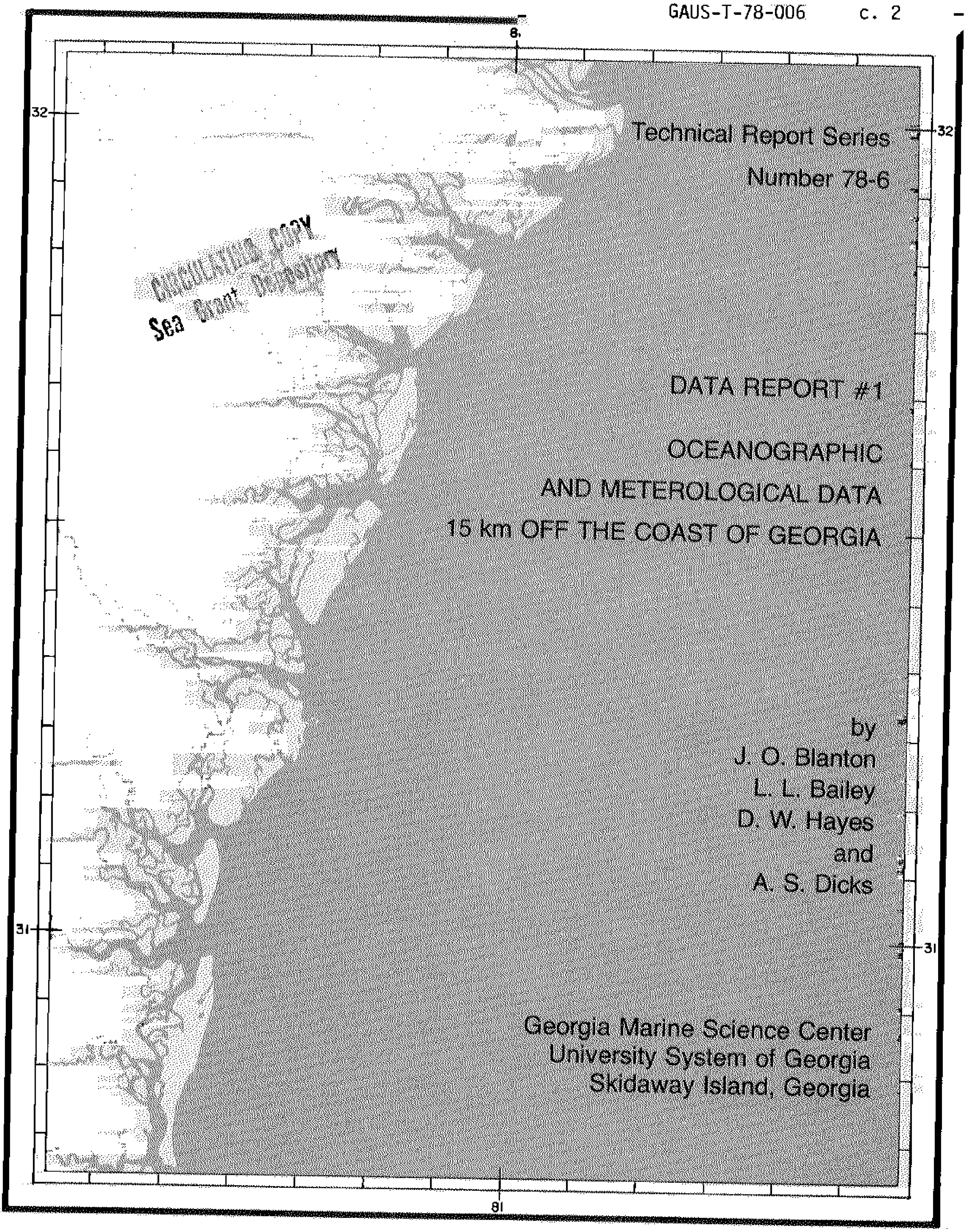

Technical Report Series
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DATA REPORT #1

OCEANOGRAPHIC AND METEROLOGICAL DATA 15 km OFF THE COAST OF GEORGIA

by
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Georgia Marine Science Center
University System of Georgia
Skidaway Island, Georgia

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October 1978

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ACKNOWLEDGMENTS

We wish to thank Jerry Miller, Dan McIntosh, and Cindy Miller for their assistance in preparing and typing the text and data plots and drafting the location map.

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INTRODUCTION

The emphasis of many oceanographic studies has shifted to areas closer to the shore because these areas are increasingly being used for recreation and resource development. Many expect that the coastal nuclear and fossil power plants and other energy-related activities in the coastal zone take place together with man's use of this zone as a recreational and food resource. Thus, the data described in this report have been collected in order to attain an understanding of the characteristics of coastal currents. This understanding is essential before one can evaluate the effect of the currents on biological, chemical, and geological processes occurring in the nearshore region or even determine the transport, dispersion, and fate of energy-related pollutants. The causes of the natural variations in these processes must be determined before man's impact on them can be assessed.

Much of the oceanographic research conducted by Savannah River Laboratory and Skidaway Institute of Oceanography under U. S. Department of Energy (DOE) sponsorship has this objective: to characterize, in a climatological sense, coastal water movements that are of particular relevance to the dispersive characteristics of nearshore waters on the continental shelf. The flow field in this environment is extremely complex due to the interaction of a number of hydrodynamic and meterological variables, such as wind stress, tidal action, bottom friction and density, and sea-surface pressure gradients. Deterministic predictions are not feasible at present, a situation which is confounded by Georgia's lack of a "solid" shore boundary. Its boundary is perforated by tidal inlets whose average spacing is only 10 to 20 km. For the immediate future, a statistical or climatological approach appears to be realistic. This requires several years of data in a region.

The objective of this series of data reports is to provide documentation and visual display of experimental data from the nearshore continental shelf off the Georgia and South Carolina coast. This is of use not only to those programs within the sponsoring agency but is of value in other research programs in this area of the coast along the southeastern United States.

STUDY LOCATION

The Savannah Navigational Light Tower (SNLT) is located about 17 km (9 nautical miles) offshore (Figure 1). The water is 16 m deep at mean low water. The dredged channel for the Savannah River entrance is found on a bearing west northwest from SNLT, and the major axes of the near-surface and near-bottom tidal current ellipses at SNLT lie approximately along this bearing. The tidal range at the mouth of the Savannah River varies between 2 and 3 m, the largest range on the Atlantic coast of the U. S. south of Cape Cod. The flood and ebb tidal flow into and out of the Savannah River appears to influence measurements of ocean currents at SNLT.

The SNLT is located in a region of the southeast U. S. Atlantic coast that is typical of the nearshore region from Cape Romain, South Carolina to Fernandina Beach, Florida. The coastline is interrupted every 10 to 20 km by tidal inlets (of which the Savannah River is one) that feed an extensive network of interconnected sounds and waterways. Many inlets are mouths of major rivers, such as the Savannah, Altamaha, and Pee Dee. Discharges of these rivers can range from 100 to 1000 m^3/s. Other inlets are no more than pocket estuaries where freshwater input is essentially zero. Nevertheless, the large tidal range and the extensive network of shallow sounds and salt marshes act together to form a 10-20 km wide band of turbid, relatively low-salinity water along this coast. The SNLT is located within this regime.

INSTRUMENTATION

Sensors

The SNLT is instrumented with a set of meteorological and oceanographic sensors whose output is sent to a

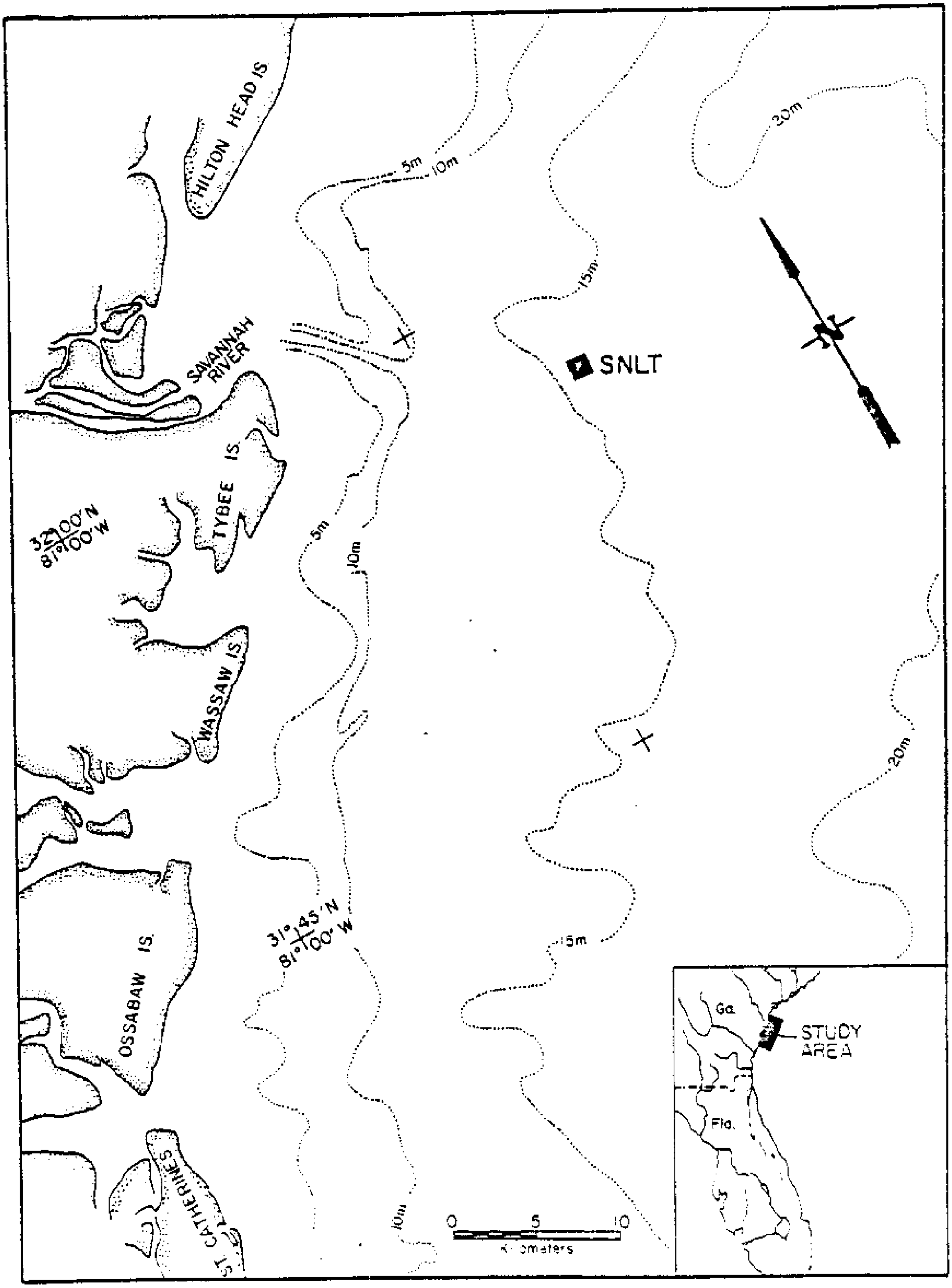

Figure 1. Location of SNLT. Depth contours are in meters.

programmable Esterline Angus multi-channel data logger. Wind velocity is measured with an MRI Model 1074-20 cup and vane anemometer. Currents are measured with Marsh-McBirney Model 511 electromagnetic current meters. Air and water temperatures are measured with thermocouples made from Constantan wire with cold junction compensation performed by the data acquisition system. Also mounted on the tower are a bubbler tide gauge with a Robinson-Halpern pressure transducer and an aneroid cell barometer, Model #B-242, by Weathermeasure Corporation. Sensor accuracies as derived from specifications from manufacturers are ± 0.5 m/s and ± 4^{o} at speeds of up to 20 m/s for wind velocity, ± 2 cm/s at speeds of up to 100 cm/s for each component of ocean current, ± 0.6^{o}C for air and ocean temperature, ± 5 cm for sea level up to 3 m above mean low water (MLW), and ± 1 mb for barometric pressure. A quartz crystal in the data logger measures time to ± 1 min/month.[1]

Wind velocity is measured at a height of 27 m above MLW. Three thermocouples are located 18 m above MLW and we average their data to report air temperature. Sea level is measured relative to MLW. North and east components of ocean currents are measured with electromagnetic current meters at 4.3 m and 13.4 m below MLW. Six thermocouples measure ocean temperature at 1.5 m, 3.0 m, 6.7 m, 10.4 m, 14.0 m, and 15.8 m, respectively, below MLW.

Data Return

Usable data excludes those 10-min values that were designated with 99999.99 or asterisks as well as those values that we judge were unrealistic. Table 1 indicates a 100% data return from all but five sensors.

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[1]The types of sensors and the data acquisition system are covered in a separate document entitled "Oceanographic and Meteorological Data Acquisition System for the Savannah Navigational Light Tower", by D. W. Hayes (in preparation).

