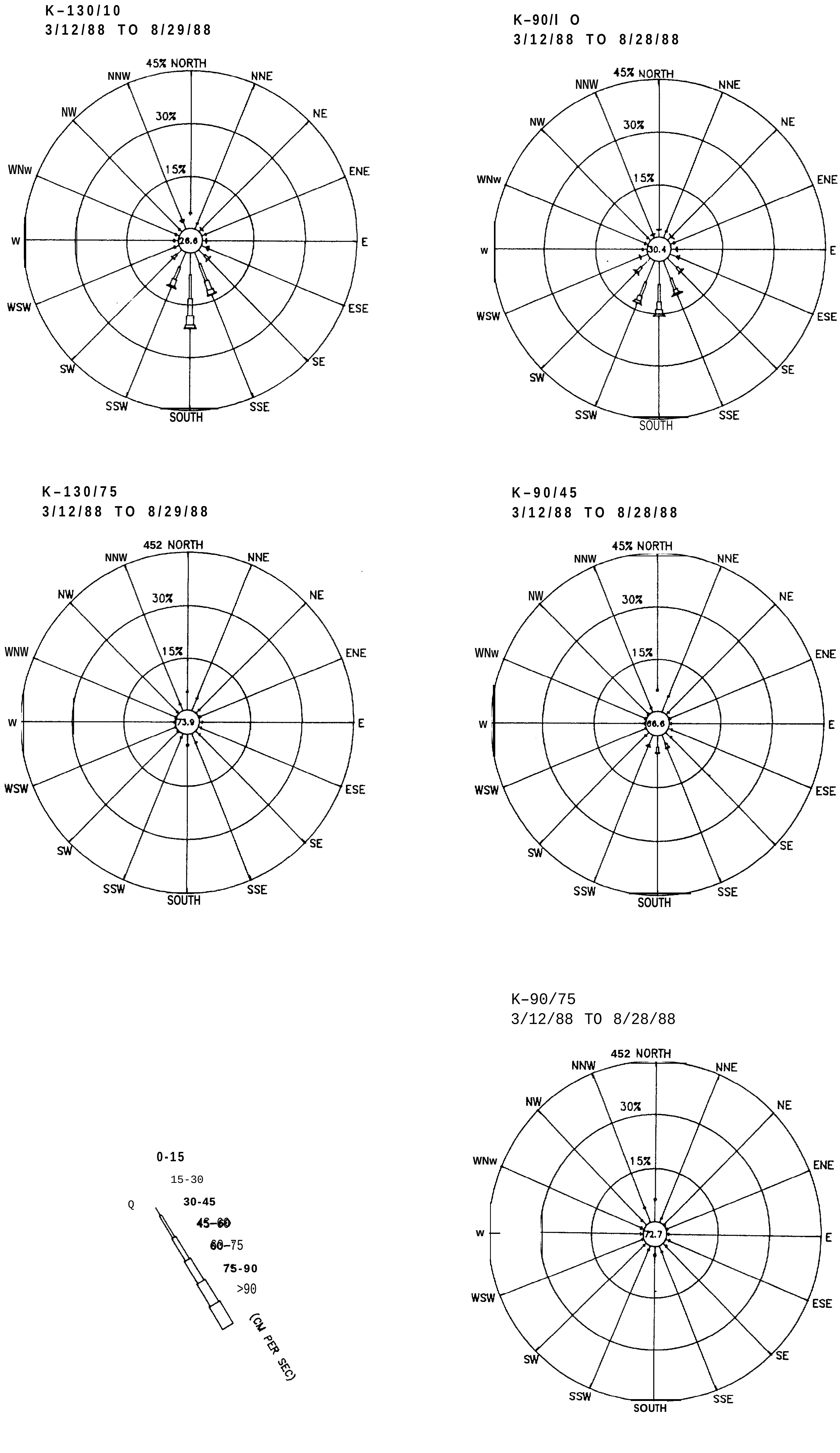


Figure 4-9b. Current roses based on hourly values: K-130 and K-90.

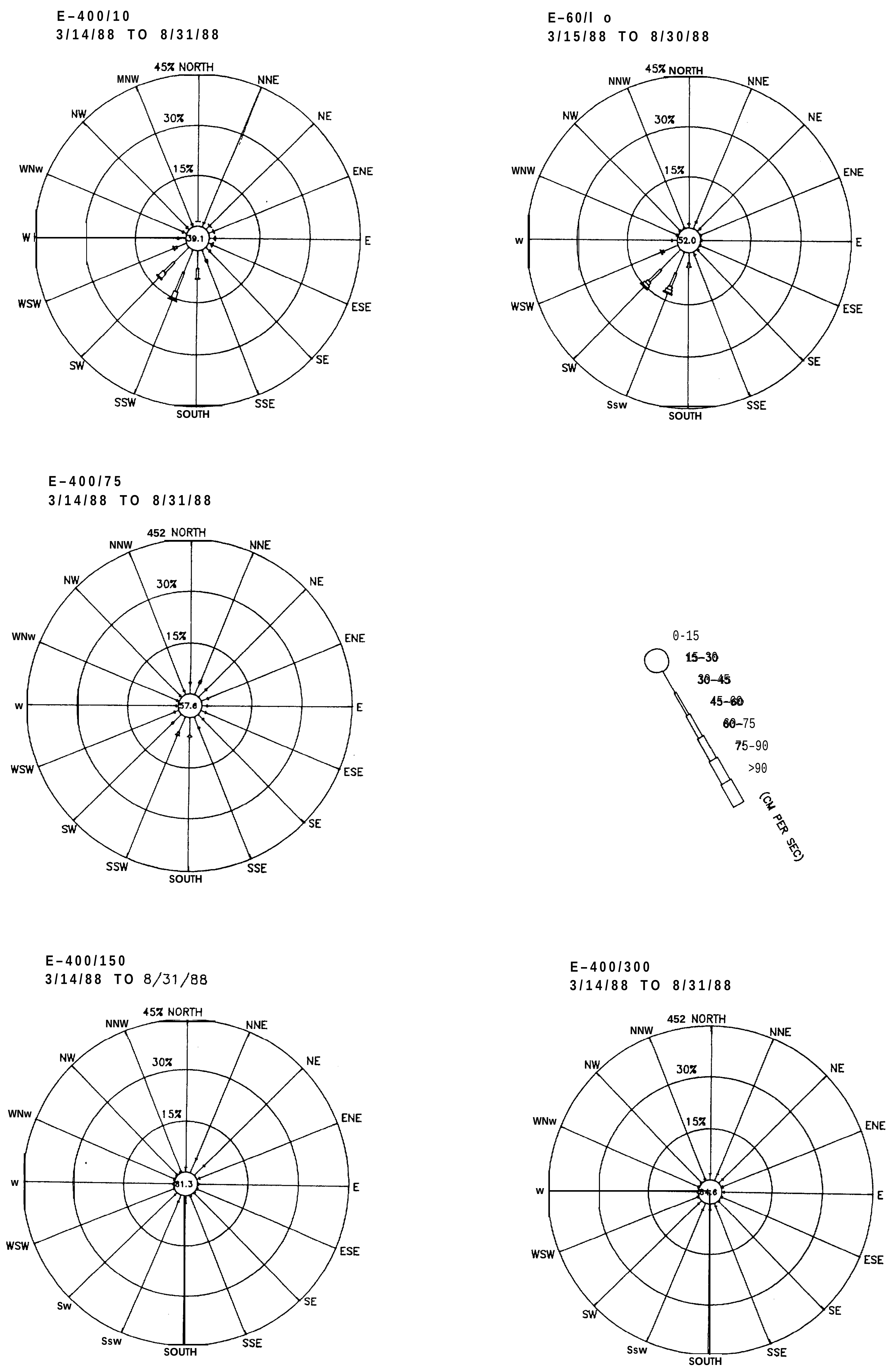


Figure 4-9c. Current roses based on hourly values: E-400 and E-60.

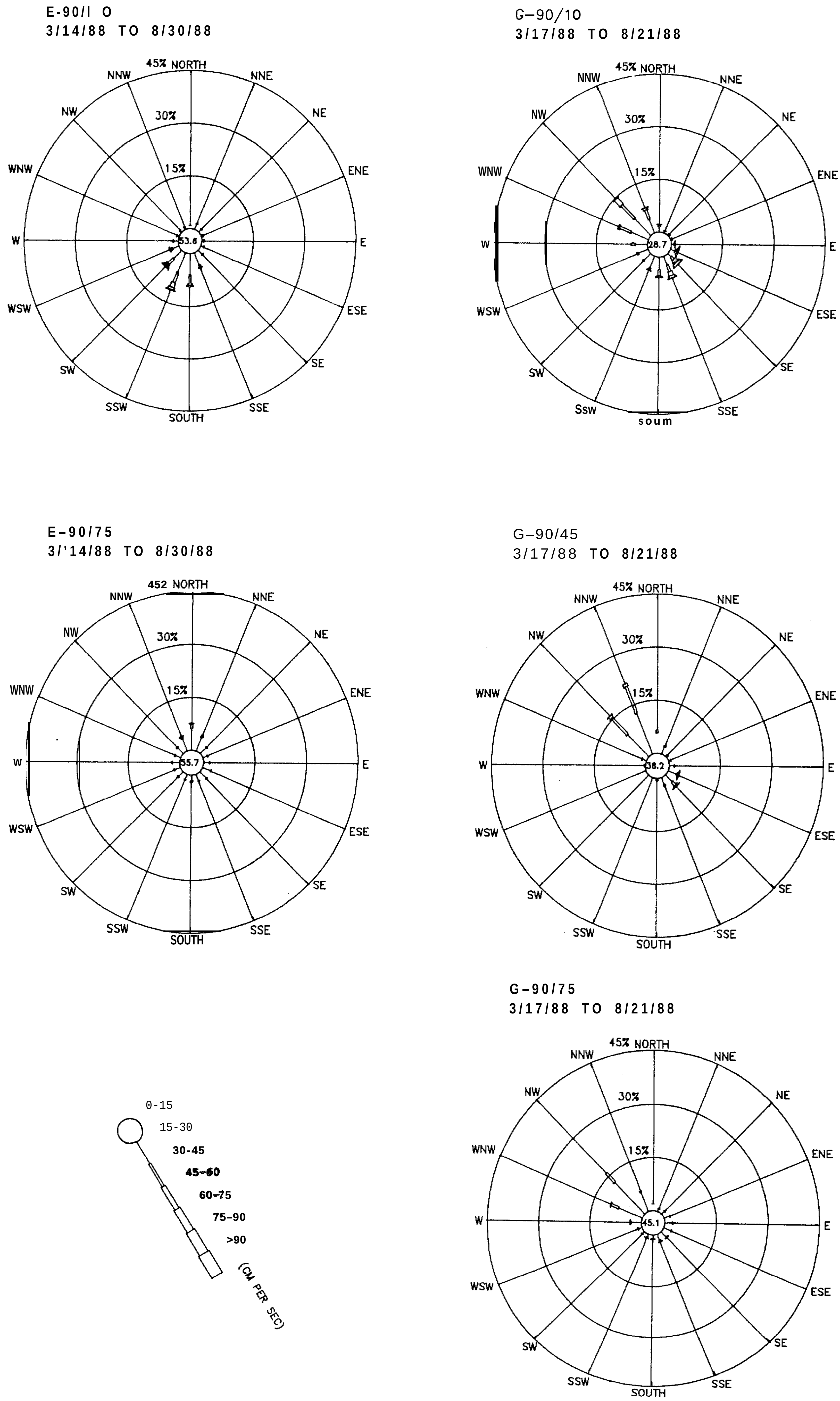


Figure 4-9d. Current roses based on hourly values: E-90 and G-90.

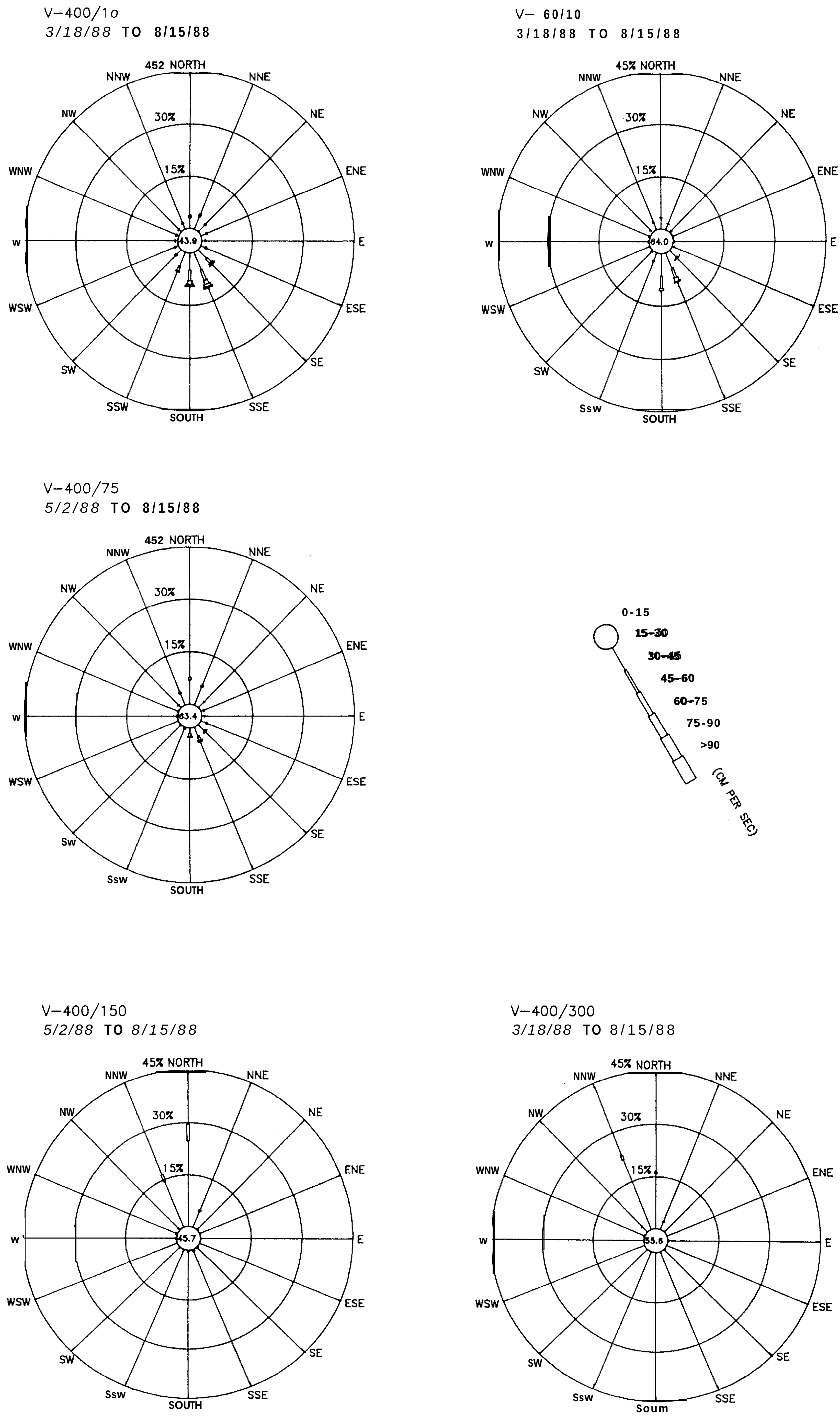


Figure 4-9e. Current roses based on hourly values: V-400 and V-60.

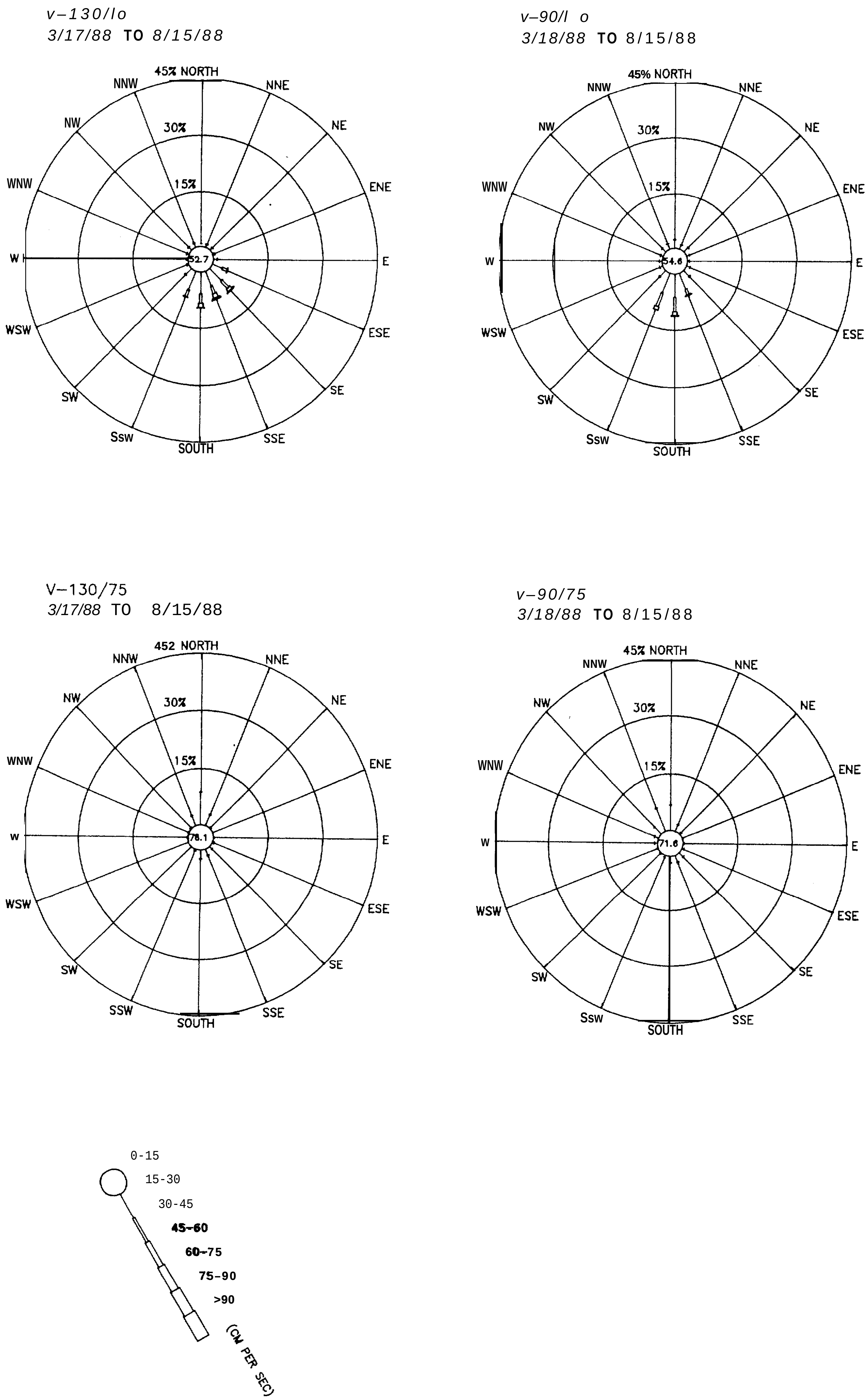


Figure 4-9f. Current roses based on hourly values: V-130 and V-90.

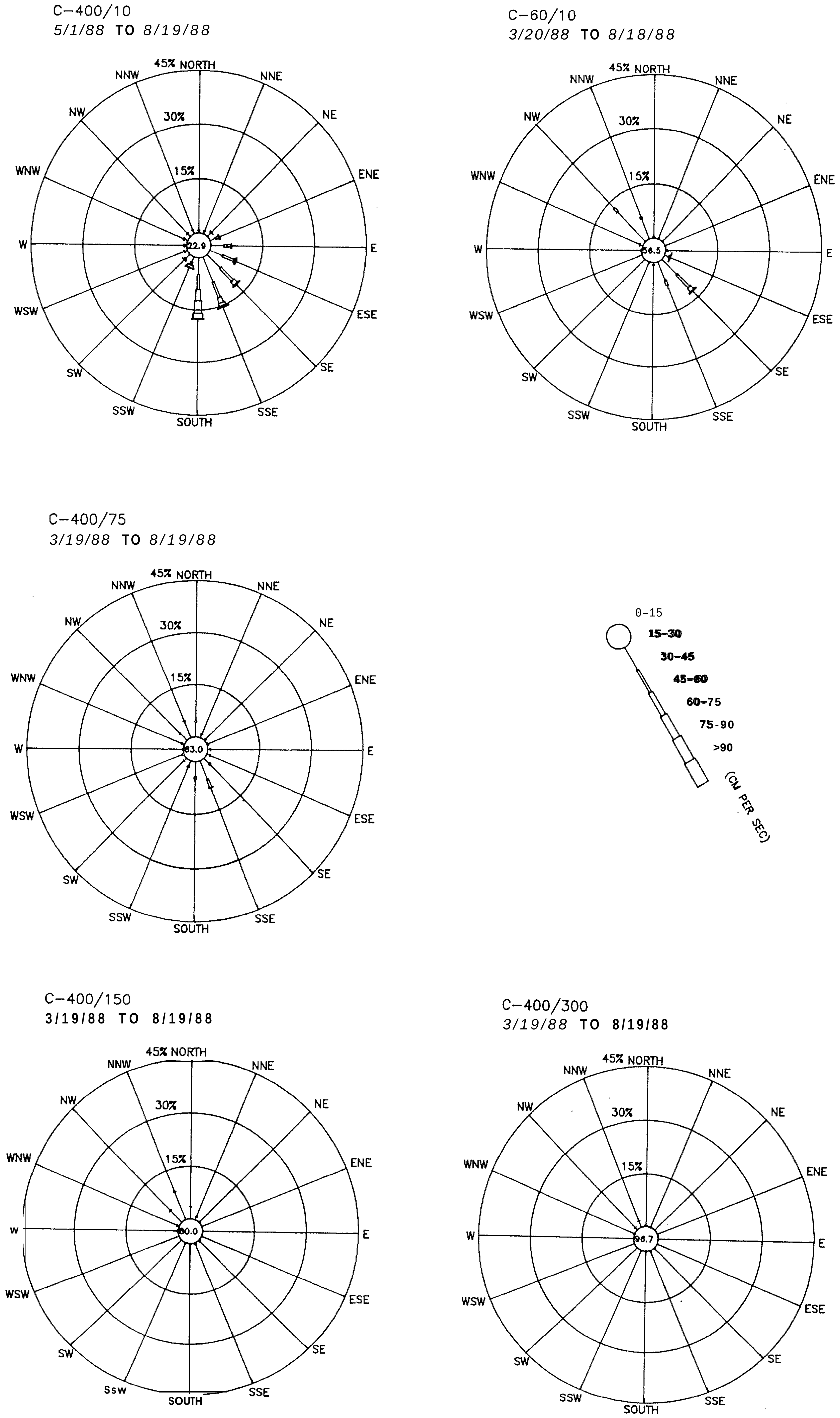
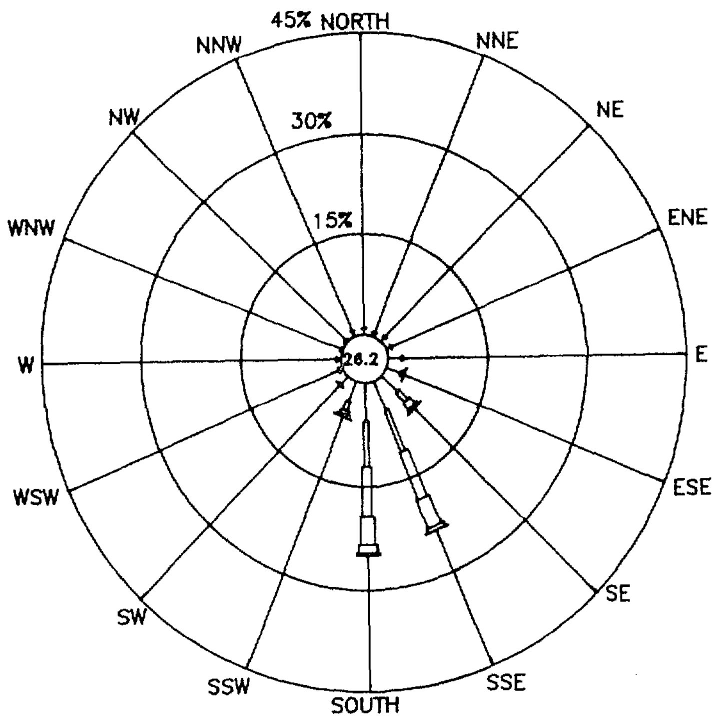
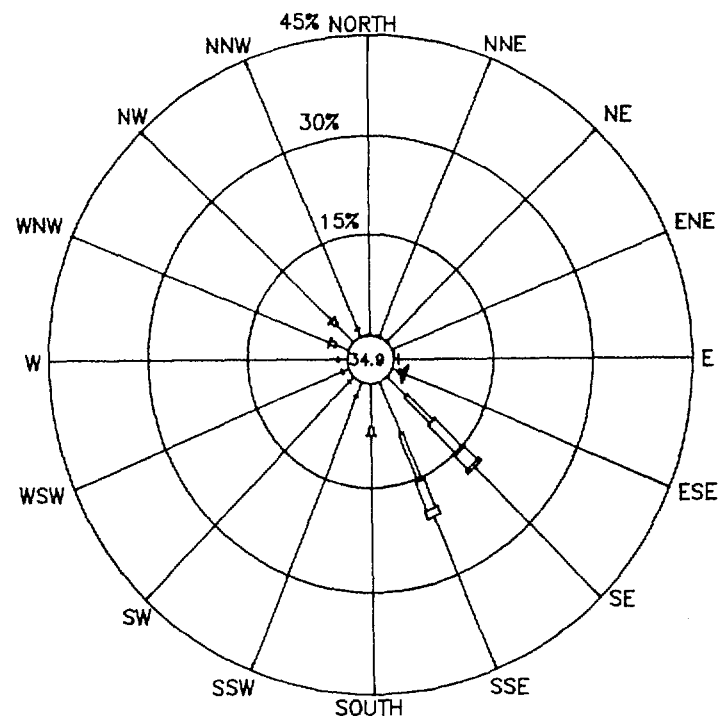


Figure 4-9g. Current roses based on hourly values: C-400 and C-60.

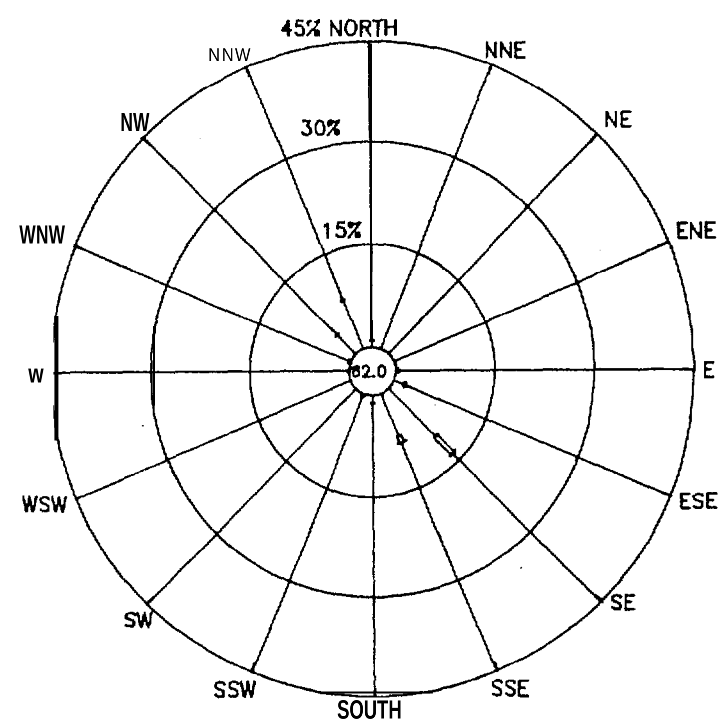
c-130/lo
3/19/88 TO 8/18/88



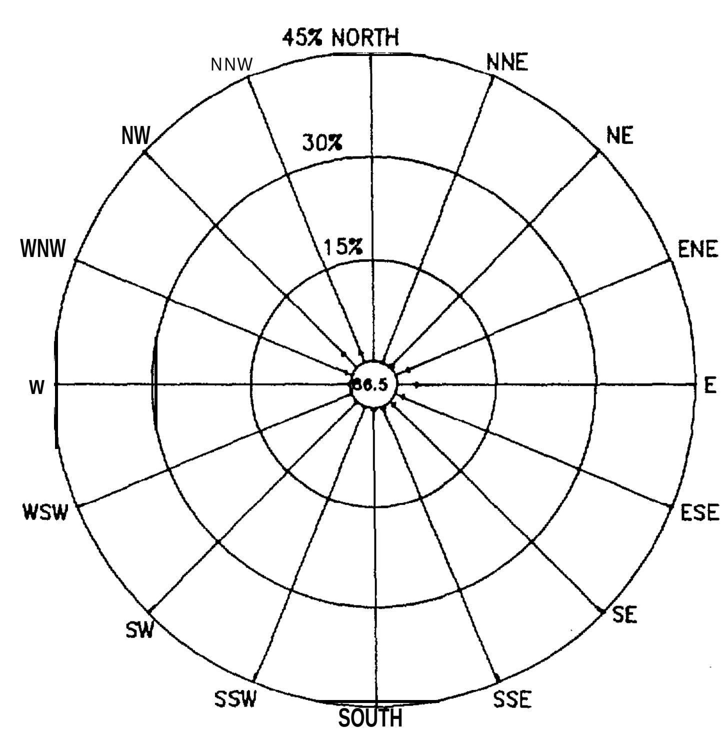
c-90/lo
3/20/88 TO 8/18/88



c-90/45
3/19/88 TO 8/18/88



c-90/75
3/20/88 TO 8/18/88



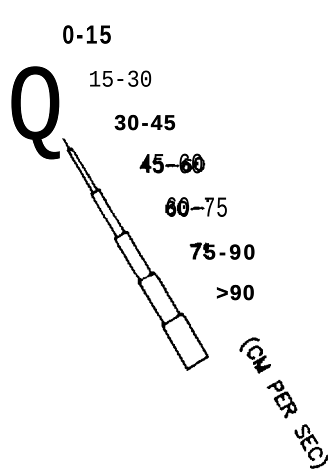


Figure 4-9h. Current roses based on hourly values: C-130 and C-90.

Table 4-5. Tidal harmonic constituents of current components and tidal ellipse parameters, March-August 1988.

K-60/10 Upcoast alongshore direction is 355° true

Constituent & Period (hours)		On-off Shore Ampl. (cm/see)	On-off Shore Phase[1] (deg)	Alongshore Ampl. (cm/see)	Alongshore Phase[1] (deg)	Major Axis (cm/see)	Minor Axis (cm/see)	Major Axis Orientation (° true)	Phase of Max. Curr.[3] (deg)	Sense of Rotation
Q_1	26.868	0.463	32.9	0.776	14.4	0.895	0.128	25.1	19.1	CW
O_1	25.819	0.247	191.4	1.660	70.8	1.664	0.212	350.6	70.2	CW
M_1	24.833	0.100	162.3	0.207	96,4	0.212	0.089	8.5	102.2	Cw
K_1	23.934	0.629	143.3	2.570	94.9	2.605	0.465	4.5	96.6	CW
J_1	23.098	0.163	284.9	0.150	197.7	0.164	0.149	249,7	90.9	CW
μ_2	12.872	0.967	139.3	0.967	55.3	1.017	0.914	40.2	97.5	CW
N_2	12.658	0,483	74.7	0.282	13.2	0.507	0.236	64.9	65.1	CW
M_2	12.421	0.795	218.6	4.396	154,2	4.410	0.715	359.6	154.9	CW
L_2	12.192	0.150	33.7	0.033	246.9	0.153	0.018	95,7	35.0	CW
S_2	12.000	1.006	189.1	2.132	143.4	2.257	0.680	15,2	149.7	Cw

K-90/10 Upcoast alongshore direction is 355" true

Constituent & Period (hours)		On-off Shore Ampl. (cm/see)	On-off Shore Phase[1] (deg)	Alongshore Ampl. (cm/see)	Alongshore Phase[1] (deg)	Major Axis (cm/see)	Minor Axis (cm/see)	Major Axis Orientation (° true)	Phase of Max. Curr.[3] (deg)	Sense of Rotation
Q_1	26.868	0.434	29.6	0.611	15.3	0.744	0.088	30.1	20.0	CW
O_1	25.819	0.568	164.5	1.975	81.7	1.977	0.563	357.2	82.4	CW
M_1	24.833	0.126	140.9	0.227	89.1	0.243	0.093	17.5	98.1	CW
K_1	23.934	1.282	77.4	2.314	80.3	2.644	0.057	24.0	79.6	Ccw
J_1	23.098	0.193	-52.3	0.162	208.2	0.198	0.155	286.2	144.6	CW
μ_2	12.872	1.222	52.1	1.113	321.6	1.222	1.113	87.7	54.6	CW
N_2	12.658	1.784	81.2	1.138	334.4	1.830	1.062	100.9	90.6	CW
M_2	12.421	4.220	121.9	2.658	111.2	4.969	0.422	53.0	118.9	CW
L_2	12.192	0,146	233.6	0.229	151.5	0.230	0.144	3,2	156.7	CW
S_2	12.000	1.819	359.1	2.348	222,1	2.779	1.049	139.7	27.1	CW

K-90/45 Upcoast alongshore direction is 355° true

Constituent & Period (hours)		On-off Shore Ampl. (cm/see)	On-off Shore Phase[1] (deg)	Alongshore Ampl. (cm/see)	Alongshore Phase[1] (deg)	Major Axis (cm/see)	Minor Axis (cm/see)	Major Axis Orientation[2] (° true)	Phase of Max. Curr.[3] (deg)	Sense of Rotation
Q_1	26.868	0.201	131.0	0.462	49.3	0.463	0.198	359.4	51.2	CW
O_1	25.819	0.817	111.1	1.752	49.9	1.804	0.695	9.9	55.7	CW
M_1	24.833	0.045	128.5	0.114	76.0	0.117	0.034	9.7	80.4	CW
K_1	23.934	1.386	153.7	3.003	94.8	3.101	1.149	10.6	100.7	CW
J_1	23.098	0.137	141.6	0.243	89.8	0.260	0.100	17.8	99.1	CW
μ_2	12.872	0.272	213.2	0.386	137.3	0.396	0.257	12.2	148.7	CW
N_2	12.658	0.635	247.1	1.395	154.1	1.395	0.634	353,3	153.3	CW
M_2	12.421	1.494	222.0	5.037	156.1	5.077	1.353	2.4	158.1	Cw
L_2	12.192	0.043	62.0	0.085	176.4	0.087	0.038	160.2	3.0	Ccw
S_2	12<000	0.742	206.4	2.203	157.4	2.260	0.546	8.3	160.7	CW

K-90/75 Upcoast alongshore direction is 355° true

Constituent & Period (hours)		On-off Shore Ampl. (cm/see)	On-off Shore Phase[1] (deg)	Alongshore Ampl. (cm/see)	Alongshore Phase[1] (deg)	Major Axis (cm/see)	Minor Axis (cm/see)	Major Axis Orientation (° true)	Phase of Max. Curr.[3] (deg)	Sense of Rotation
Q_1	26.868	0.359	177.2	0.472	85.3	0.472	0.358	351.5	82.6	Cw
O_1	25.819	0.809	148.7	1.746	64.6	1.749	0.804	358.5	66.2	CW
M_1	24.833	0.034	207.7	0.093	86.7	0.095	0.029	343.3	83.2	CW
K_1	23.934	1.835	198.9	3.153	107.8	3.153	1.835	354.1	107.3	Cw
J_1	23.098	0.185	162.1	0.307	91.8	0.316	0.169	11.3	100.7	Cw
μ_2	12.872	0.433	225.4	0.543	130.7	0.546	0,430	345.2	123.0	CW
N_2	12.658	0.374	0.7	0.721	137.7	0.777	0.236	331.9	145.1	Ccw
M_2	12.421	0.215	237,2	4.026	148.3	4.026	0.215	355,1	148.3	CW
L_2	12.192	0.148	114.4	0.086	95.1	0.169	0.025	55.6	109.7	CW
S_2	12.000	1.606	212.6	2.364	152.3	2.548	1.295	20.7	166.0	Cw

K-130/10 Upcoast alongshore direction is 355° true

Constituent & Period (hours)		On-off Shore Ampl. (cm/see)	On-off Shore Phase[1] (deg)	Alongshore Ampl. (cm/see)	Alongshore Phase[1] (deg)	Major Axis (cm/see)	Minor Axis (cm/sec)	Major Axis Orientation (" true)	Phase of Max. Curr.[3] (deg)	Sense of Rotation
Q_1	26.868	0.491	1.3	0.471	27.4	0.663	0.153	41.3	13.8	Ccw
O_1	25.819	0.553	156.7	1.383	57.5	1.386	0.545	350.7	55.8	Cw
M_1	24.833	0.150	119.1	0,113	75.3	0,176	0.067	50.9	104.7	CW
K_1	23.934	2.079	63.4	1.162	68.0	2.380	0.082	55,8	64.5	Ccw
J_1	23.098	0.177	-55.5	0.068	216.6	0.177	0.067	264.1	124,2	CW
μ_2	12.872	0.478	343.4	0.563	249.8	0.566	0.475	164.6	61.1	CW
N_2	12.658	1.862	5.4	1.295	247.5	2.003	1.064	110.8	19.8	CW
M_2	12.421	4.487	48.2	2.787	214.9	5.254	0.544	116.5	44.5	Ccw
L_2	12.192	0.167	89.9	0.090	132.5	0.182	0.056	60.9	97.8	CCW
S_2	12.000	2.099	210.7	2.331	164.3	2.886	1.228	215.7	4.4	Cw

Table 4-5. Continued.

K-130/75 Upcoast alongshore direction is 355″ true

Constituent & Period (hours)	On-off Shore Ampl. (cm/see)	On-off Shore Phase[1] (deg)	Alongshore Ampl. (cm/see)	Alongshore Phase[1] (deg)	Major Axis (cm/see)	Minor Axis (cm/see)	Major Axis Orientation[2] (″ true)	Phase of Max. Curr.[3] (deg)	Sense of Rotation
Q_1 26.868	0.302	160.5	0.402	58.8	0.412	0.289	337.6	46.4	CW
O_1 25.819	0.772	125.7	1.169	59.1	1.228	0.675	16.5	71.3	CW
M_1 24.833	0.026	171.8	0.085	99.3	0.086	0.025	0.7	101.0	CW
K_1 23.934	1.624	179.0	2.602	102.0	2.642	1.559	7.3	109.3	CW
J_1 23.098	0.177	146.7	0.190	83.0	0.221	0.137	35.5	110.8	CW
μ_2 12.872	0.500	99.9	0.299	65.8	0.563	0.149	56.5	91.7	CW
N_2 12.658	1,275	130.5	0.988	89.9	1.520	0.540	49.4	116.3	CW
M_2 12.421	3.158	177.2	4.754	139.7	5.457	1.672	26.0	150.2	CW
L_2 12.192	0.121	233.5	0.168	154.7	0,171	0.116	10.1	165,2	CW
S_2 12.000	0.911	344.0	2.041	191.2	2.201	0.387	152.6	7.1	CW

K-400/10 Upcoast alongshore direction is 355″ true

Constituent & Period (hours)	On-off Shore Ampl. (cm/see)	On-off Shore Phase[1] (deg)	Alongshore Ampl. (cm/see)	Alongshore Phase[1] (deg)	Major Axis (cm/see)	Minor Axis (cm/see)	Major Axis Orientation (° true)	Phase of Max. Curr.[3] (deg)	Sense of Rotation
Q_1 26.868	0.576	9.9	0.288	5.8	0.643	0.018	58.4	9.1	CW
O_1 25.819	1.181	128.1	1.349	90.2	1.698	0.577	35.2	106.2	CW
M_1 24.833	0.216	118.3	0.158	85,5	0.258	0.072	50.3	107.4	CW
K_1 23.934	2.334	90.5	1.602	73.5	2.804	0.392	51.0	85.1	CW
J_1 23.098	0.153	258.7	0.103	200.3	0.166	0.081	238.8	65.2	CW
μ_2 12.872	0.369	308.7	0.585	202.3	0.599	0.346	159.8	13.4	CW
N_2 12.658	1.360	336.0	1.651	216.0	1.869	1.041	140.7	15.1	CW
M_2 12.421	3.182	335.8	5.798	205.0	6,221	2.246	152.1	16.4	CW
L_2 12.192	0.040	117.0	0.084	143.6	0.092	0.017	18.9	139.1	CCW
S_2 12.000	2.098	188.0	2.042	134.8	2.618	1.311	41.3	162.4	CW

K-400/75 Upcoast alongshore direction is 355° true

Constituent & Period (hours)	On-off Shore Ampl. (cm/see)	On-off Shore Phase[1] (deg)	Alongshore Ampl. (cm/see)	Alongshore Phase[1] (deg)	Major Axis (cm/see)	Minor Axis (cm/see)	Major Axis Orientation (o true)	Phase of Max. Curr.[3] (deg)	Sense of Rotation
Q_1 26.868	0.398	91.2	0.379	55.7	0.523	0.167	41.8	74.5	CW
O_1 25.819	0.555	111.0	1.490	89.4	1.578	0.193	14.4	91.9	CW
M_1 24.833	0.063	175.2	0.146	105.8	0.148	0.058	5.3	110.0	CW
K_1 23.934	1.068	158.3	2.674	107.6	2.766	0.799	10.5	112.2	CW
J_1 23.098	0.021	-5.7	0.126	121.0	0,127	0.016	349.3	121.7	CCW
μ_2 12.872	0.368	306.6	0.370	161.7	0.497	0.157	310.2	144.3	CW
N_2 12.658	0.720	292.1	1.356	174.6	1.407	0.616	337.8	166.9	CW
M_2 12.421	0.747	275.2	5.663	161.1	5.671	0.682	351.9	160.7	CW
L_2 12.192	0.026	176.0	0.084	151.9	0.088	0.010	11.3	153.9	CW
S_2 12.000	1.017	224.1	2.905	168.2	2.966	0.825	7.0	171.6	CW

K-400/150 Upcoast alongshore direction is 355° true

Constituent & Period (hours)	On-off Shore Ampl. (cm/see)	On-off Shore Phase[1] (deg)	Alongshore Ampl. (cm/see)	Alongshore Phase[1] (deg)	Major Axis (cm/sec)	Minor Axis (cm/see)	Major Axis Orientation (° true)	Phase of Max. Curr.[3] (deg)	Sense of Rotation
Q_1 26.868	0.064	107.0	0.294	82.5	0.300	0.026	6.3	83.4	CW
O_1 25.819	0.510	118.7	1.068	93.5	1.166	0.198	19.1	97.9	CW
M_1 24.833	0.042	133.0	0,086	114.1	0.095	0.012	20.0	117.6	CW
K_1 23.934	1.064	159.0	1.876	116.9	2.056	0.651	20.6	125.5	CW
J_1 23.098	0.107	161.8	0.109	109.3	0.137	0.067	38.8	134.6	CW
μ_2 12.872	0.375	147.9	0.463	109.6	0.565	0.191	32.4	124.1	CW
N_2 12.658	1.006	198.1	2.091	136.8	2.157	0.855	10.5	143.1	CW
M_2 12.421	2.154	191.4	5.520	150.0	5.766	1.363	12.3	154.2	CW
L_2 12.192	0.079	327.5	0.162	211,6	0.167	0,069	160,4	25.4	CW
S_2 12.000	0.865	150,1	1.266	181.6	1.484	0.385	27.7	172.1	CCW

K-400/300 Upcoast alongshore direction is 355° true

Constituent & Period (hours)	On-off Shore Ampl (cm/see)	On-off Shore Phase[1] (deg)	Alongshore Ampl. (cm/see)	Alongshore Phase[1] (deg)	Major Axis (cm/see)	Minor Axis (cm/see)	Major Axis Orientation[2] (″ true)	Phase of Max. Curr.[3] (deg)	Sense of Rotation
Q_1 26.868	0.074	16.7	0.330	23.2	0.338	0.008	7.6	22.9	CCW
O_1 25.819	0.489	117.1	0.820	130.7	0.949	0.099	25.4	127.2	CCW
M_1 24.833	0.044	119.0	0.125	134,8	0.132	0.011	13.9	133.1	CCW
K_1 23.934	0.679	180.7	1.499	149.1	1.612	0.331	17.1	153.9	CW
J_1 23.098	0.123	200,7	0.167	216.2	0.206	0.027	211.0	30.8	CCW
μ_2 12.872	0.549	56,7	0.053	355.1	0.549	0.047	82.3	56.5	CW
N_2 12.658	1.312	79.9	0,512	116.8	1.377	0.292	66.8	83.9	CCW
M_2 12.421	3.937	134.3	3.582	141.9	5.311	0.352	42,7	137.7	CCW
L_2 12.192	0.131	177.3	0.134	157.9	0,184	0,031	39.3	167.4	CW
S_2 12.000	1.331	250.4	2.412	193.5	2.544	1.056	195.5	22.3	CW

Table 4-5. Continued.