Table 1. Time over which usable data were obtained from each sensor for the period 17 February through 17 May 1977.

	FEB	MAR	APR	MAY	Percent of Usable data
Wind direction, 27 m	XXXXXX	XXXXXXX XX	X X X XXXX	XX	55
Wind speed, 27 m	XXXXXX	XXXXXXXXXXX	XXXXXXXXXXXX	XXXXX	100
Barometric pressure	XXXXXX	XXXXXXXXXXX	XXXXXXXXXXXX	XXXXX	100
Sea level		(no	data)		0
Temperature, 1 m	XXXXXX	XXXXXXXXXXX	XXXXXXXXXXXX	XXXXX	100
Temperature, 3 m	XXXXXX	XXXXXXXXXXX	XXXXXXXXXXXX	XXXXX	100
Temperature, 7 m			XXXXXXXX	XXXXX	38
Temperature, 10 m	XXXXXX	XXXXXXXXXXX	XXXXXXXXXXXX	XXXXX	100
Temperature, 14 m	XXXXXX	XXXXXXXXXXX	XXXXXXXXXXXX	XXXXX	100
Temperature, 16 m	XXXXXX	XXXXXXXXXXX	XXXXXXXXXXXX	XXXXX	100
North current, 4 m	XXXXXX	XXXXXXXXXXX	XXXXXXXXXXXX	XXXX	96
East current, 4 m	XXXXXX	XXXXXXXXXXX	XXXXXXXXXXXX	XXXX	96
North current, 13 m	XXXXXX	XXXXXXXXXXX	XXXXXXXXXXXX	XXXXX	100
East current, 13 m	XXXXXX	XXXXXXXXXXX	XXXXXXXXXXXX	XXXXX	100

The wind direction sensor operated continuously for the first four and one-half weeks (35% of the total record) after which the data became only sporadically usable. We were able to extract a total of almost eight weeks of hourly direction data (see next section) after an arduous effort of programming. The 65% return (Table 1) reflects the total usable hourly data we were able to extract.

Sea level data were so sporatic in quality that no usable data resulted. The temperature sensor at 6.7 m functioned during the later portion of our record. The other temperature sensors functioned 100% of the time.

The sensor for the two components of velocity at 4.3 m operated about 96% of the time (Table 1). We are including these data with reservation. The north component is consistently positive and large enough to result in a residual flow (tides removed) that never reverses even when the wind direction reverses. This is so unusual that we must interpret the data with considerable caution.

The velocity sensors had operated for almost three months before the beginning of the data reported here. A shift in the "zero" voltage position of the sensor cannot be ruled out. On 13 May 1977, the velocity values of the north component at 4.3 m suddenly jumped to more than +100 cm/s, and we rejected the final portion of the record. The corresponding east component did not experience a similar increase.

DATA PROCESSING

Error checks on 10-min values

The primary data were acquired for each sensor by the data logger on magnetic tape at selected time intervals. For this report the time interval was 10 min except for the first two weeks when the interval was 3 min. These data were converted to engineering units and bad data fields filled with 99999.99 for unrealistic or erroneous values. The 10-min data form the basic data set for this report.

If less than five values were found to be bad in any particular field, the values were inserted by linear interpolation and the field reported to be 100% good. Wind direction data contained many blocks of missing data and linear interpolation schemes could not be used exclusively.

We tried to salvage as much wind velocity data as possible by using two smoothing schemes. If we had at least 5 hours of continuously good 10-min data, we utilized a smoothing filter as described below. In many cases, this scheme was not possible. If we had 1 or more hours of continuous data, but less than 5 hours, we block-averaged the good data to produce hourly values.

Smoothing of 10-min irregularities

The irregularities in the 10-min data were smoothed with a symmetric Lanczos-squared filter containing 13 weights.[2] This filter removes one-half of the amplitude of fluctuations having 2-hour periods and removes 90%

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[2]The weight (w_j) were computed according to the formula

$$w_j = \left[\frac{\sin[\pi(j-1)/M]}{\pi(j-1)/M}\right]^a$$

where $j = 1,2,\ldots M$
M = (no. of weights + 1)/2
a = 2 for Lanczos-squared filters
a = 1 for Lanczos filters

of the amplitude of fluctuations with periods of 1 hour. Higher attenuation occurs at periods below 1 hour. We have sacrificed a sharp cutoff (i.e., an abrupt attenuation of higher frequencies) by keeping our data loss to a minimum. These filtered data are selected at 1-hour intervals and placed on a file for plotting. Irregularities occurring at frequencies less than 0.5 cycles per hour (cph) are retained and tidal fluctuations are easily resolved. Table 2 summarizes the characteristics of the file of hourly data that results from the basic 10-min data. This file is hereafter referred to by the term "hourly data file."

Removal of tidal and daily fluctuations

During the 13 weeks covered by this report, the tidal and daily fluctuations often obscure the slow changes in water currents and temperature induced by changes in weather. Thus, a second file of data was created that removed all fluctuations that occurred more frequently than once about every 30 hours. A large symmetric Lanczos filter containing 193 weights was applied to the hourly data file. A new file of data was created that contained values every 6 hours (Table 2). While data loss was large, the filter had a sharp cutoff. This filter is identical to that used by the University of Miami and North Carolina State University in smoothing their ocean current data. This facilitates comparison of the many data currently being obtained in the U. S. South Atlantic Bight under the sponsorship of DOE and the U. S. Department of Interior. This file is hereafter called the "40-hour low-pass data file."

Plotting of hourly and 6-hour data

The two basic data files (Table 2) form the basis of this report. Each file is maintained internally formatted on a CDC-CYBER-74. These files were translated into statements that were plotted on a digital plotter controlled by a Hewlett-Packard 9825A.

Table 2. Data files that resulted from smoothing the 10-min data.

File Characteristics	2-hr low-pass	40-hr low-pass
Data interval	1 hr	6 hr
0.5 amplitude period (frequency)	2 hr (0.5 cph)	40 hr (0.6 cpd)
0.1 amplitude period (frequency)	1 hr (0.1 cph)	34 hr (0.7 cpd)
Filter type	Lanczos-squared	Lanczos
Number of weights	13	193
Data loss, each end	1 hr	4 days
Beginning date, hr (EST)	17 Feb. 1977,1800	21 Feb. 1977,1800
End date, hr (EST)	17 May 1977,0300	12 May 1977, 2400

The hourly data file is conveniently broken into 7-day increments. The oceanographic and meteorological data are placed on two plots for each week. The first plot contains all available wind and ocean current data in the form of hourly vector plots. Barometer pressure is also included. The vectors point along the direction toward which air and water are going. We caution the reader that these plots appear to give vectors perpendicular to the time axis more emphasis than those that plot more nearly parallel to the axis (in this case, east or west winds or currents).

The second plot for each week contains all available air and ocean temperature data. Sea level would have been included here had data been available for the 17 February to 17 May time period. Ocean temperature at 6.7 m was unavailable for much of this period (Table 1).

The 40-hour low-pass data file is broken into monthly segments. Each segment covers an entire calendar month even though data may not be available for the entire month. The available data are contained in two plots each month. The first plot contains the vector plot of 40-hour low-pass wind followed by the respective alongshore and offshore component of ocean velocity. The shoreline near SNLT trends NE-SW, so the original north and east ocean current components were transformed to an alongshore axis bearing northeast and an offshore axis bearing southeast.

The second monthly plot contains the 40-hour low-pass temperature and barometric pressure along with the same vector winds plotted on the first monthly chart. The same caution concerning vector plots is particularly applicable in interpreting the vector plots of winds during March. These plots emphasize two episodes of northwestward to northeastward winds, but they partially obscure the strong westward winds that preceded these events. The wind sensor periodically malfunctioned (Table 1) after 16 March and no 40-hour low-pass wind data are displayed after that data.

THE DATA

Weekly Plots of Hourly Data

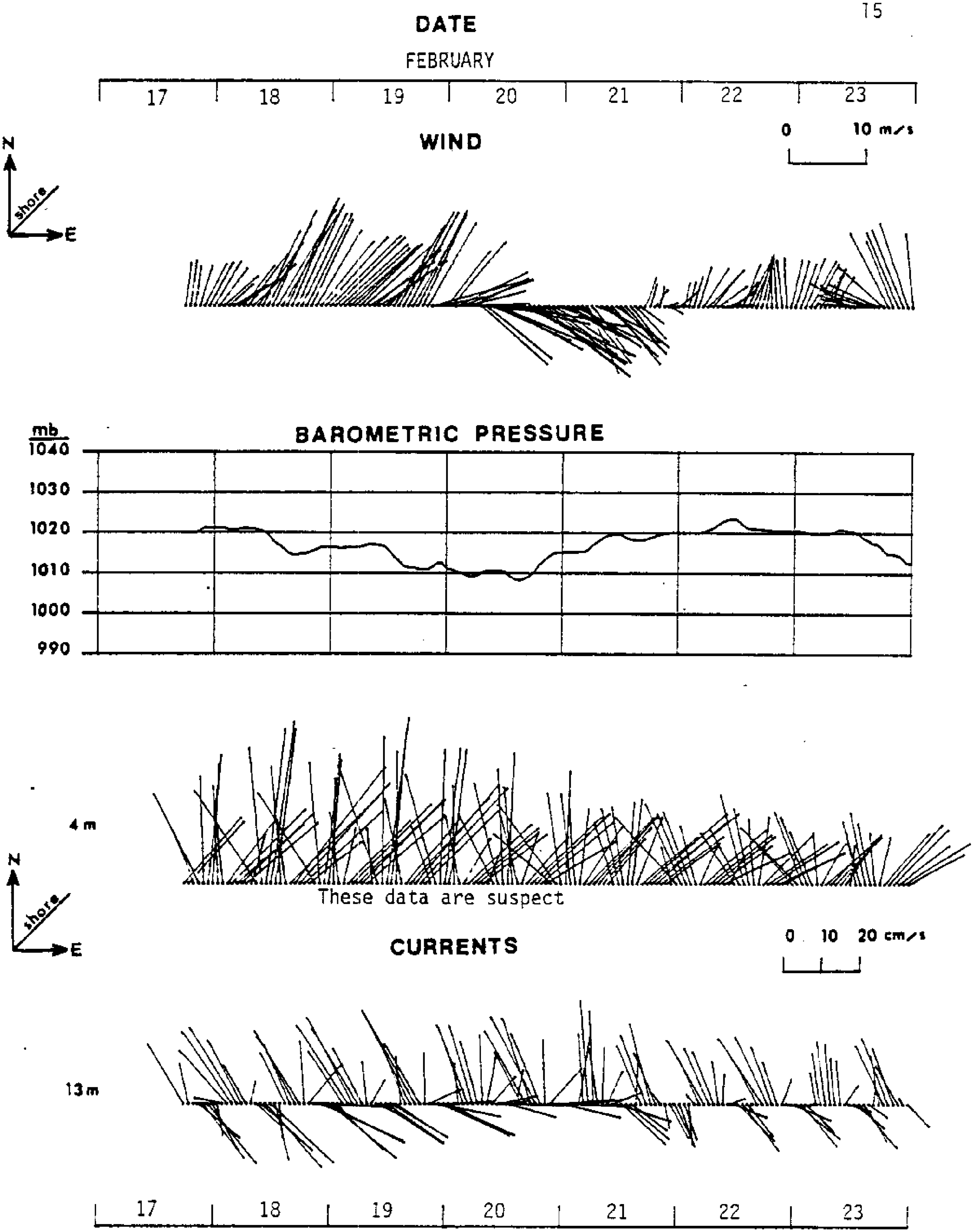

Figure 2. Wind, barometric pressure, and ocean currents from 17-23 February 1977. Hourly values are plotted.

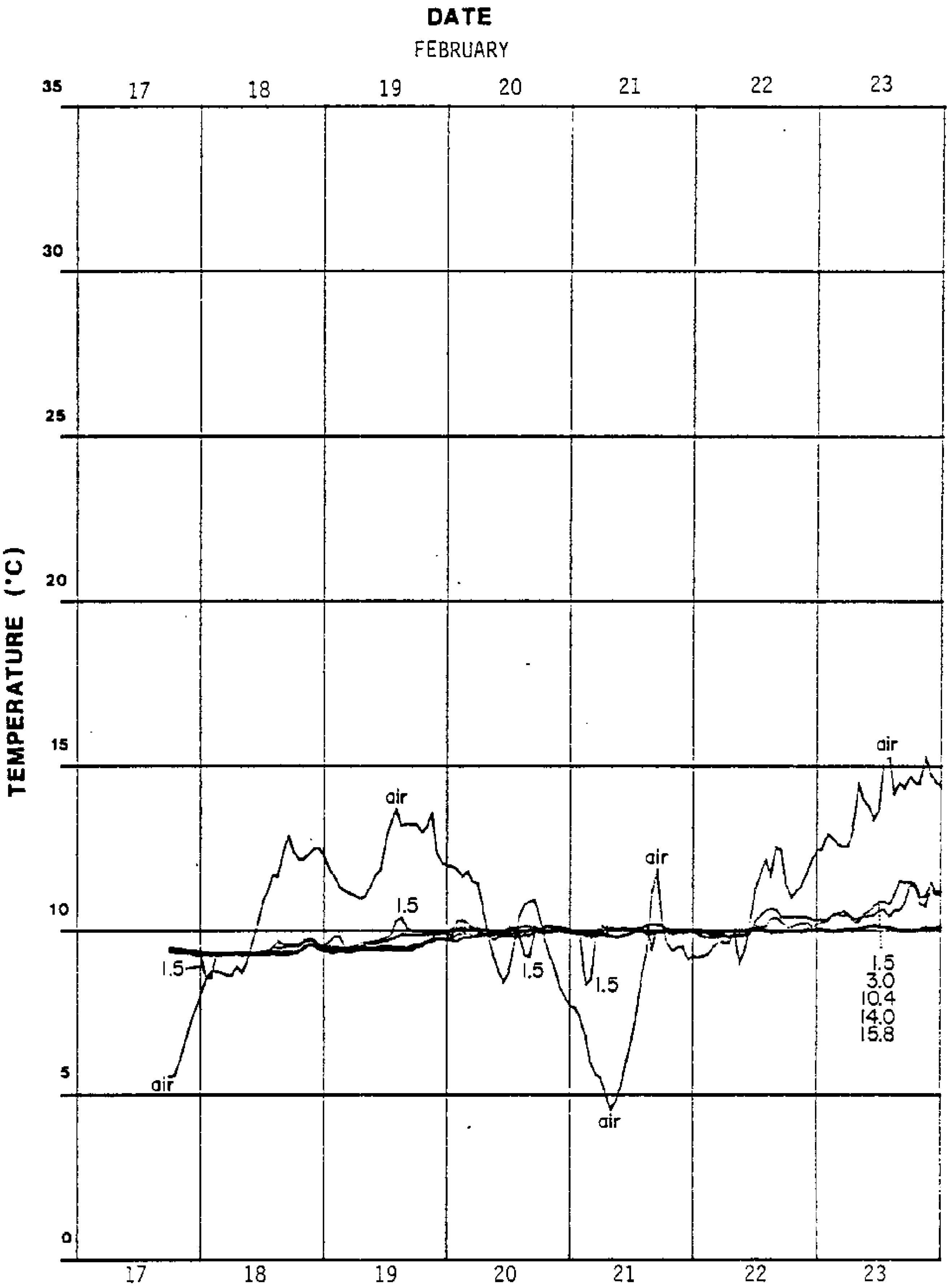

Figure 3. Air and ocean temperature from 17-23 February 1977. Numbers identify depth in meters. Hourly values are plotted.

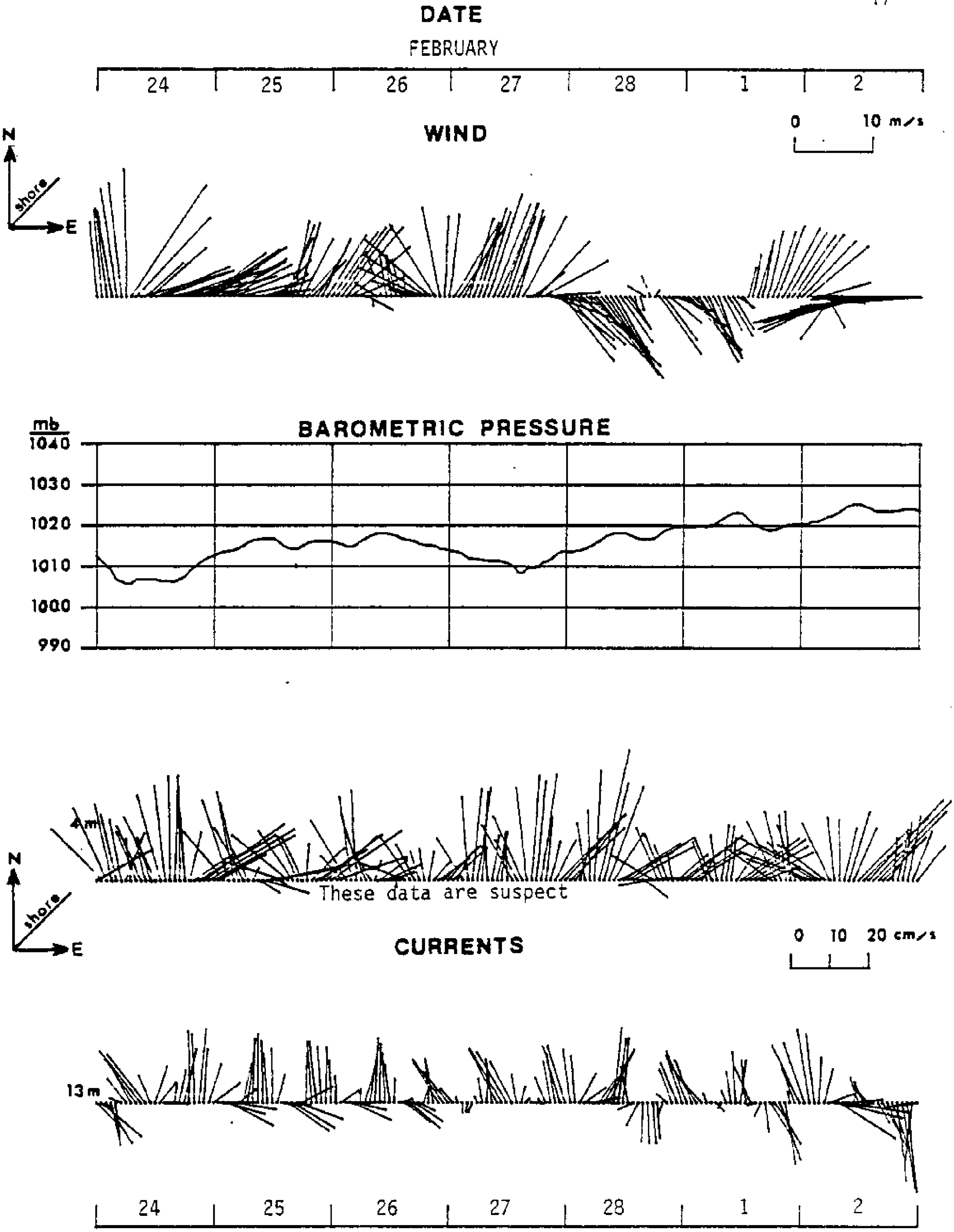

Figure 4. Wind, barometric pressure, and ocean currents from 24 February - 2 March 1977. Hourly values are plotted.

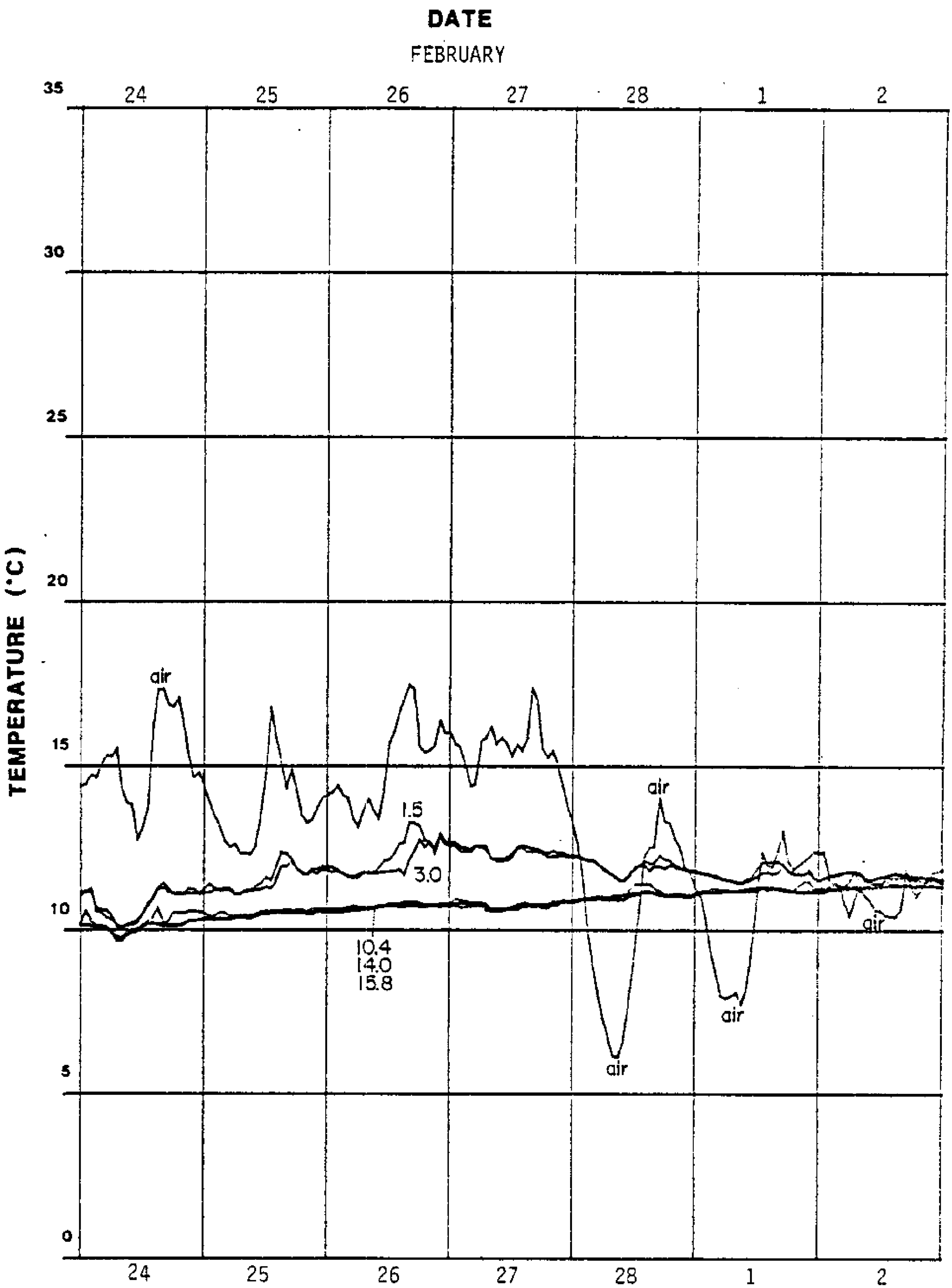

Figure 5. Air and ocean temperature from 24 February - 2 March 1977. Numbers identify depth in meters. Hourly values are plotted.

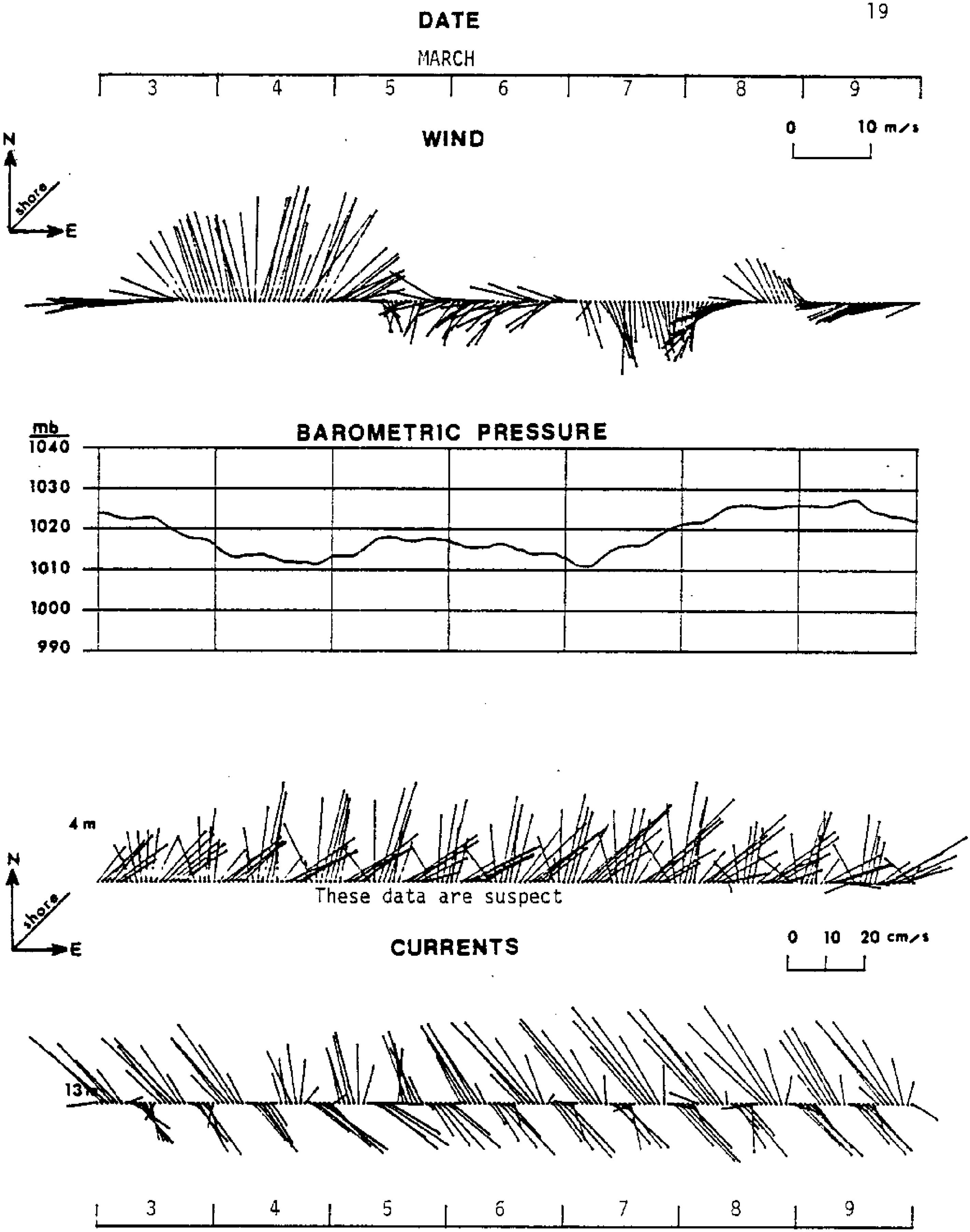

Figure 6. Wind, barometric pressure, and ocean currents from 3-9 March 1977. Hourly values are plotted.