E-60/10 Upcoast alongshore direction is 27″ true

Constituent & Period (hours)		On-off Shore Ampl. (cm/see)	On-off Shore Phase[1] (deg)	Alongshore Ampl. (cm/see)	Alongshore Phase[1] (deg)	Major Axis (cm/see)	Minor Axis (cm/see)	Mater Axis Orientation[2] (° true)	Phase of Max. Curr.[3] (deg)	Sense of Rotation
Q_1	26.868	0.228	302.4	0.396	272.5	0.446	0.101	235.1	99.4	CW
O_1	25.819	0.601	-0.1	2.907	281.5	2.909	0.588	209.5	102.0	CW
M_1	24.833	0.081	39.4	0.247	290.8	0.248 ″	0.076	200.4	108.8	CW
K_1	23.934	2.090	51.7	5.583	-51.1	5,605	2.030	201.5	126.9	CW
J_1	23.098	0.168	60.1	0.491	-46,0	0,493	0.160	200.9	132.0	CW
μ_2	12.872	0.187	126.3	0.119	79.7	0.207	0.078	89.0	115.0	CW
N_2	12.658	0.197	189.5	0.930	158.0	0.945	0.102	37.4	159.1	CW
M_2	12.421	1.293	341.3	4.836	192.2	4.964	0.647	193.8	10.4	CW
L_2	12.192	0.089	323.1	0.185	202.9	0.191	0.075	190.8	16.4	CW
S_2	12.000	1.106	103.6	0.536	269.5	1.223	0.118	142.4	101.0	CCW

E-90/10 Upcoast alongshore direction is 27° true

Constituent & Period (hours)		On-off Shore Ampl. (cm/see)	On-off Shore Phase[1] (deg)	Alongshore Ampl. (cm/see)	Alongshore Phase[1] (deg)	Major Axis (cm/see)	Minor Axis (cm/see)	Major Axis Orientation (″ true)	Phase of Max. Curr.[3] (deg)	Sense of Rotation
Q_1	26.868	0.389	56.1	0.472	279,3,	0.570	0.220	169.5	82.8	CW
O_1	25.819	1.176	69.3	1.998	286,2	2.230	0.632	179.4	97.8	CW
M_1	24.833	0.114	95.0	0.154	-52.8	0.184	0.050	172.0	116.3	CW
K_1	23.934	2.863	84.6	3.756	-40.4	4.241	2.078	174.8	122.5	CW
J_1	23.098	0.177	58.7	0,285	-43.6	0.289	0.170	195.4	129.5	CW
μ_2	12.872	0.159	78.9	0.092	252.6	0.184	0.009	146.9	77.3	CCW
N_2	12.658	0.731	339.0	0.644	177.7	0.962	0.157	338.2	167.2	CW
M_2	12.421	2.303	316.5	5,613	192.3	5.779	1.849	192.5	7.6	CW
L_2	12.192	0.061	13.2	0.182	179.0	0.192	0.014	189.0	0.4	CCW
S_2	12.000	1.578	57.9	1.913	273.1	2.369	0.734	168.7	79.3	CW

E-90/75 Upcoast alongshore direction is 27° true

Constituent & Period (hours)		On-off Shore Ampl. (cm/see)	On-off Shore Phase[1] (deg)	Alongshore Ampl. (cm/see)	Alongshore Phase[1] (deg)	Maj or Axis (cm/see)	Minor Axis (cm/see)	Major Axis Orientation (° true)	Phase of Max. Curr.[3] (deg)	Sense of Rotation
Q_1	26.868	0.696	-39.8	0.567	231.4	0.697	0.566	294.2	137.9	CW
O_1	25.819	3.200	9.0	4.155	268.5	4.246	3.079	189.6	75.7	CW
M_1	24.833	0.275	30.7	0.341	277.1	0.372	0.230	176.3	76.8	CW
K_1	23.934	5.650	68.0	6.046	-49.6	7.086	4.274	166.2	102.9	CW
J_1	23.098	0.638	86.9	0.662	-27.3	0.772	0.499	164.6	122.2	CW
μ_2	12.872	0.225	273.6	0.401	163.1	0.411	0.205	12.1	155.5	CW
N_2	12.658	0.961	261.8	1,951	155.9	1.974	0.914	17.2	151.3	CW
M_2	12.421	3.343	60.0	2.921	184.7	3.945	2.036	155.3	.37.8	CCW
L_2	12.192	0.188	22.8	0.164	231.9	0.242	0.062	157.6	35.2	CW
S_2	12.000	2.414	149.3	0.973	107.5	2.528	0.618	99.2	144.8	CW

E-400/10 Upcoast alongshore direction is 27° true

Constituent & Period (hours)		On-off Shore Ampl. (cm/see)	On-off Shore Phase[1] (deg)	Alongshore Ampl. (cm/see)	Alongshore Phase[1] (deg)	Major Axis (cm/see)	Minor Axis (cm/sec)	Major Axis Orientation (° true)	Phase of Max. Curr.[3] (deg)	Sense of Rotation
Q_1	26.868	0,621	31.7	0.436	275.3	0.666	0.364	142.4	46.3	CW
O_1	25.819	1.048	33.7	1.564	286.9	1.611	0.974	189.5	96.1	CW
M_1	24.833	0.083	98.7	0.131	-52.5	0.151	0.035	176.1	119.7	CW
K_1	23.934	1.992	76.7	2.921	-52.4	3.251	1.390	177.9	114.2	CW
J_1	23.098	0.096	8.3	0.170	296.4	0.174	0.090	220.7	123.6	CW
μ_2	12.872	0.358	234.0	0.818	145.7	0.818	0.358	27.9	146.0	CW
N_2	12.658	0.875	262,3	2.060	163.4	2.066	0.862	22.4	161.4	CW
M_2	12,421	3.600	234.1	8.108	166.4	8.244	3.277	38.4	170.9	CW
L_2	12,192	0.052	127.8	0.070	163.2	0.084	0.025	61.8	151.3	CCW
S_2	12.000	1.497	284.4	2.920	190.1	2.923	1.491	204.0	8.6	CW

E-400/75 Upcoast alongshore direction is 27° true

Constituent & Period (hours)		On-off Shore Ampl. (cm/see)	On-off Shore Phase[1] (deg)	Alongshore Ampl. (cm/see)	Alongshore Phase[1] (deg)	Major Axis (cm/see)	Minor Axis (cm/see)	Major Axis Orientation[2] (° true)	Phase of Max. Curr.[3] (deg)	Sense of Rotation
Q_1	26.868	0.304	1.7	0.071	255.6	0.305	0.068	120.9	2.6	CW
O_1	25.819	1.647	42.0	1.179	284.1	1.782	0.963	143.9	57.4	CW
M_1	24.833	0.152	52.7	0.113	284.8	0.172	0.078	148.8	68.4	CW
K_1	23.934	2.571	68.5	2.232	303.7	3.029	1.555	155.0	90.4	CW
J_1	23.098	0.193	97.1	0.206	-41.7	0.264	0.099	164.5	119.3	CW
μ_2	12.872	0.311	228.1	0.428	142.9	0.430	0.309	34.3	148.2	CW
N_2	12.658	0.891	253.0	1.587	151.8	1.600	0.867	18.2	147.0	CW
M_2	12.421	2.819	277.7	7.777	174.9	7.805	2.739	21.8	173.0	CW
L_2	12.192	0.059	317.5	0.207	174.9	0.213	0.035	13.9	172.7	CW
S_2	12.000	0.379	234.4	1.765	198.7	1.792	0.218	217.0	19.9	CW

Table 4-5. Continued.

E-400/150 — Upcoast alongshore direction is 27° true

Constituent	Period (hours)	On-off Shore Ampl. (cm/sec)	On-off Shore Phase[1] (deg)	Alongshore Ampl. (cm/sec)	Alongshore Phase[1] (deg)	Major Axis (cm/sec)	Minor Axis (cm/sec)	Major Axis Orientation[2] (° true)	Phase of Max. Curr.[3] (deg)	Sense of Rotation
Q_1	26.868	0.072	18.4	0.156	159.0	0.166	0.043	6.1	164.6	CCW
O_1	25.819	0.902	24.1	0.758	275.5	0.970	0.667	147.6	46.2	CW
M_1	24.833	0.076	27.0	0.095	272.5	0.104	0.063	176.3	72.7	CW
K_1	23.934	1.589	53.6	1.280	291.3	1.804	0.953	150.9	73.2	CW
J_1	23.098	0.163	64.6	0.137	-19.6	0.165	0.135	102,1	52.3	CW
μ_2	12.872	0.510	113.2	0.354	40.4	0.528	0.327	97.8	101.0	CW
N_2	12.658	0.444	166.0	0.663	114.4	0.733	0.315	55.2	127.4	CW
M_2	12.421	1.277	217.8	4.141	149.7	4.170	1.177	34,1	151.7	CW
L_2	12.192	0.101	309.0	0.132	178.3	0.152	0.066	353.0	161.9	CW
S_2	12.000	0.891	148.4	0.813	162.4	1.197	0.146	74.7	154.8	CCW

E-400/300 — Upcoast alongshore direction is 27° true

Constituent	Period (hours)	On-off Shore Ampl. (cm/sec)	On-off Shore Phase[1] (deg)	Alongshore Ampl. (cm/sec)	Alongshore Phase[1] (deg)	Major Axis (cm/sec)	Minor Axis (cm/sec)	Major Axis Orientation[2] (° true)	Phase of Max. Curr.[3] (deg)	Sense of Rotation
Q_1	26.868	0,031	35.6	0.103	183.0	0.106	0.016	192.6	5.2	CCW
O_1	25.819	0.330	30.6	0.428	148.0	0.470	0.267	356.8	166.3	CCW
M_1	24.833	0.038	39.7	0.012	157.0	0.038	0.010	125.7	37.4	CCW
K_1	23.934	1.103	44.2	0.642	230.9	1.275	0.065	147.1	45.9	CW
J_1	23.098	0.097	35.9	0.082	210.5	0.127	0.006	157.3	33.6	CCW
μ_2	12.872	0.591	342.5	0.257	306.7	0.628	0.142	276.5	157.7	CW
N_2	12.658	0.361	342.6	0.503	140.2	0.609	0.113	352.1	147.6	CCW
M_2	12.421	3.610	25.6	2.183	123.3	3.628	2.153	124.2	21.4	CCW
L_2	12.192	0.066	306.2	0.100	174.1	0.112	0.044	358.6	162.1	CW
S_2	12.000	2.181	45.4	0.380	166.2	2.189	0.325	122.2	44.6	CCW

G-90/10 — Upcoast alongshore direction is 317° true

Constituent	Period (hours)	On-off Shore Ampl. (cm/sec)	On-off Shore Phase[1] (deg)	Alongshore Ampl. (cm/sec)	Alongshore Phase[1] (deg)	Major Axis (cm/sec)	Minor Axis (cm/sec)	Major Axis Orientation[2] (° true)	Phase of Max. Curr.[3] (deg)	Sense of Rotation
Q_1	26.868	0.715	41.6	1.538	-16.2	1.592	0.584	153.2	169.9	CW
O_1	25.819	2.247	50.4	3.861	12.6	4.292	1.239	344.1	21.0	CW
M_1	24.833	0.172	79.1	0.356	54.5	0.390	0.065	341.5	58.9	CW
K_1	23.934	4.033	82.0	7.562	66.2	8.514	0.975	344.6	69.6	CW
J_1	23.098	0.235	70.3	0.448	85.8	0.503	0.056	344.2	82.5	CCW
μ_2	12.872	0.524	157,0	0.631	124.7	0.789	0.224	355.8	137.5	CW
N_2	12.658	0.857	137.7	3.722	145.2	3.818	0.109	329.9	144,8	CCW
M_2	12.421	3.576	185.6	14.626	160.6	14,984	1.476	329.6	161.8	CW
L_2	12.192	0.089	171.7	0.430	182.1	0.439	0.016	148.5	1.6	CCW
S_2	12.000	2.723	217.9	4.509	169.8	4.930	1.854	162.9	0.1	CW

G-90/45 — Upcoast alongshore direction is 317° true

Constituent	Period (hours)	On-off Shore Ampl. (cm/sec)	On-off Shore Phase[1] (deg)	Alongshore Ampl. (cm/sec)	Alongshore Phase[1] (deg)	Major Axis (cm/sec)	Minor Axis (cm/sec)	Major Axis Orientation (° true)	Phase of Max. Curr.[3] (deg)	Sense of Rotation
Q_1	26.868	0.430	52.0	0.532	-8.4	0.598	0.332	350.3	11.7	CW
O_1	25.819	1.229	67.2	2.435	25.2	2.618	0.765	339.6	32.1	CW
M_1	24.833	0.089	95.3	0.210	53.7	0.221	0.056	335,9	58.7	CW
K_1	23.934	1.538	99.9	5.425	79.4	5.614	0.521	332.0	80.8	CW
J_1	23.098	0.047	116.5	0.513	85.9	0.515	0.024	321.5	86.2	CW
μ_2	12.872	0.448	121.1	0,484	75.8	0.609	0.254	358.9	96.2	CW
N_2	12.658	1.025	98.5	2.125	138.9	2.276	0.621	338.9	132.7	CCW
M_2	12.421	5.328	145.8	11.001	144.5	12.223	0,112	342.8	144.7	CW
L_2	12.192	0.183	125.9	0.232	168.8	0.276	0,105	352.9	153.6	CCW
S_2	12.000	1.531	173.0	3.239	169.5	3.582	0.084	342.3	170.1	CW

G-90/75 — Upcoast alongshore direction is 317″ true

Constituent	Period (hours)	On-off Shore Ampl. (cm/sec)	On-off Shore Phase[1] (deg)	Alongshore Ampl. (cm/sec)	Alongshore Phase[1] (deg)	Major Axis (cm/sec)	Minor Axis (cm/sec)	Major Axis Orientation[2] (° true)	Phase of Max. Curr.[3] (deg)	Sense of Rotation
Q_1	26.868	0.372	94.6	0.489	57.3	0.585	0,189	352.4	70.2	CW
O_1	25.819	0.625	138.0	1.910	33.2	1.917	0.602	311.7	31.5	CW
M_1	24.833	0.059	184.8	0.100	62.6	0.106	0.047	295.2	52.6	CW
K_1	23.934	0.703	244.9	4.143	85.7	4.195	0.247	308.0	85,2	CW
J_1	23.098	0.156	288.5	0.431	68.5	0.448	0.096	300.7	72.0	CCW
μ_2	12.872	0.152	44.8	0.216	80.7	0.253	0.076	350,0	69.7	CCW
N_2	12.658	1.166	78.0	1.881	117.6	2.111	0.662	345.6	107.9	CCW
M_2	12.421	4.819	114.0	9.515	136.1	10.540	1.635	342.8	131.8	CCW
L_2	12.192	0.198	123.9	0.289	152.8	0.341	0.081	350.0	144.0	CCW
S_2	12.000	0.658	58.7	3.413	186.6	3.437	0.515	130.1	7.6	CCW

Table 4-5. Continued

v-60/10 Upcoast alongshore direction is 354° true

Constituent & Period (hours)	On-off Shore Ampl. (cm/see)	On-off Shore Phase[1] (deg)	Alongshore Ampl. (cm/see)	Alongshore Phase[1] (deg)	Major Axis (cm/see)	Minor Axis (cm/see)	Major Axis Orientation[2] (° true)	Phase of Max. Curr.[3] (deg)	Sense of Rotation
Q_1 26.868	0.106	156.7	0.405	59.8	0.405	0.105	352.0	59.2	CW
O_1 25.819	0.224	16.3	0.985	117.8	0.986	0.219	351.3	118.4	CCW
M_1 24.833	0.022	-15.8	0.070	142.6	0.073	0.008	337.4	144.4	CCW
K_1 23.934	0.608	62.2	1.395	254.7	1.517	0.121	150.8	72.7	CW
J_1 23.098	0.116	57.5	0.322	254.7	0.340	0.032	154.8	72.8	CW
μ_2 12.872	1.320	351.7	0.901	270.2	1.332	0.883	253.6	164.7	CW
N_2 12.658	1.806	314.8	1.479	226.9	1.808	1.476	258.9	130.7	CW
M_2 12.421	2.048	76.2	0.445	87.2	2.094	0.083	71.9	76.7	CCW
L_2 12.192	0.011″	345.0	0.019	197.9	0.022	0.005	147.0	10.8	CW
S_2 12.000	0.453	19.7	0.991	212.6	1.085	0.093	149.8	30.4	CW

v-90/lo Upcoast alongshore direction is 354″ true

Constituent & Period (hours)	On-off Shore Ampl. (cm/see)	On-off Shore Phase[1] (deg)	Alongshore Ampl. (cm/see)	Alongshore Phase[1] (deg)	Major Axis (cm/see)	Minor Axis (cm/see)	Major Axis Orientation[2] (° true)	Phase of Max. Curr.[3] (deg)	Sense of Rotation
Q_1 26.868	0.198	133,3	0.201	64.7	0.233	0.159	37.3	97.7	CW
O_1 25.819	0.348	82.5	1.008	115.0	1.051	0.179	10.7	112.0	CCW
M_1 24.833	0.014	34.6	0.047	127.6	0.047	0.014	353.0	127.9	CCW
K_1 23.934	0.713	57.9	1.780	240.7	1.917	0.033	152.2	60.3	CW
J_1 23.098	0.111	40.8	0.311	230.0	0.329	0.017	154.5	49.0	CW
μ_2 12.872	1.216	318.3	0.620	247.2	1.238	0,576	252.0	132.6	CW
N_2 12.658	1.675	285.4	1.178	190,1	1.682	1.169	271.1	110.3	CW
M_2 12.421	3.443	55.1	0.740	309.7	3.449	0.712	87.4	55.9	CW
L_2 12.192	0.075	27.7	0.089	240.6	0.112	0.032	135.0	47.4	CW
S_2 12.000	0.813	304.5	0.835	214.1	0.836	0.813	166.8	27.1	CW

v-90/75 Upcoast alongshore direction is 354″ true

Constituent & Period (hours)	On-off Shore Ampl. (cm/see)	On-off Shore Phase[1] (deg)	Alongshore Ampl. (cm/see)	Alongshore Phase[1] (deg)	Major Axis (cm/see)	Minor Axis (cm/see)	Major Axis Orientation (″ true)	Phase of Max. Curr.[3] (deg)	Sense of Rotation
Q_1 26.868	0.223	184.6	0.288	109.6	0.300	0.207	16,5	125.6	CW
O_1 25.819	0.190	147.3	1.078	118.2	1.091	0.091	2.8	118.9	CW
M_1 24.833	0.014	-52.6	0.056	155.5	0.057	0.006	341.4	154.1	CW
K_1 23.934	0.288	148.0	1.802	199.7	1.811	0.225	179.8	19.0	CCW
J_1 23.098	0.090	95.0	0.191	200.3	0.193	0.086	165.1	24.3	CCW
μ_2 12.872	1.315	112.6	0.718	23.7	1.315	0.718	83.1	112,1	CW
N_2 12.658	2.066	84.9	0.669	4.2	2.069	0.659	80.7	83.9	CW
M_2 12.421	1.950	187.7	2.097	128.1	2.488	1.418	34.9	154.3	CW
L_2 12.192	0.031	205.2	0.045	190.5	0.054	0.007	208.5	15.2	CW
S_2 12.000	0.772	68.5	0.261	124.1	0.787	0.211	72.3	71.7	CCW

v-130/lo Upcoast alongshore direction is 354″ true

Constituent & Period (hours)	On-off Shore Ampl. (cm/see)	On-off Shore Phase[1] (deg)	Alongshore Ampl. (cm/see)	Alongshore Phase[1] (deg)	Major Axis (cm/sec)	Minor Axi S (cm/sec)	Major Axis Orientation (° true)	Phase of Max. Curr.[3] (deg)	Sense of Rotation
Q_1 26.868	0.240	70.9	0.400	-18.0	0.400	0.240	175.0	162.6	CW
O_1 25.819	0.244	244.9	0.799	128.3	0.807	0.216	345.6	126.1	CW
M_1 24.833	0.042	153.3	0.098	95.3	0.101	0.035	8.7	100.5	CW
K_1 23.934	2.166	49,5	1.527	293.8	2.317	1.287	109.3	64.2	CW
J_1 23.098	0.315	3,8	0,412	245.5	0.453	0.252	144.0	47.7	CW
μ_2 12.872	0.657	4,7	0.477	272.1	0.658	0.476	87.9	7.5	CW
N_2 12.658	0.841	327.6	0.880	214.9	1.014	0.673	132.4	4,4	CW
M_2 12.421	2.526	356.6	0.951	236.9	2.574	0.811	95.7	0.4	CW
L_2 12.192	0.100	298.5	0.068	223.3	0.103	0.065	247.4	107.9	CW
S_2 12.000	1.465	55.0	0.404	311.0	1.469	0.391	88.1	56.1	CW

v-130/75 Upcoast alongshore direction is 354″ true

Constituent & Period (hours)	On-off Shore Ampl. (cm/see)	On-off Shore Phase[1] (deg)	Alongshore Ampl. (cm/see)	Alongshore Phase[1] (deg)	Major Axis (cm/see)	Minor Axis (cm/see)	Major Axis Orientation (″ true)	Phase of Max. Curr.[3] (deg)	Sense of Rotation
Q_1 26.868	0.230	192.0	0.302	132.9	0.336	0.178	24.9	150.5	CW
O_1 25.819	0.562	154,7	1.200	122.1	1.295	0.281	16.7	127.2	CW
M_1 24.833	0.017	135.7	0.042	141,3	0,045	0.002	16.5	140.4	CCW
K_1 23.934	0.537	155.6	1,426	210.1	1.464	0.426	187.5	26.1	CCW
J_1 23.098	0.076	129.0	0.170	203.3	0.172	0.073	182.5	19.7	CCW
μ_2 12.872	0.149	348.0	0.093	281.2	0.156	0.082	244.5	157.4	CW
N_2 12.658	0.235	338.8	0.358	189.4	0.416	0.103	142.3	0.7	CW
M_2 12.421	2.072	114.1	1.234	105.0	2.405	0.168	53.4	111.7	CW
L_2 12.192	0.086	88.7	0.011	349.1	0.086	0.011	85.2	88.8	CW
S_2 12.000	0.066	92.0	0.410	189.6	0.410	0.066	172.7	9.8	CCW

Table 4-5. Continued.

V-400/10 Upcoast alongshore direction is 354° true

Constituent & Period (hours)	On-off Shore Ampl. (cm/see)	On-off Shore Phase[1] (deg)	Alongshore Ampl. (cm/see)	Alongshore Phase[1] (deg)	Major Axis (cm/see)	Minor Axis (cm/see)	Major Axis Orientation (° true)	Phase of Max. Curr.[3] (deg)	Sense of Rotation
Q_1 26.868	0.353	22.4	0.216	283.0	0.356	0.212	92.9	27.7	CW
O_1 25.819	0.616	169.9	1.270	124.0	1.348	0.417	14.7	130.6	CW
M_1 24.833	0.126	122.4	0.113	66.9	0.150	0.078	44.5	99.2	CW
K_1 23.934	2.699	46.1	2.095	-54.1	2.756	2.020	101.3	58.9	CW
J_1 23.098	0.307	-27.1	0.376	241.3	0.376	0.307	169.9	57.9	CW
μ_2 12.872	0.579	129.4	0.366	108.3	0.676	0.113	52.5	123.6	CW
N_2 12.658	0.889	81.7	0.367	179.5	0.890	0.363	87.8	80.1	CCW
M_2 12.421	1.686	173.3	2.254	138.0	2.694	0.815	29.1	150.0	CW
L_2 12.192	0.087	107.6	0.081	4.1	0.094	0.073	120.2	137.3	CW
S_2 12.000	0.619	43.5	1.026	191.9	1.164	0.286	144,9	19.7	CCW

V-400/75 Upcoast alongshore direction is 354° true

Constituent & Period (hours)	On-off Shore Ampl. (cm/see)	On-off Shore Phase[1] (deg)	Alongshore Ampl. (cm/see)	Alongshore Phase[1] (deg)	Major Axis (cm/see)	Minor Axis (cm/sec)	Major Axis Orientation (" true)	Phase of Max. Curr.[3] (deg)	Sense of Rotation
Q_1 26.868	0.327	168.9	0.143	49.3	0.335	0.121	98.1	174.1	CW
O_1 25.819	0.082	128.0	1.241	165.9	1.242	0.050	357.0	165.8	Ccw
M_1 24.833	0.057	294.6	0.127	162.9	0.134	0.041	335.7	157.1	CW
K_1 23.934	0.774	258.1	1.892	199.3	1.940	0.646	187.5	23.9	CW
J_1 23.098	0.051	85.2	0.259	230.5	0.263	0.028	164.8	51.5	CCW
μ_2 12.872	0.250	164.2	0.041	109.1	0.251	0.033	78.6	163.5	CW
N_2 12.658	0.268	86.4	0,489	194.0	0.498	0.251	161.3	20.5	CCW
M_2 12.421	1.181	153.6	1.644	157.0	2.023	0.057	29.7	155.8	CCW
L_2 12.192	0.053	105.8	0.021	216.9	0.054	0.019	93.3	102.5	Ccw
S_2 12.000	2.013	227.3	1.578	149.8	2.076	1.493	243.3	32.1	CW

V-400/150 Upcoast alongshore direction is 354° true

Constituent & Period (hours)	On-off Shore Ampl. (cm/see)	On-off Shore Phase[1] (deg)	Alongshore Ampl. (cm/see)	Alongshore Phase[1] (deg)	Major Axis (cm/see)	Minor Axis (cm/sec)	Major Axis Orientation (° true)	Phase of Max. Curr.[3] (deg)	Sense of Rotation
Q_1 26.868	0.060	204.5	0.078	223.4	0.097	0.016	211.3	36.4	Ccw
O_1 25.819	0.182	231.5	1.308	154.4	1.309	0.177	355.8	154.6	CW
M_1 24.833	0.012	282.2	0.093	149.3	0.094	0.009	348.9	148.9	CW
K_1 23.934	0.393	-38.5	2.117	201.8	2.127	0.340	168.6	21,0	CW
J_1 23.098	0.042	-33.0	0.304	206.0	0.305	0.036	169.8	25.5	CW
μ_2 12.872	0.418	89.7	0.176	4.0	0.418	0.175	81.8	88.8	CW
N_2 12.658	0.532	22.0	0.679	229.3	0.839	0.198	136.7	39.2	CW
M_2 12.421	1.253	194.1	2.435	146.9	2.600	0.861	15.8	154.5	CW
L_2 12.192	0.051	84.5	0.033	348.1	0.052	0.032	90.7	88.8	CW
S_2 12.000	0.991	62.1	0.626	195.8	1.099	0.408	111.7	51.0	Ccw

V-400/300 Upcoast alongshore direction is 354° true

Constituent & Period (hours)	On-off Shore Ampl. (cm/see)	On-off Shore Phase[1] (deg)	Alongshore Ampl. (cm/see)	Alongshore Phase[1] (deg)	Major Axis (cm/see)	Minor Axis (cm/see)	Major Axis Orientation (" true)	Phase of Max. Curr.[3] (deg)	Sense of Rotation
Q_1 26.868	0.063	203.5	0.178	194.4	0.189	0.009	193.3	15.4	CW
O_1 25.819	0.271	201.2	1.456	144.8	1.463	0.225	0.0	145.7	CW
M_1 24.833	0.010	166.7	0.088	139.8	0.089	0.005	0.0	140.1	CW
K_1 23.934	0.292	32.5	2.161	192.9	2.178	0.097	166.7	13.2	Ccw
J_1 23.098	0.046	-4.5	0,300	192.2	0.304	0.013	165.6	11.8	CW
μ_2 12.872	0.617	282.3	0.542	166.1	0.701	0.428	300.8	126.8	CW
N_2 12.658	0.848	264.1	0.745	163.4	0.883	0.703	291,6	106.7	CW
M_2 12.421	2.675	42.8	1.718	233.9	3.167	0.278	116.5	46.0	CW
L_2 12.192	0.091	39,0	0.026	253,0	0.094	0.014	97.6	41.1	CW
S_2 12.000	0.437	188.9	1.530	149.3	1.568	0.272	6.8	151.5	CW

V-400/300a Upcoast alongshore direction is 354° true

Constituent & Period (hours)	On-off Shore Ampl. (Cm/see)	On-off Shore Phase[1] (deg)	Alongshore Ampl. (cm/see)	Alongshore Phase[1] (deg)	Major Axis (cm/see)	Minor Axis (cm/see)	Major Axis Orientation[2] (° true)	Phase of Max. Curr.[3] (deg)	Sense of Rotation
Q_1 26.868	0.174	-19.9	0.391	207.3	0.410	0.122	155.4	21.6	CW
O_1 25.819	0.243	185.7	2.034	160.4	2.045	0.103	0.2	160.8	CW
M_1 24.833	0.038	141.8	0.135	153.5	0.140	0.007	9.4	152.7	CCW
K_1 23.934	0.443	216.2	3.409	179.8	3.427	0.262	180.0	0.2	CW
J_1 23.098	0.124	232.7	0.382	176.0	0.389	0.102	4.9	178.9	CW
μ_2 12.872	1.318	303.9	1.304	227.0	1.452	1.153	220.4	86.8	CW
N_2 12.658	1.630	316.3	1.399	200.5	1.832	1.121	299,3	159.7	CW
M_2 12.421	5.949	25.5	3.088	280.0	6.025	2.938	94.4	30.7	CW
L_2 12.192	0.118	77.3	0.089	159.0	0.119	0.087	70.5	87.2	CCW
S_2 12.000	0.580	341.2	1.313	168.4	1.434	0.067	330.3	167.3	CW

Table 4-5. Continued.

V-400/300b Upcoast alongshore direction is 354° true

Constituent & Period (hours)	On-off Shore Ampl. (cm/see)	On-off Shore Phase[1] (deg)	Alongshore Ampl. (cm/see)	Alongshore Phase[1] (deg)	Mal or Axis (cm/see)	Minor Axis (cm/see)	Major Axis Orientation (" true)	Phase of Max. Curr.[3] (deg)	Sense of Rotation
Q_1 26.868	0.077	160.6	0.084	182.2	0.112	0.021	36.4	172.4	CCW
O_1 25.819	0.257	205.5	1.338	139.9	1.342	0.233	358.7	140.7	CW
M_1 24.833	0.014	197.9	0.088	137,3	0.088	0.012	358.4	137.9	CW
K_1 23.934	0.369	32.5	2.043	195.6	2.073	0.105	164.2	16.1	CCW
J_1 23.098	0.076	0.6	0.300	198.1	0.309	0.022	160.3	17.1	CW
μ_2 12.872	0.495	280.7	0,477	142.2	0.643	0.244	307.6	120.5	CW
N_2 12.658	0.889	254.5	0.680	151.5	0.916	0.643	283.7	88.6	CW
M_2 12.421	2.059	54.0	1.767	216.2	2.682	0.414	124.4	46.5	CCW
L_2 12.192	0.092	28.0	0.045	262.8	0.096	0.035	102,5	35.1	CW
S_2 12.000	0.559	192.6	1.165	151.8	1.246 ,	0.341	15.7	158.1	CW

C-60/10 Upcoast alongshore direction is 317° true

Constituent & Period (hours)	On-off Shore Ampl. (cm/see)	On-off Shore Phase[1] (deg)	Alongshore Ampl. (cm/see)	Alongshore Phase[1] (deg)	Mai or Axis (cm/see)	Minor Axis (cm/sec)	Major Axis Orientation[2] (° true)	Phase of Max. Curr.[3] (deg)	Sense of Rotation
Q_1 26.868	0.199	-41.4	0.307	291.7	0.357	0.077	168.6	119.2	CW
O_1 25.819	0.092	-39.4	1.690	302.4	1.692	0.029	139.9	122.4	CW
M_1 24.833	0.044	72.9	0.121	-35.6	0.122	0.042	129.5	141.8	CW
K_1 23,934	1.058	41.7	3.268	-6.0	3.349	0.764	150.0	177.0	CW
J_1 23.098	0.040	-7.3	0.326	-4.5	0.328	0.002	144.1	175.5	CCW
μ_2 12.872	0.302	29.2	0.258	300.5	0.302	0.258	43.0	25.9	CW
N_2 12.658	0.052	325.2	0.530	177.4	0.532	0.028	312.2	177.2	CW
M_2 12.421	0.477	56.9	1.494	143.8	1.494	0.476	318.1	143.5	CCW
L_2 12.192	0.067	295.1	0.093	205.7	0.093	0.067	138.0	26.4	CW
S_2 12.000	0.512	10.1	1.306	199.1	1.400	0.075	115,7	17.9	CW

c-90/lo Upcoast alongshore direction is 317° true

Constituent & Period (hours)	On-off Shore Ampl. (cm/see)	On-off Shore Phase[1] (deg)	Alongshore Ampl. (cm/see)	Alongshore Phase[1] (deg)	Major Axis (cm/see)	Minor Axis (cm/see)	Major Axis Orientation[2] (° true)	Phase of Max. Curr.[3] (deg)	Sense of Rotation
Q_1 26.868	0.131	262.8	0.334	235.1	0.354	0.057	156.7	58.4	CW
O_1 25.819	0.427	106.4	1.231	286.4	1.303	0.000	117.9	106.4	CW
Ml 24.833	0.089	81.5	0.124	-28.2	0.130	0.080	114.9	137.9	CW
K_1 23.934	2.295	75.4	4.232	-2.2	4.271	2.221	326.1	2.5	CW
J_1 23.098	0.173	74.0	0.439	-2.3	0.441	0.168	323.2	0.1	CW
μ_2 12.872	0.497	310.7	0,479	217.8	0.503	0.472	253.9	156.2	CW
N_2 12.658	0.231	262.2	0.475	157.7	0.479	0.222	308.2	153.6	CW
M_2 12.421	0.411	345.9	2.144	140.5	2.176	0.174	307.1	141.3	CCW
L_2 12.192	0.066	207.9	0.123	118.4	0.123	0.066	317.4	118.6	CW
S_2 12.000	1.614	337.9	1.975	216.8	2.242	1.217	102.7	16.5	CW

C - 90/45 Upcoast alongshore direction is 317° true

Constituent & Period (hours)	On-off Shore Ampl. (cm/see)	On-off Shore Phase[1] (deg)	Alongshore Ampl. (cm/see)	Alongshore Phase[1] (deg)	Major Axis (cm/see}	Minor Axis (cm/see)	Major Axis Orientation[2] (° true)	Phase of Max. Curr.[3] (deg)	Sense of Rotation
Q_1 26.868	0.285	67.1	0.487	-32.4	0.490	0.279	128.8	142.9	CW
O_1 25,819	0.099	238.9	1.358	299.4	1.359	0.086	139.1	119.2	CCW
M_1 24.833	0.058	188.1	0.019	-18.8	0.060	0.008	243.4	5.8	CCW
K_1 23.934	0.608	121.6	1.719	31.6	1.719	0,608	317.0	31.6	CW
J_1 23.098	0.101	-9.6	0.169	1.8	0.196	0.017	167.5	178.9	CCW
μ_2 12.872	0.118	18.1	0.155	210.2	0.194	0.020	99.9	25.8	CW
N_2 12.658	0.295	24.5	0.271	224.8	0.394	0.070	89.4	33.7	CW
M_2 12.421	1.199	102.2	1.478	111.0	1.898	0.142	356.0	107.5	CCW
L_2 12.192	0.049	108.6	0.074	61.8	0.083	0.032	345.8	73.8	CW
S_2 12.000	0.413	155.3	1.083	172.4	1.153	0.114	337,2	170.4	CCW

c-90/75 Upcoast alongshore direction is 317" true

Constituent & Period (hours)	On-off Shore Ampl. (cm/see)	On-off Shore Phase[1] (deg)	Alongshore Ampl. (cm/sec)	Alongshore Phase[1] (deg)	Major Axis (cm/see)	Minor Axis (cm/see)	Major Axis Orientation[2] (° true)	Phase of Max. Curr.[3] (deg)	Sense of Rotation
Q_1 26.868	0.278	199.0	0.226	295.9	0.281	0.221	241.8	7.3	CCW
O_1 25.819	0.593	84.4	0.643	284.4	0.861	0.152	94.5	95.3	CW
M_1 24.833	0.046	4.8	0.009	-47.7	0.046	0.007	39.8	3.7	CW
K_1 23.934	0.910	199.0	0.651	55.8	1.068	0.332	260.5	30.7	CW
J_1 23.098	0,216	146.9	0.072	48.7	0.216	0.071	50.1	147.9	CW
μ_2 12.872	0.131	163.0	0.115	121.8	0.163	0.061	7.1	145.7	CW
N_2 12.658	0.300	112.1	0.262	170.2	0.350	0.191	9.1	135.1	CCW
M_2 12.421	0.696	121.7	0.644	96.4	0.925	0.207	4.5	110.1	CW
L_2 12.192	0.033	124.1	0.041	349.5	0.049	0.020	99.9	152.4	CW
S_2 12.000	0.595	142,8	0.536	84.7	0.702	0.386	7.6	118.5	CW

Table 4-5. Continued.