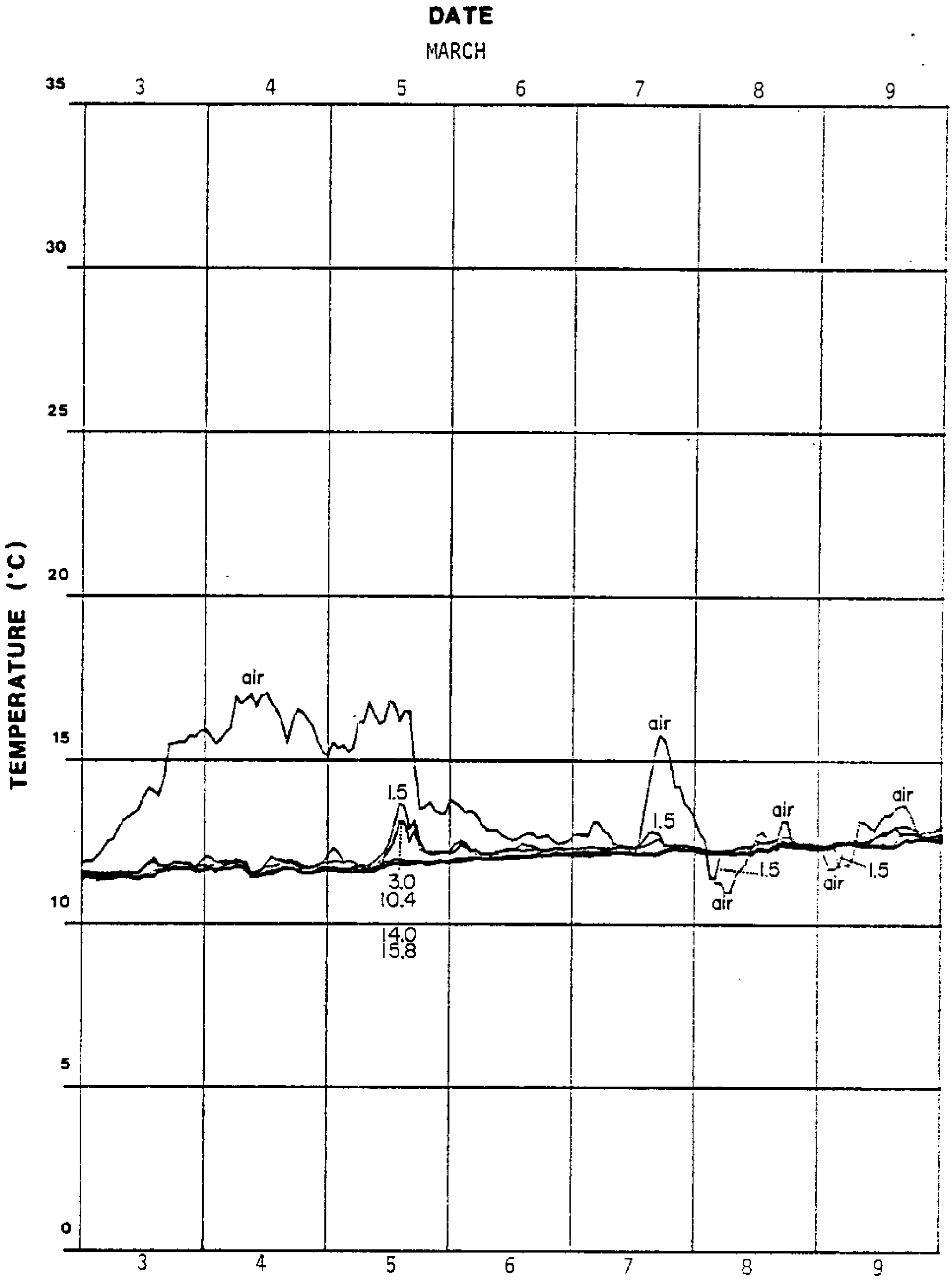

Figure 7. Air and ocean temperature from 3-9 March 1977. Numbers identify depth in meters. Hourly values are plotted.

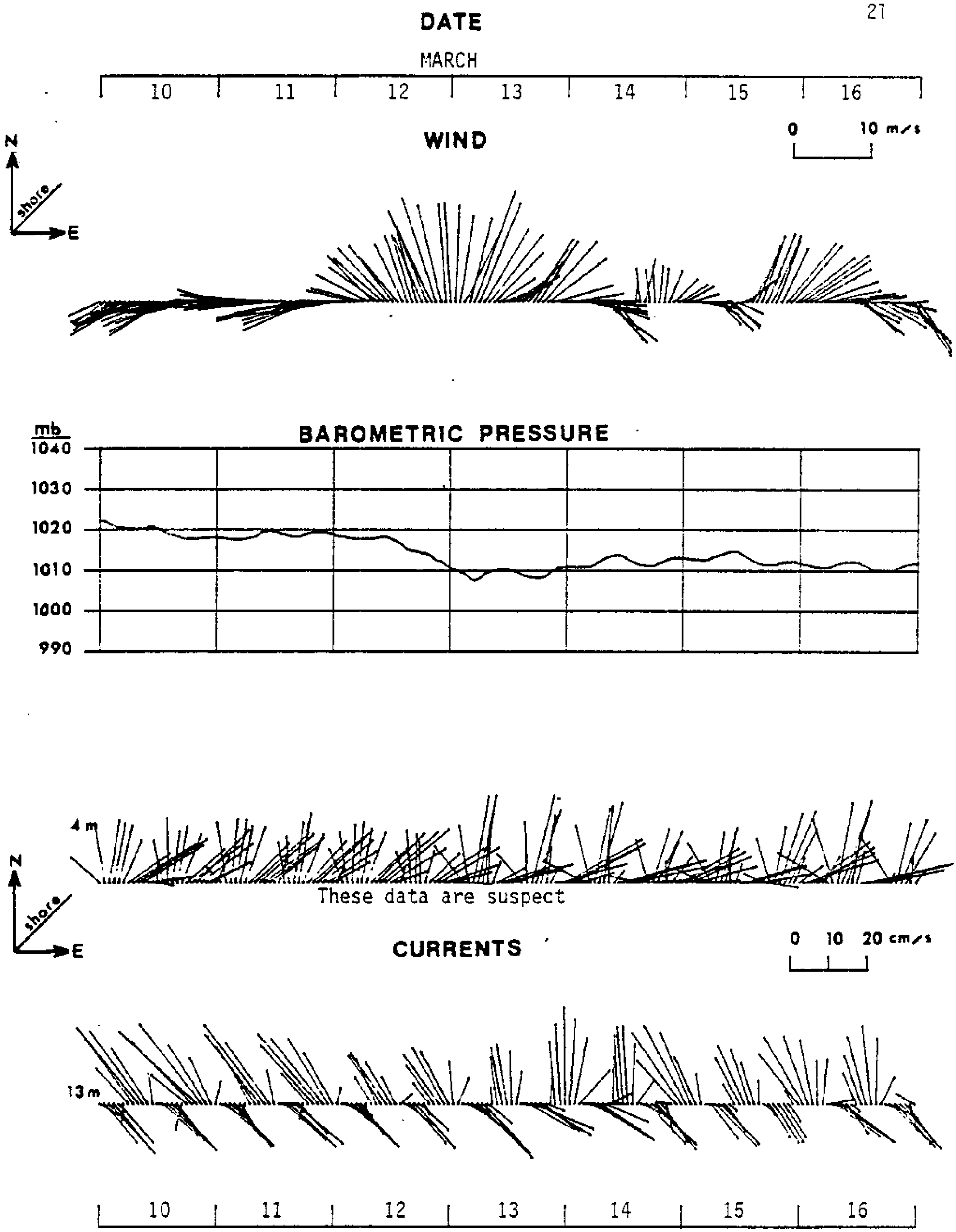

Figure 8. Wind, barometric pressure, and ocean currents from 10-16 March 1977. Hourly values are plotted.

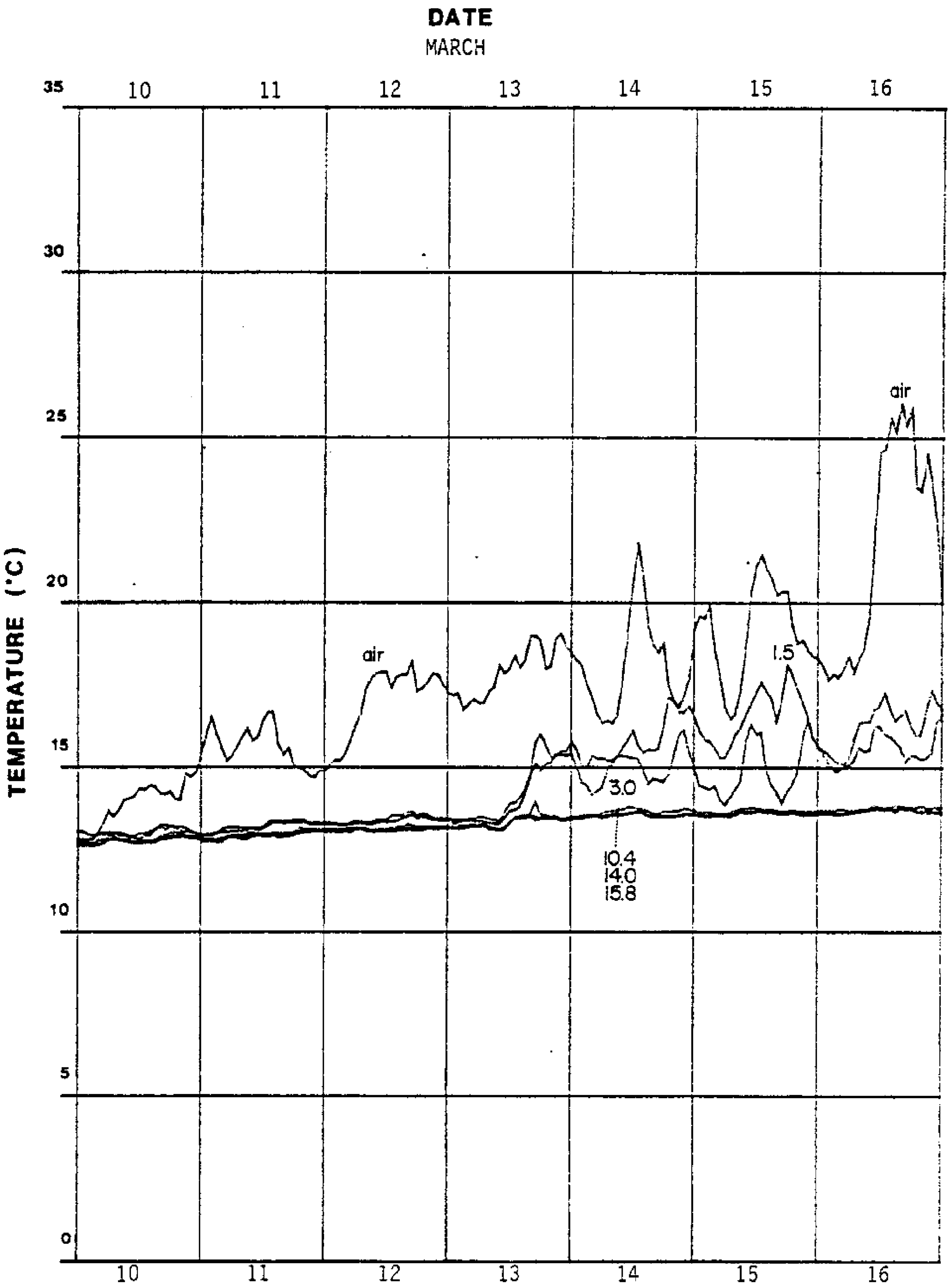

Figure 9. Air and ocean temperature from 10-16 March 1977. Numbers identify depth in meters. Hourly values are plotted.

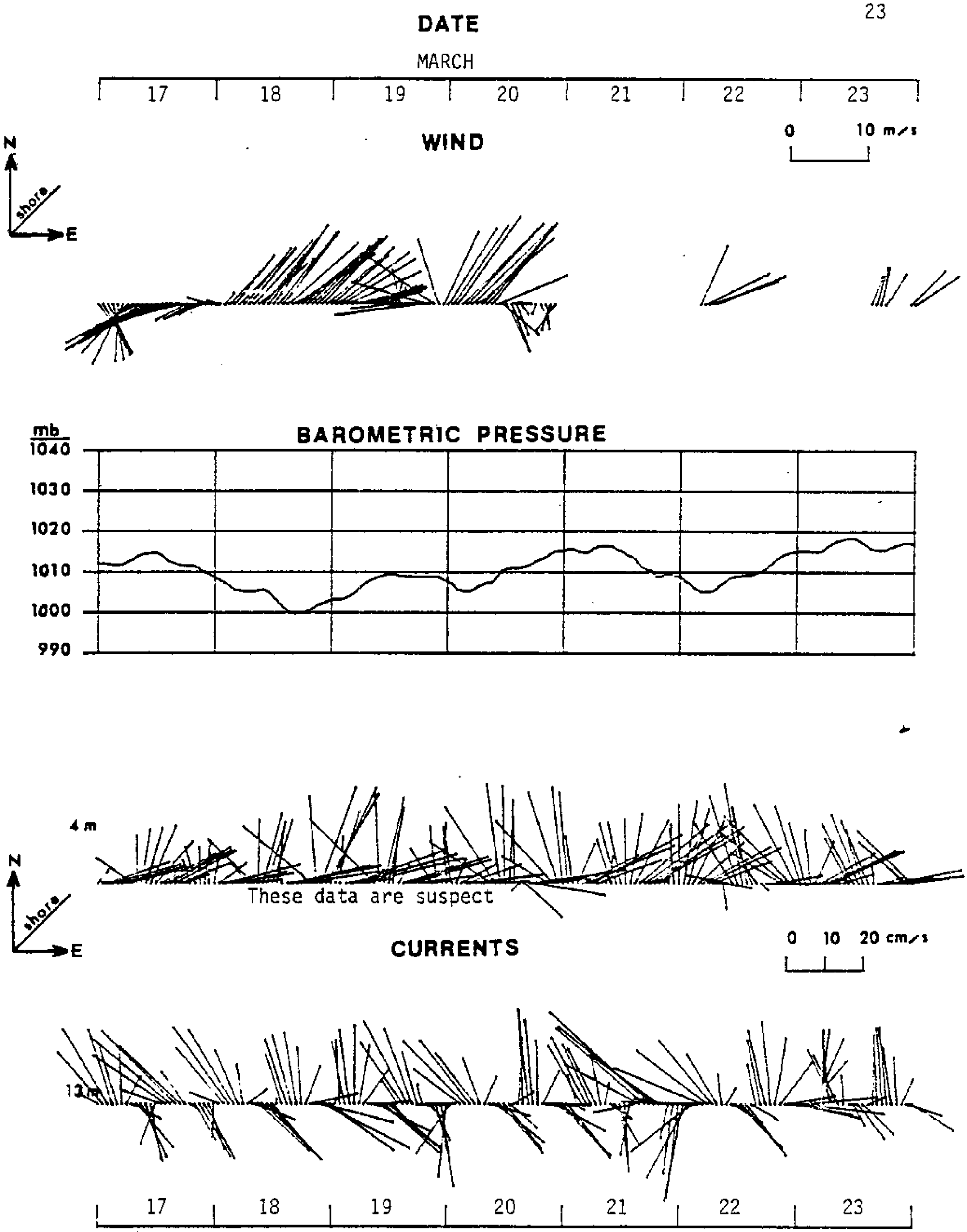

Figure 10. Wind, barometric pressure, and ocean currents from 17-23 March 1977. Hourly values are plotted.

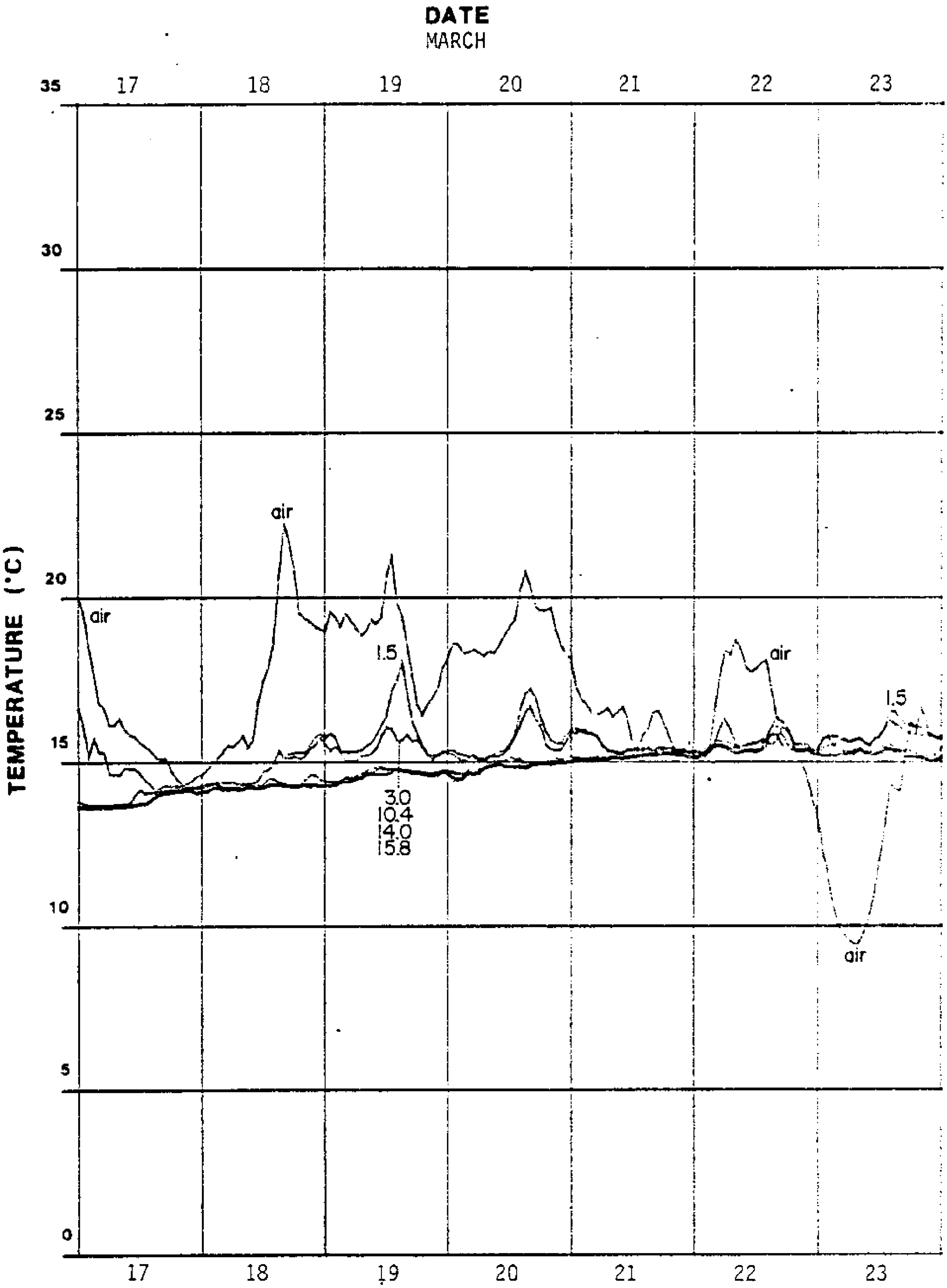

Figure 11. Air and ocean temperature from 17-23 March 1977. Numbers identify depth in meters. Hourly values are plotted.

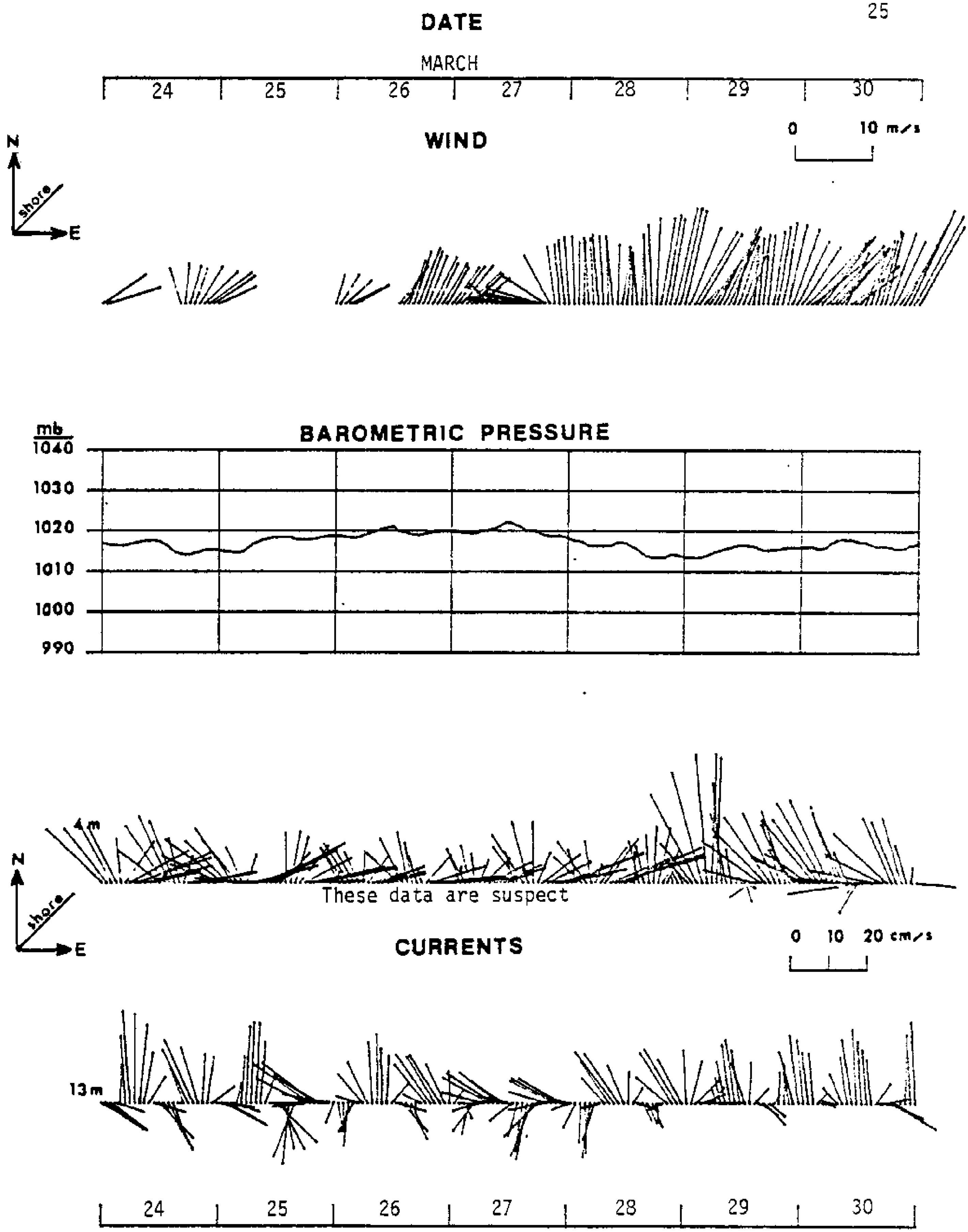

Figure 12. Wind, barometric pressure, and ocean currents from 24-30 March 1977. Hourly values are plotted.