C-130/10 Upcoast alongshore direction is 317° true

Constituent & Period (hours)	On-off Shore Ampl. (cm/see)	On-off Shore Phase[1] (deg)	Alongshore Ampl. (cm/see)	Alongshore Phase[1] (deg)	W Axis (cm/see)	Minor Axis (cm/see)	Major Axis Orientation (° true)	Phase of Max. Curr.[3] (deg)	Sense of Rotation
Q_1 26.868	0.635	20.7	0.480	273.9	0.663	0.440	69.7	36.1	CW
O_1 25.819	1.159	14,6	1.534	271.2	1.581	1.095	117.4	77.4	CW
M_1 24.833	0.096	79.5	0.115	-40.7	0.131	0.073	101.6	117.6	CW
K_1 23.934	3.208	56.9	4.290	-34.4	4.291	3.206	134.8	143.9	CW
J_1 23.098	0.236	12.5	0.369	-51.8	0.389	0.202	158.6	139.8	CW
μ_2 12.872	0.166	85.9	0.314	45.2	0.341	0.100	341.0	52.6	CW
N_2 12.658	0.201	104.0	0.582	236.2	0.599	0.145	123.1	59.6	CCW
M_2 12.421	3.424	110.6	1.550	59.0	3.574	1.165	29.4	104.7	CW
L_2 12.192	0.090	72.7	0.164	327.9	0.166	0.086	126.1	142.2	CW
S_2 12.000	1.712	158.2	1.359	128.1	2.115	0.551	9.5	146.9	CW

C-400/10 Upcoast alongshore direction is 317° true

Constituent & Period (hours)	On-off Shore Ampl. (cm/see)	On-off Shore Phase[1] (deg)	Alongshore Ampl. (cm/see)	Alongshore Phase[1] (deg)	Major Axis (cm/see)	Minor Axis (cm/see)	Major Axis Orientation (° true)	Phase of Max. Curr.[3] (deg)	Sense of Rotation
Q_1 26.868	0.525	34.9	0.442	301.0	0.528	0.439	57.6	43.7	CW
O_1 25.819	0.127	198.0	0,538	261.8	0.541	0.113	143.2	80.5	CCW
M_1 24.833	0.137	144.0	0.076	41.9	0.139	0,073	56.2	148.9	CW
K_1 23.934	3.101	90.1	3.078	-2.4	3.158	3.020	87.3	129.2	CW
J_1 23.098	0.226	15.3	0.259	-48,5	0.293	0.179	173.5	155.8	CW
μ_2 12.872	0.282	74.4	0.668	1.0	0.673	0.268	325.2	4.3	CW
N_2 12.658	1.254	44.2	1.360	302.9	1.440	1.161	103.3	94.6	CW
M_2 12.421	3.405	94.8	1.184	95.5	3.605	0.013	27.8	94.9	Ccw
L_2 12.192	0.148	97.2	0.073	359.3	0.148	0.072	52.0	99.6	CW
S_2 12.000	1,167	233.7	1.637	194.1	1.906	0.638	169.9	26.3	CW

C-400/75 Upcoast alongshore direction is 317° true

Constituent & Period (hours)	On-off Shore Ampl. (cm/see)	On-off Shore Phase[1] (deg)	Alongshore AmPl. (cm/see)	Alongshore Phase[1] (deg)	Major Axis (cm/see)	Minor Axis (cm/see)	Major Axis Orientation[2] (° true)	Phase of Max. Curr.[3] (deg)	Sense of Rotation
Q_1 26.868	0.054	282.8	0.191	230.7	0.194	0.042	147.4	53.0	CW
O_1 25.819	0.365	6.4	1.022	262.4	1.027	0.353	131.4	80.5	CW
M_1 24.833	0.028	13.2	0.081	268.4	0.081	0.027	131.4	86.6	CW
K_1 23.934	0.562	90.9	0.985	291.5	1.121	0.173	108.1	106.6	CW
J_1 23.098	0.102	97.6	0.094	-16.1	0.116	0.075	86.2	125.4	CW
μ_2 12.872	0.277	225.4	0.518	167.4	0.543	0.224	336.3	175.6	CW
N_2 12.658	0.464	230.4	0.860	126.6	0.869	0.446	306.9	121.4	CW
M_2 12.421	2,475	70.4	1.199	78.6	2.746	0.154	21.3	72.0	CCW
L_2 12.192	0.131	39.8	0.053	59.7	0,141	0.017	25.8	42,5	CCW
S_2 12.000	1,417	152.0	0.946	120.3	1.649	0.427	15.0	142,8	CW

C-400/75a Upcoast alongshore direction is 317° true

Constituent & Period (hours)	On-off Shore Ampl. (cm/see)	On-off Shore Phase[1] (deg)	Alongshore Ampl. (cm/see)	Alongshore Phase[1] (deg)	Major Axis (cm/see)	Minor Axis (cm/see)	Major Axis Orientation (" true)	Phase of Max. Curr.[3] (deg)	Sense of Rotation
Q_1 26.868	0.817	261.6	1.171	219.8	1.347	0.473	168.9	52.1	CW
O_1 25.819	0.434	-40.0	1.733	266.0	1.753	0.347	145.7	87.7	CW
M_1 24.833	0.114	18.2	0.202	-47.5	0.209	0.101	154.2	141.0	CW
K_1 23.934	0.679	112.5	1.893	-15.4	1.942	0.522	123.6	160.9	CW
J_1 23.0.98	0.374	136.7	0.388	61.5	0.427	0.329	358.0	95.2	CW
μ_2 12.872	0,427	181.9	0.741	197.2	0.850	0.098	166,5	13.5	CCW
N_2 12.658	0.451	292.8	1.082	158.4	1.131	0.308	299.4	153.4	CW
M_2 12.421	2.358	84.2	2.065	63.7	3,085	0.553	6.0	75.3	CW
L_2 12.192	0.239	55.6	0.104	41.5	0.259	0.023	23.9	53.4	CW
S_2 12.000	2.305	152.6	0.438	147.0	2.346	0.042	36.3	152.4	CW

C-400/75b Upcoast alongshore direction is 317° true

Constituent & Period (hours)	On-off Shore Ampl. (cm/see)	On-off Shore Phase[1] (deg)	Alongshore Ampl. (cm/see)	Alongshore Phase[1] (deg)	Major Axis (cm/see)	Minor Axis (cm/see)	Major Axis Orientation (" true)	Phase of Max. Curr.[3] (deg)	Sense of Rotation
Q_1 26.868	0.205	81.0	0.083	-34.2	0.209	0,074	58.2	85.0	CW
O_1 25.819	0.394	17.4	0.819	256.1	0,849	0.325	120.5	69.6	CW
M_1 24.833	0.008	275.8	0.062	240.7	0,062	0.004	142.8	61.1	CW
K_1 23.934	0.600	79.4	1.041	278.8	1.189	0.174	107.8	94.1	CW
J_1 23.098	0.107	35.6	0.140	294.3	0.143	0.102	119.3	101.5	CW
μ_2 12.872	0.347	277,8	0.423	165.5	0.461	0.294	285.9	144.4	CW
N_2 12.658	0.572	201.5	0.723	111.6	0.723	0.572	317.3	111.8	CW
M_2 12.421	2.514	69.3	0.837	99.3	2.619	0.401	30.5	71.9	CCW
L_2 12.192	0.047	5.5	0.060	106.6	0.062	0.045	298.4	120.3	CCW
S_2 12.000	0.430	222.7	1.229	129.2	1.229	0.429	315.6	128.7	CW

Table 4-5. Continued,

C-400/150 Upcoast alongshore direction is 317" true

Constituent & Period (hours)		On-off Shore Ampl. (cm/see)	On-off Shore Phase[1] (deg)	Alongshore Ampl. (cm/see)	Alongshore Phase[1] (deg)	Major Axis (cm/see)	Minor Axis (cm/sec)	Major Axis Orientation[2] (" true)	Phase of Max. Curr.[3] (deg)	Sense of Rotation
Q_1	26.868	0.203	117.0	0.284	-39.7	0.343	0.067	102.3	132.7	CW
O_1	25.819	0.527	83.0	0.882	270.3	1.026	0.058	106.2	88.4	CW
M_1	24.833	0.024	114.8	0.016	222.6	0.024	0.015	66.6	102.5	CCW
K_1	23.934	1.198	119.0	0.962	3.2	1.320	0.786	78.5	139.1	CW
J_1	23.098	0.132	89.2	0.140	-35.0	0.170	0.090	95.2	119.7	CW
μ_2	12.872	0.305	218.5	0.404	179.2	0.480	0.163	171.9	12.5	CW
N_2	12.658	0.333	141.1	0.569	148.7	0.658	0.038	347.2	146.8	CCW
M_2	12.421	1.672	125.0	1.535	118.8	2.266	0.122	4.5	122.2	CW
L_2	12.192	0.099	111.4	0.070	74.5	0.116	0.036	13.7	99.8	CW
S_2	12.000	0.728	209.7	1.027	165.9	1.181	0.438	349.1	179.0	CW

C-400/300 Upcoast alongshore direction is 317" true

Constituent & Period (hours)		On-off Shore Ampl. (cm/see)	On-off Shore Phase[1] (deg)	Alongshore Ampl. (cm/see)	Alongshore Phase[1] (deg)	Major Axis (cm/see)	Minor Axis (cm/see)	Major Axis Orientation (° true)	Phase of Max. Curr.[3] (deg)	Sense of Rotation
Q_1	26.868	0.118	118.5	0.058	271.8	0.129	0.024	71.5	113.7	CCW
O_1	25.819	0.244	78.9	0.372	230.3	0.434	0.100	105.2	58.5	CCW
M_1	24.833	0.006	114.5	0.019	220.0	0.019	0.006	131.4	41.8	CCW
K_1	23.934	0.470	112.7	0.400	289.8	0.617	0.015	87.4	111.5	CCW
J_1	23.098	0.060	74.8	0,062	287.2	0.083	0.024	93.2	91.6	CW
μ_2	12.872	0,135	36.2	0.123	286.8	0.149	0.105	84.5	64.4	CW
N_2	12.658	0.261	30.1	0.537	208.0	0.597	0.008	111.1	28.4	CCW
M_2	12.421	1,651	74.8	0.548	140.3	1.668	0.494	38.4	77.4	CCW
L_2	12.192	0.046	49.6	0.033	268.4	0.053	0.018	80,6	62.0	CW
S_2	12.000	0.293	114.4	0.846	139.8	0,887	0.120	334.7	137.3	CCW

Table 4-6. Summary of current statistics - moored instrument data, March-August 1988.

	Data Span 1987	Number of Hourly Averages	Upcoast Alongshore Direction (deg True)	Mean Current (cm/sec) Alongshore	Mean Current (cm/sec) Cross-shore	Standard Deviation of Hourly Averages (cm/sec) Alongshore	Standard Deviation of Hourly Averages (cm/sec) Cross-shore	Standard Deviation of Low-pass Filtered Time Series (cm/see) Alongshore	Standard Deviation of Low-pass Filtered Time Series (cm/see) Cross-shore	Maximum/Minimum of Hourly Averages (cm/sec) Alongshore	Maximum/Minimum of Hourly Averages (cm/sec) Cross-shore
K-400/10	3/12 to 8/29	4066	355	-18.88	-4.48	24.68	13.29	22.43	8.47	50.35/ -89.00	47.20/ -49.84
K-400/75	3/12 to 8/28	4045	355	-1.96	1.79	20.00	9.20	16.24	6,20	57.68/ -56.64	34.61/ -29.80
K-400/150	3/12 to 8/28	4049	355	5.79	1.25	14.62	6.69	13.29	4.59	53.16/ -65.99	21.31/ -56.51
K-400/300	3/12 to 8/28	4030	355	5.40	1.17	10.46	5.78	9.51	2.80	39.76/ -30.15	20.94/ -21.97
K-130/10	3/12 to 8/29	4068	355	-16.68	-0.68	25.12	12.28	22.83	6.18	51.71/ -99.34	50.09/ -42.39
K-130/75	3/12 to 8/29	4069	355	1.28	2.14	11.30	6.59	9,53	2.64	34.18/ -39.48	25,07/ -21.53
K-90/10	3/12 to 8/28	4057	355	-14.28	-1.43	20.51	13.21	16.95	6.22	52.22/ -93.37	54.25/ -49.27
K-90/45	3/12 to 8/20	4057	355	-0.93	1.66	13.94	7.03	11.81	4.10	40.60/ -59.47	29.75/ -26,76
K-90/75	3/12 to 8/28	4057	355	2.40	-0.49	11.42	7.40	9.24	3.29	36.43/ -44.89	28.25/ -32.42
K-60/lo	3/12 to 8/12	3659	355	-1.81	0.96	15.94	9.70	12.92	5.35	40.11/ -76.09	41.331 -34.32
E 400/10	3/14 to 8/31	4075	027	-12.19	0.51	17.96	11,26	14.29	7.07	43.30/ -73.37	45.92/ -39.85
E-400/75	3/14 to 8/31	4073	027	-1.20	2.34	13..63	8.?5	10.44	4,91	43.47/ -47.88	30.62/ -29.35
E-400/150	3/15 to 8/31	4063	027	1.84	1.13	10,07	5.65	8.58	2.95	33.32/ -35.69	23.19/ -19.59
E-400/300	3/14 to 8/31	4075	027	1.34	0.70	8.98	6.13	8.01	2.24	28.25/ -31.02	25.05/ -23,15
E-90/10	3/14 to 8/30	4044	027	-8.62	1.04	17.50	9.75	14.91	5.17	42.21/ -82.10	40.36/ -38.52
E-90/75	3/14 to 8/30	4044	027	3.26	-1.21	12.35	11.06	8.10	3.48	48.98/ -43.19	31.98/ -41.60
E-60/lo	3/15 to 8/30	4042	027	-11.23	-1.80	18.20	8.12	15.75	3.69	42.28/ -08.65	37.18/ -30.52
G-90/ 10	3/17 to 8/21	3770	317	4.48	-5.04	25.26	12.15	19.01	6.81	64. 80/-102. 06	53.88/ -45.22
G-90/45	3/17 to 8/21	3770	317	9.97	4.88	19.09	7.33	15.64	2,98	64.96/ -77.02	35.95/ -25.97
G-90/75	3/17 to 8/21	3770	317	7.23	-0.60	15.06	9,48	11.17	4.58	49,93/ '48.61	30.66/ -45.05
V-400/10	3/18 to 8/15	3622	354	-7.22	2.44	19.69	10.61	18.15	6.65	43. 90/ -82.93	36.74/ -34.24
V-400/75	5/02 to 8/15	2509	354	2.40	2.98	13.88	7.32	12,04	3.99	38.58/ -56.87	30.53/ -20.21
V-400/150	5/02 to 8/15	2508	354	14.45	0.30	10.69	4.80	9.04	2.25	43.381 -27.16	15.98/ -18.21
V-400/300	3/19 to 4/13										
	5/02 to 8/15	3129	354	13.39	-1.53	6.97	4.34	5.09	1.35	37.98/ -10.36	20.17/ -17.45
v-130/lo	3/17 to 8/15	3623	354	-10.06	1.59	15.67	10.88	14.23	8.16	37.01/ -78.37	46.48/ -29.96
v-130/75	3/17 to 8/15	3624	354	4.48	1.23	10.05	4.48	9.45	1.93	32.07/ -30.76	28.77/ '14.38
v-90/ 10	3/M to 8/15	3610	354	-6.85	-1.15	16.44	8.86	15.26	4,19	33.84/ -69.11	24.51/ -31.46
v-90/75	3/18 to 8/15	3610	354	4.59	-0.44	10.45	6.47	9.64	2.35	29.46/ -31.61	26.05/ -26.30
V-60/ 10	3/18 to 8/15	3615	354	-5.08	0.52	15.76	6.72	14.94	2.57	32.50/ -62.16	34.53/ -21,69
C-400/10	5/01 to 8/19	2645	317	-18.63	-5.76	19.65	19.56	18.36	17.73	38.53/ -80.56	58.271 -75.16
C-400/75	3/19 to 5/11										
	6/07 to 8/19	2397	317	-0,80	0.38	12.95	8.95	11.74	7.67	28.52/ '46.19	25.04/ -39.05
C-400/150	3/19 to 8/19	3663	317	6.22	3.21	8.47	5.68	7.58	3.87	30.59/ -18.25	20.39/ -19.21
C-400/300	3/19 to 8/19	3664	317	5.22	1.95	4.79	3.49	3.93	1.50	21.29/ -10.76	13.35/ '12,46
c-130/lo	3/19 to 8/18	3666	317	-22.94	-12.74	21.46	17.02	19.66	14.76	25.35/ -87.47	33.09/ -70.41
c-90/lo	3/19 to 8/18	3634	317	-15.10	-5.24	24.42	8.12	23.59	5.43	52.90/ -83.10	30.03/ -26.76
c-90/45	3/19 to 8/18	3635	317	-2.77	1.21	15.06	5.00	14.64	3.69	33.17/ -50.27	16.90/ -17.44
c-90/75	3/20 to 8/18	3634	317	0.92	1.73	7.67	5.85	6.78	4.33	27.07/ -36.63	31.90/ -18.03
C-60/10	3/20 to 8/18	3635	317	-1.10	-0.21	18.35	4.77	17.51	2.32	43.37/ -77.49	31.33/ -16.08

Recovery of temperature data from current meters and bottom pressure gauges during the first main program deployment

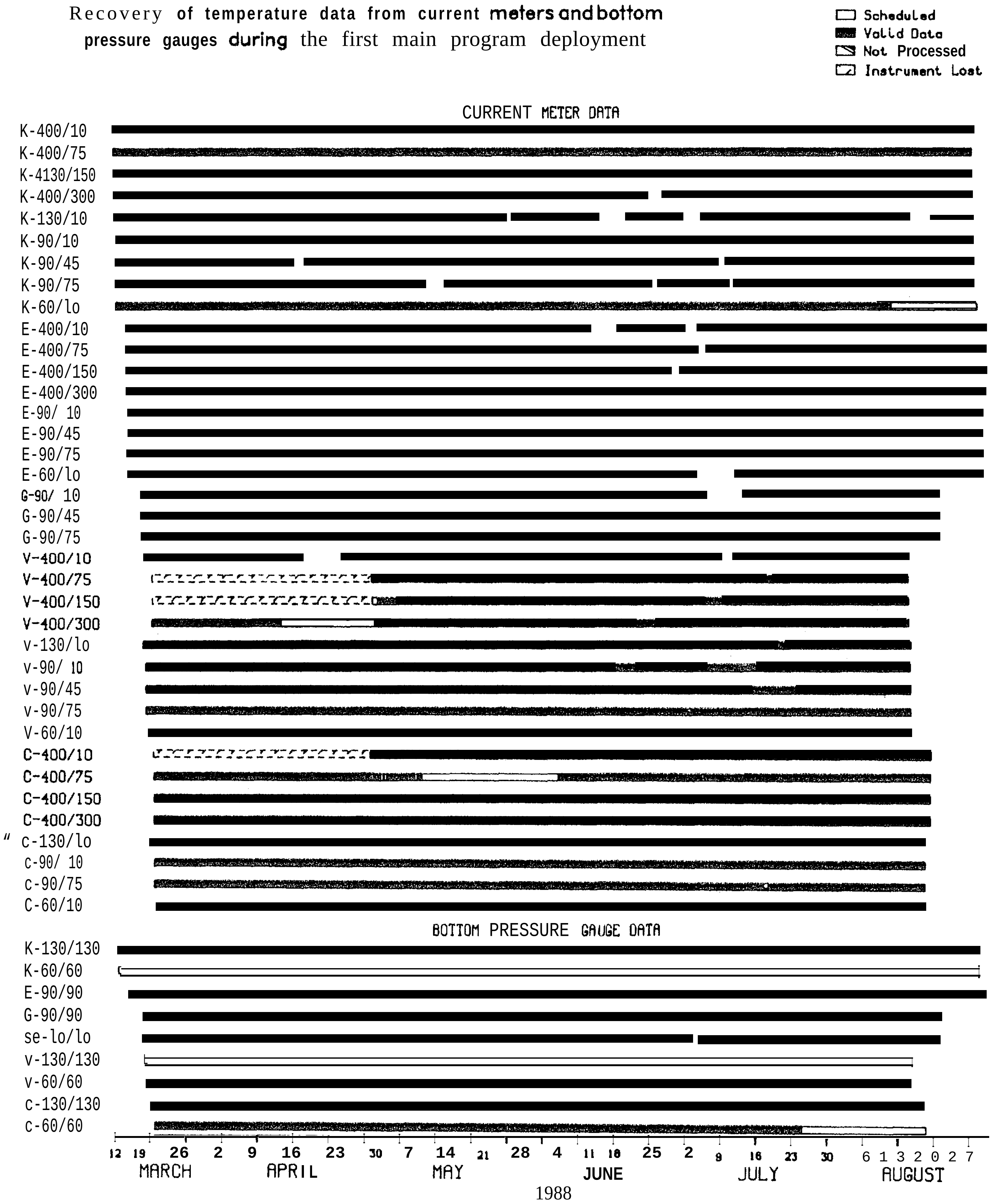


Figure 4-10. First deployment of the main program data coverage: temperature data from moored current meters and bottom pressure recorders.

Table 4-$. Summary of temperature statistics - moored instrument data, March-August 1988.

	Data Span	Number of Hourly Averages	Average Temperature (degrees C)	Maximum Temperature (degrees C)	Minimum Temperature (degrees C)	Standard Deviation (degrees C) Hourly Averages	Low-Pass Filtered
K-400/10	3/12 to 8/29	4066	10.81	14.46	8.83	1.08	1.05
K-400/75	3/12 to 8/28	4045	8.24	10.11	7.14	0.54	0.52
K-400/150	3/12 to 8/28	4050	7.51	8.38	6,70	0.36	0.35
K-400/300	3/12 to 8/28	4050	6.51	7.55	5.74	0.37	0.35
K-130/10	3/12 to 8/29	4068	10.37	13.43	8.20	1.00	0.95
K-130/130	3/12 to 8/29	4068	7.53	8.71	6.68	0.46	0.46
K-90/10	3/12 to 8/28	4057	10.05	13.36	7.76	1.05	0.99
K-90/45	3/12 to 8/28	4057	8.37	10.04	7.03	0.52	0.48
K-90/75	3/12 to 8/28	4057	7.87	9.14	6.48	0.54	0.54
K-60/lo	3/12 to 8/12	3659	9.86	, 13.53	7.76	1.10	1.04
E-400/10	3/14 to 8/31	4075	11.01	14.26	8.69	1.18	1.13
E-400/75	3/14 to 8/31	4071	8.39	9.64	7.20	0.38	0.35
E-400/150	3/15 to 8/31	4063	7.66	8,54	6.84	0.39	0.38
E-400/300	3/14 to 8/31	4075	6.65	8.05	5.68	0.51	0.48
E-90/10	3/14 to 8/30	4044	11.85	15.97	9.62	1.57	1.50
E-90/45	3/14 to 8/30	4044	8.63	11.69	7.37	0.55	0.49
E-90/75	3/14 to 8/30	4044	8.06	9.65	4.87	0.52	0.48
E-90/90	3/14 to 8/30	4044	7.79	9.34	6.55	0.51	0.49
G-90/10	3/17 to 8/21	3770	9.12	12,32	7.00	1.07	1.03
G-90/45	3/17 to 8/21	3770	8.31	10.36	6.75	0.73	0.69
G-90/75	3/17 to 8/21	3770	7.98	9.73	6.50	0.64	0.62
G-90/90	3/17 to 8/21	3770	7.93	9.48	6.51	0.62	0.60
se-lo/lo	3/17 to 8/21	3767	10.16	14.01	7.56	1.34	1.32
V-400/10	3/18 to 8/15	3622	10.53	13.59	8.46	1.03	0.99
V-400/75	5/02 to 8/15	2509	8.83	10.55	7,67	0.56	0.53
V-400/150	5/02 to 8/15	2508	7.78	8.89	6.79	0.46	0.45
V-400/300	3/19 to 4/13						
	5[02 to 8/15	3130	6.89	8.01	5.92	0.41	0.39
v-130/lo	3/17 to 8/15	3623	10.09	12.92	8.10	1.02	0.96
v-90/lo	3/18 to 8/15	3610	9.94	13.25	7.74	1.11	1.06
v-90/45	3/18 to 8/15	3610	8.54	10.66	7.22	0.65	0.63
v-90/75	3/18 to 8/15	3610	8.14	10.63	6.99	0.59	0.57
V-60/10	3/18 to 8/15	3615	9.92	13.06	7.50	1.19	1.16
v-60/60	3/18 to 8/15	3615	8.36	10.23	7.12	0.63	0.61
C-400/10	5/01 to 8/19	2645	11.66	15.25	8.55	1.34	1.32
C-400/75	3/19 to 5 / n						
	6/07 to 8/19	2397	8.98	19.95	8.02	0.60	0.24
C-400/150	3/19 to 8/19	3664	7.51	8.32	6.61	0.29	0.27
C-400/300	3/19 to 8/19	3664	6.87	7.63	6.16	0.23	0.21
c-130/lo	3/19 to 8/18	3666	10.37	14,88	8.26	1.28	1.26
c-130/130	3/19 to 8/18	3666	8.14	9.06	7.26	0.40	0.40
c-90/lo	3/20 to 8/18	3634	9.85	14.69	7.78	1.40	1.39
c-90/75	3/20 to 8/18	3634	8.28	9.86	7.18	0.58	0.57
C-60/10	3/20 to 8/18	3635	9.73	14.78	7.87	1.59	1.59
c-60/60	3/20 to 7/25	3050	8.29	9.95	7.38	0.55	0.53

HOURLY TEMPERATURE AT ALL LEVELS ON THE K, E AND G LINES
AND 33 HOUR FILTERED WIND STRESS VECTORS (UPCOAST TOWARD TOP OF PAGE)

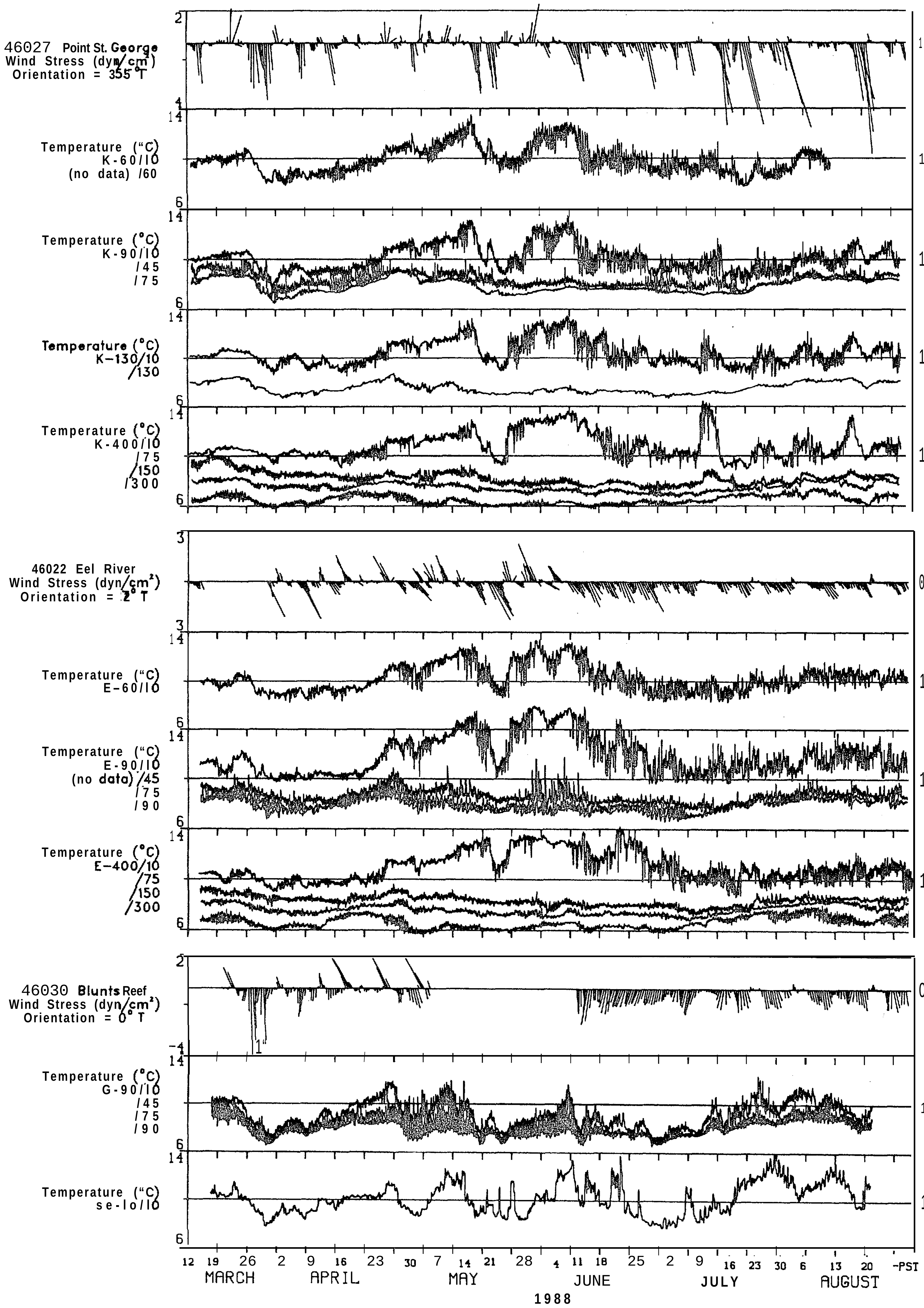


Figure 4-ha. Time series of temperature, March-August 1988: hourly values of temperature and low-passed local wind stress.

HOURLY TEMPERATURE AT ALL LEVELS ON THE V ANC C **LINES**
AND 33 HOUR FILTERED WIND STRESS VECTORS (UPCOAST **TOWARD TOP** OF PAGE)

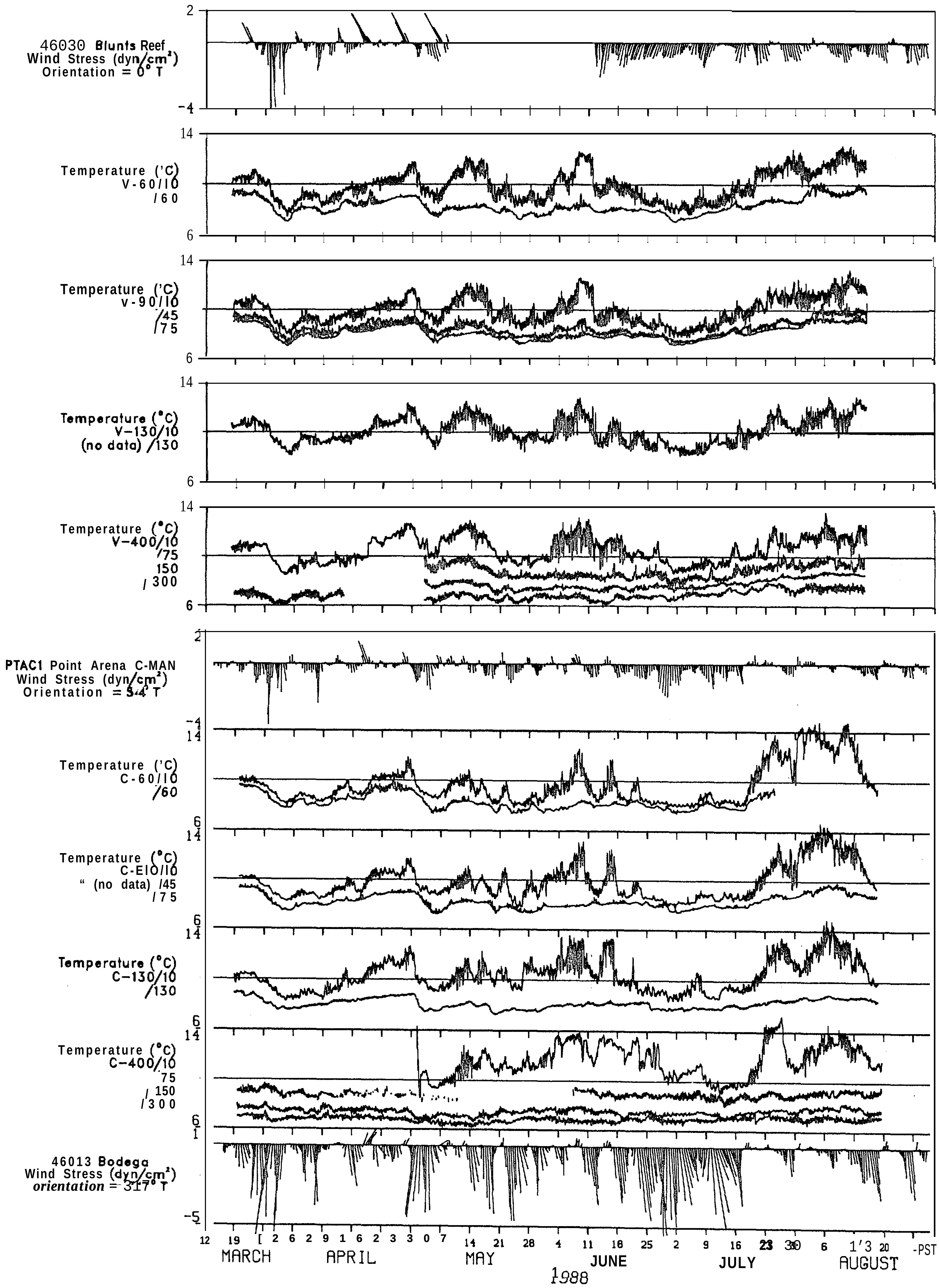


Figure 4-ha. Continued.

33 HOUR FILTERED TEMPERATURE AT ALL LEVELS ON THE K, E AND G LINES
AND WIND STRESS VECTORS (UPCOAST TOWARD TOP OF PAGE)

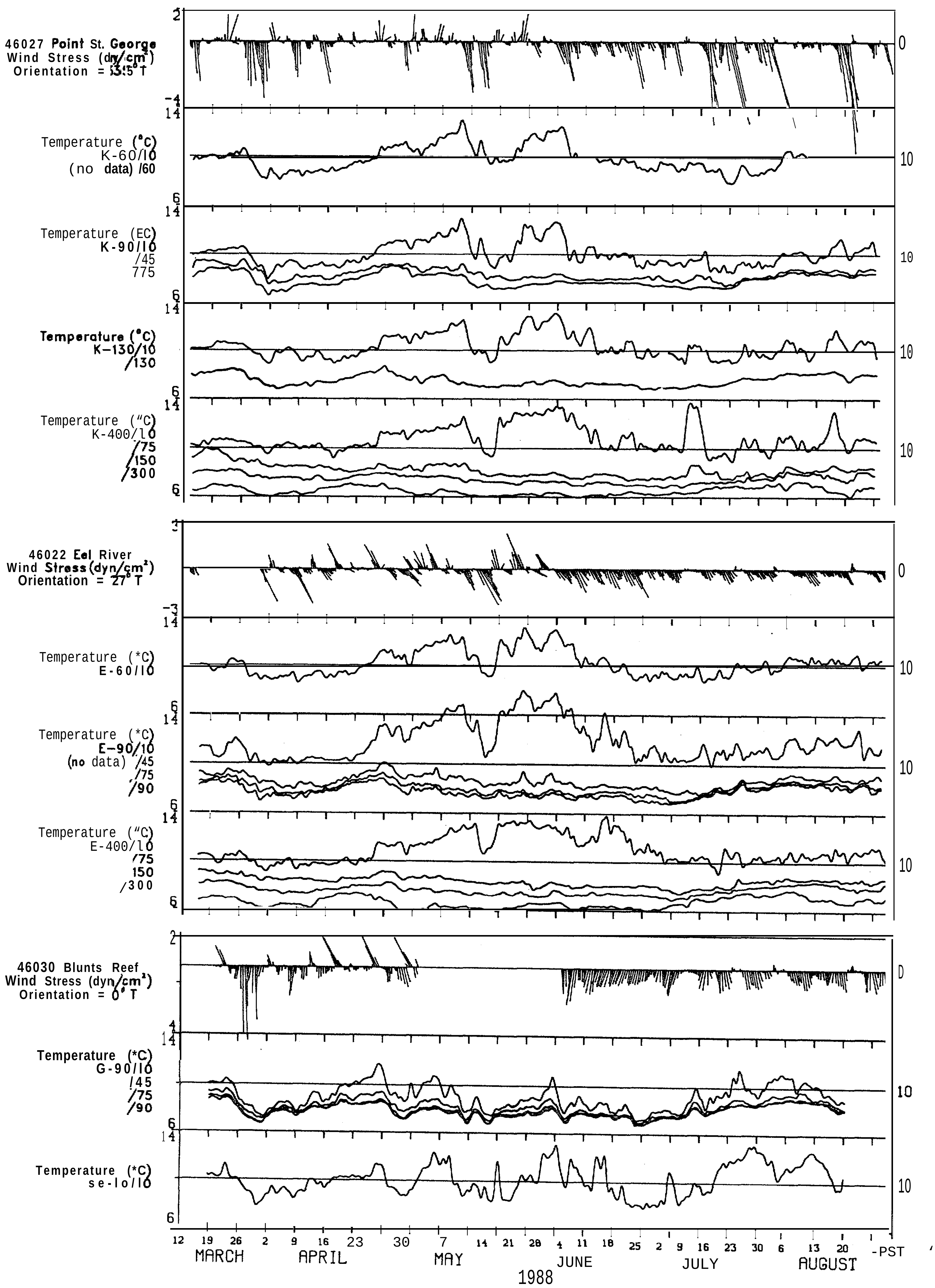


Figure 4- 11b. Time series of temperature, March-August 1988: low-passed temperatures and local wind stress .

33 HOUR FILTERED TEMPERATURE AT ALL LEVELS ON THE V ANC C LINES
AND WIND STRESS VECTORS (UPCOAST TowARD TOp OF PAGE)

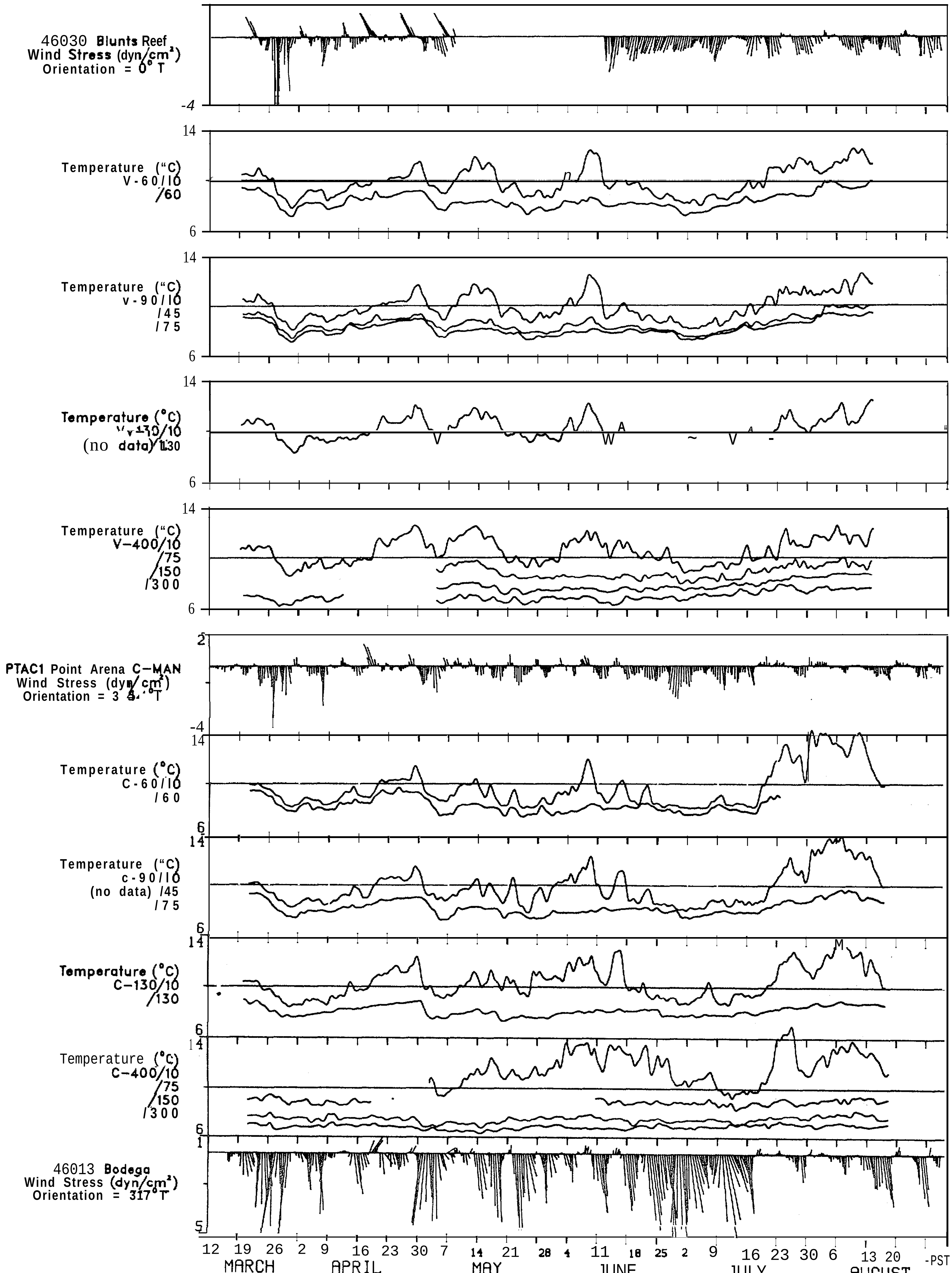


Figure 4-11b. Continued.

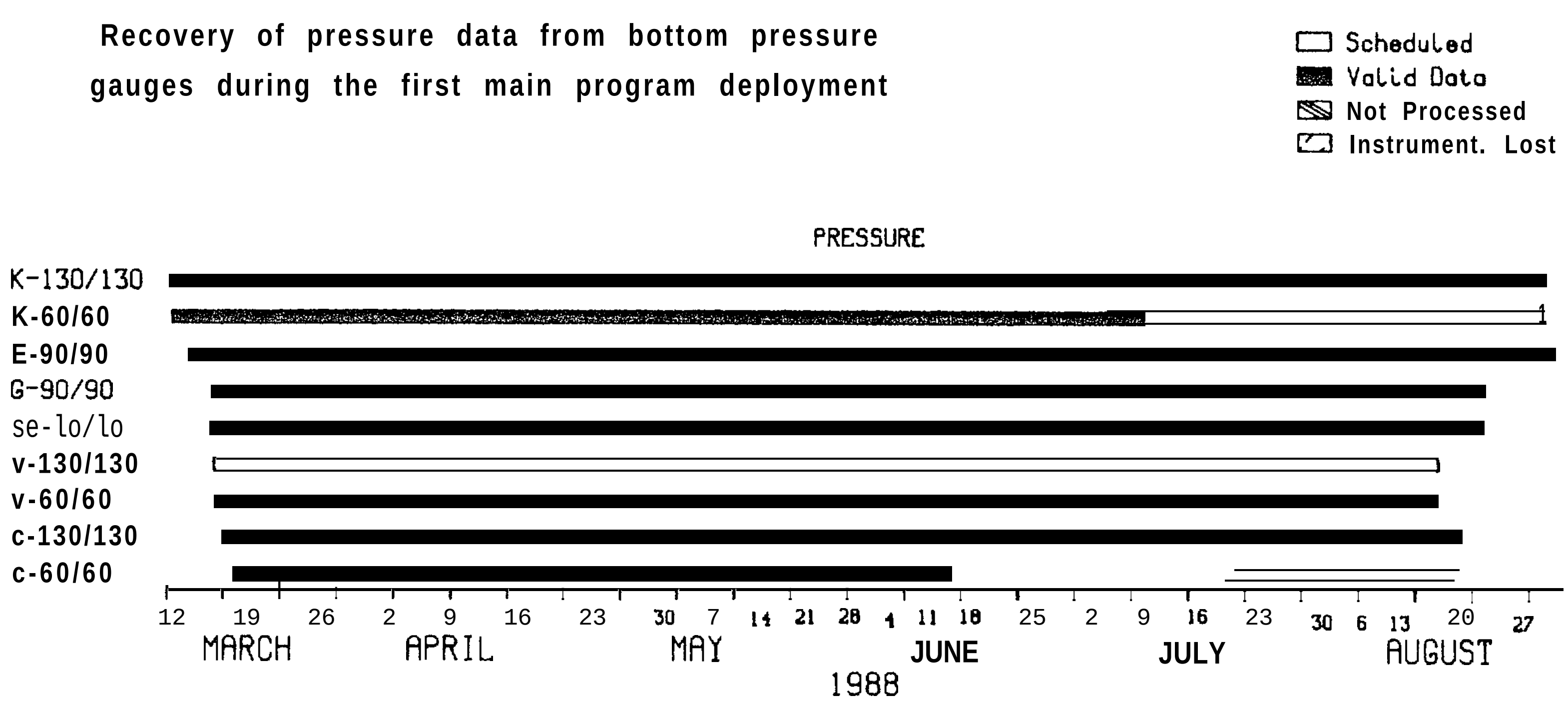


Figure 4-12. First deployment of the main program data coverage: bottom pressure data.