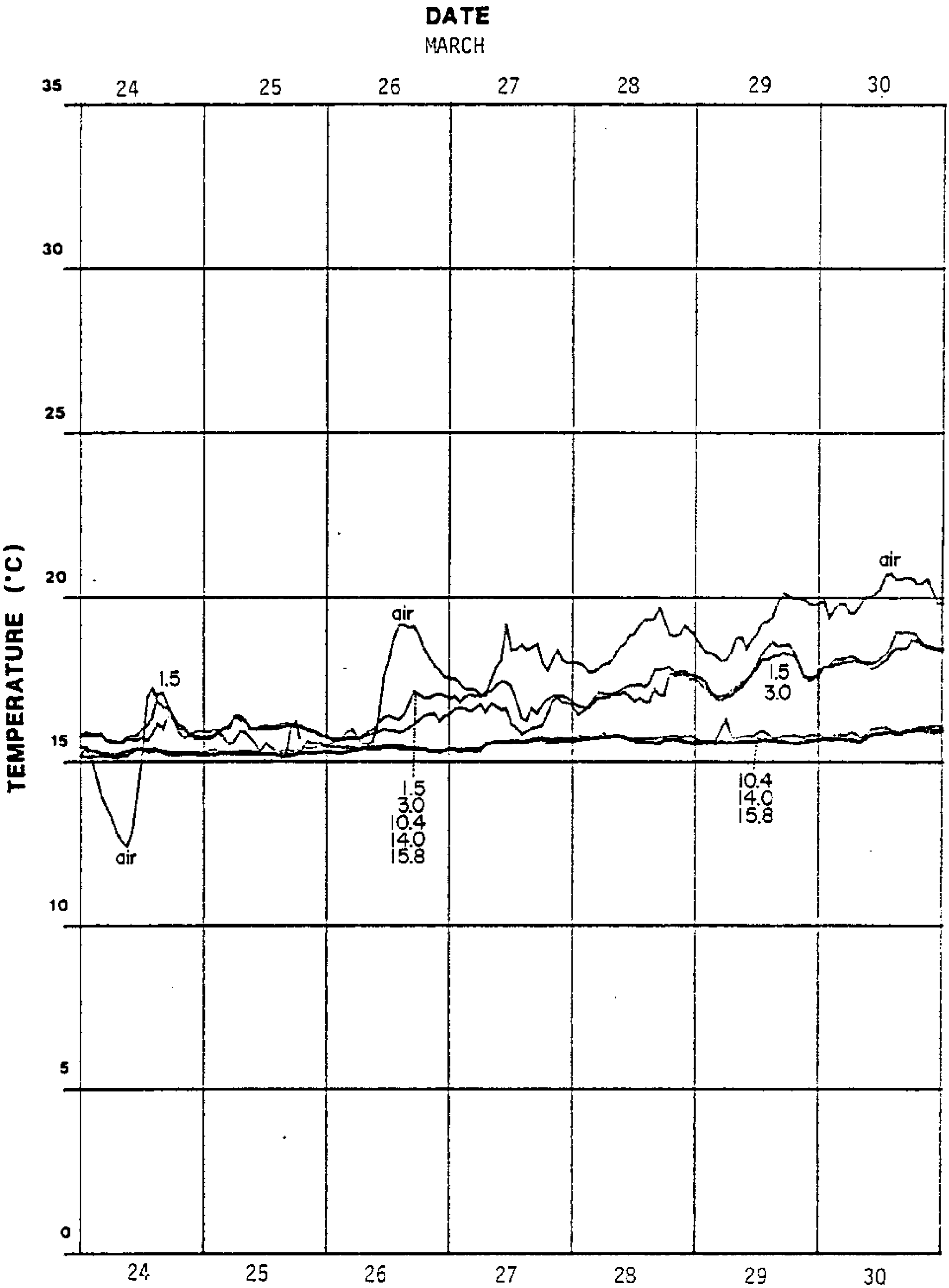

Figure 13. Air and ocean temperature from 24-30 March 1977. Numbers identify depth in meters. Hourly values are plotted.

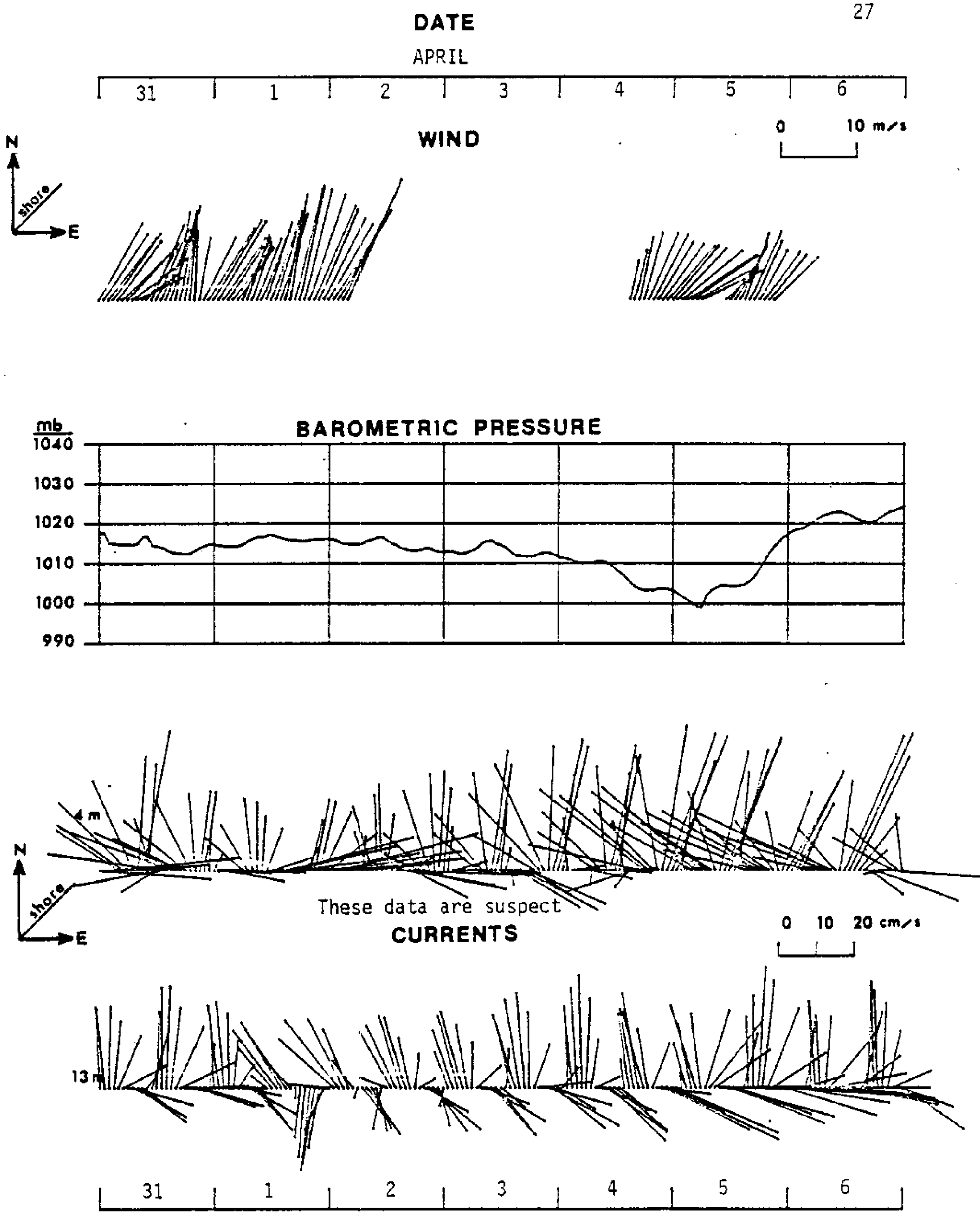

Figure 14. Wind, barometric pressure, and ocean currents from 31 March - 6 April 1977. Hourly values are plotted.

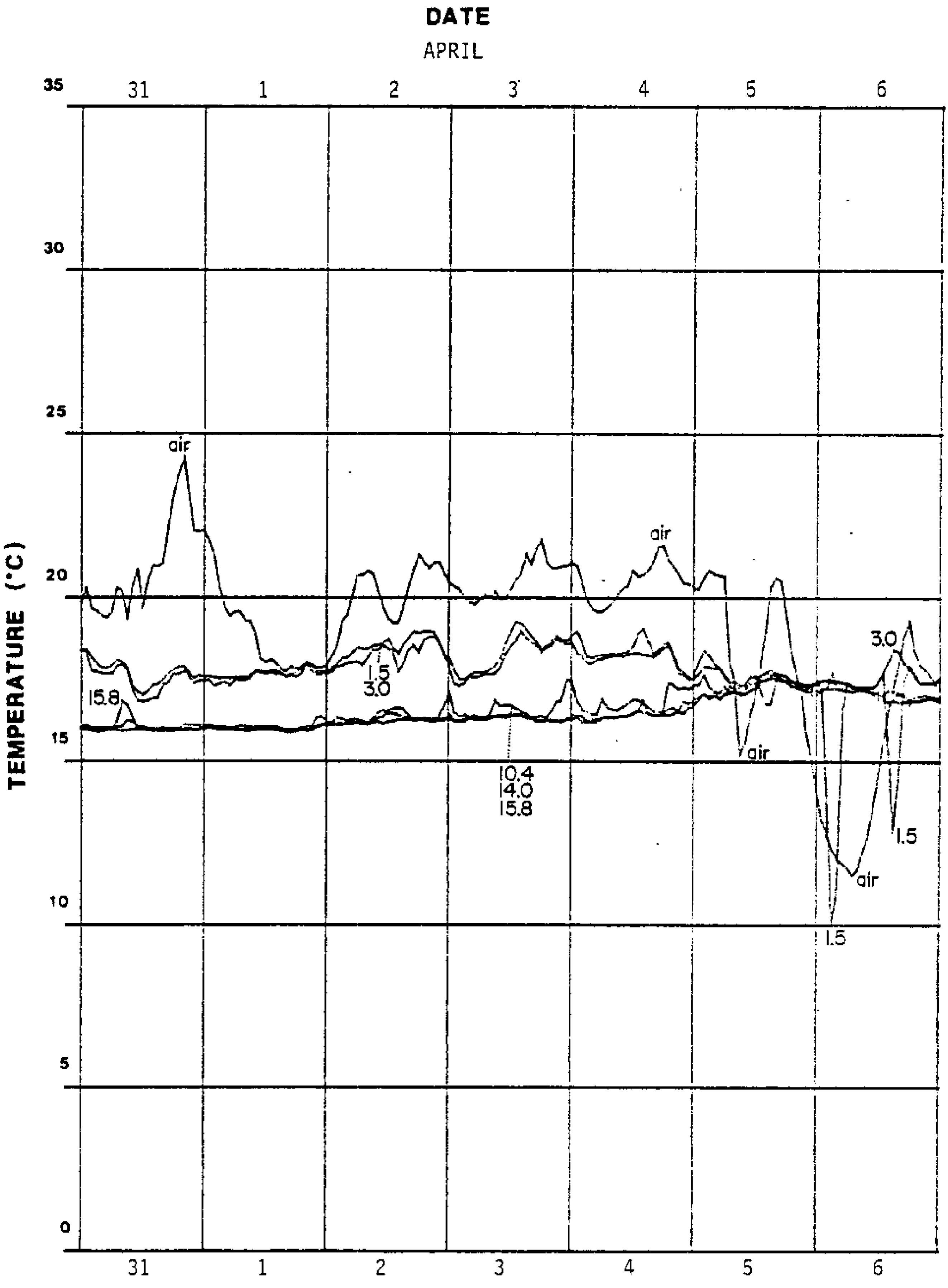

Figure 15. Air and ocean temperature from 31 March - 4 April 1977. Numbers identify depth in meters. Hourly values are plotted.

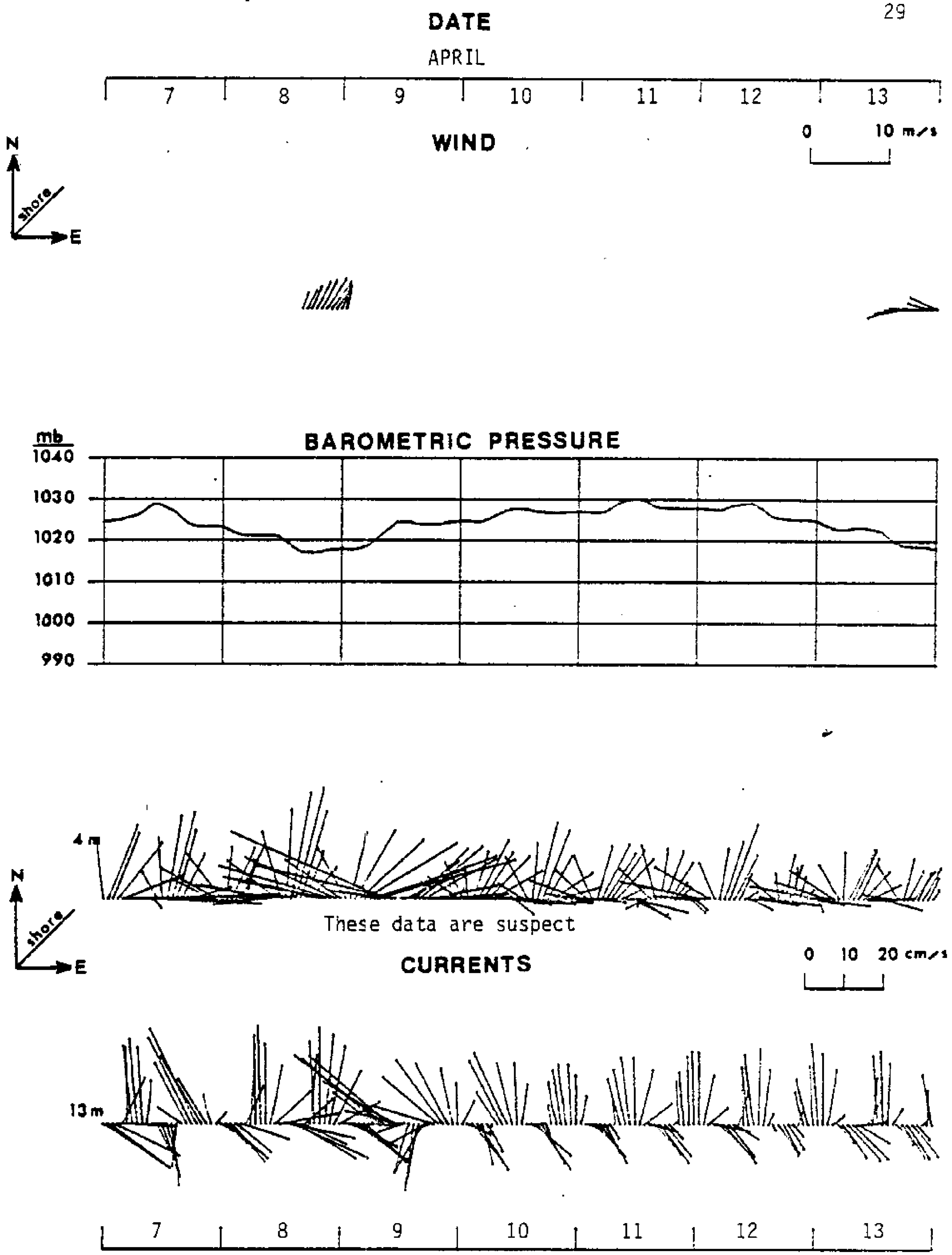

Figure 16. Wind, barometric pressure, and ocean currents from 7-13 April 1977. Hourly values are plotted.

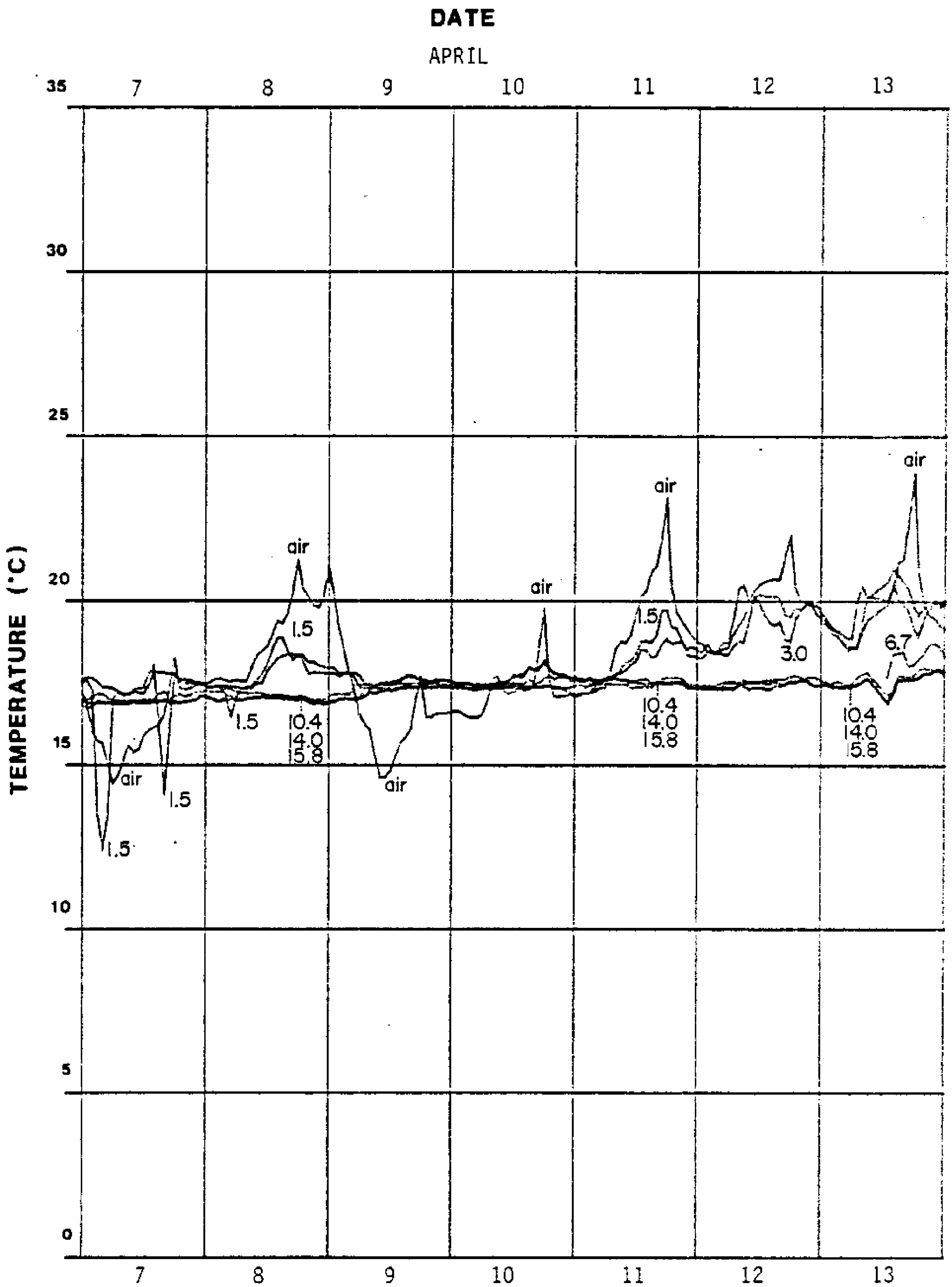

Figure 17. Air and ocean temperature from 7-13 April 1977. Numbers identify depth in meters. Hourly values are plotted.

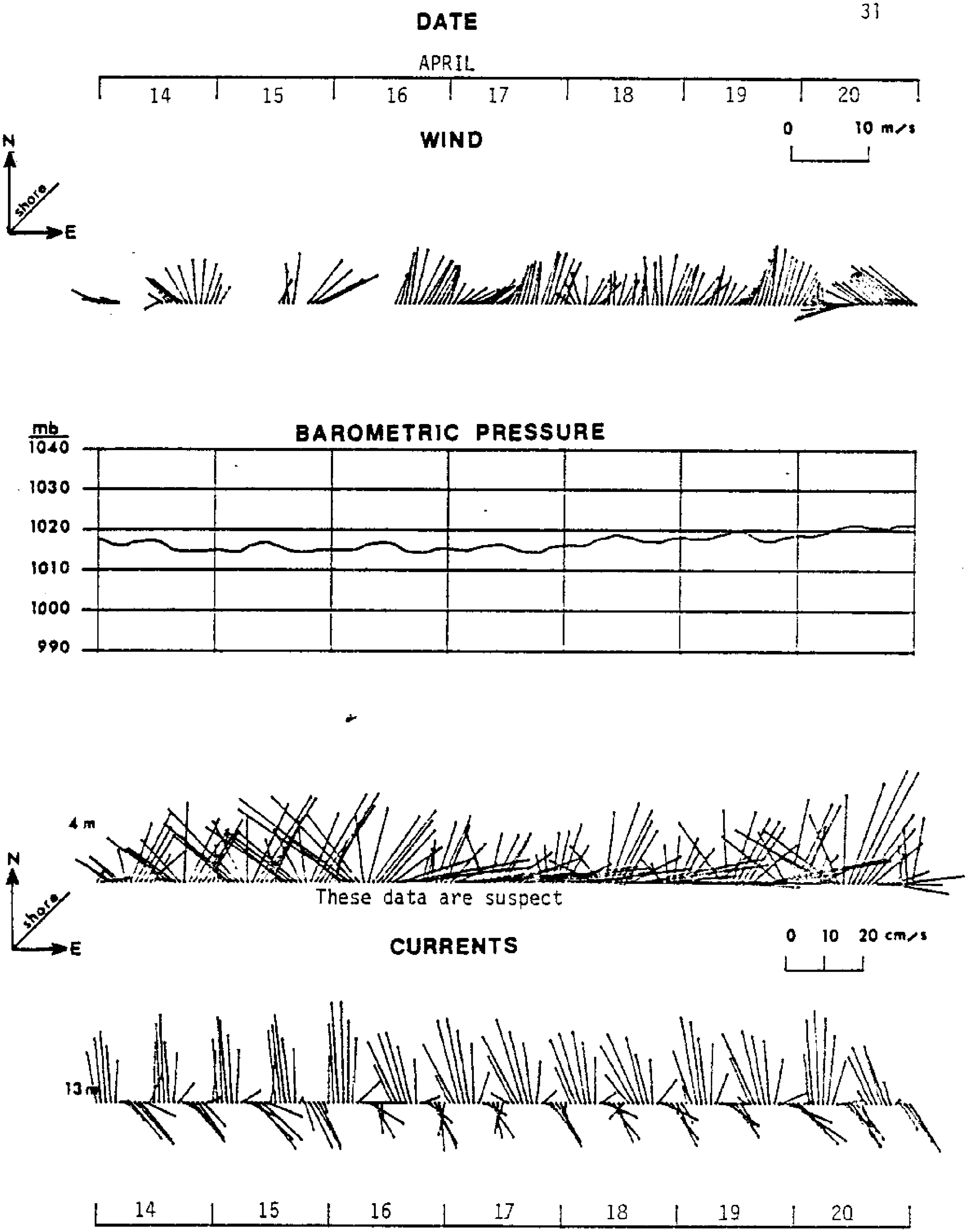

Figure 18. Wind, barometric pressure, and ocean currents from 14-20 April 1977. Hourly values are plotted.

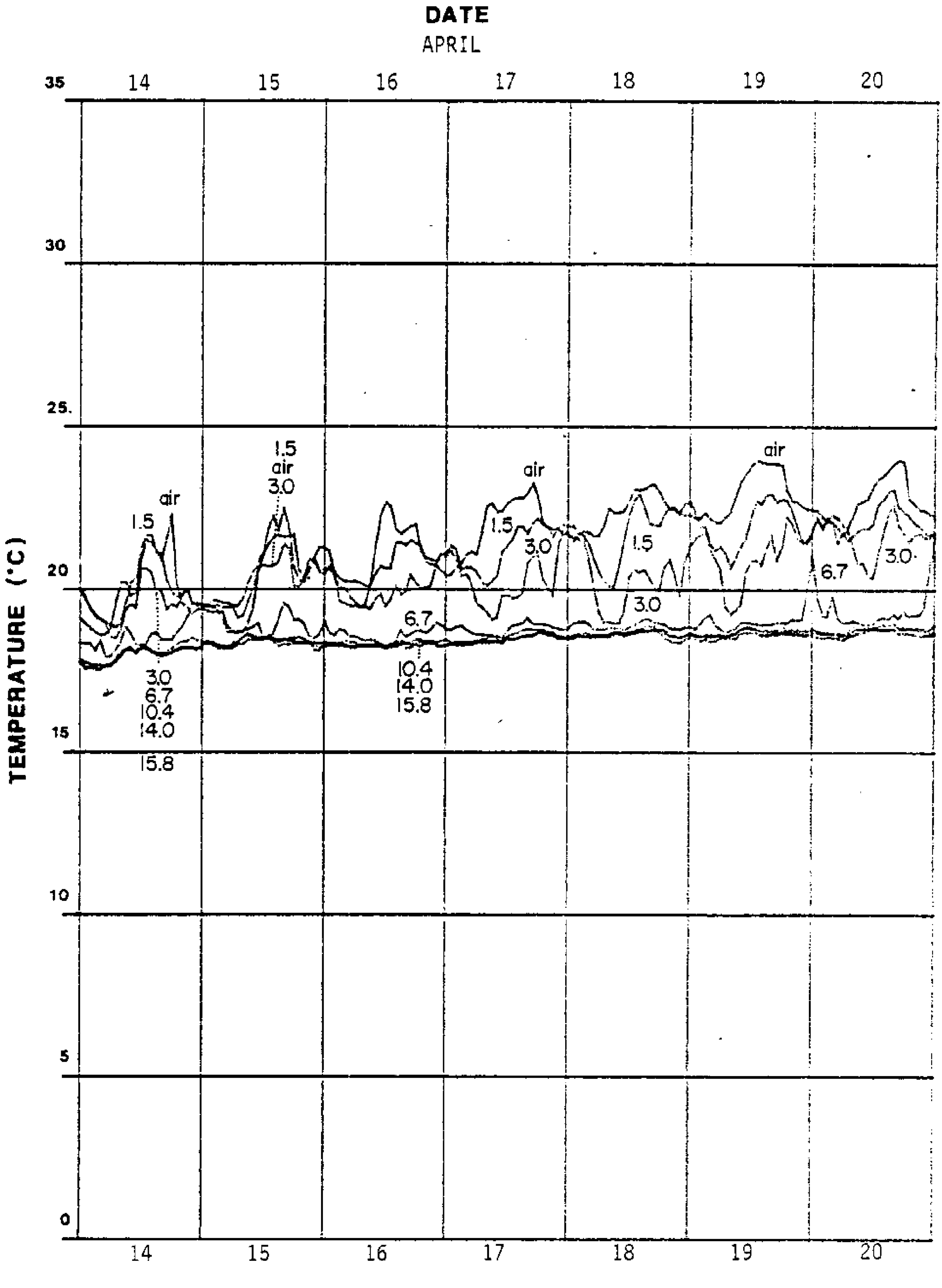

Figure 19. Air and ocean temperature from 14-20 April 1977. Numbers identify depth in meters. Hourly values are plotted.