UNFILTERED BOTTOM PRESSURES **AND FILTERED WIND STRESS VECTORS**
UPCOAST IS TOWARD TOP OF PAGE

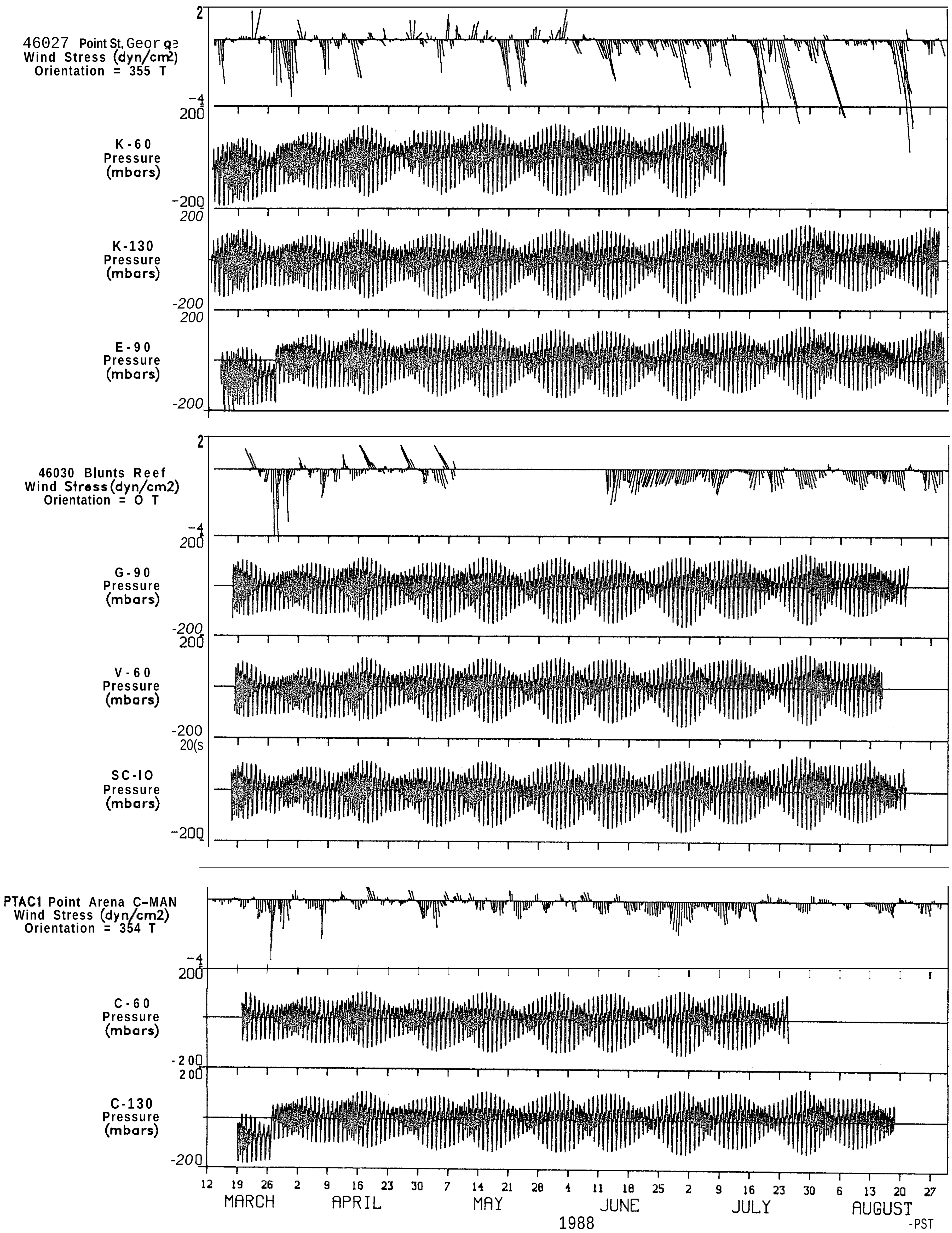


Figure 4-13a. Time series of bottom pressure, March-August 1988: hourly values of bottom pressure and low-passed local wind stress.

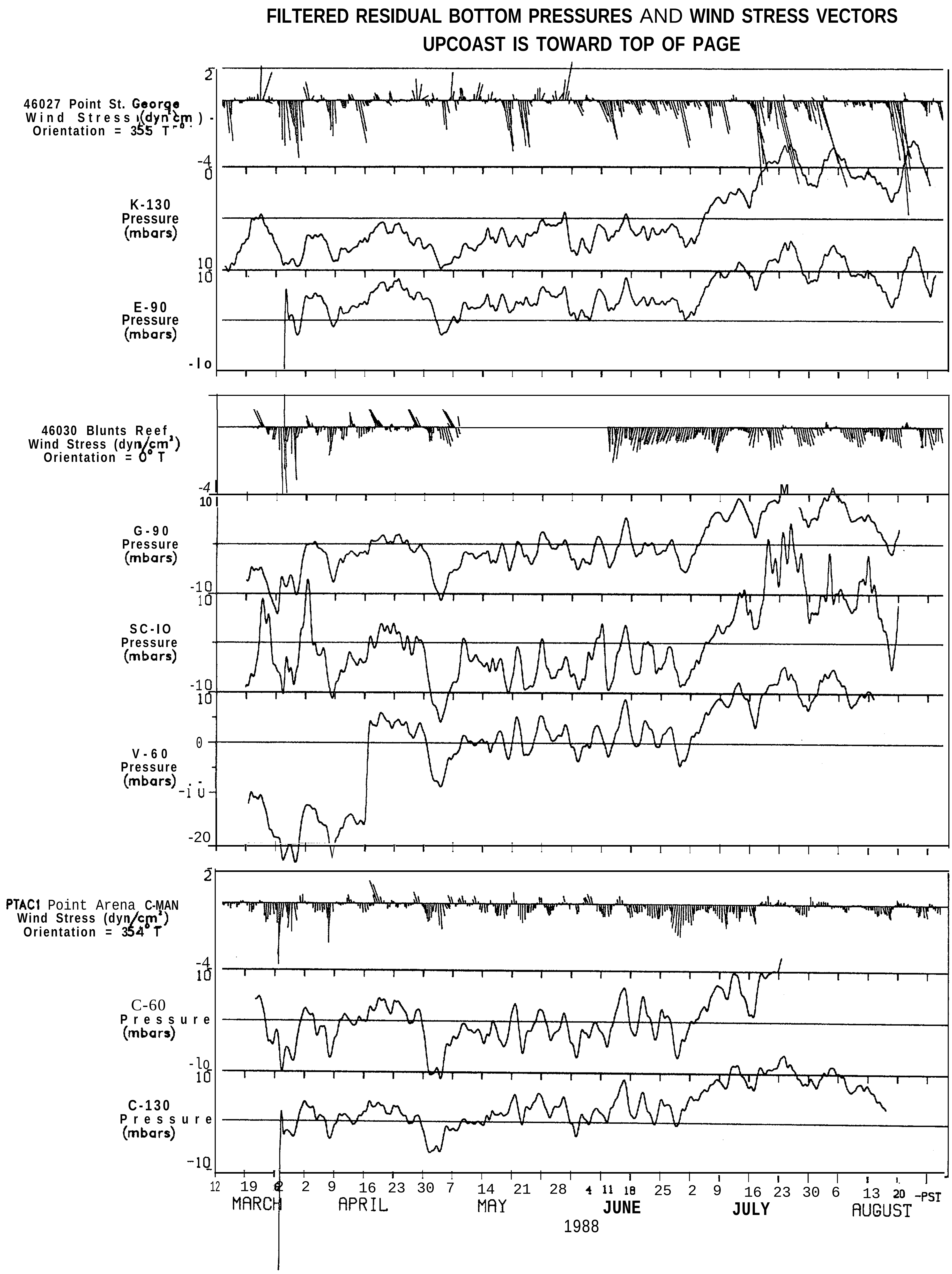


Figure 4-13b. Time series of bottom pressure, March-August 1988: low-passed bottom pressures and local wind stress.

Table 4-8. Tidal harmonic constituents of bottom pressure, March-August 1988.

K- 60/60

Constituent	Period (hours)	Amplitude (mbars)	Phase[1] (deg)
Q_1	26.868	4.732	195.5
O_1	25.819	23.684	212.5
M_1	24.833	2.021	222.4
K_1	23.934	38.322	228.9
J_1	23.098	2.320	237.3
μ_2	12.872	3.748	166.0
N_2	12.658	14.155	188.7
M_2	12.421	68.859	211.3
L_2	12.192	1.746	219.0
S_2	12.000	15.043	237.3

K-130/130

Constituent	Period (hours)	Amplitude (mbars)	Phase[1] (deg)
Q_1	26,868	4.664	198.6
O_1	25.819	24.694	213.3
M_1	24.833	2.086	221.3
K_1	23.934	39.256	228.3
J_1	23.098	2.446	237.1
μ_2	12.872	3.623	165.3
N_2	12.658	14.118	189.0
M_2	12.421	69.913	211.3
L_2	12.192	1.804	218.7
S_2	12.000	15.943	236.3

E-90/90

Constituent	Period (hours)	Amplitude (mbars)	Phase[1] (deg)
Q_1	26.868	4.665	197.9
O_1	25.819	24,436	212.6
M_1	24.833	2.058	220.9
K_1	23.934	38.760	228.1
J_1	23.098	2.414	236.9
μ_2	12.872	3.506	162.2
N_2	12.658	13.475	185.6
M_2	12.421	66.335	208.6
L_2	12.192	1.721	215.9
S_2	12.000	14.491	231.6

G-90/90

Constituent	Period (hours)	Amplitude (mbars)	Phase[1] (deg)
Q_1	26.868	4.663	194.3
O_1	25.819	24.284	209.6
M_1	24.833	2.052	217.9
K_1	23.934	38.359	224.6
J_1	23.098	2.345	233.7
μ_2	12.872	3.373	156.2
N_2	12.658	12.899	178.7
M_2	12.421	62.402	202.2
L_2	12.192	1.638	209,7
S_2	12.000	13.417	221.9

se-lo/lo “

Constituent	Period (hours)	Amplitude (mbars)	Phase[1] (deg)
Q_1	26.868	4.488	191.6
O_1	25.819	24.073	209.8
M_1	24.833	2.059	218.2
K_1	23.934	37.999	226.5
J_1	23.098	2.387	238.8
μ_2	12.872	3.413	153.3
N_2	12.658	12.544	177.5
M_2	12.421	60.144	201.5
L_2	12.192	1.554	210.1
S_2	12.000	12.661	219.5

Table 4-8. Continued.

v-60/60

Constituent	Period (hours)	Amplitude (mbars)	Phase[1] (deg)
Q_1	26.868	4.494	193.9
O_1	25.819	23.782	208.4
M_1	24.833	2.007	216.8
K_1	23.934	38.147	224.3
J_1	23.098	2.416	232.7
μ_2	12.872	3.368	154.3
N_2	12.658	12.343	175.2
M_2	12.421	59.710	200.1
L_2	12.192	1.578	206.3
S_2	12.000	12.537	216.6

c-60/60

Constituent	Period (hours)	Amplitude (mbars)	Phase[1] (deg)
Q_1	26.868	4.485	193.7
O_1	25.819	23.254	208.6
M_1	24.833	1.951	216.8
K_1	23.934	36.253	223.7
J_1	23.098	2.210	233.1
μ_2	12.872	3.268	151.5
N_2	12.658	11,748	170.5
M_2	12.421	55.065	194.3
L_2	12.192	1.425	200.2
S_2	12,000	11.418	203.8

c-130/130

Constituent	Period (hours)	Amplitude (mbars)	Phase[1] (deg)
Q_1	26.868	4.468	196.2
O_1	25.819	23.485	208.4
M_1	24.833	1.948	216.0
K_1	23.934	36.740	223.1
J_1	23.098	2.302	230.9
μ_2	12.872	3.113	148.9
N_2	12.658	11.610	169.9
M_2	12.421	54.903	193.9
L_2	12.192	1.455	200.8
S_2	12.000	11.621	203.9

VARIANCE CONSERVING AUTOSPECTRA
NCCCS FIRST MAIN, MARCH - AUGUST 1988

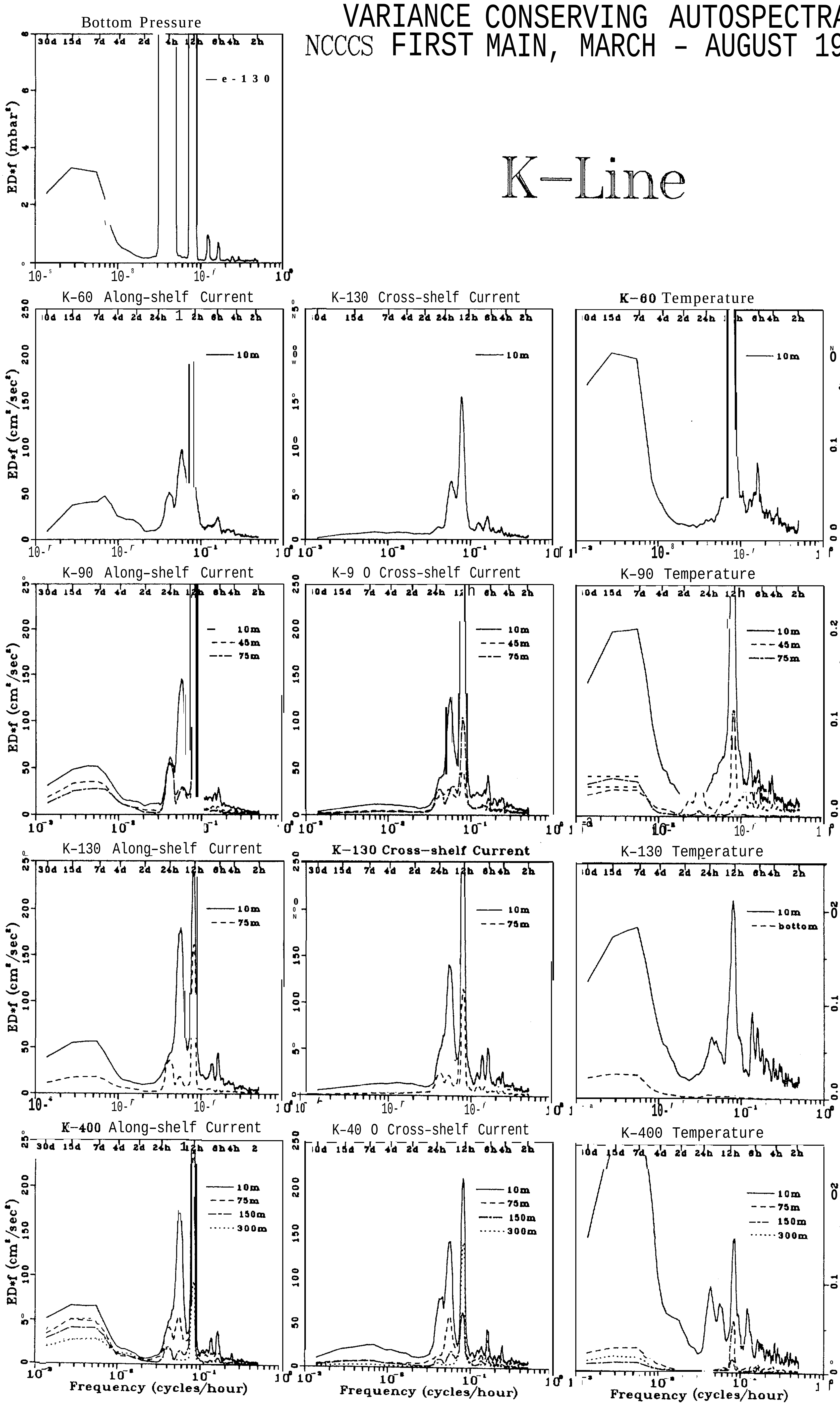


Figure 4-14a, Autospectra of current components , bottom pressures, and temperatures: K- line spectra.

VARIANCE CONSERVING AUTOSPECTRA
NCCCS FIRST MAIN, MARCH - AUGUST 1988

IiE-lLine

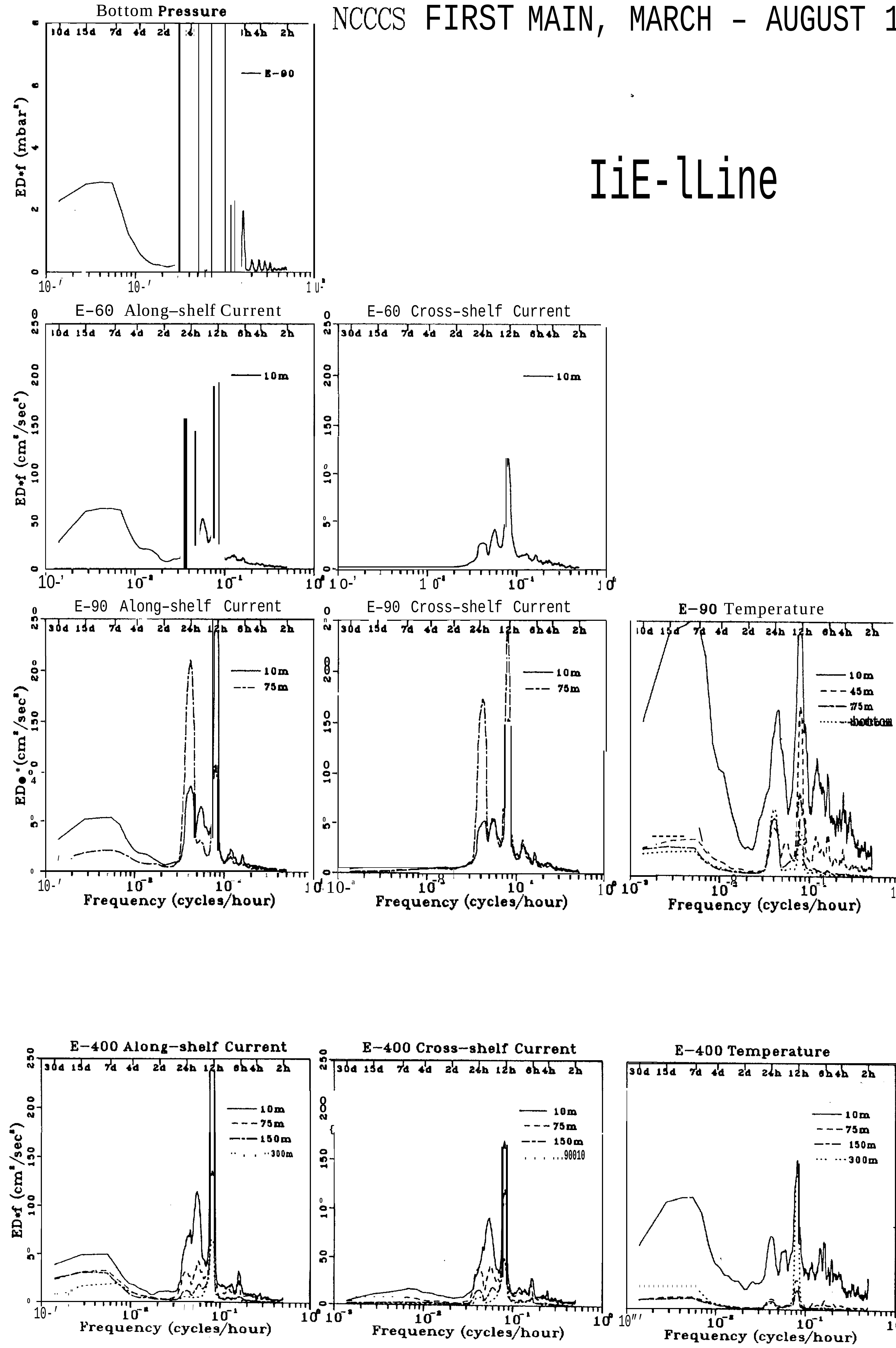
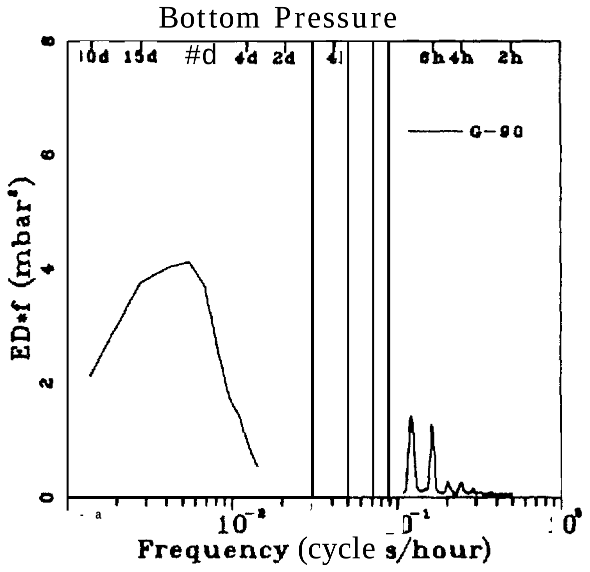


Figure 4- 14b. Autospectra of current components, bottom pressures, and temperatures: E-line spectra.

VARIANCE CONSERVING AUTOSPECTRA
NCCCS FIRST MAIN, MARCH - AUGUST 1988

G-Line



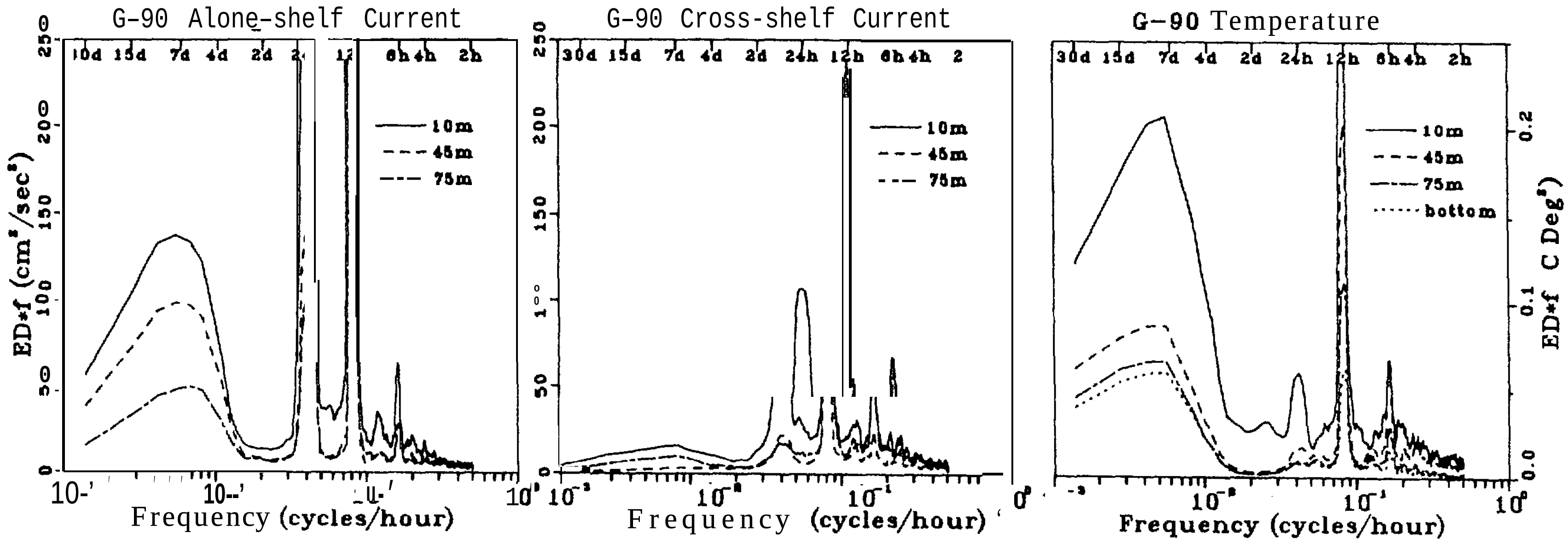


Figure 4- 14c. Autospectra of current components, bottom pressures, and temperatures: G- line spectra

VARIANCE CONSERVING AUTOSPECTRA
NCCCS FIRST MAIN, MARCH - AUGUST 1988

V-Line

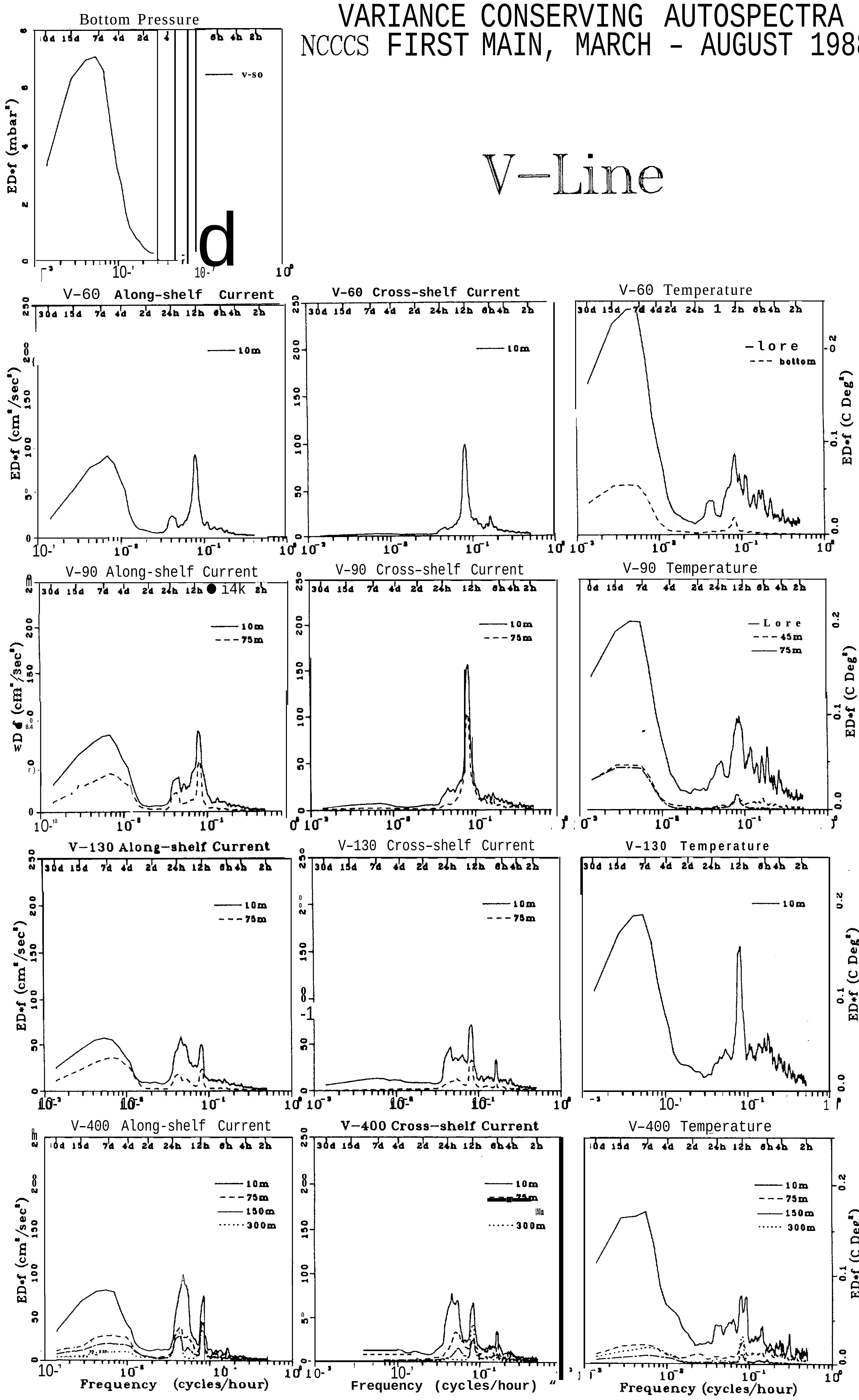


Figure 4- 14d. Autospectra of current components, bottom pressures, and temperatures: V- line spectra.

VARIANCE CONSERVING AUTOSPECTRA
NCCCS FIRST MAIN, MARCH - AUGUST 1988

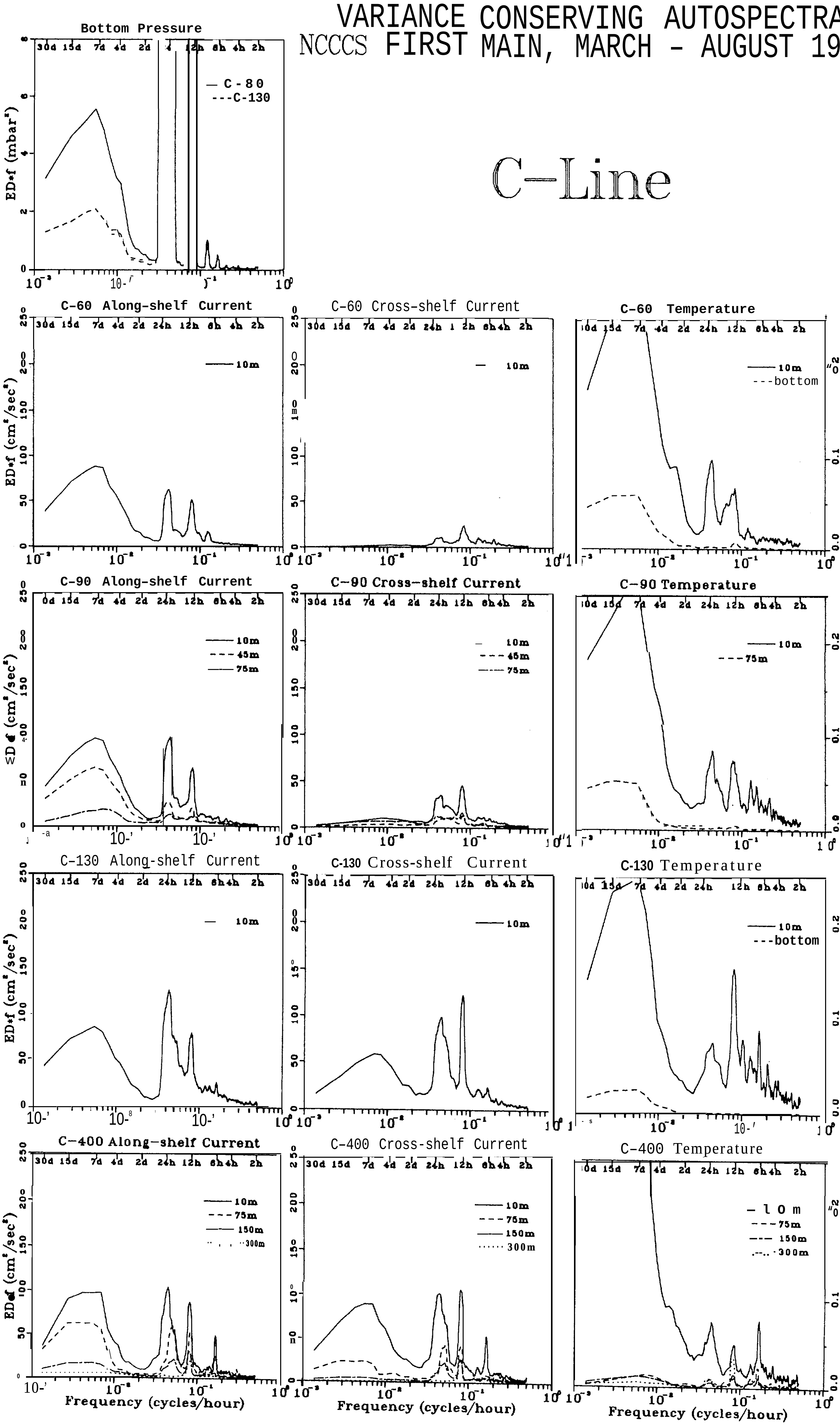


Figure 4-14e. Autospectra of current components, bottom pressures, and temperatures: C- line spectra.

Table 4-9. Spectral analysis summary - moored instrument data, NCCCS main program, March-August 1988.

CURRENT SPECTRA

	Data Span (start 0000 PST)	30-day Segments[2]	Overlap	90% Confidence Limits (lower/upper)[1] at Periods of: 30 days	15 days	10 days	7.5 days
K-400/300	3/15 to 8/27	10	50%	63%/188%	74%/142%	78%/132%	80%/127%
K-400/150	3/15 to 8/27	10	50%	63%/188%	74%/142%	78%/132%	80%/127%
K-400/75	3/15 to 8/27	10	50%	63%/188%	74%/142%	78%/132%	80%/127%
K-400/10	3/15 to 8/27	10	50%	63%/188%	74%/142%	78%/132%	80%/127%
K-130/75	3/15 to 8/27	10	50%	63%/188%	74%/142%	78%/132%	80%/127%
K-130/10	3/15 to 8/27	10	50%	63%/188%	74%/142%	78%/132%	80%/127%
K-90/75	3/15 to 8/27	10	50%	63%/188%	74%/142%	78%/132%	80%/127%
K-90/45	3/15 to 8/27	10	50%	63%/188%	74%/142%	78%/132%	80%/127%
K-90/10	3/15 to 8/27	Lo	50X	63%/188%	742/142%	78%/132%	80%/127%
K-60/lo	3/15 to 8/12	9	50%	62%/195%	73%/148%	77%/135%	80%/129%
E-400/300	4/02 to 8/27	8	50%	60%/205%	71%/153%	76%/140%	79x/130%
E-400/150	3/15 to 8/27	10	50%	63%/188%	74%/142%	78%/132%	80%/127%
E-400/75	3/15 to 8/27	10	50%	63%/188%	74%/142%	78%/132%	80%/127%
E-400/10	3/15 to 8/27	10	50%	63%/188%	74%/142%	78%/132%	80%/127%
E-90/75	3/15 to 8/27	10	50%	63%/188%	74%/142%	78%/132%	80%/127%
E-90/10	3/15 to 8/27	10	50%	63%/188%	74%/142%	78%/132%	80%/127%
E-60/lo	3/15 to 8/27	10	50%	63%/188%	74%/142%	78%/132%	80%/127%
G-90/75	3/20 to 8/17	9	50%	62%/195%	73%/148%	77%/135%	80%/129%
G-90/45	3/20 to 8/17	9	50%	62%/195%	73%/148%	77%/135%	80%/129%
G-90/10	3/20 to 8/17	9	50%	62%/195%	73%/148%	77%/135%	80%/129%
V-400/300	5/03 to 8/15	6	52%	57%/236%	68%/164%	73%/148%	76%/139%
V-400/150	5/03 to 8/15	6	52%	57%/236%	68%/164%	73%/148%	76%/139%
V-400/75	5/03 to 8/15	6	52%	57%/236%	68%/164%	73%/148%	76%/139%
V-400/10	3/18 to 8/15	9	50%	62%/195%	73%/148%	77%/135%	80%/129%
V-130/75	3/18 to 8/15	9	50%	62%/195%	73%/148%	77x/135%	80%/129%
V-130/lo	3/18 to 8/15	9	50%	62%/195%	73%/148%	77%/135%	80%/129%
V- 90/75	3/18 to 8/15	9	50%	62%/l195%	73%/148%	77%/135%	80%/129%
V-90/lo	3/18 to 8/15	9	50%	62%/195%	73%/148%	77%/135x	80%/129%
V-60/10	3/18 to 8/15	9	50%	62%/195%	73%/148%	77%/135%	80%/129%
C-400/300	3/20 to 8/17	9	50%	62%/195%	73%/148%	77%/135%	80%/129%
C-400/150	3/20 to 8/17	9	50%	62%/195%	73%/148%	77%/135%	80%/129%
C-400/75	6/07 to 8/17	3	50%	47%/381%	60%/209%	65%/179%	68%/162%
C-400/10	5/02 to 8/17	6	50%	57%/236%	68%/164%	73%/148%	76%/139%
C-130/lo	3/20 to 8/17	9	50%	62%/195%	73%/148%	77%/135%	80%/129%
C-90/75	3/20 to 8/17	9	50%	62%/195%	73%/148%	77%/135%	80%/129%
C-90/45	3/20 to 8/17	9	50%	62%/195%	73%/148%	77%/135%	80%/129%
C-90/10	3/20 to 8/17	9	50%	62%/195%	73%/148%	77%/135x	80%/129%
C-60/10	3/20 to 8/17	9	50%	62%/195%	73%/148%	77%/135%	80%/129%

TEMPERATURE SPECTRA

	Data Span (start 0000 PST)	30-day Segments[2]	Overlap	90% Confidence Limits (lower/upper)[1] at Periods of: 30 days	15 days	10 days	7.5 days
K-400/300	3/15 to 8/27	10	50%	63%/188%	74%/142%	78%/132%	80%/127%
K-400/150	3/15 to 8/27	10	50%	63%/188%	74%/142%	78%/132%	80%/127%
K-400/75	3/15 to 8/27	10	50%	63%/188%	74%/142%	78%/132%	80%/127%
K-400/10	3/15 to 8/27	10	50%	63%/188%	74%/142%	78%/132%	80%/127%
K-130/10	3/15 to 8/27	10	50%	63%/188%	74%/142%	78%/132%	80%/127%
K-90/75	3/15 to 8/27	10	50%	63%/188%	74%/142%	78%/132%	80%/127%
K-90/45	3/15 to 8/27	10	50%	63%/188%	74%/142%	78%/132%	80%/127%
K-90/10	3/15 to 8/27	10	50%	63%/188%	74%/142%	78%/132%	80%/127%
K-60/lo	3/15 to 8/12	9	50%	62%/195%	73%/148%	77%/135%	80%/1292
E-400/300	4/02 to 8/27	8	50%	60%/205%	71%/153%	76%/140%	79%/130%
E-400/150	3/15 to 8/27	10	50%	63%/188%	74%/142%	78%/132%	80%/127%
E-400/75	3/15 to 8/27	10	50%	63%/188%	74%/142%	78%/132%	80%/127%
E-400/10	3/15 to 8/27	10	50%	63%/188%	74%/142%	78%/132%	80%/127%
E-90/75	3/15 to 8/27	10	50%	63%/188%	74%/142%	78%/132%	80%/127%
E- 90/45	3/15 to 8/27	10	50%	63%/188%	74%/142%	78%/132%	80%/127%
E-90/10	3/15 to 8/27	10	50%	63%/188%	74%/142%	78%/132%	80%/127%
G-90/75	3/20 to 8/17	9	50%	62%/195%	73%/148%	77%/135%	80%/129%
G-90/45	3/20 to 8/17	9	50%	62%/195%	73%/148%	77%/135%	80%/129%
G-90/10	3/20 to 8/17	9	50%	62%/195%	73%/148%	77%/135%	80%/129%

Table 4-9. Continued.

TEMPERATURE SPECTRA (Continued)

	Data Span (start 0000 PST)	30-day Segments[2]	Overlap	90% Confidence Limits (lower/upper)[1] at Periods of: 30 days	15 days	10 days	7.5 days
V-400/300	5/03 to 8/15	6	52%	57%/236%	68%/164%	73%/148%	76%/139%
V-400/150	5/03 to 8/15	6	52%	57%/236%	68%/164%	73%/148%	76%/139%
V-400/75	5/03 to 8/15	6	52%	57%/236%	68%/164%	73%/148%	76%/139%
V-400/10	3/18 to 8/15	9	50%	62%/195%	73%/148%	77%/135%	80%/129%
V-130/10	3/18 CO 8/15	9	50%	62%/195%	73%/148%	77%/135%	80%/129%
V-90/75	3/18 to 8/15	9	50%	62%/195%	73%/148%	77%/135%	80%/129%
V-90/45	3/18 to 8/15	9	50%	62%/195%	73%/148%	77%/135%	80%/129%
V-90/10	3/18 to 8/15	9	50%	62%/195%	73%/148%	77%/135%	80%/129%
V-60/10	3/18 to 8/15	9	50%	62%/195%	73%/148%	77%/135%	80%/129%
C-400/300	3/20 to 8/17	9	50%	62%/195%	73%/148%	77%/135%	80%/129%
C-400/150	3/20 to 8/17	9	50%	62%/195%	73%/148%	77%/135%	80%/129%
C-400/75	6/07 to 8/17	3	50%	47%/381%	60%/209%	65%/179%	68%/162%
C-400/10	5/02 to 8/17	6	50%	57%/236%	68%/164%	73%/148%	76%/139%
C-130/10	3/20 to 8/17	9	50%	62%/195%	73%/148%	77%/135%	80%/129%
C-90/75	3/20 to 8/17	9	50%	62%/195%	73%/148%	77%/135%	80%/129%
C-90/10	3/20 to 8/17	9	50%	62%/195%	73%/148%	77%/135%	80%/129%
G-60/10	3/20 to 8/17	9	50%	62%/195%	73%/148%	77%/135%	80%/129%

BOTTOM PRESSURE SPECTRA

	Data Span (start 0000 PST)	30-day Segments[2]	Overlap	90% Confidence Limits (lower/upper)[1] at Periods of: 30 days	15 days	10 days	7.5 days
K-130	3/15 to 8/27	10	50%	63%/188%	74%/142%	78%/132%	80%/127%
E-90	3/29 to 8/27	9	50%	62%/195%	73%/148%	77%/135%	80%/129%
G-90	3/20 to 8/17	9	50%	62%/195%	73%/148%	77%/135%	80%/129%
Se-10	3/20 to 8/17	9	50%	62%/195%	73%/148%	77%/135%	80%/129%
V-60	3/18 to 8/15	9	50%	62%/195%	73%/148%	77%/135%	80%/129%
C-130	3/29 to 8/17	8	50%	60%/205%	71%/153%	76%/140%	79%/130%
C-60	3/20 to 7/25	7	50%	58%/217%	70%/158%	74%/143%	77%/136%

Notes:

[1]Geometric progression running-mean band averaging:
- 1st spectral estimate (1.39 x 10^{-3} cycles/hour): 1 pt. averaged
- 2nd spectral estimate (2.78 x 10^{-3} cycles/hour): 3 pts. averaged
- 3rd spectral estimate (4.17 x 10^{-3} cycles/hour): 5 pts. averaged
- 4th and higher (5.56 x 10^{-3} cycles/hour): 7 pts. averaged

[2]Hanning (full cosine) taper applied to linear de-trended segments.

5. METEOROLOGICAL OBSERVATIONS

by John F. Borchardt

5.1 INTRODUCTION

The data collection objectives of the meteorological component of the NCCCS include the measurement of winds, barometric pressure, air temperature, and other atmospheric parameters of interest within the marine boundary layer for joint analysis with oceanographic data. A secondary, but still important objective, is to further the scientific understanding of meteorological processes within the marine boundary layer itself, particularly within local areas where prominent coastal topographic features are thought to have important effects. The network of meteorological stations selected to meet these objectives is essentially the same as during the NCCCS pilot program performed in 1987, with certain additions to satisfy specialized analysis requirements. Coverage extends over a wide section of the west coast, from Washington (47°N) to southern California (34°N).

5.2 METEOROLOGICAL DATA COLLECTION METHODOLOGY

5,2.1 Station Descriptions

The meteorological station network for the main program is shown in Figure 5-1. The primary component of this network is the station array operated by the National Data Buoy Center (NDBC). During the pilot program, data were collected from 14 offshore buoys and four coastal (C-MAN) stations. Two additional NDBC buoys were included for the main program: SE Papa (46006), which is located well offshore (137°W) and is not shown on the station map, and Cape Elizabeth (46041), which extends the coverage farther north (47°N). Table 5-1 presents a listing of the 16 buoys included in the data base for the first deployment period.

Table 5-2 presents a listing of 14 coastal stations which are included in the data base to supplement the coverage offered by the buoy array. These stations were carefully screened during the pilot program according to several criteria designed to insure that the winds were reasonably representative of over-the-water conditions within the marine layer and were suitable in terms of measurement accuracy and sampling frequency [EG&G, 1988].

Data from two of these stations, Pillar Point and Pigeon Point, are available only in paper-copy format and at less than hourly sampling intervals. These records have not been entered into the NCCCS data base due to the extensive manual data entry effort involved. Instead, they are included in the station listing on a provisional basis, with the intention that the data could be accessed during selected time internals or meteorological events of interest. In particular, these stations provide a cross-shelf match with winds and sea-level pressure measured at the Santa Cruz buoy (46012) and could be used to investigate this aspect of the wind field if it is indicated to be a worthwhile analysis objective.

Among the remaining 12 stations in the listing are four C-MAN stations, operated by the NDBC, which were also included in the pilot program data base. These stations are essentially similar to the offshore buoys, except that they are located at lighthouse facilities on prominent headlands.

Data records in computer-compatible format are available from two Flight Service Stations (North Bend, Oregon, and Arcata, California) as continuous, hourly records. The observations are manually recorded by FAA personnel at the stations, and the logs are entered into the computer archives at the National Climatic Data Center (NCDC) on a monthly schedule.

Data from two additional Flight Service Stations, not shown in the table listing, have been obtained from NCDC as a source of sea-level pressure only. These include Astoria, Oregon, which provides the barometric pressure adjustment for the nearby tide gauges at Astoria and Hammond. Also, sea-level pressure records were obtained for Redding, California, with the objective of monitoring the thermal low-pressure system which develops over the central California valleys during the summer.

The Flight Service Station at the Crescent City airport (Jack McNamara Field) is a source of meteorological observations in the form of handwritten logs during daylight hours only. This station location is potentially important as an onshore match with the Point St. George buoy (46027), but the lack of continuous coverage limits the usefulness of the data records. Consequently, an automated Data Acquisition System (DAS) was Installed at the airport to record hourly wind speed and direction. Unfortunate ly, this system experienced a power failure early in the deployment period and the data return was limited to a 6-week record.

Another station location of critical importance is Shelter Cove, located south of Cape Mendocino. Although observations are routinely provided here by an NWS observer, the lack of continuous monitoring again limits the usefulness of the data for many prospective analysis applications. A second DAS was installed here during the pilot program and has been maintained in nearly continuous operation since that time.

Data for two of the coastal stations, North Spit and Trinidad Head, have been provided by the Humboldt Bay Harbor District (HBHD). The district operates a computerized real-time data display system at the Woodley Island Marina in Eureka, California. This system is programmed to automatically access two NWS anemometers at the Humboldt Bay (Samoa) Coast Guard Station and at Trinidad Head. The data are accessed via a dial-up system (DARDC) every 20 minutes and displayed on a monitor at the HBHD office at the marina for use by local commercial and recreational fishermen and boaters. The system also logs the data to diskette, including wind speed and direction and tide height from the NOAA tide gauge at the Coast Guard Station. Unfortunately, the communications interface for the tide gauge has been operating only intermittently. However, the gauge itself has continued to function reliably and the sea-level data are available from the National Ocean Service archives (see Section 6). Coast Guard personnel log wind data manually and submit the records to the National Climatic Data Center on a monthly basis. Similar records are kept by personnel at the Humboldt State University Laboratory at Trinidad. These records serve as excellent back-up sources for the HBHD system and may be useful in filling several short data gaps.

The Bodega Marine Laboratory of the University of California operates its own meteorological and oceanographic monitoring station which logs a wide variety of parameters at 20-minute sampling intervals. The laboratory does not routinely report to NWS, but maintains its own archive for research purposes. This station offers an excellent primary data source due to its desirable location, the high quality of instrumentation, and the scientific qualifications of the attending personnel. After a short period of trial operation during the pilot program in 1987, the station was temporarily shut down during the winter of 1987/88 while a hardware upgrade was completed. The station resumed operation in April 1988 and has been in nearly continuous operation since then. Data records were recently received from the laboratory, but not in sufficient time to be included in this report.

5.2.2 Instrumentation

One of the primary advantages of the NDBC data sets is the use of uniform instrumentation which insures comparable measurement characteristics between stations. Specifications for the instrumentation utilized by the NDBC have been provided in the Data Report for the pilot program [EG&G, 1988]. Essentially, wind measurements are obtained with vane-directed impellers (Belfort/R.M. Young) with speed resolution to within 0.1 m/see and directional resolution to within 1 degree. Wind sensor outputs (speed and direction) are burst sampled (1 Hz) and averaged. The GSBP payload performs vector averaging of both speed and direction while the DACT payload performs scalar averaging of speed and vector averaging of direction. Payloads at C-MAN stations typically collect 2-minute bursts, while buoy payloads collect 8-minute bursts, in order to remove the effects of platform motion. The data are transmitted via the GOES satellite through the National Weather Service Telecommunications Gateway (NWSTG) and disseminated in near real time. However, the data presented here have been obtained from the archives at the National Oceanographic Data Center (NODC). These records have been subjected to quality assurance inspection and editing by NDBC personnel prior to being transferred to NODC. Total system accuracy specifications as stated by NDBC (E. Meindl, personal communication) are as follows: wind speed, ±1 m/see; wind direction, ±15 degrees; barometric pressure, ±1 mb; air and water temperature, ±1° C.

Uniform instrumentation is also utilized at the various NWS coastal stations, and is calibrated and serviced on a regular schedule by NWS technicians. The typical wind sensor configuration consists of a cup-and-vane anemometer (F420C) mounted on a 20-foot (6.1-m) tower. Barometric pressure is typically measured with an aneroid barometer calibrated to an accuracy of 0.3 mb (0.01 inch Hg) . Meteorological observations at Flight Service Stations are manually recorded by FAA personnel at least hourly and the completed log sheets transmitted to NCDC, where the data are transcribed in computer-compatible format, reviewed and edited, and archived.

The DAS installations at Shelter Cove and Crescent City employed different instrumentation configurations. The Shelter Cove measurements were acquired using an Aanderaa Automatic Weather Station. This system utilizes a cup-and-vane anemometer which outputs the mean speed over the full sampling interval and an instantaneous direction measured at the end of the interval. The vane design incorporates fluid damping and so provides some filtering effect on rapid changes in direction. The manufacturer's specifications state a speed accuracy of ±2% of the measured value and a directional accuracy of ±2.5 degrees. The station also includes an air temperature sensor (±0.1°C) and barometric pressure sensor (±0.2 rob).

The Crescent City DAS was equipped to record wind speed only. The wind speed sensor consisted of a Belfort Type L Wind Transmitter with sampling and recording capability provided by a Sea Data 1250B Data Logger. The recorder was set to burst sample each hour at 1 Hz for 256 seconds. This corresponds to the same sampling protocol used by NDBC for C-MAN stations. Unfortunately, this system experienced a power failure after roughly 6 weeks of operation, and could not be repaired until after the end of the first deployment period.

5.2.3 Data Coverage and Quality

In general, temporal coverage and data quality were excellent throughout the first deployment period, as indicated by the time chart in Figure 5-2. Perhaps the most significant enhancement in coverage, in comparison with the pilot program, was the data return from the Blunts Reef buoy (46030) located directly off Cape Mendocino. This station was inoperable throughout the pilot program, but was returned to service on 19 March 1988". Shortly thereafter, it experienced a l-month outage during May and early June 1988, but provided reliable data return throughout the remainder of the first deployment period.

The most significant failure was the Point Arena buoy (46014) which provides the only offshore coverage in the central portion (Point Arena Basin) of the study area. This station failed in late February and was inoperable until the end of May. The Bodega buoy was inoperable throughout most of the 1987/88 winter season, but was returned to service by mid-March. The Eel River buoy (46022) experienced a short outage in late March.

The most prolonged data gap occurred with the SE Papa buoy (46006). This buoy is located well offshore (137°W) at approximately the mean position of the North Pacific subtropical high during the summer and early fall months. It was hoped that the barometric pressure at this station would be a useful measure of the position and strength of this system. Unfortunately, the buoy failed in mid-March and was not returned to service until early August. Effective evaluation of this station will have to be deferred until the second and third deployment periods.

The data return from the coastal stations was nearly complete, except for the Crescent City DAS. The missing data indicated in Figure 5-2 for July at Arcata and North Bend are currently being processed at NCDC and will be added to the data base in the near future.

5.2.4 Data Processing Procedures

Data for all NDBC platforms were obtained from the archives of NODC. The data from each platform are routinely reviewed and edited on a monthly basis by NDBC personnel before being sent to NODC. These records required no further editing prior to being added to the NCCCS data base. Also, records from all FAA Flight Service Stations archived at the National Climatic Data Center (NCDC) were received in similarly edited form and added directly to the NCCCS database. Standard quality assurance procedures were applied to the data collected with the automated stations at Crescent City and Shelter Cove, and to the Woodley Island data sets.

All of the NCCCS archived files contain wind data in the form of direct measurements, i.e., wind speed and direction with reference to true north. It should be noted that none of the wind data have been adjusted to account for variations in anemometer height, as listed in Tables 5-1 and 5-2. It was judged that, although such adjustments will be necessary for analysis purposes, in general, it was preferable not to alter the data contained in the basic archive files, Also, the barometric pressure measured at Shelter Cove has not been adjusted to equivalent sea-level pressure.

5.2.5 Ancillary Meteorological Data

The time-series measurements described above form the basic component of the meteorological data base. However, additional data sources exist which provide information of a specialized nature to assist in meeting certain analysis tasks. First, as noted in Section 3 (Volume I), extensive meteorological observations were recorded during the hydrographic cruises. These observations provide a valuable source of information regarding the spatial variability of the wind field during time periods when joint analysis is possible with data from the drifter, moored, hydrographic, and satellite components.

Further data are also available from the archives maintained by the National Center for Atmospheric Research (NCAR) containing the operational output of the LFM and NGM numerical models. Assistance in obtaining these data has been provided by Dr. P. Ted Strub of Oregon State University under a cooperative data exchange agreement between principal investigators of the NCCCS and Coastal Transition Zone program. Additional available data consists of daily surface analysis charts, published by NOAA, and GOES visible and IR satellite imagery, available from NOAA/NESDIS archives for selected time periods of interest.

5.3 DESCRIPTION OF OBSERVATIONS

5.3.1 Time Series Data and Statistics

Table 5-3 presents a statistical summary of the meteorological records for the first deployment period. Significant data gaps are identified, together with the total number of valid data points over the 6-month duration of the time series.

Figure 5-3 presents vector plots of the wind data collected at the offshore buoys and onshore coastal stations for the first deployment period. Although these plots are low-pass filtered, it is emphasized that the original data were archived at the original sampling rates. The filtering removes a considerable degree of diurnal variance during some portions of the record, especially during mid to late summer. It is not the intention to ignore this variability, but simply to provide plots which are comparable with the low-passed current vectors shown in Section 4. It is also important to note that the vector plot for each station has been rotated to align the coastal orientation given in Table 5-3 with the vertical direction for the respective tier in the figures. Thus, any horizontal component in the plotted wind corresponds to a cross-shore flow. This plotting procedure is again consistent with the presentation of the moored current measurements shown in Section 4.

The second variable of major interest is the sea-level barometric pressure. This parameter has application in connection with adjustments to the records of coastal sea level as discussed in Section 6. Also, it can be analyzed in conjunction with the wind data to describe processes within the marine boundary layer from a purely meteorological perspective. Figure 5-4 presents scalar plots of the available pressure data from the offshore and coastal stations. Again, these data have been low-pass filtered for the sake of consistency.

Air temperature is also routinely available at most of the offshore and coastal stations, as plotted in Figure 5-5.

5.3.2 Autospectrum Analysis

Figure 5-6 presents autospectra of the alongshelf and cross-shelf wind components and the barometric pressure at selected stations. Where cross-shelf station pairs are available, the spectra have been overplotted to allow convenient comparison. These plots reveal the diurnal and higher-frequency energy removed by the filtering operations in the vector time series plots. Table 5-4 lists the parameters describing the spectral computations, primarily the averaging procedures, for each of the data records.

5.4 REFERENCES

EG&G. 1988. Northern California Coastal Circulation Study Data Report No. 1: Pilot Measurement Program, March-August 1987. Prepared for Department of Interior, Minerals Management Service, EG&G WASC Oceanographic Services Report No. NCCCS-88-9, Waltham, Massachusetts, 268 pp. September.

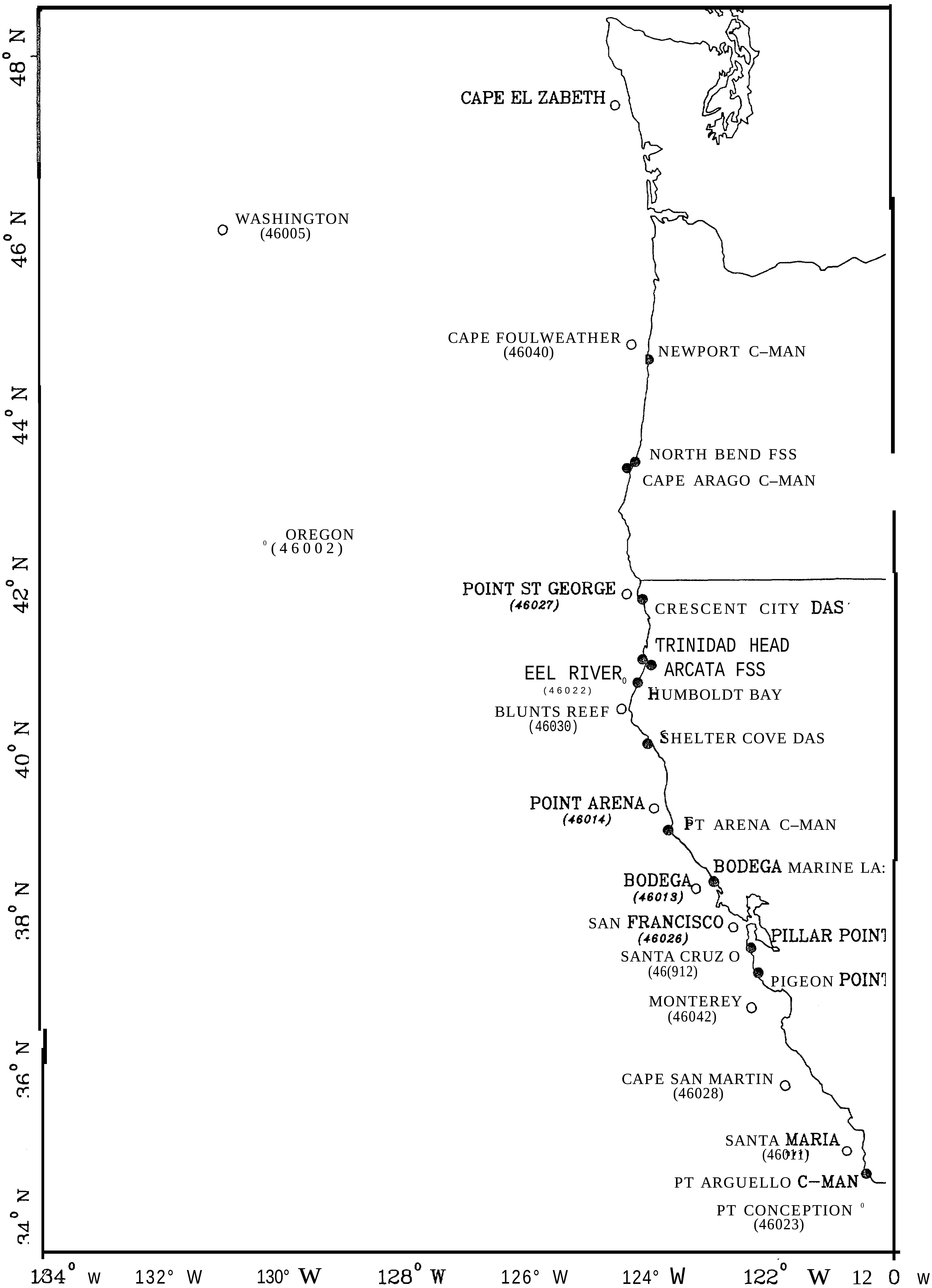


Figure 5-1. Meteorological stations during the NCCCS main program, March-August 1988.

Table 5-1. Offshore meteorological stations, NDBC buoys.

ID	Station Name	Location Latitude	Location Longitude	Buoy Type	Payload	Anemometer Height
46002	Oregon	42°31.6N	130°23.4W	6N	GSBP	5.0 m
	(prior to 4/29/87)	42°27.0N	130°16.9W	6N	GSBP	5.0 m
46005	Washington	46°05.0N	131°00.0W	6N	GSBP	5.0 m
46006	SE Papa	40°48.7N	137°39.0W	12D	DACT	10.0 m
46011	Santa Maria	34°52.8N	120°52.1W	10D	GSBP	10.0 m
	(prior to 4/29/87)	34°52.8N	120°52.4W	6N	GSBP	5.0 m
46012	Santa Cruz	37°23.1N	122°39.7W	10D	GSBP	10.0 m
	(prior to 9/16/88)	37°23.8N	122°40.1W	3D	DACT	5.0 m
	(prior to 6/16/87)	37°23.4N	122°39.6W	3D	DACT	5.0 m
46013	Bodega	38°13.9N	123°18.1W	10D	GSBP	10,0 m
46014	Point Arena	39°13.3N	123°58.4W	10D	GSBP	10.0 m
46022	Eel River	40″44.8N	124°30.1W	6N	GSBP	5.0 m
	(prior to 3/21/87)	40°45.5N	124°30.8W	6N	GSBP	5.0 m
46023	Point Conception	34°15.0N	120°40.0W	10D	GSBP	10.0 m
	(1/27/88 thru 5/19/88)	34°15.0N	120°40.0W	3D	DACT	5.0 m
46026	San Francisco	37°45.0N	122°41.5W	LNB	DACT	13.8 m
46027	Point St. George	41°50.2N	124°23.8W	LNB	DACT	13.8 m
46028	Cape San Martin	35°45.3N	121°52.0W	6N	GSBP	5.0 m
46030	Blunts Reef	40°26.5N	124°30.2W	ELB	DACT	7.2 m
46040	Cape Foulweather	44″46.9N	124°18.1W	3D	DACT	5.0 m
	(prior to 1/5/89)	44°46.3N	124°17.4W	3D	DACT	5.0 m
46041	Cape Elizabeth	47°25.0N	124°32.0W	3D	DACT	5.0 m
46042	Monterey	36°45.0N	122°24.4W	3D	DACT	5.0 m
	(prior to 12/1/87)	36°45.9N	122°13.5W	3D	DACT	5.0 m

Table 5-2. Coastal meteorological stations .

Station	Station ID	Source	Location Lat	Location Long	Station Elevation	Anemometer Height	Sampling Interval	Averaging Interval	Other Variables
Newport C-MAN	NWPO3	NDBC	44 35.9N	124 06.7W	9.1 m	9.4 m	60 min	2 min	P/T
North Bend FSS	24284	NCDC	43 25.0N	124 14.5W	3.5 m	6.1 m	60 min	1 min[1]	P/T
Cape Arago C-MAN	CARO3	NDBC	43 20.5N	124 22.5W	18.0 m	14.9 m	60 min	2 min	P/T
Crescent City FSS	CEC	NCDC	41 46.4N	124 14.2W	17.4 m	6.1 m	60 min	1 min[1]	P
Crescent City DAS		EG&G	41 46.4N	124 14.2W	17.4 m	10.0 m	60 min	1 min[2]	
Trinidad Head DARDC	96Q	NWS/HBHD	41 03.3N	124 08.9W	109.1 m	6.1 m	20 min	1 min[1]	
Arcata FSS	24263	NCDC	40 58.6N	124 06.4W	68.6 m	6.1 m	60 min	1 min[1]	P/T
Humboldt Bay DARDC	88Q	NWS/HBHD	40 46.1N	124 13.8W	1.8 m	6.1 m	20 min	1 min[1]	
Shelter Cove DAS		EG&G	40 01.3N	124 04.3W	14.5 m	10.0 m	30 min	30 min	P / T
Point Arena C-MAN	PTAC 1	NDBC	3 8 57.3N	123 44.4W	17.4 m	12.5 m	60 min	2 min	P/T
Bodega Marine Lab		BML	38 19.1N	123 04.2W	11 m	15 m	60 min	20 min[2]	P/T
Pillar Point MARS	53Q	NWS/NCDC	37 29.6N	122 29.9W	39.6 m	15.2 m	180 min	1 min[3]	
Pigeon Point DARDC	93Q	NWS/NCDC	37 10.9N	122 23.6W	15,5 m	6.1 m	180 min	1 min[1]	T
Point Arguello C-MAN	PTGC 1	NDBC	34 34.6N	120 38.8W	12.2 m	9.4 m	60 min	2 min	P/T

Abbreviation :

C-MAN : Coastal Marine Automated Network
FSS : Flight Service Station
DARDC : Device for Automatic Remote Data Collection
MARS : Marine Reporting Station
DAS : Data Acquisition System

Notes:

[1]Approximate time constant for F420C anemometer.
[2]Vector average.
[3]Manually recorded wind speed and direction, subjective averaging.

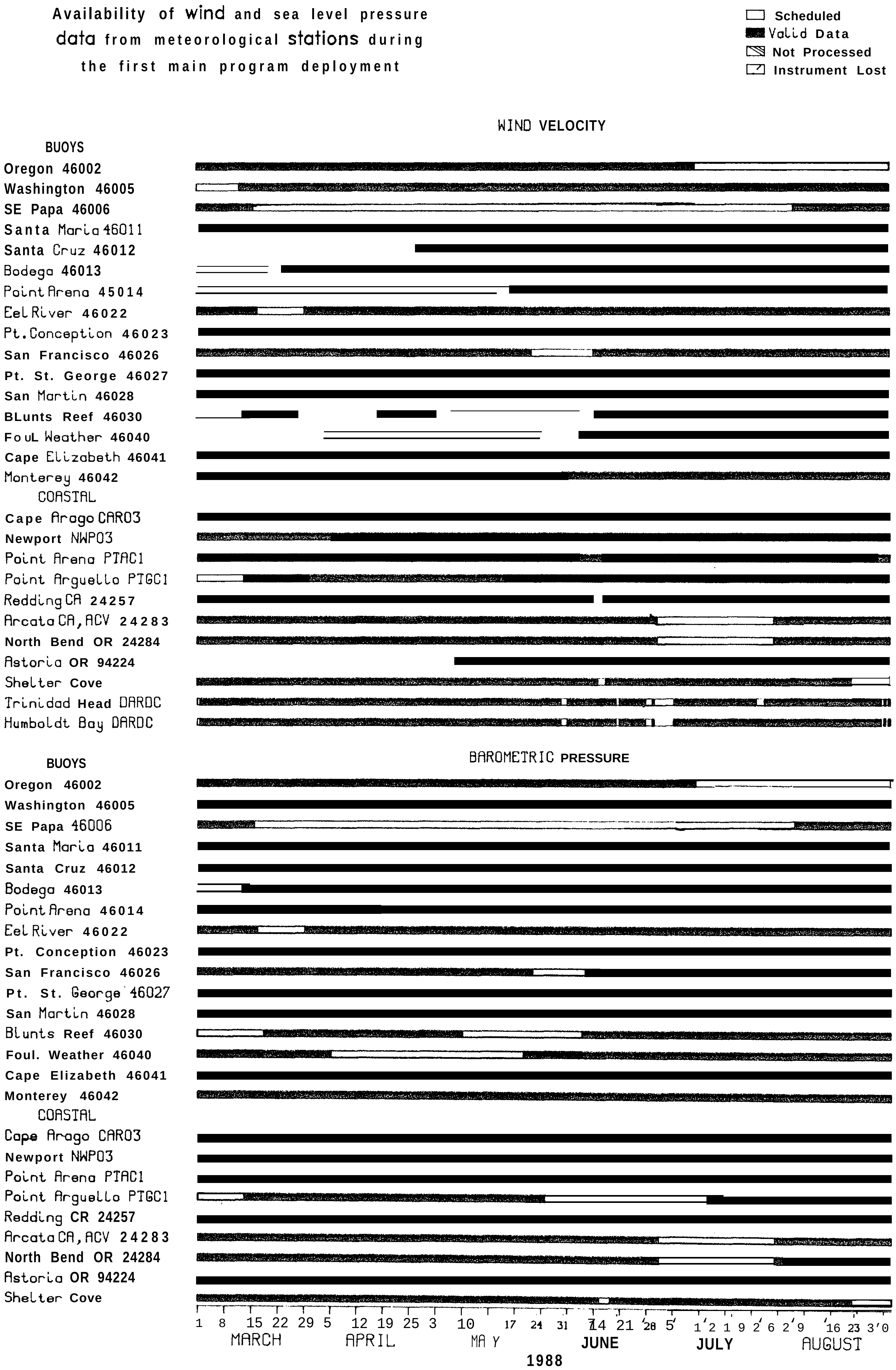


Figure 5-2. Time chart of meteorological data coverage, March-August 1988.

Table 5-3 Statistical summary of meteorological measurements

Station		Period of Record Start	Period of Record End	Data Gaps Start	Data Gaps End	Valid Data Pts.	Valid Data %	Coastal Orientation (deg true)	Alongshore Wind (m/sec) Mean	Alongshore Wind Std Dev	Alongshore Wind Max	Alongshore Wind Min	Cross-shore Wind (m/sec) Mean	Cross-shore Wind Std Dev	Cross-shore Wind Max	Cross-shore Wind Min	Barometric Pressure (mb) Mean	Barometric Pressure Std Dev	Air Temperature (deg C) Mean	Air Temperature Std Dev
Ocean Buoys																				
Washington	46005	3/12	8/31			4127	93	-	0.23	4.8	16.2	-11.3	2.62	4.2	17.6	-16.1	1018.71	7.8	10.96	2.6
Oregon	46002	3/01	7/11			1702	38	-	0.16	4.7	15.5	-11.0	2.82	3.8	14.3	-7.9	1021.45	7.2	10.36	1.4
SE Papa	46006	3/01	8/31	3/15	8/[illegible]	858	19	-	-0.16	5.7	14.2	-9.9	1.48	4.2	16.8	-9.4	1023.06	4.5	15.41	3.3
Offshore Buoys																				
Cape Elizabeth	46041	3/01	8/31			4395	99	335	-0.69	4.2	15.9	-10.9	0.87	2.4	12.6	-9.2	1018.16	5.7	10.43	2.3
Cape Foulweather	46040	3/01	8/31	4/05	5/26	3164	72	5	-1.81	5.4	18.7	-12.0	1.24	2.4	13.1	-9.4	1019.70	4.7	11.45	2.3
Point St. George	46027	3/01	8/31			4320	98	355	-2.57	5.7	15.4	-17.9	0.65	1.9	9.0	-7.0	1019.01	5.1	10.83	1.6
Eel River	46022	3/01	8/31	3/16	3/29	4082	92	27	-2.50	4.5	12.7	-12.1	1.74	2.7	9.4	-7.9	1018.15	4.6	11.58	1.4
Blunts Reef	46030	3/18	8/31	5/10	6/11	3208	73	0	-4.27	4.8	11.5	-16.0	-0.31	1.9	9.5	-9.6	1017.12	4.9	10.96	1.2
Point Arena	46014	5/26	8/31			2324	53	354	-4.33	4.9	9.2	-15.2	1.06	1.8	6.8	-4.4	1016.72	4.8	11.65	1.4
Bodega	46013	3/15	8/31			4052	92	317	-6.12	5.8	9.2	-18.2	0.81	1.6	7.8	-5.3	1016.18	4.3	11.81	1.3
San Francisco	46026	3/01	8/31	5/28	6/14	3991	90	317	-3.87	4.4	10.5	-17.5	2.25	1.9	9.2	-7.9	1016.25	4.4	12.06	1.6
Santa Cruz	46012	3/01	8/31			4381	99	345	-2.19	3.6	10.0	-13.6	2.06	2.0	10.6	-4.0	1017.05	4.3	11.49	1.3
Monterey	46042	3/01	8/31			4168	94	340	-3.87	4.0	10.8	-13.2	2.08	1.8	7.7	-5.0	1016.14	4.1	12.38	1.5
Cape San Martin	46028	3/01	8/31			4393	99	320	-5.92	4.8	10.1	-16.2	-0.56	1.4	6.4	-6.3	1016.46	3.8	13.43	1.5
Santa Maria	46011	3/01	8/31	multiple gaps		3817	86	0	-3.12	3.4	8.0	-13.8	3.75	3.3	15.7	-6.8	1015.77	3.3	13.48	1.7
Pt Conception	46023	3/01	8/31			4384	99	0	-5.05	3.6	6.9	-13.0	3.85	2.6	13.0	-7.0	1015.14	3.3	13.93	1.8
Coastal Stations																				
Astoria FSS	94224	3/01	8/31			4417	100	0	0.09	3.6	18.5	-9.4	1.79	3.0	12.1	-9.6	1018.87	5.3	1[illegible].02	[illegible].6
Newport C-MAN	NWPO3	3/01	8/31			4390	99	5	-0.68	4.8	20.5	-12.9	1.12	2.3	12.6	-8.2	1019.34	5.2	1[illegible].57	[illegible]4
North Bend FSS	24283	3/01	8/31	7/01	8/01	3672	83	17	-0.65	3.7	12.8	-12.3	1.50	3.0	10.3	-5.9	1019.49	5.3	1[illegible].43	[illegible].7
Cape Arago C-MAN	CARO3	3/01	8/31			4394	99	17	-0.36	4.8	16.6	-14.3	0.20	1.9	12.8	-4.8	1019.74	5.0	1[illegible].76	[illegible].2
Trinidad Head	DARDC	3/01	8/31	6/30	7/05	4034	91	355	-1.29	3.6	11.6	-13.1	0.69	2.2	11.6	-8.9	NA		NA	
Arcata FSS	24283	3/01	8/31	7/01	8/01	3672	83	27	-0.30	2.0	8.5	-8.1	1.20	2.8	10.5	-6.4	1018.37	5.3	10.66	3.4
Humboldt Bay	DARDC	3/01	8/31	6/30	7/05	4084	92	27	-0.52	2.3	9.6	-10.1	0.75	1.8	8.6	-6.4	NA		NA	
Redding FSS	24527	3/01	8/31			4417	100	0	-0.05	3.7	15.5	-12.3	0.56	1.9	8.1	-8.7	1014.28	5.4	21.56	9.3
Shelter Cove	EG&G	3/01	8/31	multiple gaps		3793	86	317	0.15	3.2	13.7	-10.6	-0.53	2.3	7.6	-9.2	1015.78	4.9	10.69	1.9
Point Arena C-MAN	PTAC1	3/01	8/31			4399	99	354	-2.96	4.4	12.2	-19.0	-0.03	1.3	7.2	-5.4	1017.11	4.6	[illegible]0.88	1.7
Pt Arguello C-MAN	PTGC1	3/13	8/31			4094	93	0	-6.41	5.2	13.5	-20.6	0.55	1.6	13.0	-7.9	1015.54	3.3	[illegible]3.32	1.9

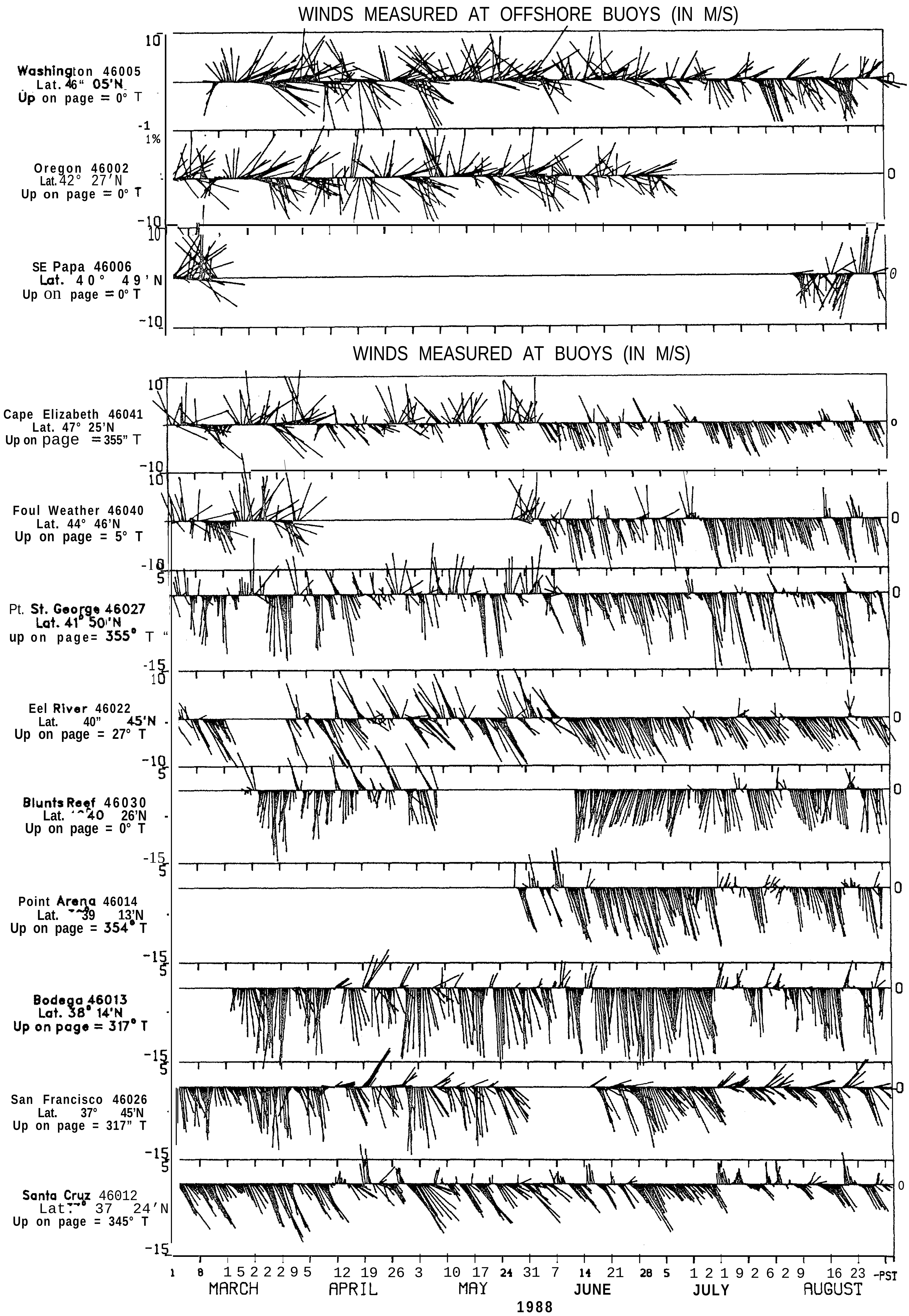


Figure 5-3. Low-pass- filtered wind vectors from offshore buoys and coastal meteorological stations . The Washington, Oregon, and SE Papa buoys are far from the coast.

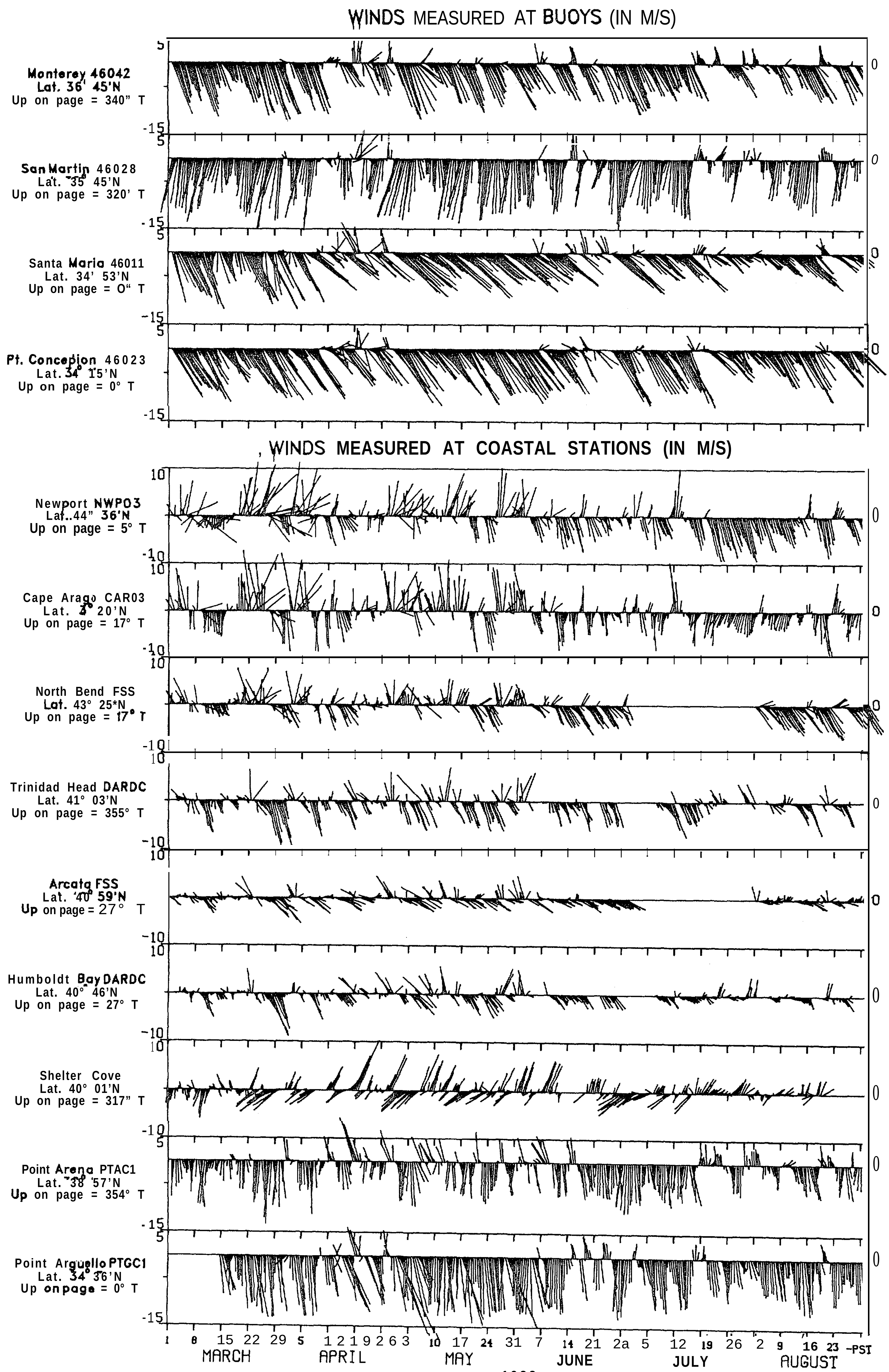


Figure 5-3. Continued.

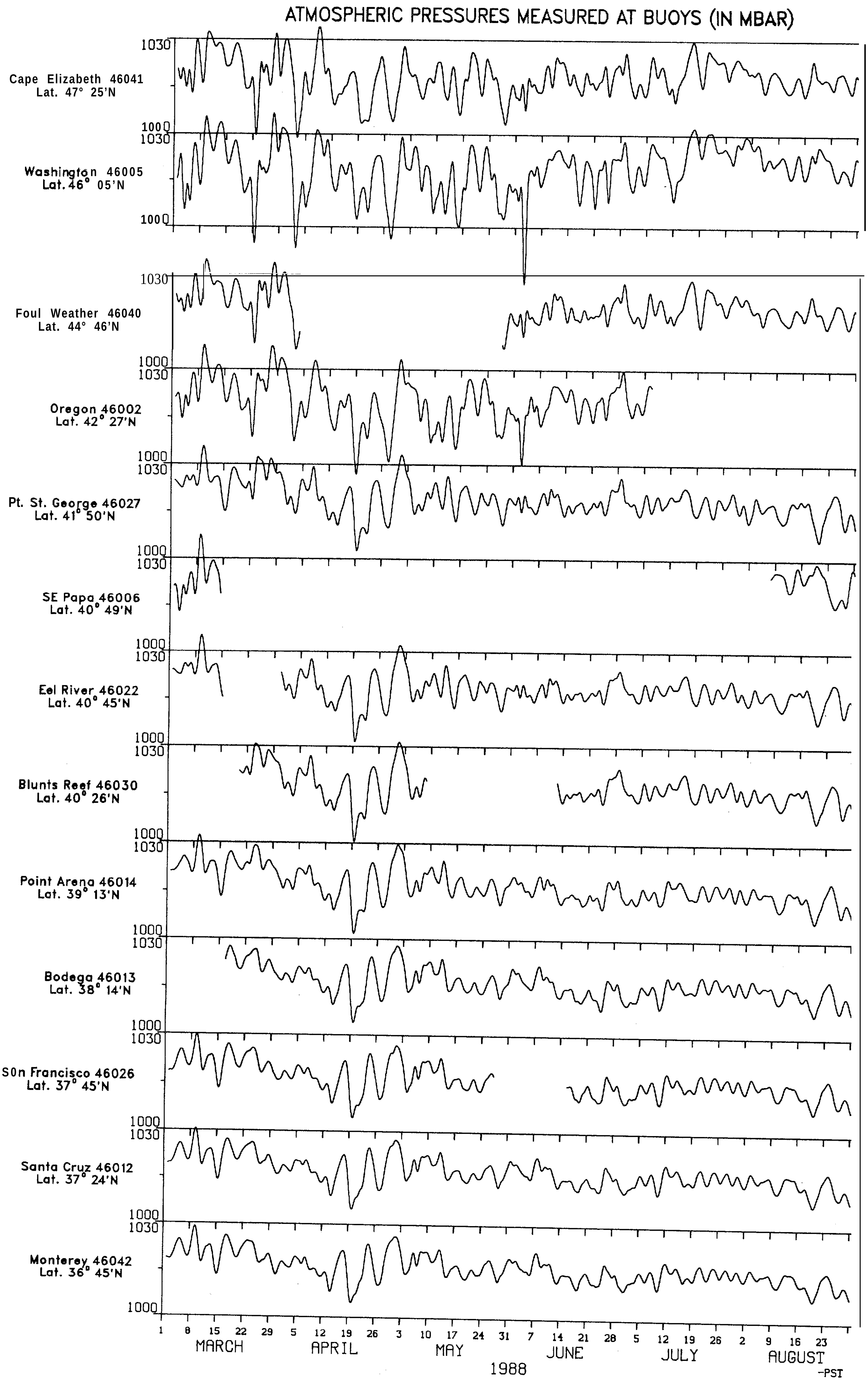


Figure 5-4. Low-pass-filtered barometric pressures from offshore buoys and coastal meteorological stations.

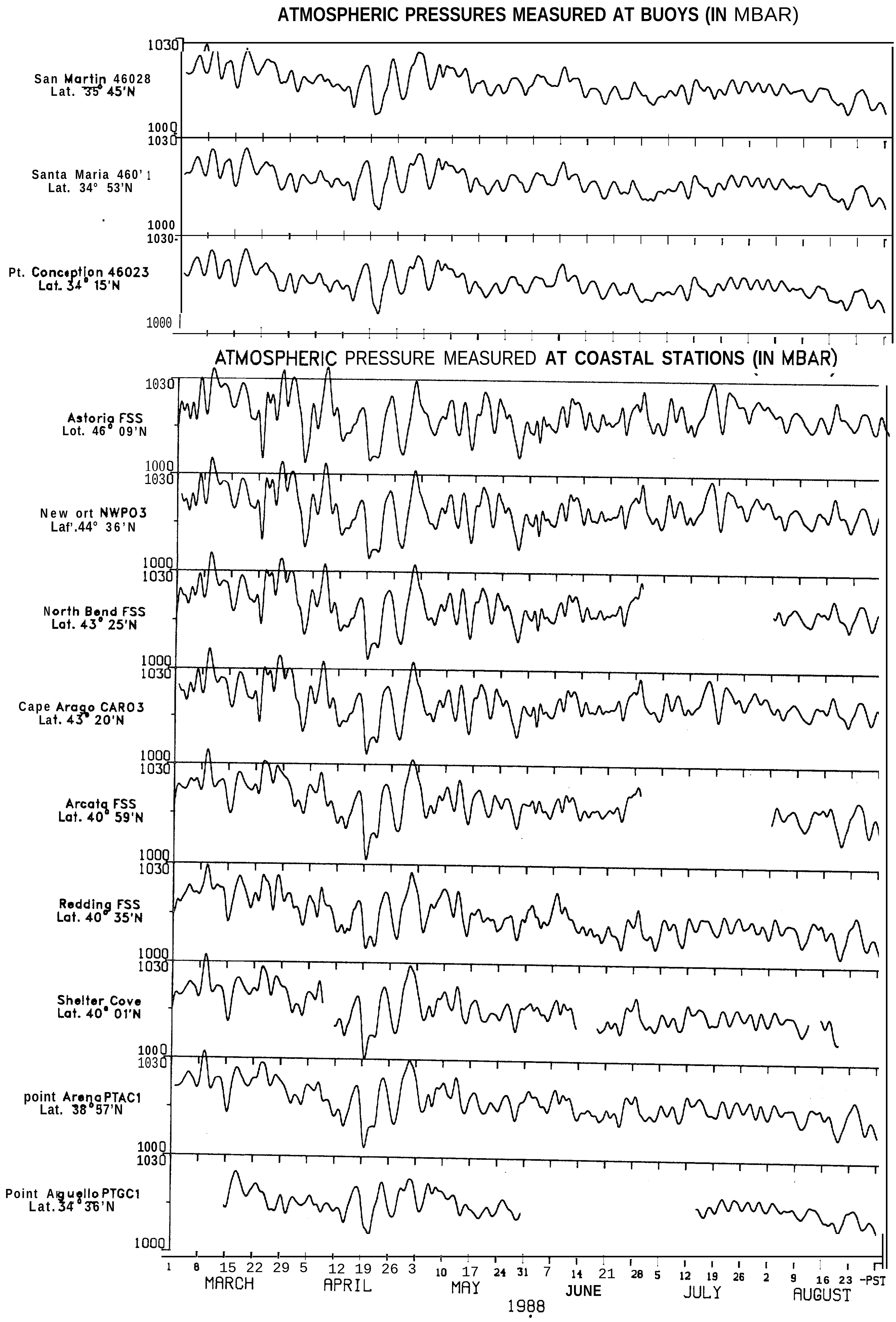


Figure 5-4. Continued.

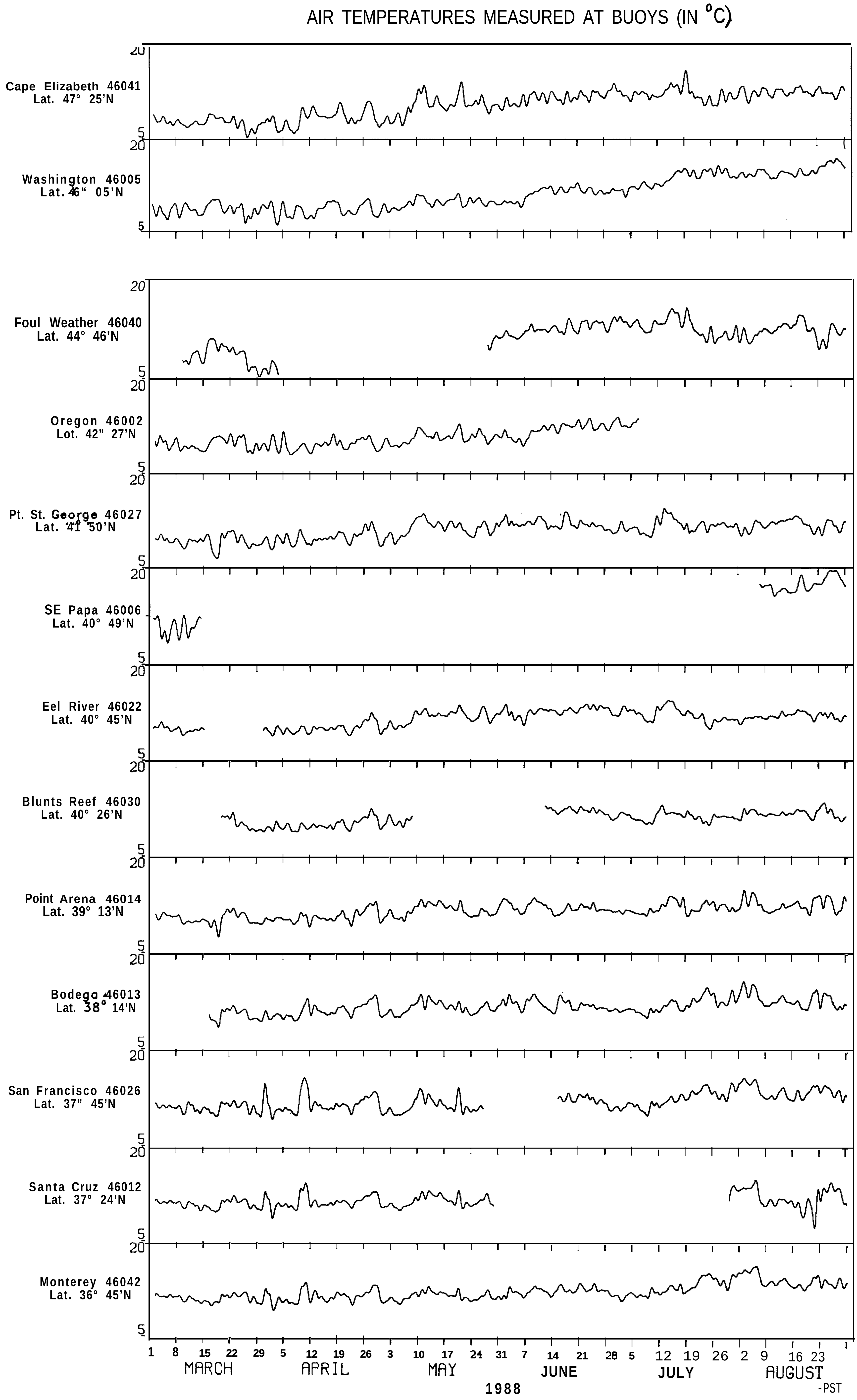


Figure 5-5. Low- pass - filtered air temperature from off shore buoys and coastal meteorological stations.

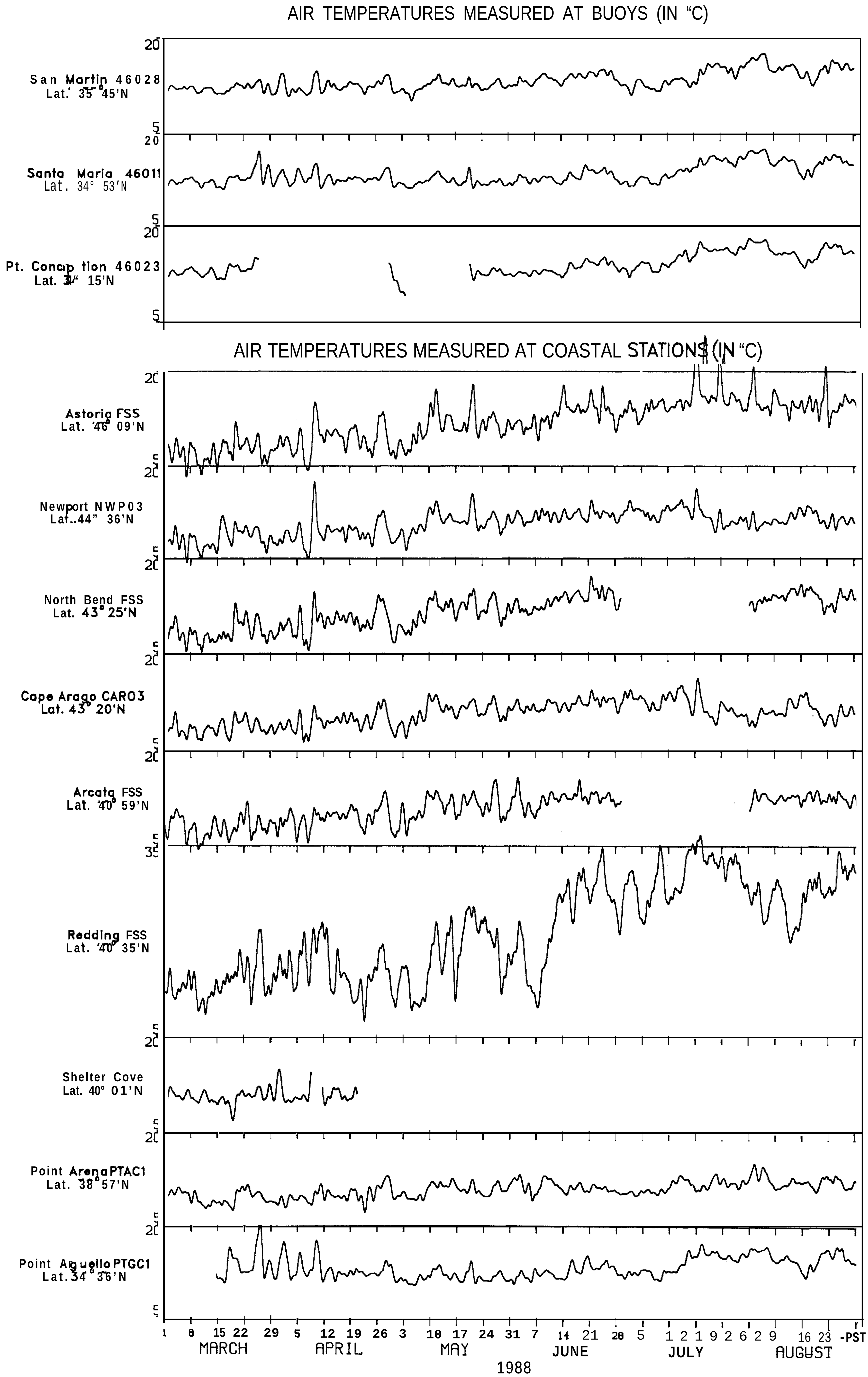


Figure 5-5. Continued.

VARIANCE CONSERVING AUTOSPECTRA
NCCCS FIRST MAIN, MARCH - AUGUST 1988

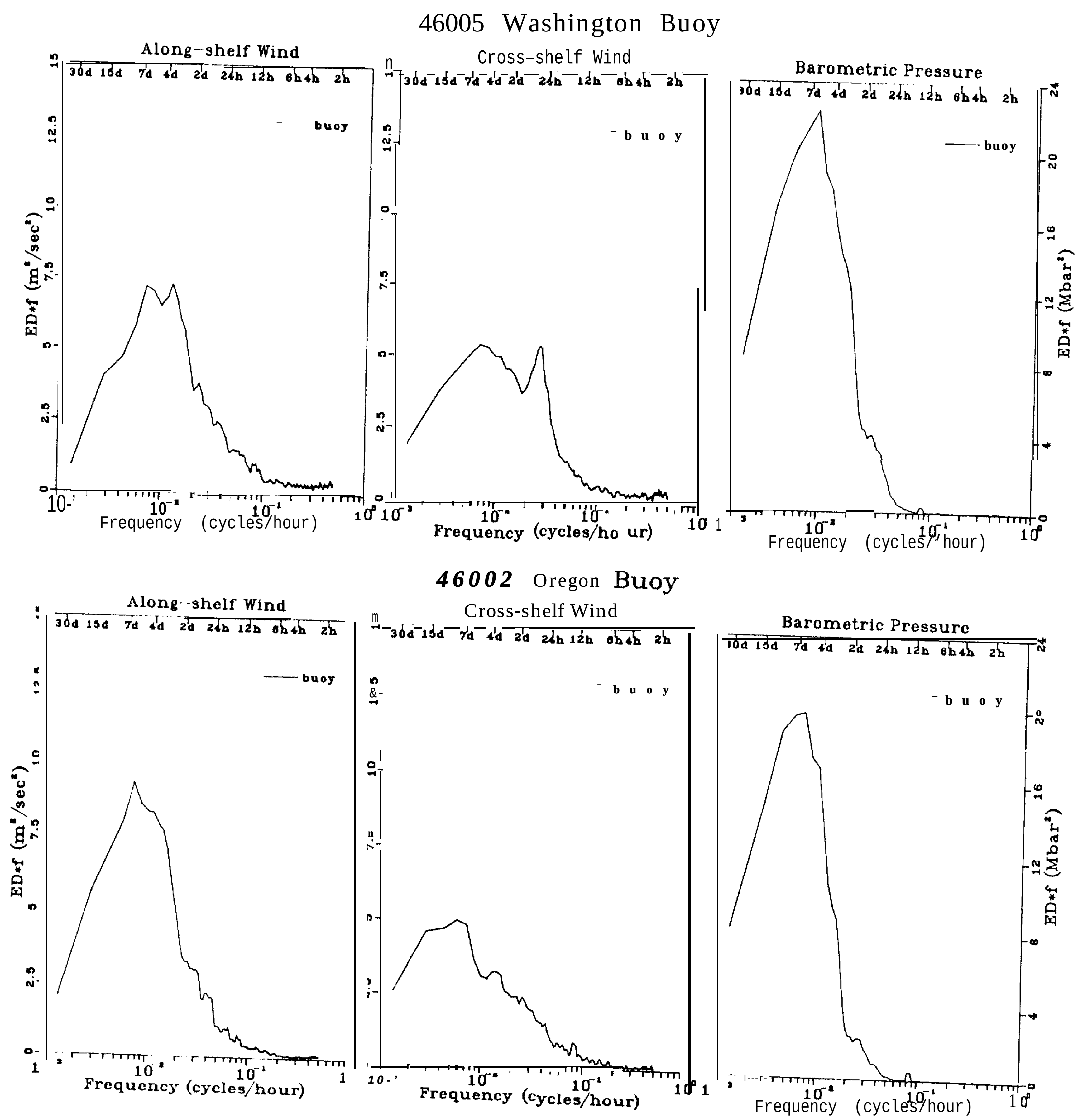


Figure 5-6a. Autospectra of wind components and barometric pressure at selected meteorological stations: Washington buoy (46005) and Oregon buoy (46002).

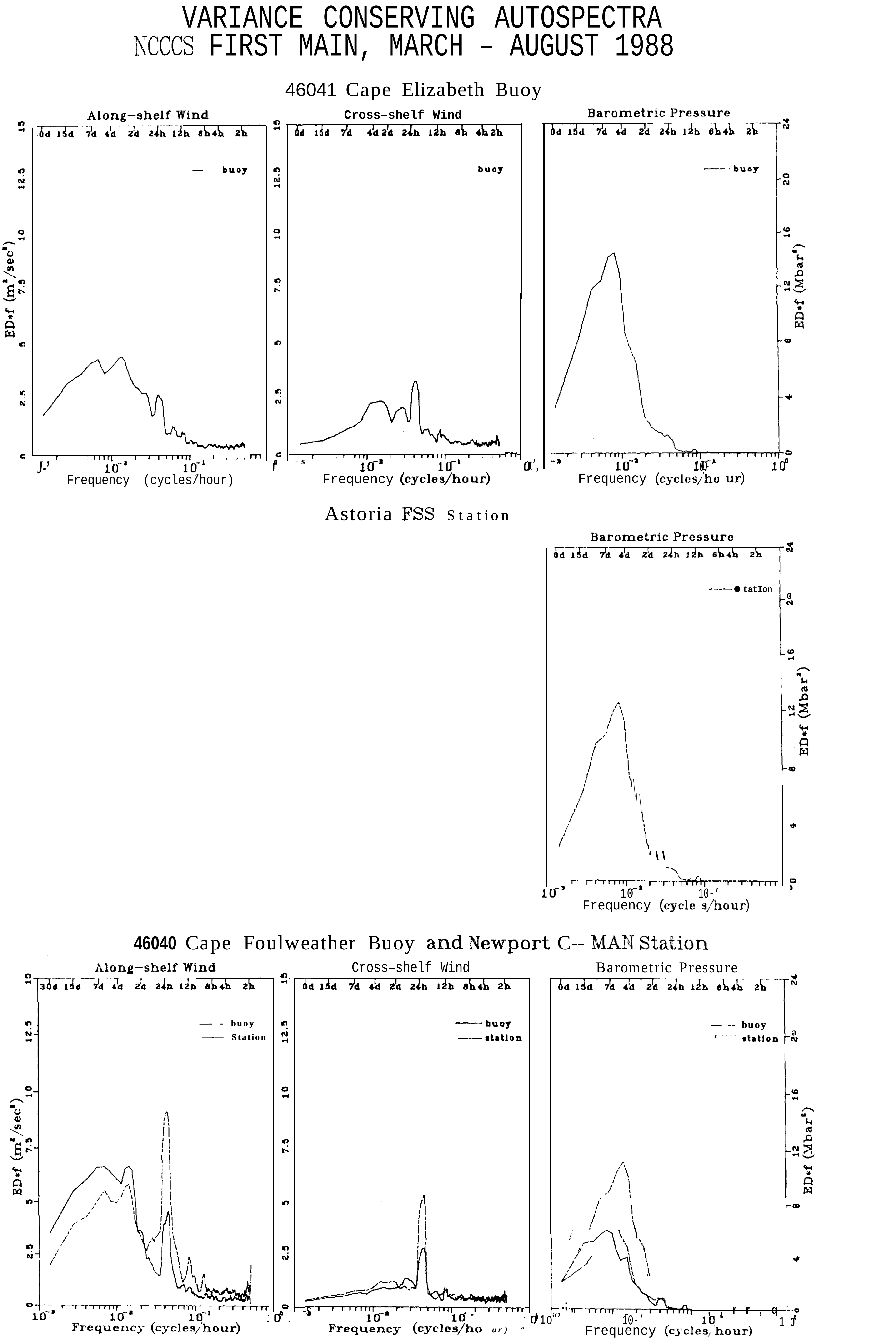


Figure 5-6b. Autospectra of wind components and barometric pressure at selected meteorological stations : Cape Elizabeth buoy (46041) , Astoria FSS, Cape Foulweather buoy (46040) , and Newport C -MAN station.

VARIANCE CONSERVING AUTOSPECTRA
NCCCS FIRST MAIN, MARCH - AUGUST 1988

Cape Arago C–MAN Station

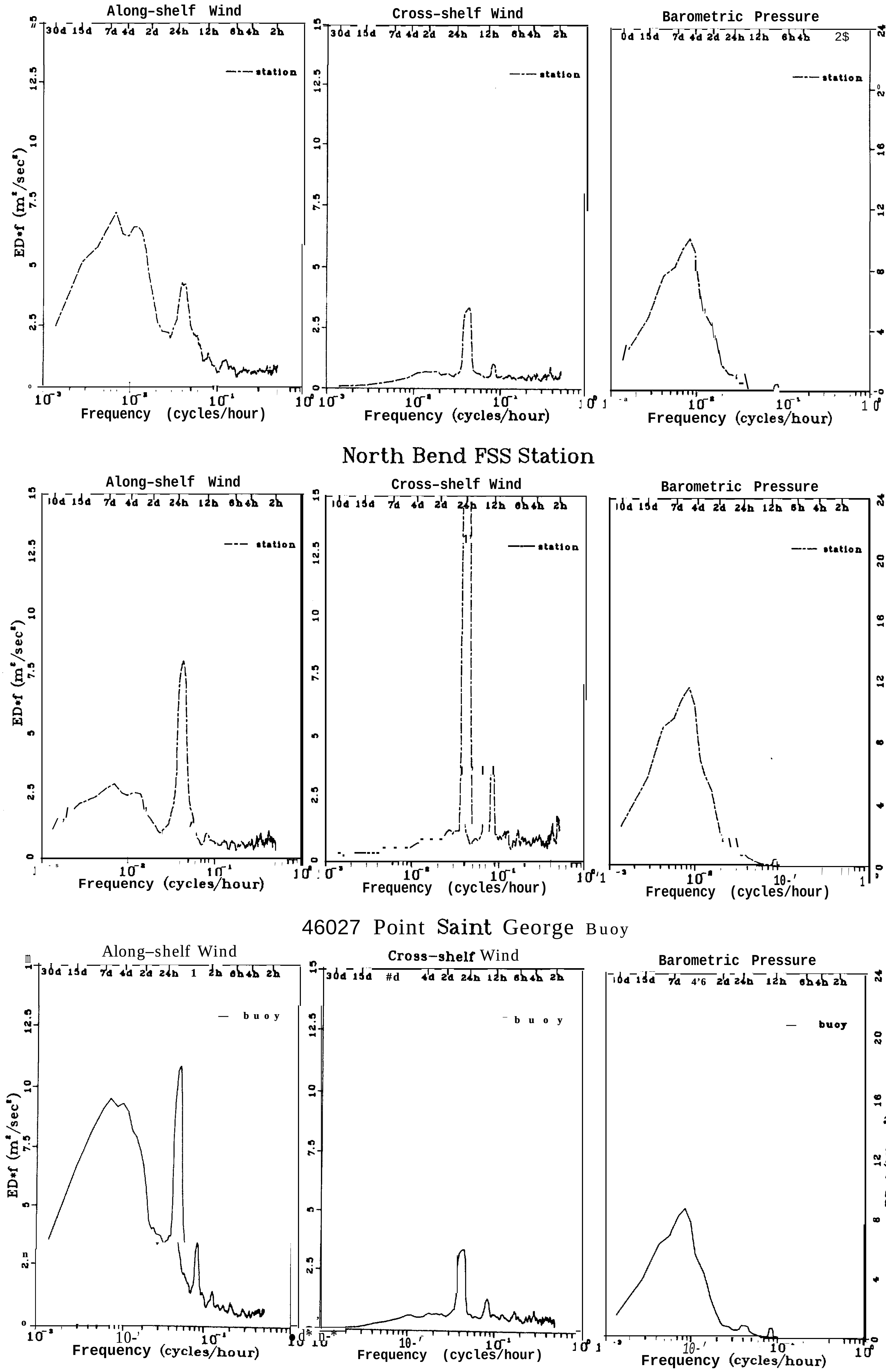
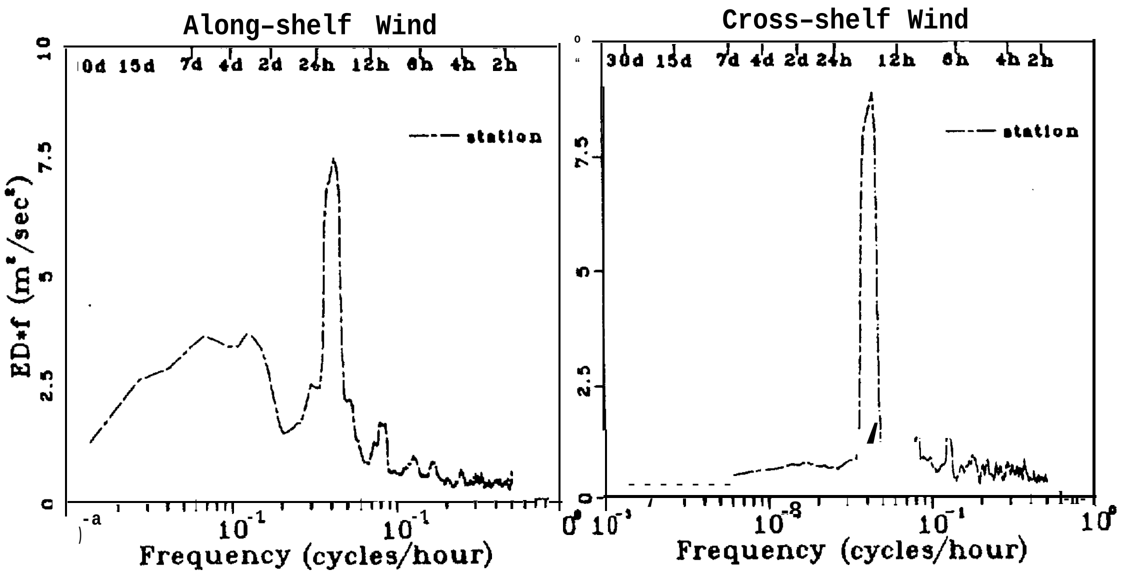


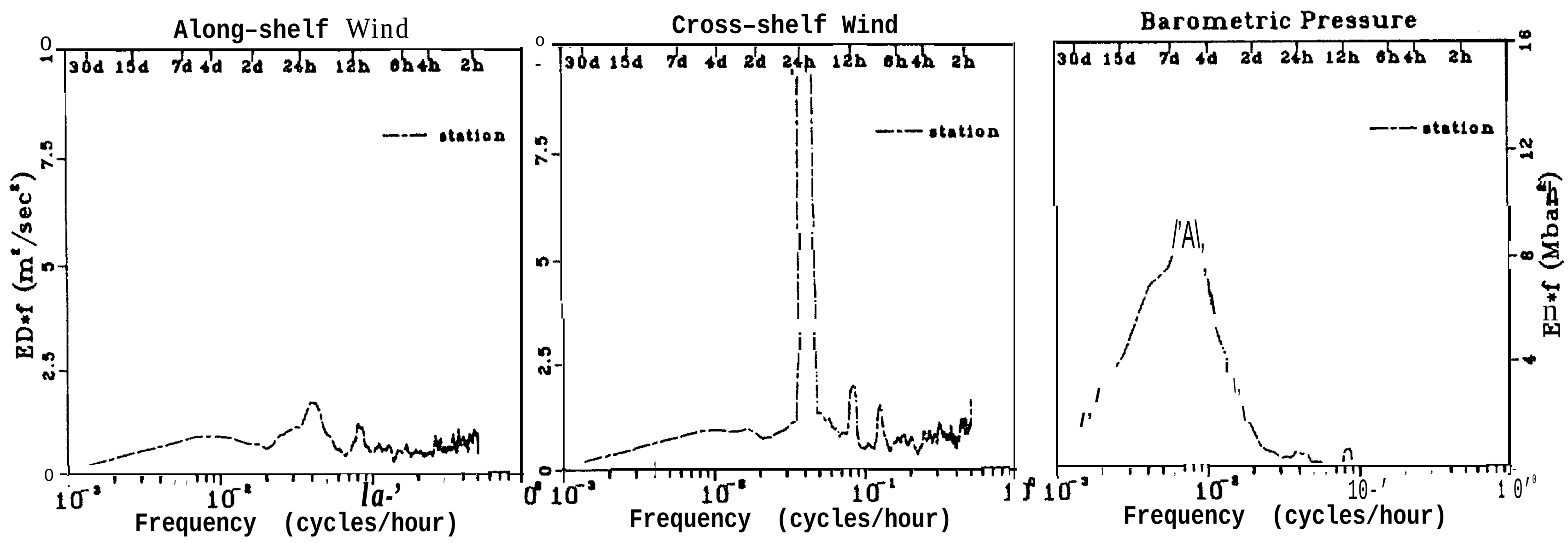
Figure 5-6c. Autospectra of wind components and barometric pressure at selected meteorological stations : Cape Arago C-MAN, North Bend FSS, and Point St. George buoy (46027) .

VARIANCE CONSERVING AUTOSPECTRA
NCCCS FIRST MAIN, MARCH - AUGUST 1988

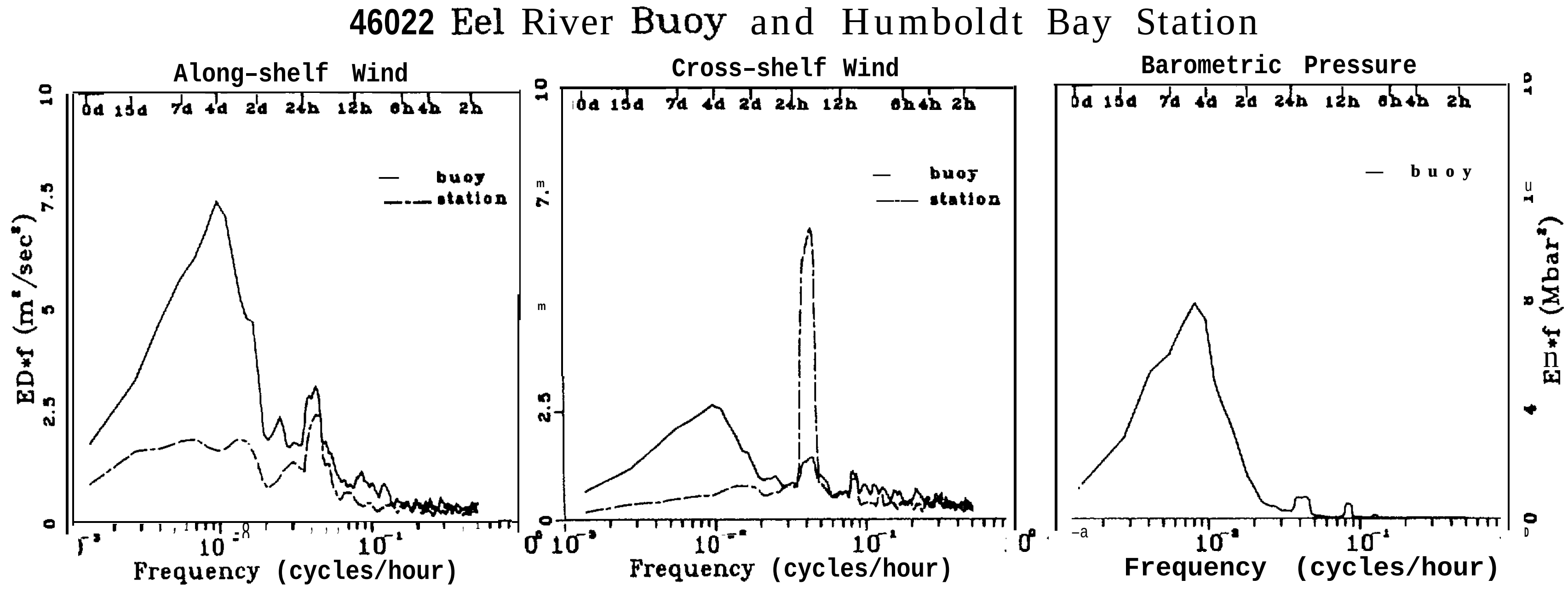
Trinidad Head Station



Arcata FSS Station



46022 Eel River Buoy and Humboldt Bay Station



Redding FSS Station

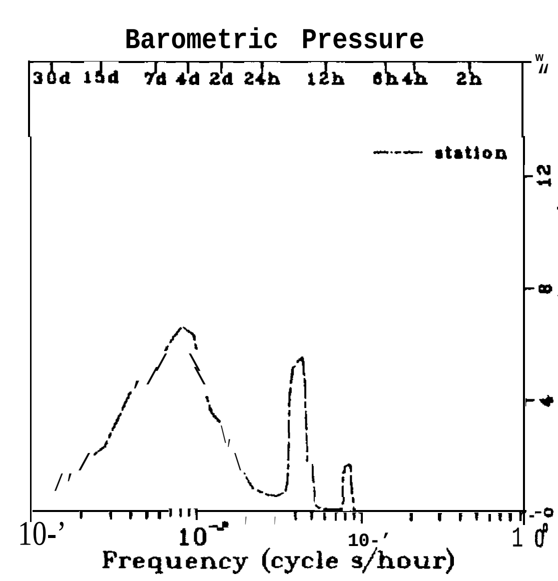


Figure 5- 6d. Autospectra of wind components and barometric pressure at selected meteorological stations: Trinidad Head, Arcata FSS, Eel River buoy (46022) , Humboldt Bay, and Redding FSS.

VARIANCE CONSERVING AUTOSPECTRA
NCCCS FIRST MAIN, MARCH - AUGUST 1988

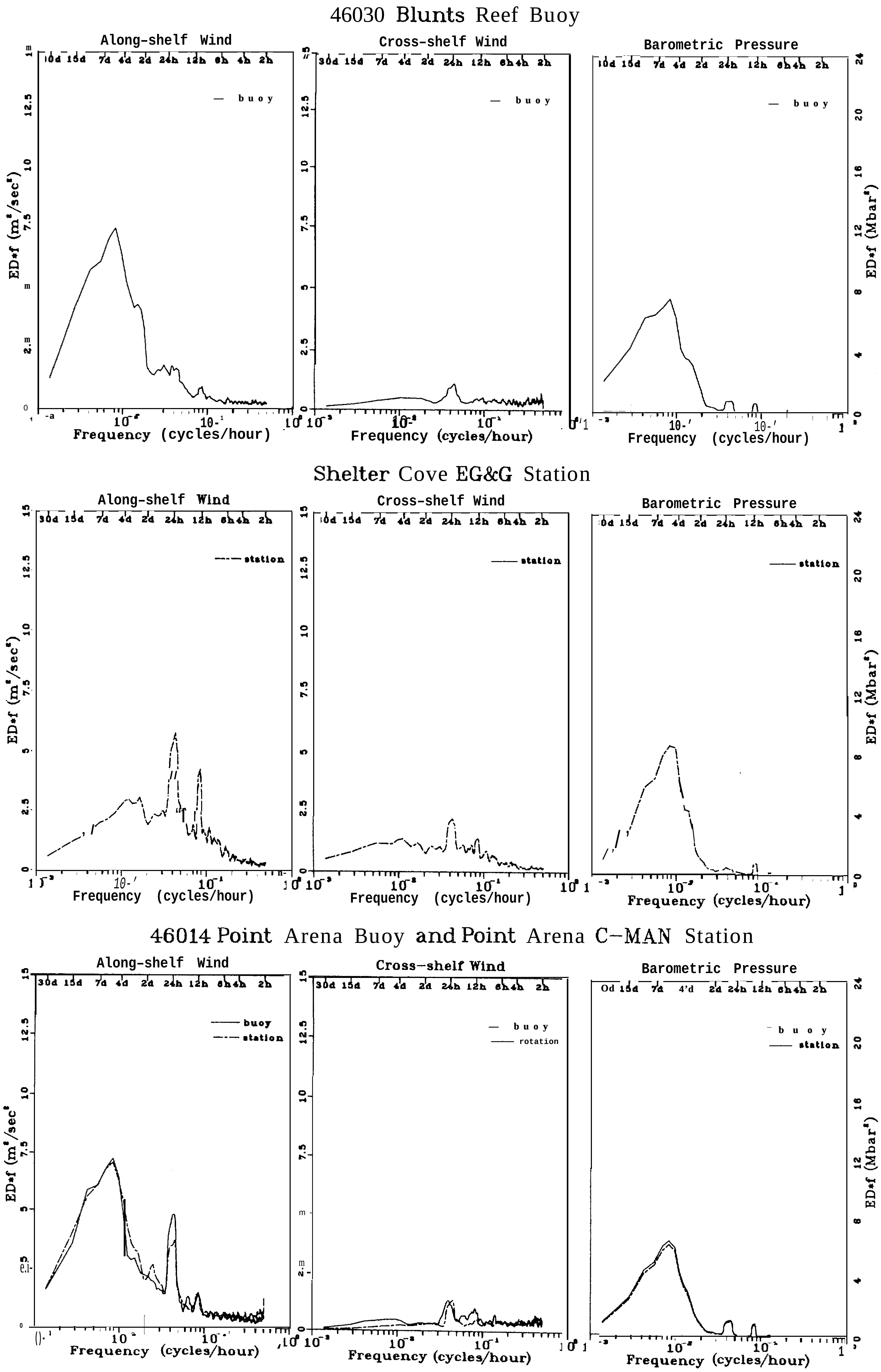


Figure 5-6e. Autospectra of wind components and barometric pressure at selected meteorological stations. Blunts Reef buoy (46030) , Shelter Cove, Point Arena buoy (46014) and Point Arena C -MAN station.

VARIANCE CONSERVING AUTOSPECTRA
NCCCS FIRST MAIN, MARCH - AUGUST 1988

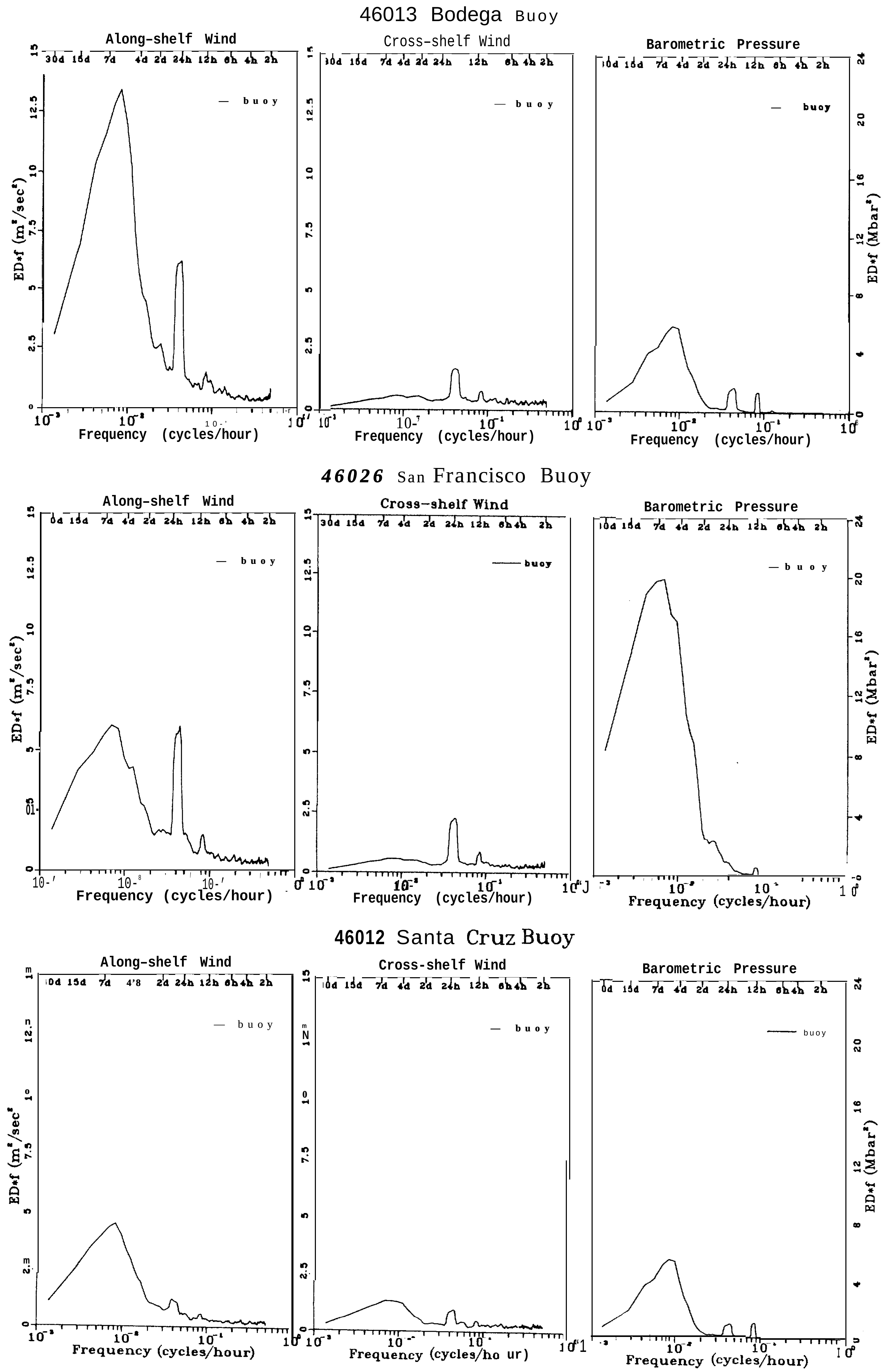


Figure 5-6f. Autospectra of wind components and barometric pressure at selected meteorological stations. Bodega buoy (46013) , San Francisco buoy (46026) , and Santa Cruz buoy (46012) .

VARIANCE CONSERVING AUTOSPECTRA
NCCCS FIRST MAIN, MARCH - AUGUST 1988

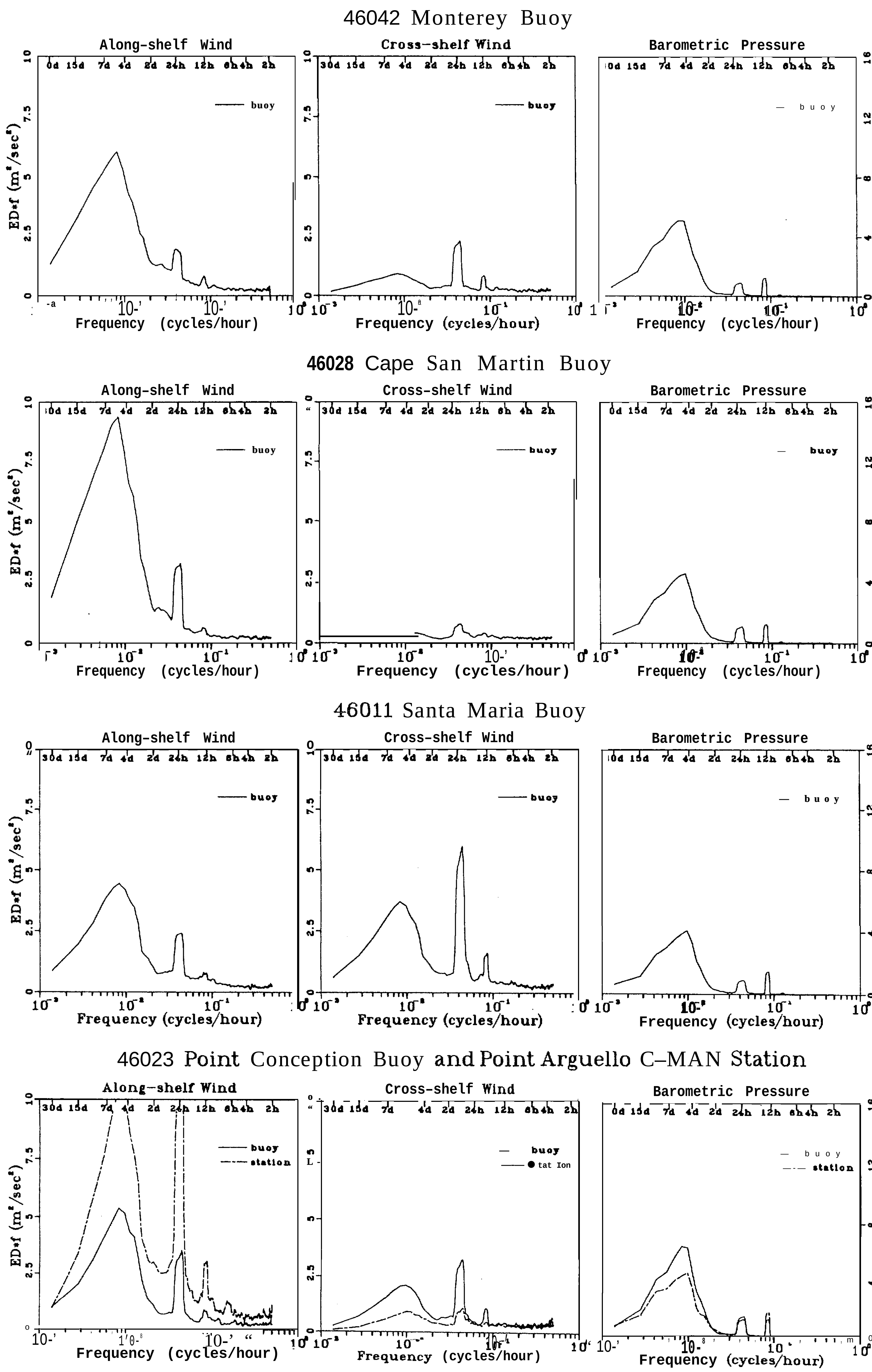


Figure 5- 6g. Autospectra of wind components and barometric pressure at selected meteorological stations: Monterey buoy (46042) , Cape San Martin buoy (46028) , Santa Maria buoy (46011) , Point Conception buoy (46023), and Point Arguello C-MAN station,

Table 5-4 Spectral analysis summary - wind data, NCCCS main program, March-August 1988.

WIND SPECTRA

	Data Span (start 0000 PST)	30-day Segments[2]	Overlap	90% Confidence Limits (lower/upper)[1] at Periods of: 30 days	15 days	10 days	7.5 days
Cape Elizabeth 46041	3/ 1 to 9/ 1	12	50%	65%/175%	76%/138%	80%/129%	82X/125%
Washington 46005	3/12 to 8/31	11	50%	64%/181%	75%/140%	79%/130%	81%/126%
Foul Weather 46040	3/ 1 to 9/ 1	7	50%	58%/217%	70%/158%	74%/143%	77%/136%
Newport NWPO3	3/ 1 to 9/ 1	12	50%	65%/175%	76%/138%	80X/129X	82%/125X
North Bend FSS	3/ 1 to 8/31	9	50%	62%/195%	73%/148%	77x/135x	80%/129X
Cape Arago CAR03	3/ 1 to 9/ 1	12	50%	65%/175%	76%/138%	80X/129%	82%/125%
Oregon 46002	3/ 1 to 9/ 1	8	50%	60%/205%	71%/153%	76X/140%	79%/130x
Pt. St. George 46027	3/ 1 to 9/ 1	12	50%	65%/175%	76%/138%	80%/129%	82X/125X
Trinidad Head DARDC	3/ 1 to 8/31	6	50%	57%/236%	68%/164%	73%/148X	76%/139%
Arcata FSS	3/ 1 to 8/31	9	50%	62%/195%	73%/148%	77%/135%	80X/129X
Humboldt Bay DARDC	3/ 1 to 8/31	6	50%	57X/236%	68%/164%	73%/148%	76X/139%
Eel River 46022	3/ 1 to 9/ 1	10	50%	63%/188%	74%/142%	78%/132%	80%/127%
Blunts Reef 46030	3/18 to 8/31	7	50%	58%/217%	70%/158%	74%/143%	77%/136%
Shelter Cove	3/ 1 to 9/ 1	7	50%	58%/217%	70X/158%	74%/143x	77X/136X
Point Arena 46014	5/26 to 8/31	6	50%	57%/236%	68X/164X	73%/148X	76%/139%
Point Arena PTAC1	3/ 1 to 9/ 1	12	50%	65%/175%	76%/138%	80%/129%	82X/125X
Bodega 46013	3/15 to 8/31	11	50%	64%/181%	75x/140%	79%/130%	81%/126%
San Francisco 46026	3/ 1 to 9/ 1	9	50%	62%/195%	73X/148%	77%/135%	80X/129%
Santa Cruz 46012	3/ 1 to 8/31	12	50%	65%/175%	76X/138%	80%/129X	82%/125X
Monterey 46042	3/ 1 to 9/ 1	12	50%	65%/175%	76%/138%	80%/129X	82%/1251
San Martin 46028	3/ 1 to 9/ 1	12	50%	65%/175%	76%/138%	80%/129%	82%/125X
Santa Maria 46011	3/ 1 to 8/31	12	50%	65%/175%	76X/138%	80%/129%	82%/125X
Point Arguello PTGC1	3/13 to 8/31	11	50%	64%/181%	75x/140x	79x/130%	81X/126%
Pt. Conception 46023	3/ 1 to 9/ 1	10	50%	63%/188%	74X/142X	78X/132%	80X/127X

Notes:

[1] Geometric progression running-mean band averaging:
 1st spectral estimate (1.39×10^{-3} cycles/hour): 1 pt. averaged
 2nd spectral estimate (2.78×10^{-3} cycles/hour): 3 pts. averaged
 3rd spectral estimate (4.17×10^{-3} cycles/hour): 5 pts. averaged
 4th and higher (5.56×10^{-3} cycles/hour): 7 pts. averaged

[2] Hanning (full cosine) taper applied to linear de-trended segments.

6 COASTAL SEA-LEVEL OBSERVATIONS
by John F. Borchardt

6.1 INTRODUCTION

Coastal sea-level data for the first deployment period of the main program have been collected from an array of 13 gauges operated by the National Ocean Service (NOS). The locations range from the vicinity of Point Conception (Port San Luis) on the central California coast, north to the Strait of Juan de Fuca (Neah Bay). This array includes all of the active, long-term control gauges within this section of the west coast located at exposed sites, or within embayments a short distance from inlets or other direct connection to the open sea. Four of the gauges are located within the NCCCS study area.

6.2 SEA-LEVEL DATA COLLECTION METHODOLOGY

6.2.1 Station Descriptions

A map of the 13 station locations is shown in Figure 6-1, and Table 6-1 lists the attributes of these and two other stations of interest. Arena Cove, California, was first established in 1978, but suffered storm damage during late 1982 and has not been returned to service. Data from this gauge were used during the CODE and SuperCODE programs and may be of historical interest in future NCCCS analyses. Also, the gauge at Trinidad was discontinued by NOS as of 27 September 1987, shortly after the end of the pilot program.

The gauge at Hammond, Oregon, was installed relatively recently (1982). The most recent tidal datums published in 1984 for this station are based on little more than 1 year of direct observations {September 1983 to January 1985) so that there is significant uncertainty in these results. Also, NOS has not published harmonic constants for this station and no relationship has been established to geodetic datum. Nevertheless, this station is considered to be a worthwhile source of data in terms of the relative variability of sea level because of its proximity (within 5 miles) to the mouth of the Columbia River. The longer-established gauge at Astoria is roughly 10 miles from the mouth, Consequently, the data from Hammond may provide a cleaner signal of oceanic variability.

The remaining stations have all been in continuous operation for at least 10 years. Five of these (Port San Luis, San Francisco, Crescent City, Astoria, and Neah Bay) are primary stations which have been in continuous operation for at least 19 years. The tidal datum planes for these stations have been established from 19-year averages over the period of the latest epoch (1960-1978). All of the stations have published benchmark sheets available from NOS which document the relative positions of the tidal datum planes and, with the exception of Astoria, provide a relationship to a common geodetic datum (NGVD 1929). In addition to benchmark sheets, NOS has published harmonic constants for all stations (except Hammond) determined by least-squares analysis of a 365-day record. In the case of Port Orford, the published constants are based on a record length of 205 days measured during 1978. This is the longest record length available for this station during the period of the latest epoch.

6.2.2 Instrumentation

All of the 13 stations are equipped with mechanical float gauges (Leupold-Stevens ADRs) which output to punched paper tape at 6-minute intervals. Some of the stations are provided with bubbler gauges as backup units; however, all of the records obtained during the first deployment period have been measured with the mechanical gauges. All gauges are installed within stilling wells of standard design.

Several of the gauges (Port San Luis, San Francisco, Crescent City, Toke Point, and Neah Bay) are equipped with telephone telemetry interface units and are accessible in near-real time. These stations have been regularly monitored since the beginning of the pilot program using the NOAA computer program TIDES ABC. The data reported here, however, have been obtained directly from the NOS archives and thus have been subjected to NOS quality assurance and data editing procedures described below.

6.2.3 Data Processing Procedures

The nature of NOS tidal data collection and processing is well documented in a variety of NOAA publications [e.g., C&GS, 1965]. The following subsection describes certain of the pertinent aspects of the NOS procedures and the additional processing steps performed in adding these records to the NCCCS data base.

All gauges are serviced monthly by NOAA personnel, and the data records are retrieved and transferred to the NOS office in Rockville, Maryland. Offset adjustments are made in accordance with any differences observed between simultaneous gauge and staff readings as noted periodically by service personnel. The recorded elevations are thus expressed relative to the staff zero datum. Further processing by NOS consists of averaging and subsampling at hourly intervals. Gaps in the records are normally filled using data from the backup gauges. If these are not available, minor gaps (several hours) may be filled by linear interpolation. Such interpolated values are flagged to distinguish them from actual observations. Gaps extending up to 3 days, depending on the noise level, may be filled with data from neighboring stations. Gaps larger than 3 days are flagged by null values, indicating missing data.

The relationships between staff zero datum and the various tidal datum planes are ideally established for each station by averaging observations over a period of a full tidal epoch, equal to 19 years (1960-1978). This is possible at the five primary stations. At the remaining secondary stations, some lesser period of record must be used, as indicated in Table 6-1. Elevation differences between various datums as determined by NOS are also listed in the table. Note that these differences are expressed relative to Mean Lower Low Water (MLLW) in units of feet. A positive difference indicates a datum plane at a higher elevation. Most of the gauges are also related to geodetic datum (e.g., NGVD 1929) so that observations can be adjusted to a common reference level and compared from one station to another. Of course, such a comparison must take into account leveling errors inherent in the datum itself.

For the purposes of constructing the NCCCS data base, sea-level records have been adjusted to a datum of MLLW as defined by the staff offsets indicated in Table 6-1. The hourly heights, initially provided in hundredths of feet, have been converted to meters.

Our primary interest in the sea-level data lies with the subtidal variability. In order to clearly reveal this underlying signal, the records were detided by subtracting the NOS predicted tide. This prediction consists of a linear superposition of up to 37 constituents as determined from harmonic analysis of a 365-day record. The NOS prediction typically includes several low-frequency constituents with periods ranging from 2 weeks up to 1 full year. There are significant tidal potentials associated with several of these constituents and, to the extent that the predicted amplitudes faithfully represent astronomic forcing, these constituents should be removed from the raw sea-level data. However, we suspect that non-astronomic forcing is also reflected in several of these predicted amplitudes. This is certainly true in the case of the annual (Sa) and semiannual (Ssa) tides which combined have typical amplitudes in the range of 10 cm. This is considerably greater than would be inferred on the basis of the theoretical tidal potentials at these frequencies. Also, we have not removed any low-frequency constituents from the bottom pressure data (Section 4) because of the insufficient record lengths yet available to reliably estimate the respective amplitudes. Accordingly, we have not removed the low-frequency constituents from the NOS sea-level data during our detiding process. Further analysis is planned later in the study based on more extensive records to determine the most appropriate procedure for detiding both types of data.

Inspection of the residual sea-level time series after detiding reveals substantial high-frequency variations still remaining in most records. These are apparently not attributable to the astronomic tides, but rather are the result of meteorological or other forcing and interactions with the coastal topography. One example is the appearance of short-period (2-4 hour) oscillations in the Humboldt Bay data. This may be attributable to seiching between Arcata Bay and South Bay. Another general feature is the presence of variable amplitude diurnal oscillations which remain after subtracting the mean amplitude of the S1 tide. Again, this presumably reflects meteorological forcing, especially during late summer. In order to examine the subtidal signal, this high-frequency variability was removed by means of low-pass filtering using the PL-33 filter (see subsection 4.4). Finally, the resulting decided, low-pass-filtered sea-level signal was converted to an equivalent pressure expressed in millibars, based on a reference seawater density of 1.025 g/cm^3.

An adjustment to include the barometric pressure must be made to the sea-level data in order to obtain the equivalent of total pressure, as measured by the bottom-mounted pressure recorders. The sources of barometric pressure data consist of selected coastal meteorological stations, as indicated in Table 6-2. These stations are limited to NDBC platforms or FAA Flight Service Stations where the data quality is expected to be high. Due to gaps in the meteorological coverage, it was necessary to concatenate pressure records from two or more neighboring sources for several of the sea-level stations. The resulting low-pass-filtered barometric pressure records for each tide station are plotted in Figure 6-2. As can be seen from this figure, the spatial correlation of the pressure field remains high over relatively large distances and there is little need for more involved spatial interpolation procedures in determining the appropriate adjustments to the sea-level data.

6.3 DESCRIPTIONS OF OBSERVATIONS

The total pressure records obtained by adding the detided sea-level records and barometric pressures are presented in Figure 6-3. These data have been termed "synthetic subsurface pressure" by Brown et al. [1985] . When expressed in equivalent height of seawater, the term "adjusted sea-level" is also commonly used. A statistical summary of the data is presented in Table 6-3.

It may be noticed that the signal plotted for Port Orford retains relatively strong diurnal and semidiurnal variations over at least a portion of the 6-month record. The reason for this may be related to the fact that the NOS predicted tide is based on a harmonic analysis of only 205 days of record available during the last year of the latest epoch (1978). Further analysis is required to obtain more efficient detiding in this case.

The SSP variability at Toke Point appears to be especially strong. This may be primarily attributable to the location of the gauge well within Willapa Bay in an area surrounded by extensive tidal flats. The broad, shallow expanse of this bay presumably serves to intensity wind surge effects, in comparison with the open coast. The utility of this station will need to be examined further during the main program.

Figure 6-4 presents autospectra of the hourly synthetic pressure data before detiding and low-pass filtering. The spectra are plotted in variance-conserving format (subsection 4.7). The tidal peaks in the spectra are deliberately allowed to be off scale in order to show the variability in subtidal energy. Pertinent details of the spectral analysis procedures are summarized in Table 6-4. The spectra, together with the time-series plots, reveal the strong increase in subtidal variability among the stations from south to north.

6.4 REFERENCES

Brown, W.S., N.R. Pettigrew, and J.D. Irish. 1985. The Nantucket Shoals Flux Experiment (NSFE79). Part II: The structure and variability of across-shelf pressure gradients. J. Phys. Ocean., 15:749-771.

C&GS . 1965. Manual of Tide Observations. Publication 30-1, Coast and Geodetic Survey, U.S. Dept. of Commerce, Washington, D.C. 72 pp.

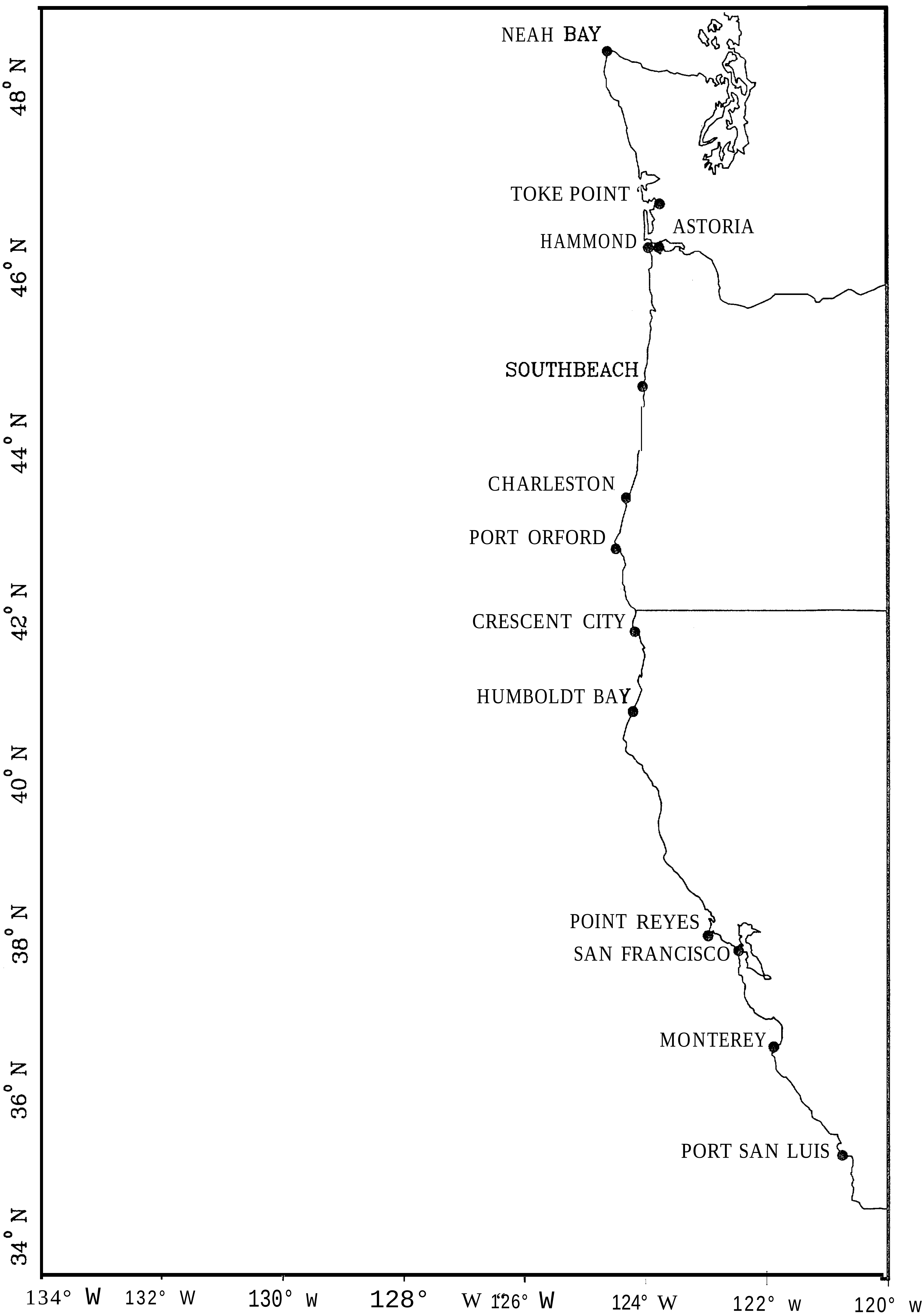


Figure 6-1. Map of NOS coastal sea-level stations.

Table 6-1. Listing of NOS coastal sea-level stations.

Station Name	NOS No.	Latitude	Longitude	Installation Date	Published BM Sheet	Averaging Period	Datum Plane Adjustments[5] NGVD	MSL	Staff
Neah Bay, WA	944-3090	48 22.1N	124 37.0W	1934	06-21-76	60-78	+4.41	+4.30	-2.15
Toke Point, WA	944-0910	46 41.0N	123 45.3W	1972	07-17-84	68-78	+4.46	4.73	-4.55
Astoria, OR	943-9040	46 12.5N	1.23 46.0W	1925	01-18-84	60-78	NA	+4.39	-2.34
Hammond, CR	943-9011	46 12.1N	123 56.6W	1982	10-11-85	83-84	NA	4.45	-2.51
Southbeach, OR	%3-5380	44 37.5N	124 02.6W	1962	03-24-88	68-84	+4.15[1]	+4.46	-4.59
Charleston, OR	943-2780	43 20.7N	124 19.3W	1972	10-30-86	71-84	+4.22	+4.08	-3.72
Port Orford, OR	943-1647	42 44.4N	1.24 29.8W	1977	05-20-86	79,82-84	+4.13[2]	+4.00	-23.02
Crescent City, CA	941-9754	41 44.7N	124 11.0W	1933	W-12-84	60-78	+3.79[3]	+3.75	-3.66
Trinidad, CA	941-9059	41 03.5N	124 08.8W	1972	08-22-84	75,78-80	NA	+3.60	-4.91
Humboldt Bay, CA	941-8767	40 46.0N	1.24 13.0W	1977	08-22-84	79-80	+3, 72	NA	-14.34
Arena Cove, CA	941-6841	38 54.8N	123 42.5W	1978	08-07-84	79-81	NA	NA	NA
Point Reyes , CA	941-5020	37 59.8N	122 58.5W	1975	10-16-86	75-84	+2. 88	+3. 14	-3.72
San Francisco, CA	941-4290	37 48.4N	I-22 27.9W	1854	01-12-84	60-78	+2.84[3]	+3.13	-5.77
MontereyH arbor, CA	941-2450	36 36,3N	121 53.3W	1973	08-22-84	74-84	+2.85[4]	+2.88	-3.14
Port San Luis, CA	941-2110	35 10.2N	12045. 1W	1%5	03-19-81	60-78	i-2.73	+2. 83	-4.13

Notes :

[1]Based on adjustment of 1966
[2]Based on adjustment of 1947
[3]Based on adjustment of 1973
[4]Based on adjustment of 1961
[5]Referenced to MLLW in feet (NA = Not Available)

Table 6-2. Sources of barometric pressure data used to adjust sea-level records at NOS gauging stations.

Station Name	Barometric Pressure Source
Neah Bay, WA	Cape Elizabeth 46041: 3/1--8/31
Toke Point, WA	Average: Cape Elizabeth 46041: 3/1--4/4, 5/28--8/31 Cape Foulweather 46040: 3/1--4/4, 5/28--8/31 Average: Cape Elizabeth 46041: 4/5--5/27 Newport NWPO3: 4/5--5/27
Astoria, OR	Same as Toke Point, WA
Hammond, OR	Same as Toke Point, WA
Southbeach, OR	Newport NWPO3: 3/1--8/31
Charleston, OR	Cape Arago CARO3: 3/1--8/31
Port Orford, OR	Average: Cape Arago CARO3: 3/1--8/31 Pt. St. George 46027: 3/1--8/31
Crescent City, CA	Point St. George 46027: 3/1--8/31
Trinidad, CA	--
Humboldt Bay, CA	Eel River 46022: 3/1--8/31
Arena Cove, CA	--
Point Reyes, CA	Bodega 46013: 3/15--8/31 San Francisco 46026: 3/1--3/14
San Francisco, CA	San Francisco 46026: 3/1--5/27, 6/14--8/31 Bodega 46013: 5/28--6/13
Monterey Harbor, CA	Santa Cruz 46012: 3/1--8/31
Port San Luis, CA	Cape San Martin 46028: 3/1--8/31

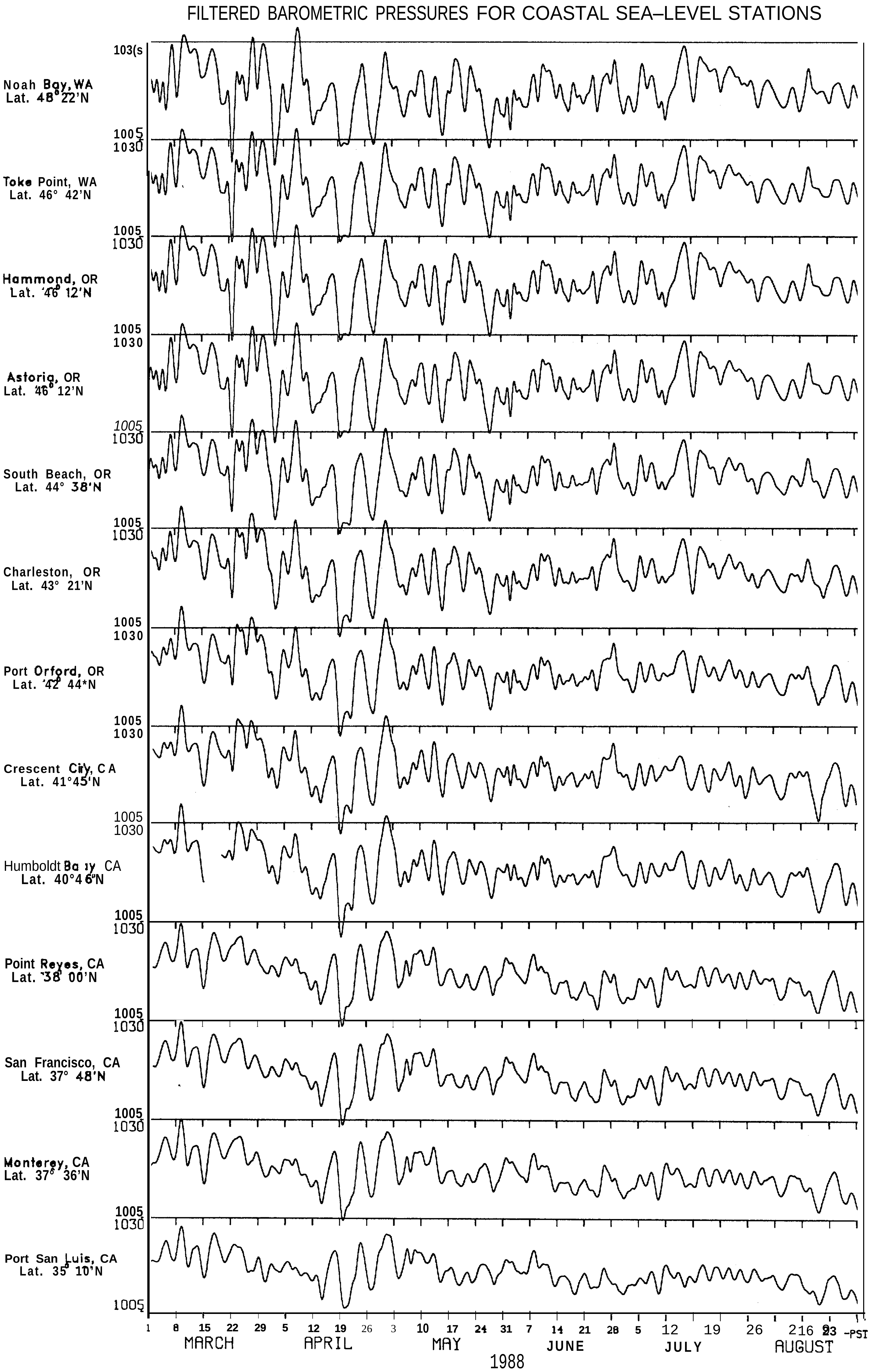


Figure 6-2. Representative barometric pressure records for coastal sea-level stations (low-pass filtered) .

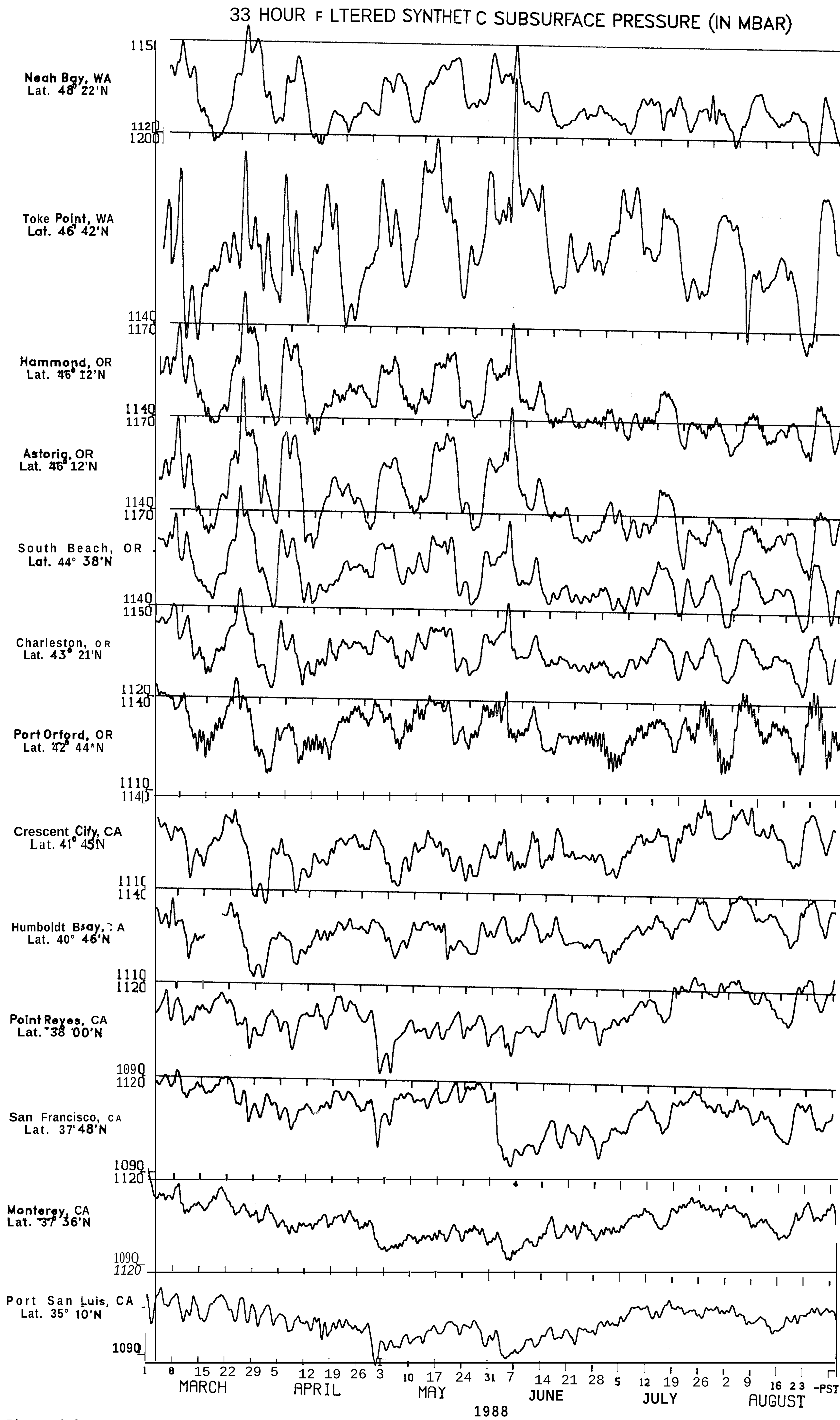


Figure 6-3. Subsurface synthetic pressure (SSP) records for coastal sea- level stations (low-pass filtered) .

Table 6-3. Statistical summary of low-pass-filtered sea-level and barometric pressure data.

Station Name	Mean Tidal Range[1] MHHW-MLLW (cm)	Barometric Pressure* (rob) Mean	Std Dev	Max	Min	Subsurface Synthetic Pressure[2] (mb) Mean	Std Dev	Max	Min
Neah Bay, WA	242.0	1017.77	5.80	1033.7	998.3	1130.65	7.53	1155.3	1115.7
Toke Point, WA	268.2	1018.30	5.38	1033.0	1002.1	1165.09	13.18	1219.1	1133.0
Astoria, OR	256.6	1018.30	5.38	1033.0	1002.1	1143.04	10.87	1183.2	1119.1
Hammond, OR	256.6	1018.30	5.38	1033.0	1002.1	1145.88	9.21	1180.2	1128.1
South Beach, OR	254.7	1018.95	5.20	1034.5	1003.5	1150.16	7.11	1177.8	1134.7
Charleston, OR	231.9	1019.38	5.09	1035.7	1002.8	1135.98	5.44	1155.7	1123.0
Port Orford, OR	226.1	1018.99	4.93	1035.4	1002.5	1130.92	5.88	1146.6	1115.8
Crescent City, CA	212.1	1018.60	5,11	1035.4	1002.1	1123.94	6.00	1138.4	1105.8
Humboldt Bay, CA	210.9	1018.17	4.82	1035.0	1000.9	1128.10	5.49	1140.9	1111.6
Point Reyes, CA	177.3	1016.26	4.49	1029.5	1003.4	1111.05	6.36	1124.7	1092,1
San Francisco, CA	177.6	1015.99	4.31	1029.5	1003.7	1111.27	5.63	1122.1	1094.1
Monterey, CA	165.1	1016,66	4.24	1030.2	1004.4	1105.97	4.83	1116,4	1093.8
Port San Luis, CA	164,2	1016,08	3.82	1027.9	1006.1	1103.15	4.95	1112.4	1087.9

Notes:

[1]Source: NOS Tidal Datum Sheets

[2]Period of Record: 1 March 1988 through 31 August 1988

Table 6-4. Spectral analysis summary - sea level data, NCCCS main program, March-August 1988.

SEA LEVEL SPECTRA

	Data Span (start 0000 PST)	30-day Segments[2]	Over-lap	90% Confidence Limits (lower/upper)[1] at Periods of: 30 days	15 days	10 days	7.5 days
Hammond, OR	3/01 to 9/01	13	50%	66%/173%	77%/137%	80%/127%	82%/125%
Toke Point, WA	3/01 to 9/01	13	50%	66%/173%	77%/137%	80%/127%	82%/125%
Neah Bay, WA	3/01 to 9/01	13	50%	66%/173%	77%/137%	80%/127%	82%/125%
Astoria	3/01 to 9/01	13	50%	66%/173%	77%/137%	80%/127%	82%/125%
South Beach	3/01 to 9/01	13	50%	66%/173%	77%/137%	80%/127%	82%/125%
Charleston	3/01 to 9/01	13	50%	66%/173%	77%/137%	80%/127%	82%/125%
Port Orford	3/01 to 9/01	13	50%	66%/173%	77%/137%	80%/127%	82%/125%
Crescent City	3/01 to 9/01	13	50%	66%/173.2	77%/137%	80%/127%	82%/125%
Humboldt Bay	3/01 to 9/01	12	50%	65%/175%	76%/138%	80%/129%	82%/125%
Point Reyes	3/01 to 9/01	13	50%	66%/173%	77%/137%	80%/127%	82%/125%
San Francisco	3/01 to 9/01	13	50%	66%/173%	77%/137%	80%/127%	82%/125%
Monterey	3/01 to 9/01	13	50%	66%/173%	77%/137%	80%/127%	82%/125%
Port San Luis	3/01 to 9/01	13	50%	66%/173%	77%/137%	80%/127%	82%/125%

Notes:

[1]Geometric progression running-mean band averaging:
1st spectral estimate (1.39 x 10^{-3} cycles/hour): 1 pt. averaged
2nd spectral estimate (2.78 x 10^{-3} cycles/hour): 3 pts. averaged
3rd spectral estimate (4.17 x 10^{-3} cycles/hour): 5 pts. averaged
4th and higher (5.56 x 10^{-3} cycles/hour): 7 pts. averaged

[2]Hanning (full cosine) taper applied to linear de-trended segments,

VARIANCE CONSERVING AUTOSPECTRA
NCCCS FIRST MAIN, MARCH - AUGUST 1988

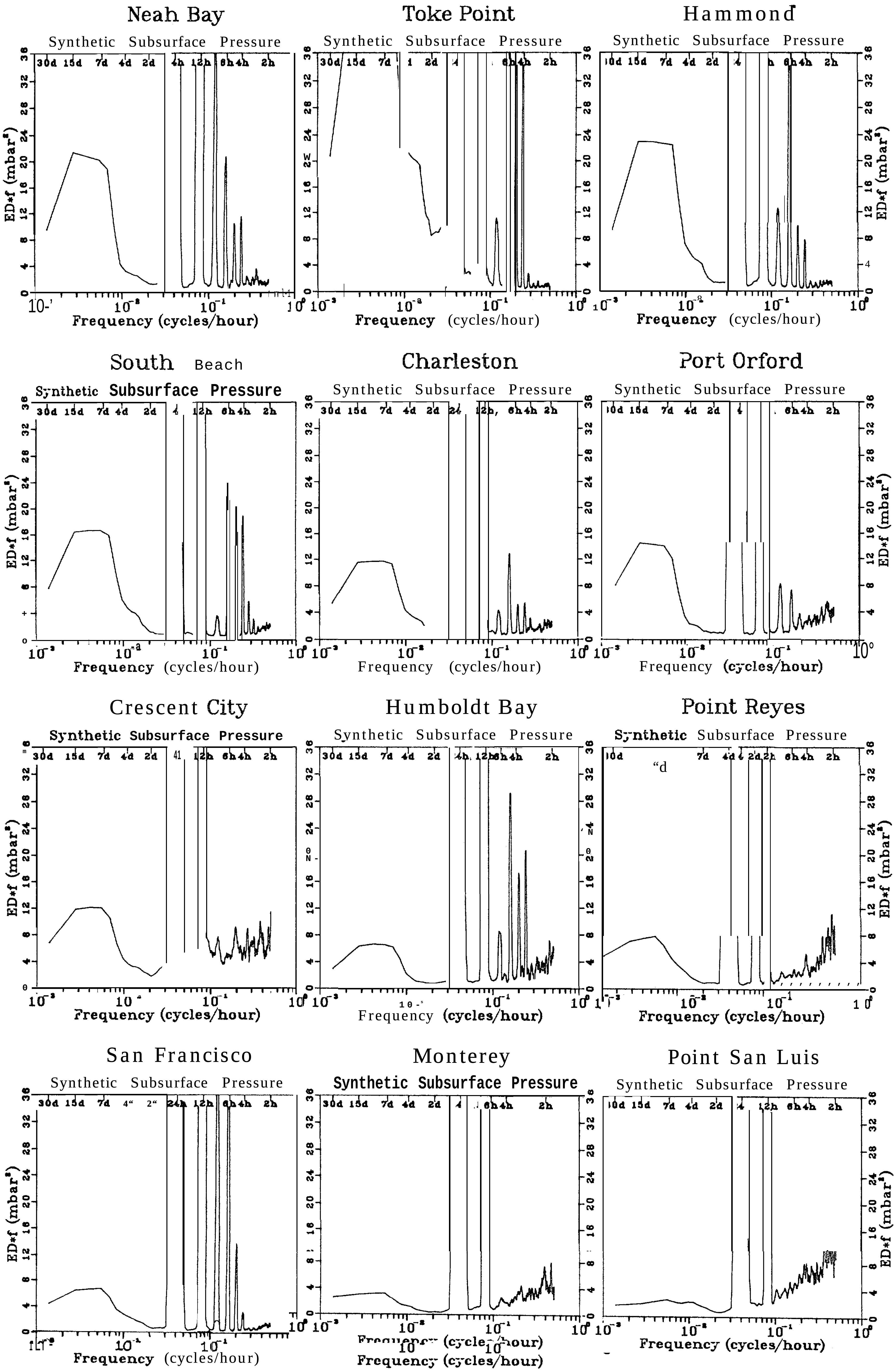


Figure 6-4. Autospectra of unfiltered subsurface synthetic pressure records.

APPENDIX A

INTERIM MOORING DEPLOYMENT

INTRODUCTION

The original design of the NCCCS included a temporary suspension of data collection activities during the interim period between the pilot and main programs (August 1987 through March 1988). Following its initial review, the Quality Review Board recommended that current measurements should be collected continuously at one location over the entire duration of the field investigation, including the interim period. The NCCCS investigators and MMS concurred with this recommendation, and the program was expanded to include provisions for maintenance of the E-130 mooring off Eureka. Instrumentation included a single near-surface (15-m) VMCM and a bottom-mounted pressure gauge. Data return from this interim deployment period was essentially complete and the quality was excellent.

DESCRIPTION OF OBSERVATIONS

Time series of plots of the currents measured at the E-130 mooring are presented in vector and component form in Figure A-1. The orientation of the alongshelf and cross-shelf component directions is consistent with the specifications given in Section 4. This figure also includes vector plots of the winds measured at selected meteorological buoys and coastal stations. In particular, the coastal station established during the pilot program at Shelter Cove was maintained in operation during the interim period, except for a gap of roughly 6 weeks from mid-October until early December 1987.

Figure A-2 presents a composite plot for the current measurements, including a progressive vector diagram, low-pass-filtered variance ellipse, and current rose diagram. It is interesting to note that the virtual alongshelf displacement over the full deployment period was essentially zero, despite the many large excursions associated with individual current events during the winter season.

In addition to the meteorological records, sea-level data were collected from NOS gauging stations to complement the moored measurements. The data from selected gauging stations is shown in Figure A-3 in the form of synthetic subsurface pressures (see Section 6 for a description of processing procedures).

Finally, autospectra of the various components of the interim period data base are presented in Figures A-4 through A-6. Figure A-4 contains the spectra for the alongshelf and cross-shelf current components and water temperature. Figure A-5 contains the spectra of selected synthetic subsurface pressure records. Consistent with the treatment in Section 6, these spectra have been calculated from hourly records prior to the detiding and filtering operations used in preparing the time-series plots in Figure A-3. As expected, the low-frequency portions of these spectra contain substantially more energy in comparison with the results of the pilot program from the previous summer months.

Figure A-6 presents spectra from selected meteorological stations, including alongshelf and cross-shelf wind components and barometric pressure. The orientation of the wind components is consistent with the specifications given in Section 5. The computational procedures applicable to individual spectrums in this figure, including record lengths and confidence intervals, are listed in Table A-1.

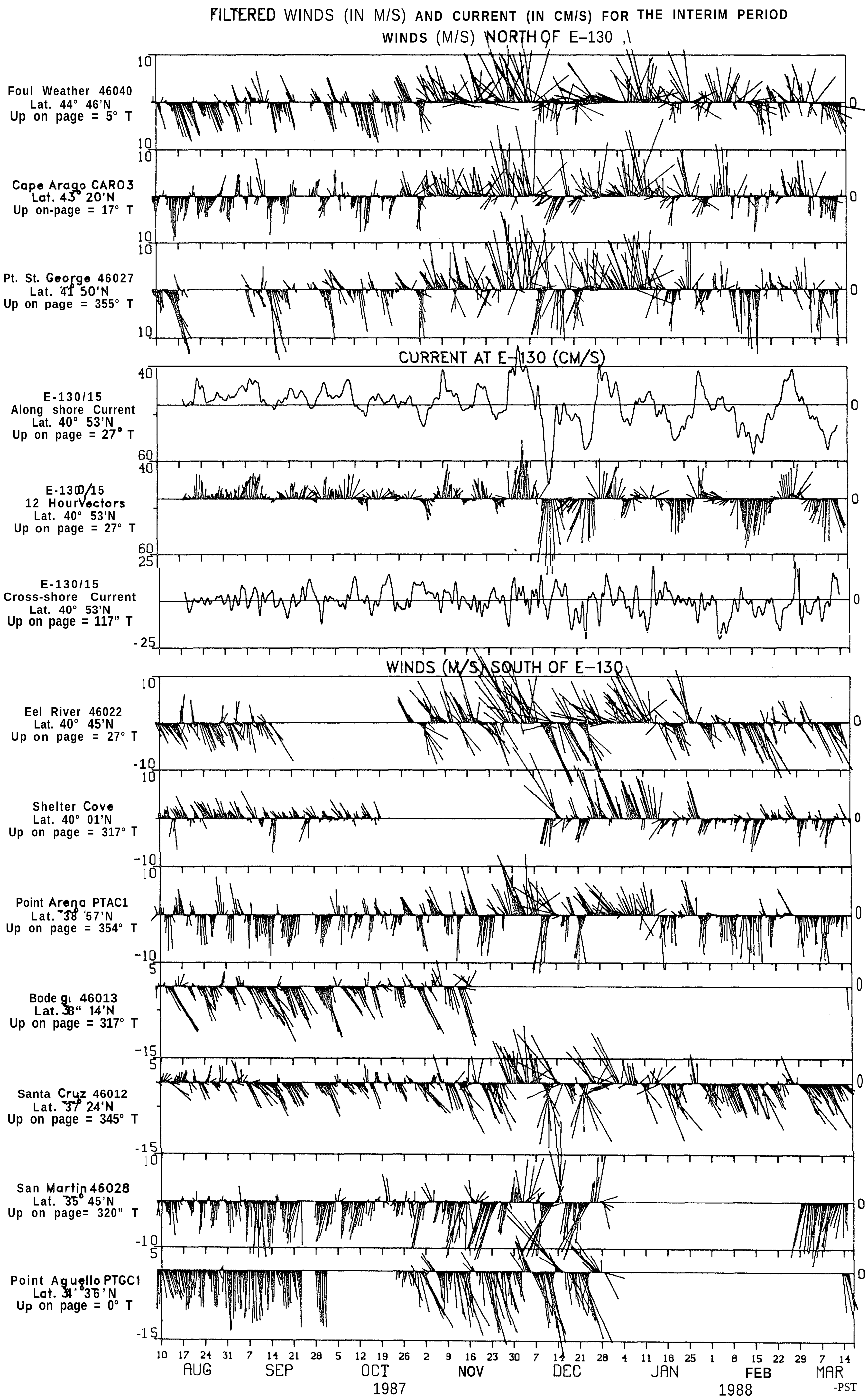


Figure A-1. Law-pass- filtered currents from the E- 130 mooring and winds from selected meteorological stations for the interim period August 1987 through March 1988.

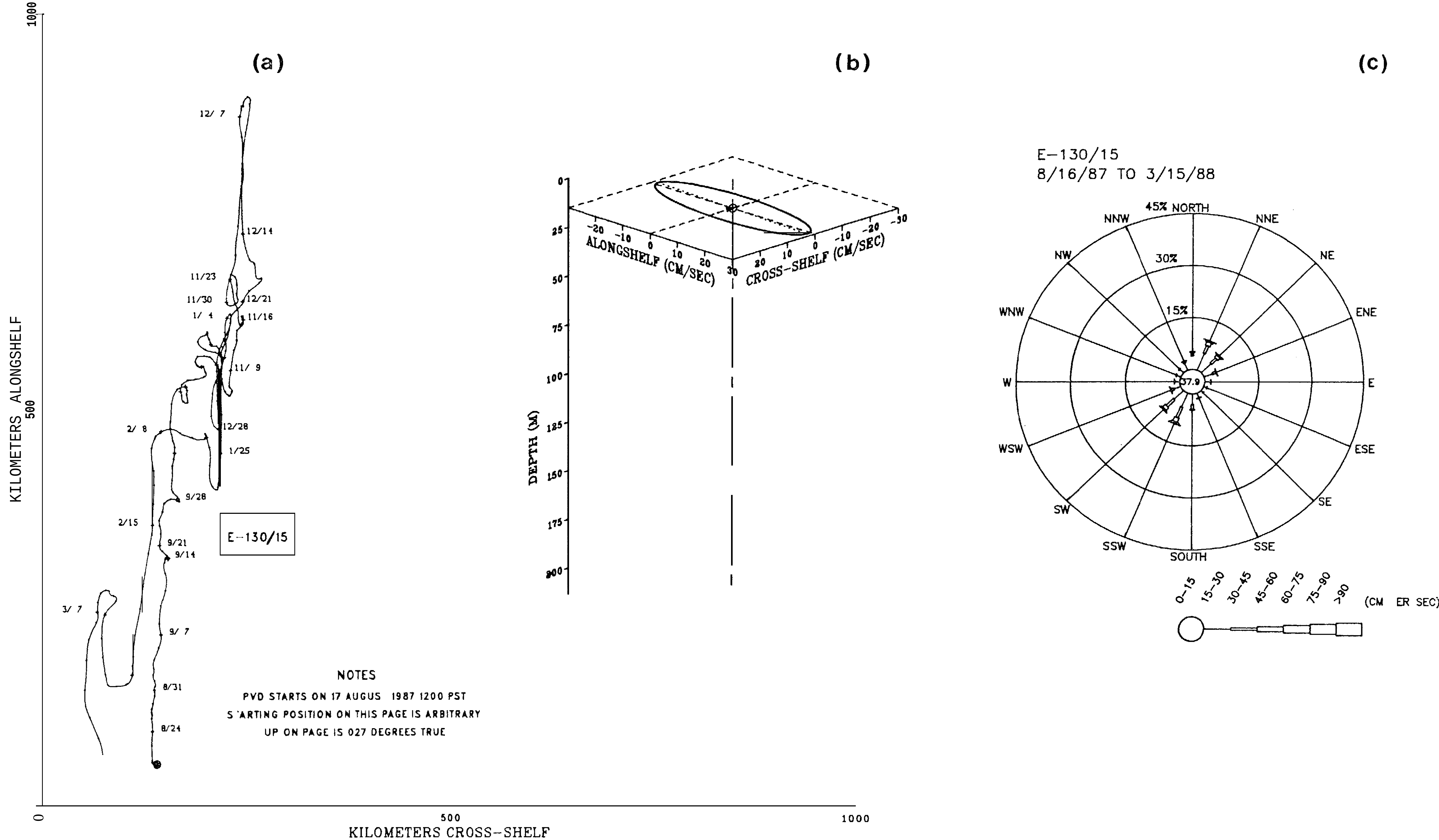


Figure A-2. Current plots from the interim E-130 mooring, including (a) progressive vector diagram, (b) low-pass-filtered variance ellipse, and (c) current rose based on hourly averages.

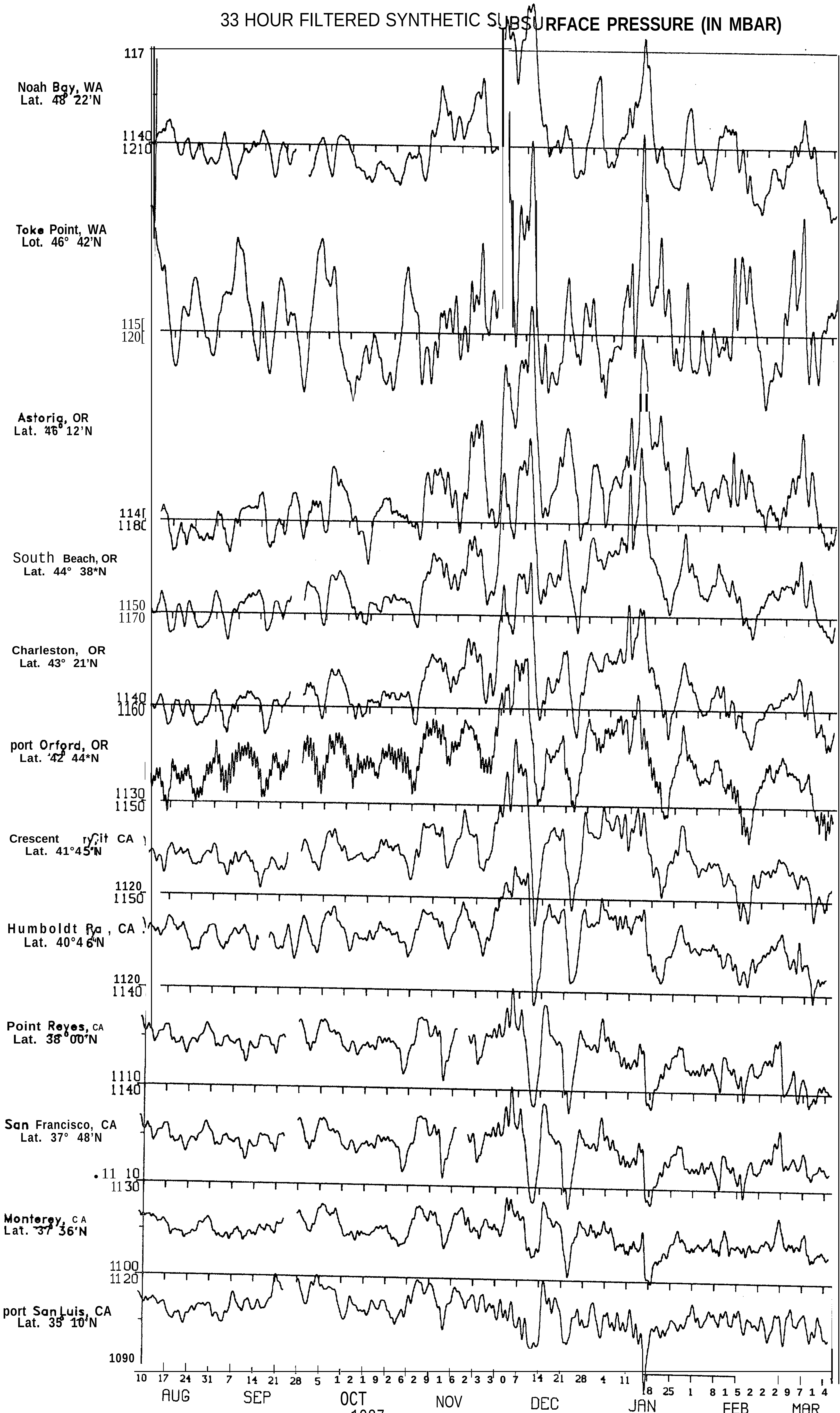


Figure A-3. Time series of synthetic subsurface pressure (SSP) during the interim mooring period August 1987 through March 1988.

VARIANCE CONSERVING AUTOSPECTRA
NCCCS INTERIM AUGUST 1987 - MARCH 1988 E-Line

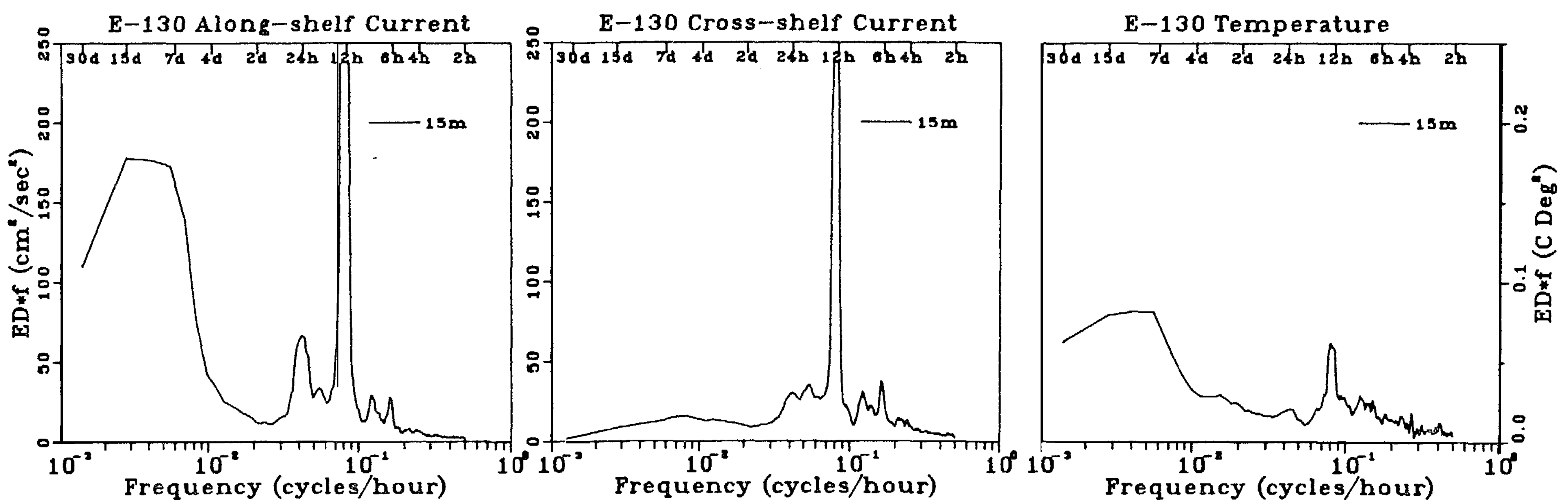


Figure A-4. Autospectra of alongshelf and cross-shelf current components and temperature from the interim E-130 mooring, August 1987 through March 1988.

VARIANCE CONSERVING AUTOSPECTRA
NCCCS INTERIM, AUGUST 1987 – MARCH 1988

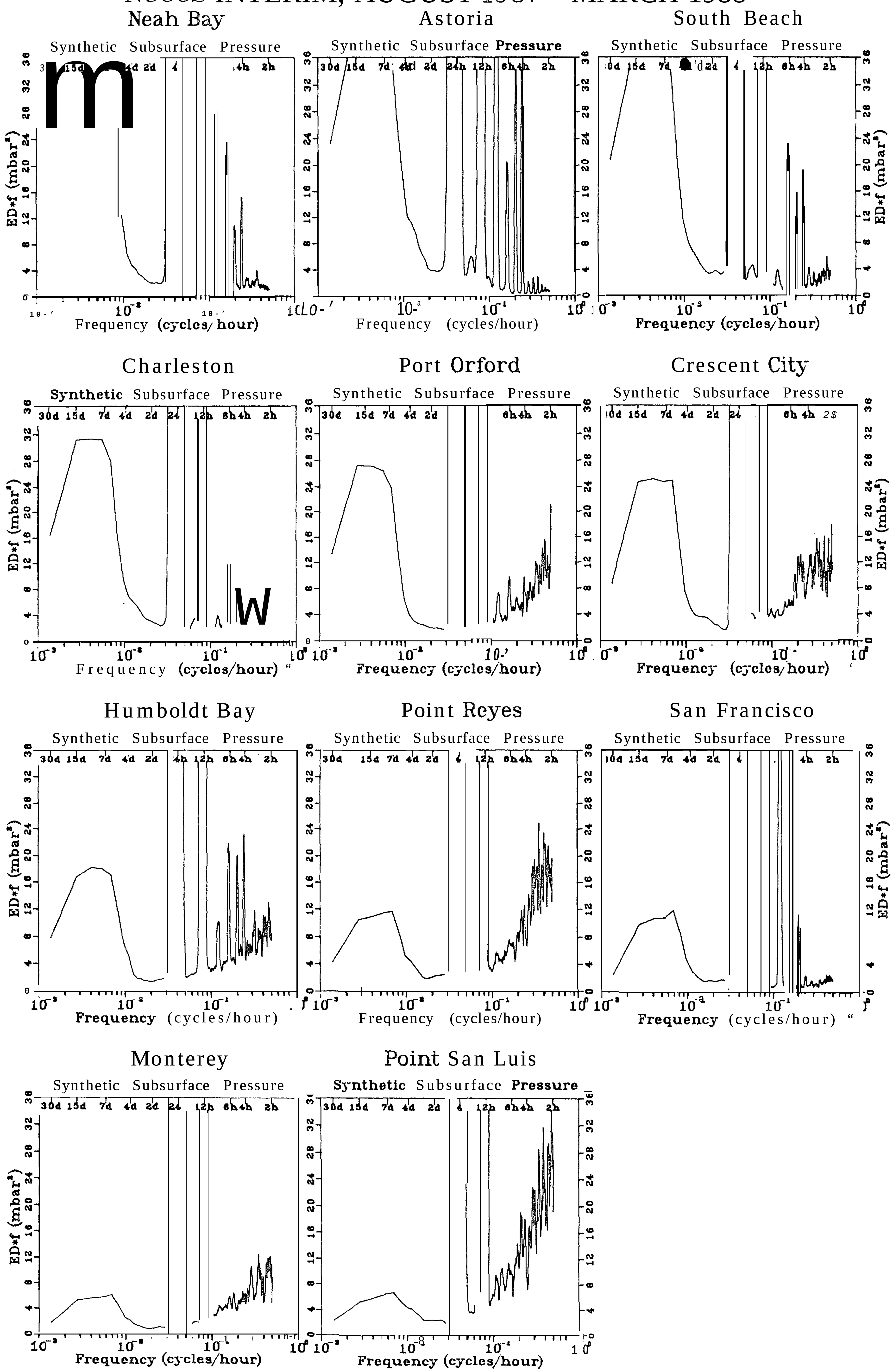
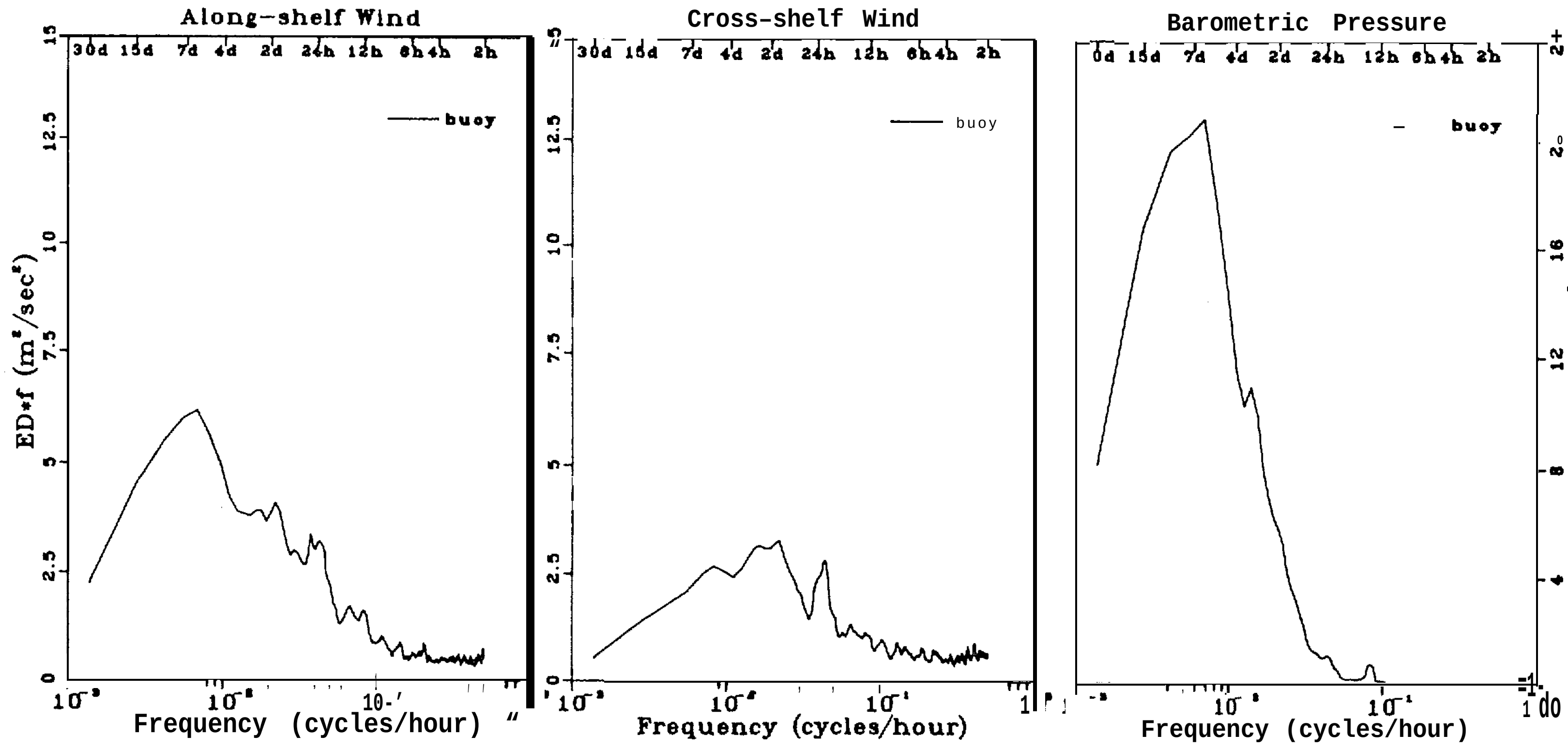


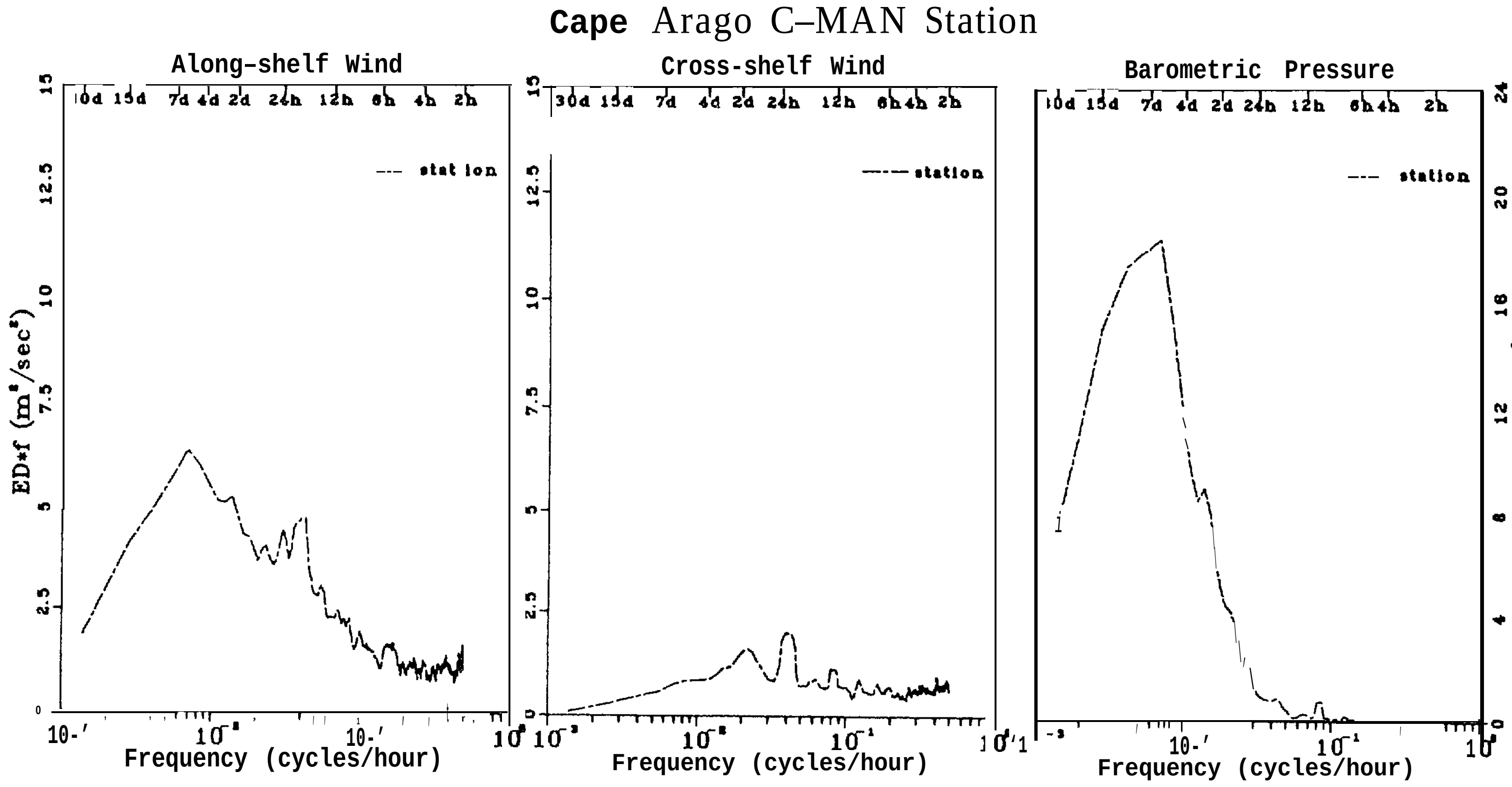
Figure A-5. Autospectra of synthetic subsurface pressures (SSP) from selected NOS gauging stations during the interim mooring period August 1987 through March 1988.

VARIANCE CONSERVING AUTOSPECTRA
NCCCS INTERIM, AUGUST 1987 - MARCH 1988

46040 Cape Foulweather Buoy



Cape Arago C–MAN Station



46027 Point Saint George Buoy

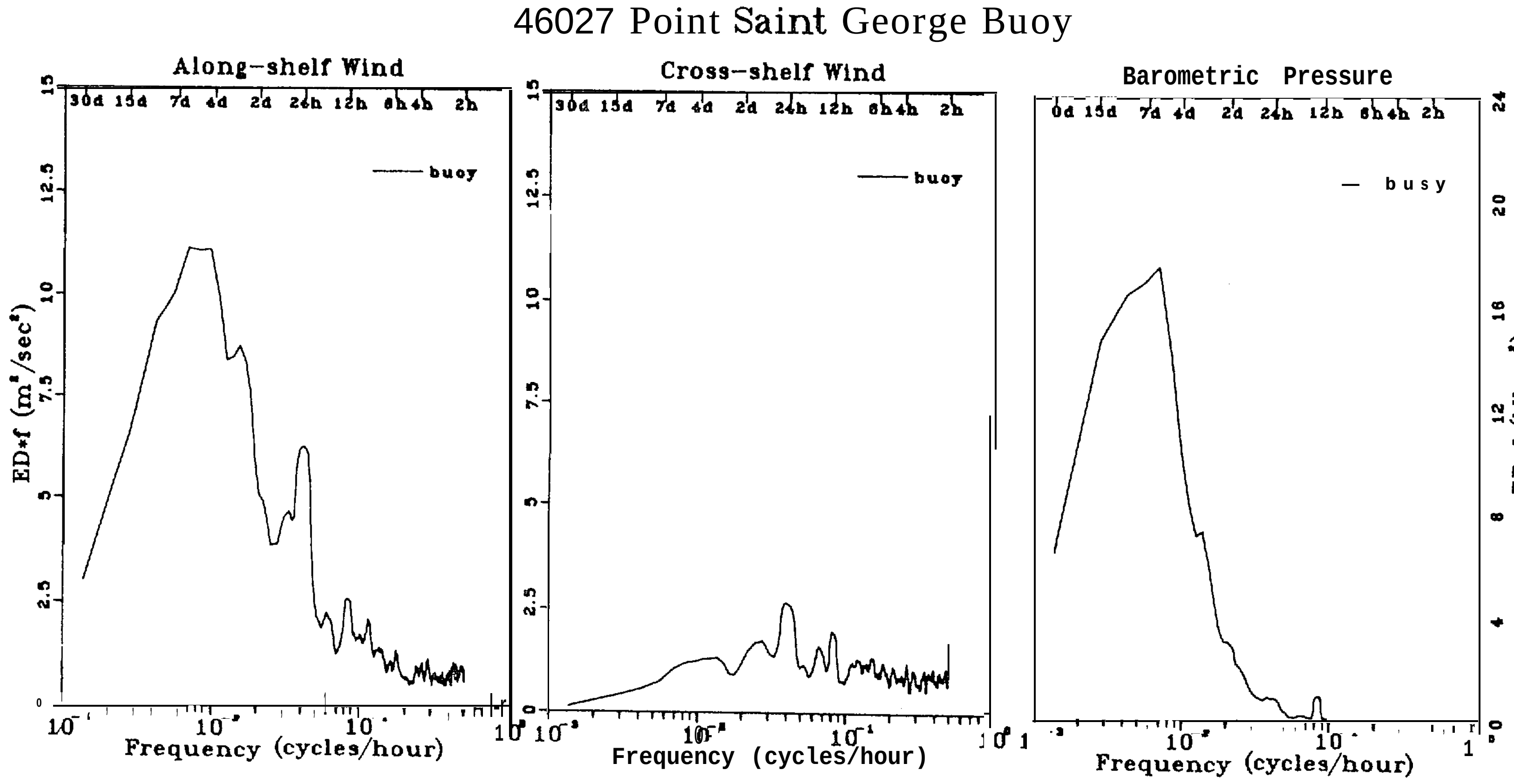


Figure A-6. Autospectra of alongshelf, cross-shelf, and barometric pressure from selected meteorological stations during the interim mooring period August 1987 through March 1988.

VARIANCE CONSERVING AUTOSPECTRA
NCCCS INTERIM, AUGUST 1987 - MARCH 1988

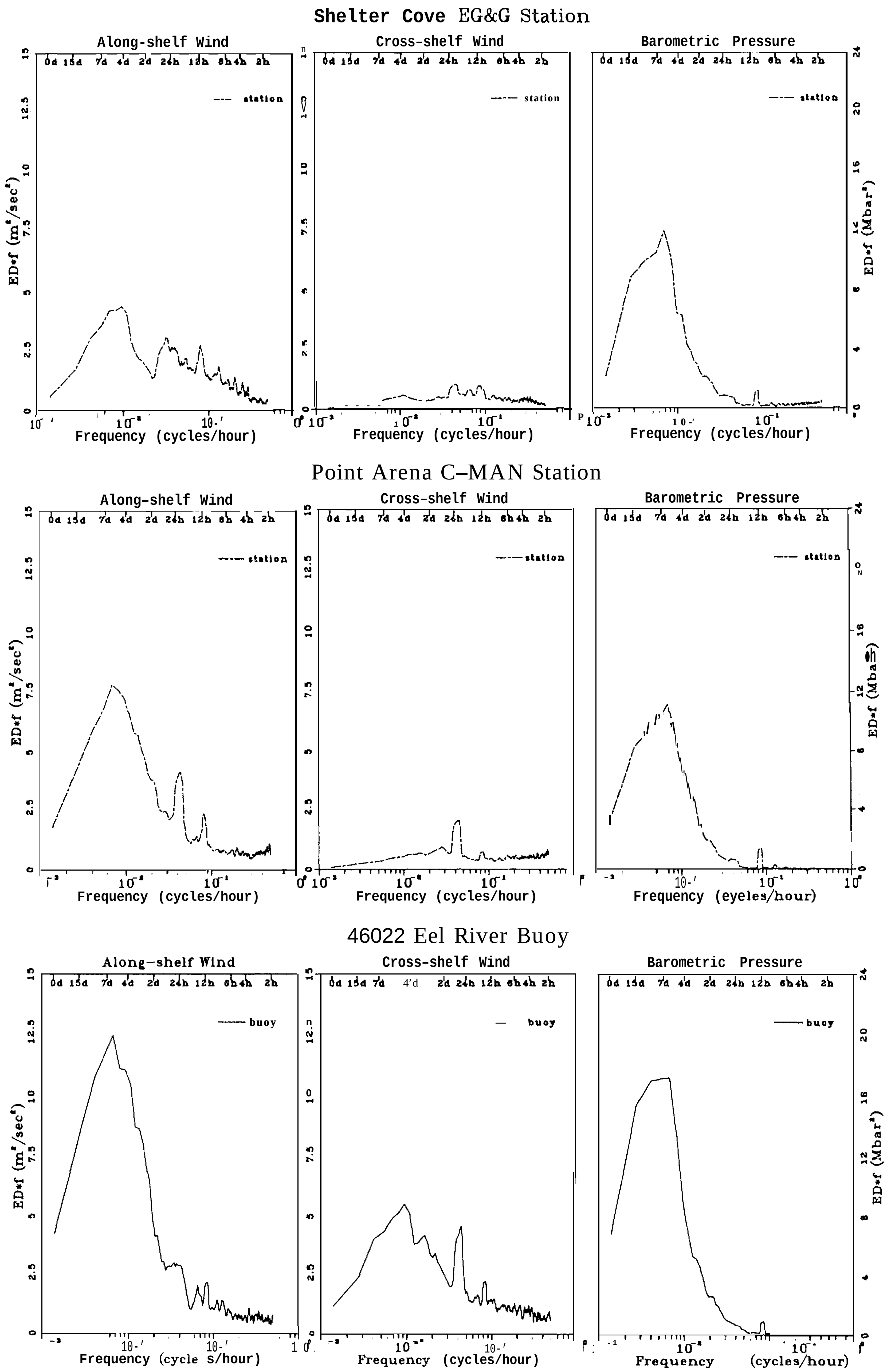
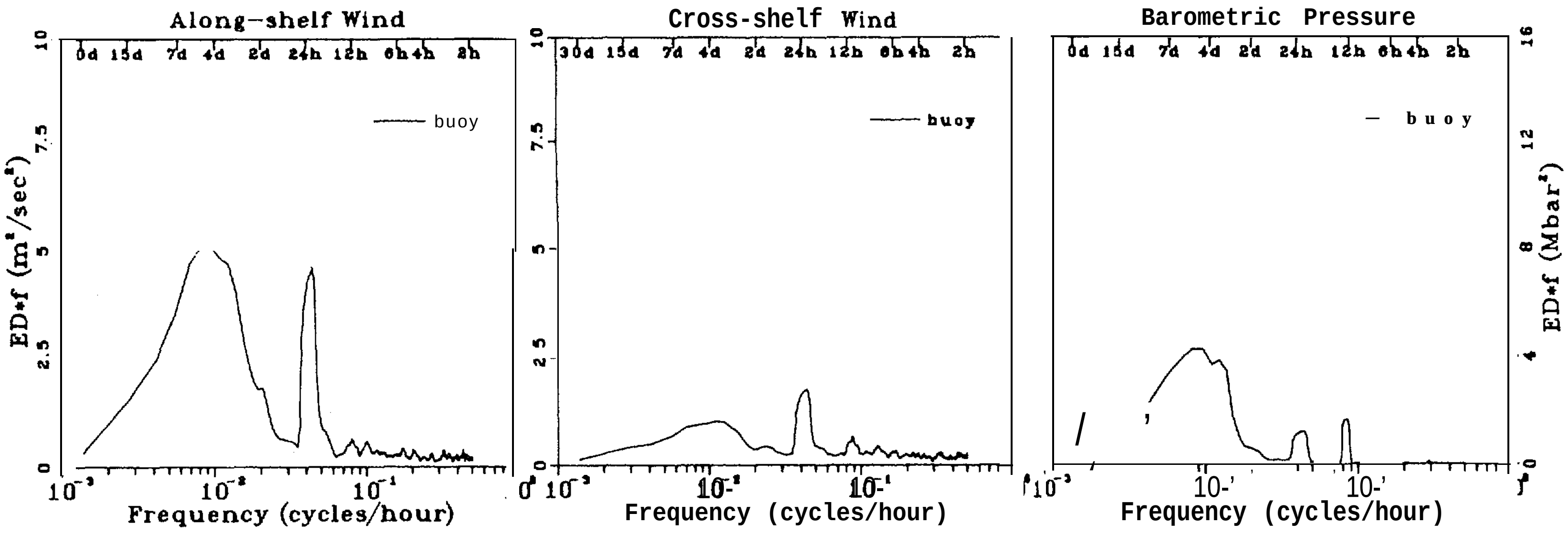


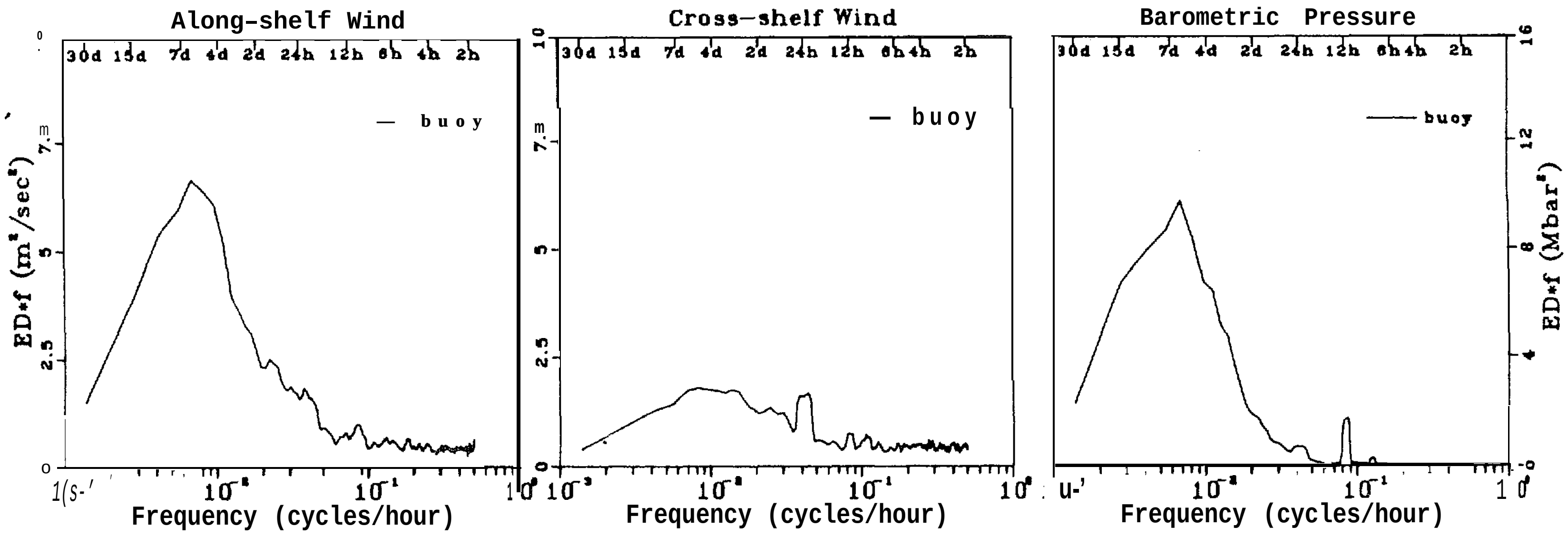
Figure A-6. Continued.

VARIANCE CONSERVING AUTOSPECTRA
NCCCS INTERIM, AUGUST 1987 - MARCH 1988

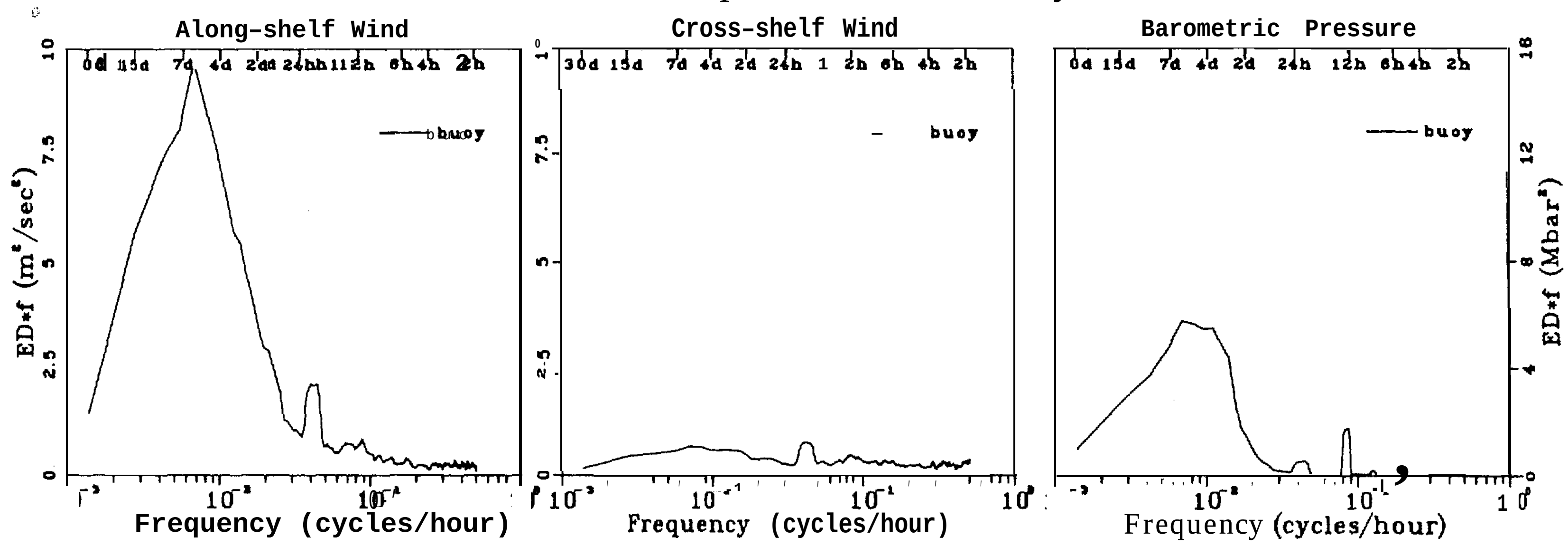
46013 Bodega Buoy



46012 Santa Cruz Buoy



46028 Cape San Martin Buoy



46011 Santa Maria Buoy

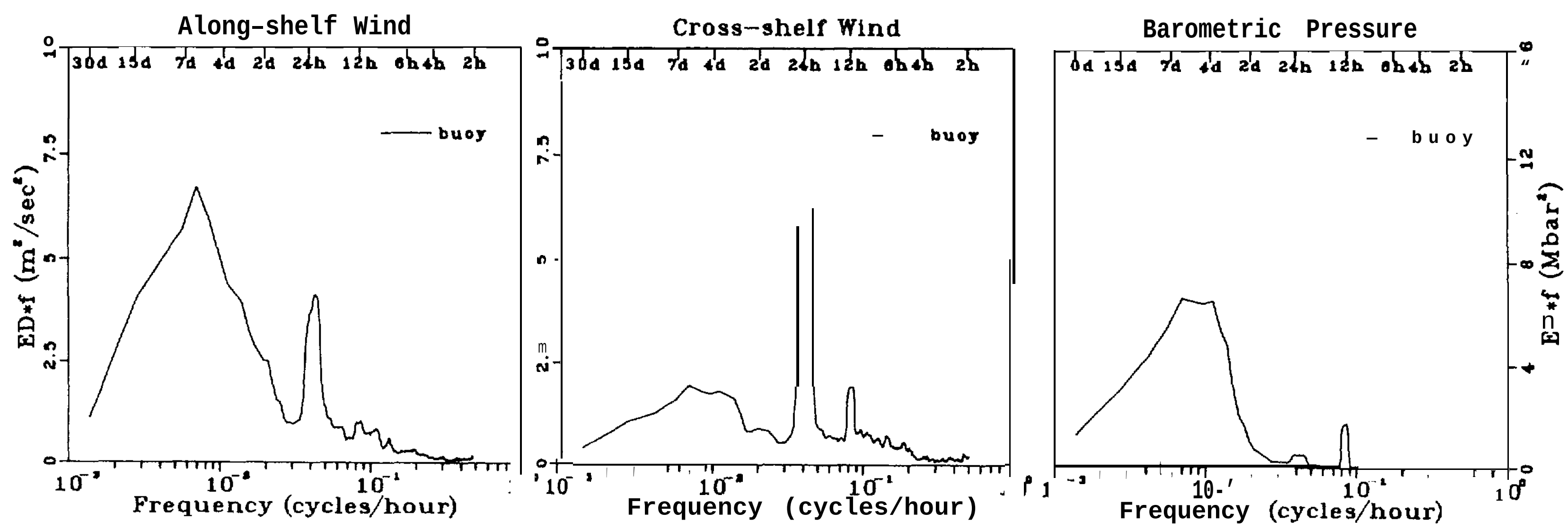


Figure A-6. Continued.

Table A-1. Summary of wind spectra record lengths and confidence intervals.

	Data Span (start 0000 PST)	30-day Segments[2]	Overlap	90% Confidence Limits (lower/upper)[1] at Periods of: 30 days	15 days	10 days	7.5 days
Foulweather 46040	8/10/87 to 3/31/88	14	50%	67%/170%	77%/134%	81%/126%	82%/125%
Cape Arago CARO3	8/10/87 to 3/31/88	14	50%	67%/170%	77%/134%	81%/126%	82%/125%
Pt. St. George 46027	8/10/87 to 3/31/88	12	50%	65%/175%	76%/138%	80%/129%	82%/125X
Eel River 46022	8/10/87 to 3/31/88	10	50%	67%/170%	77%/134%	81%/126%	82%/125X
Shelter Cove	8/10/87 to 3/31/88	9	50%	62%/195%	73%/148%	77%/135%	80%/129%
Point Arena PTAC1	8/10/87 to 3/31/88	14	50%	67%/170%	77%/134%	81%/126%	82%/125%
Bodega 46013	8/10/87 to 3/31/88	5	50%	54%/260%	66%/173%	71%/154%	74%/144%
Santa Cruz 46012	8/10/87 to 3/31/88	15	50%	68%/165%	78%/131%	81%/1.26%	82%/125%
Cape San Martin 46028	8/10/87 to 3/31/88	9	50%	62%/195%	73%/148%	77%/135%	80%/129%
Santa Maria 46011	8/10/87 to 3/31/88	9	50%	62X/195%	73%/148%	77%/135%	80%/129%

Notes:

[1]Geometric progression running-mean band averaging:
1st spectral estimate (1.39×10^{-3} cycles/hour): 1 pt. averaged
2nd spectral estimate (2.78×10^{-3} cycles/hour): 3 pts. averaged
3rd spectral estimate (4.17×10^{-3} cycles/hour): 5 pts. averaged
4th and higher (5.56×10^{-3} cycles/hour): 7 pts. averaged

[2]Hanning (full cosine) taper applied to linear de-trended segments.