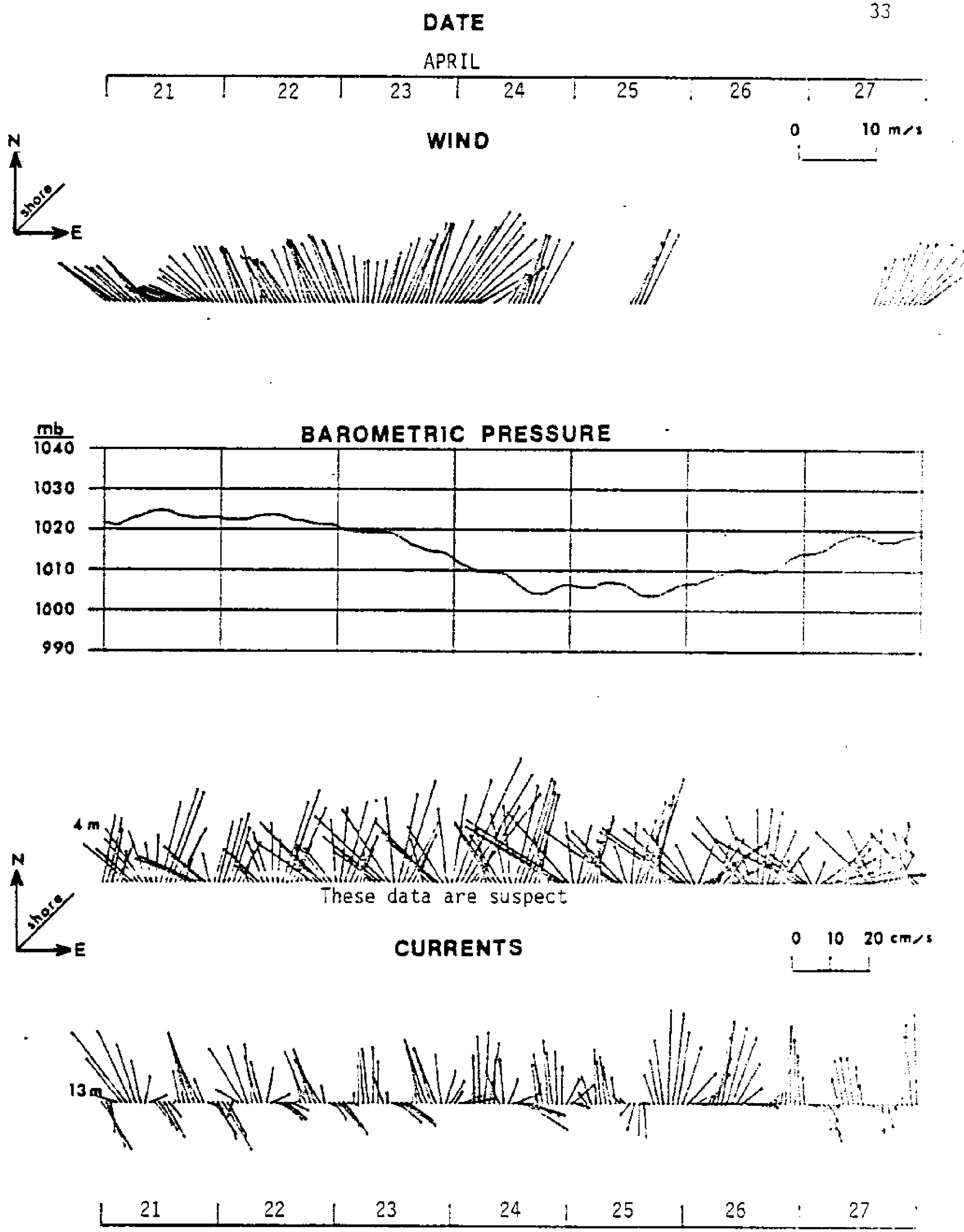

Figure 20. Wind, barometric pressure, and ocean currents from 21-27 April 1977. Hourly values are plotted.

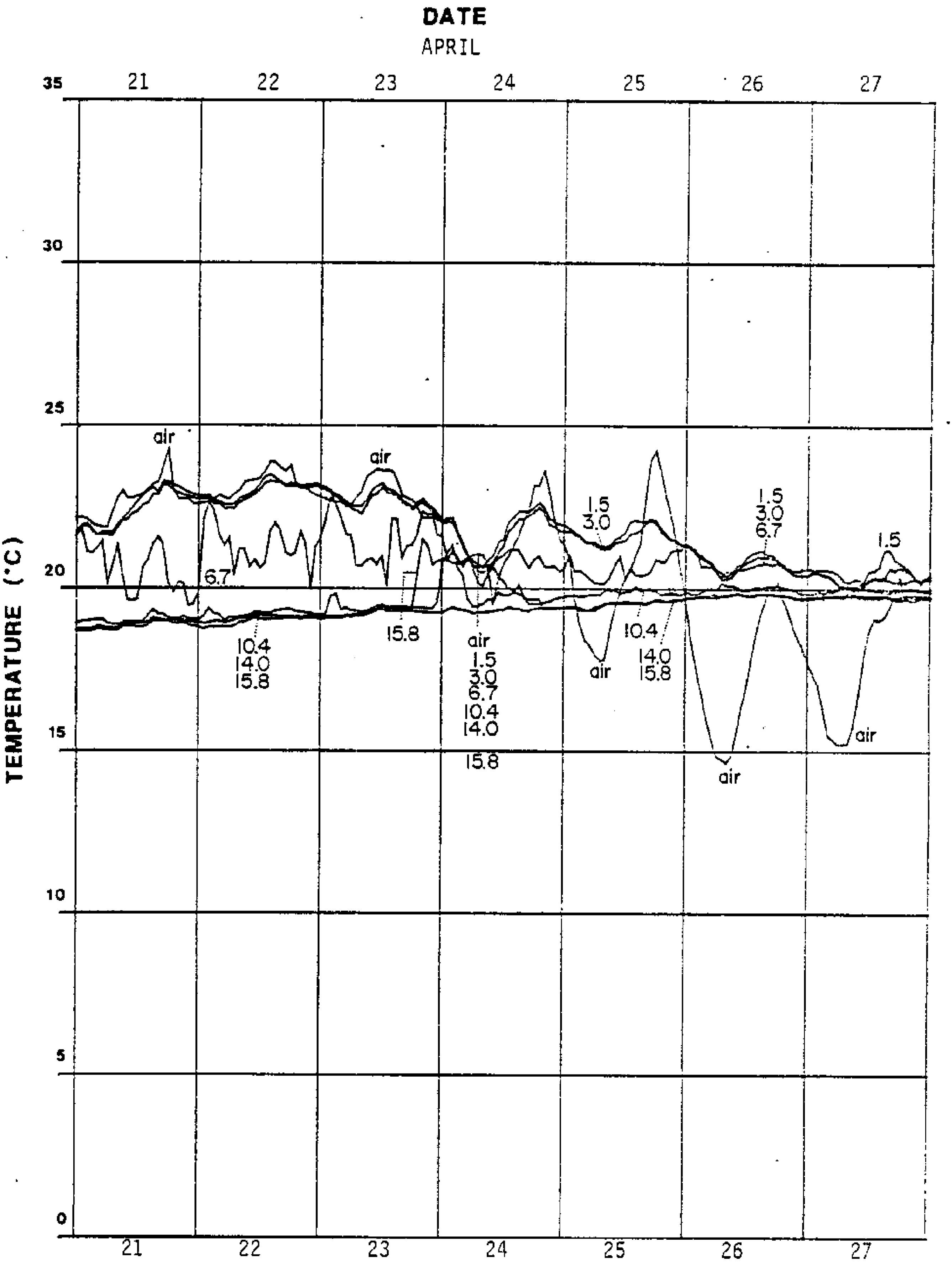

Figure 21. Air and ocean temperature from 21-27 April 1977. Numbers identify depth in meters. Hourly values are plotted.

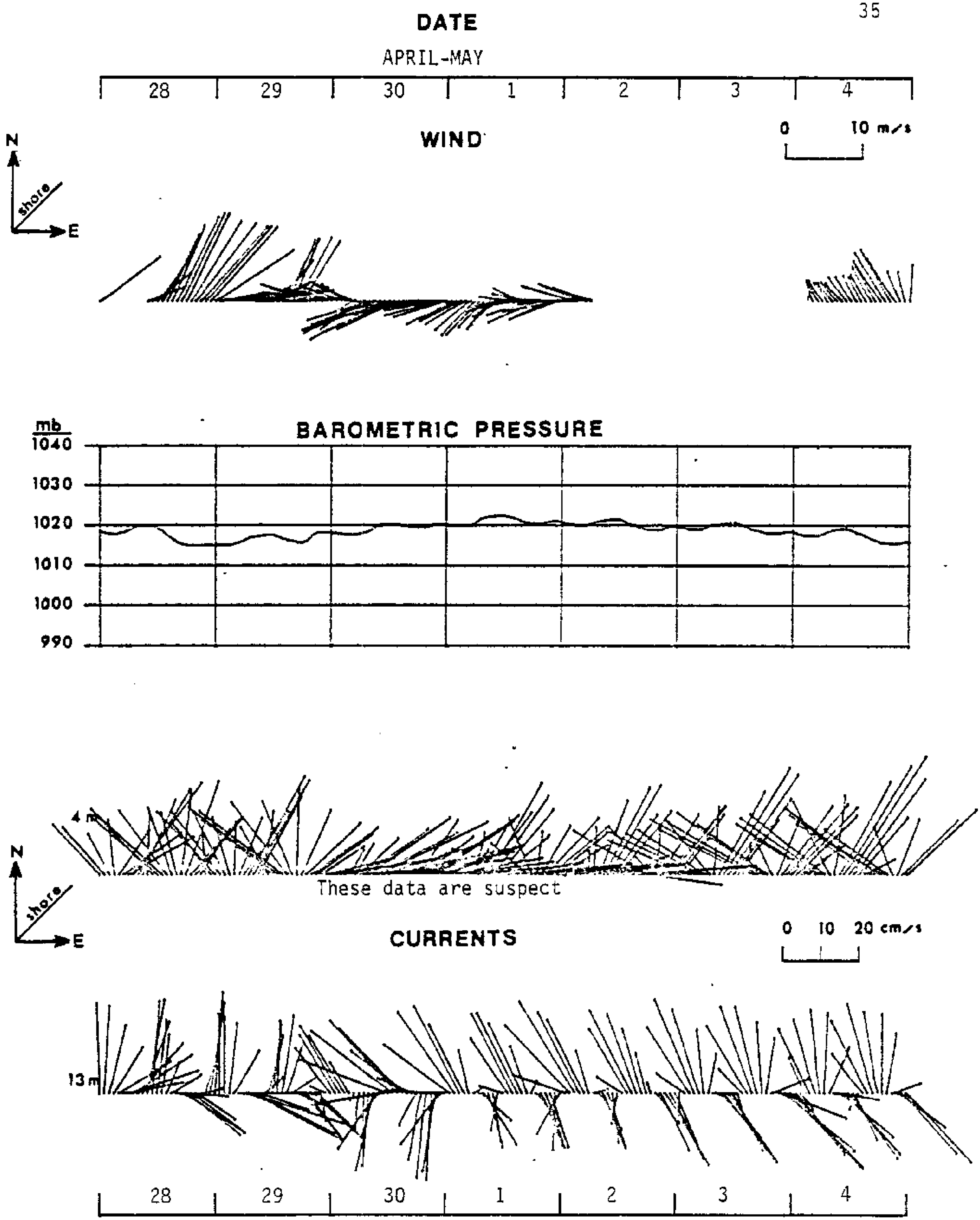

Figure 22. Wind, barometric pressure, and ocean currents from 28 April - 4 May 1977. Hourly values are plotted.

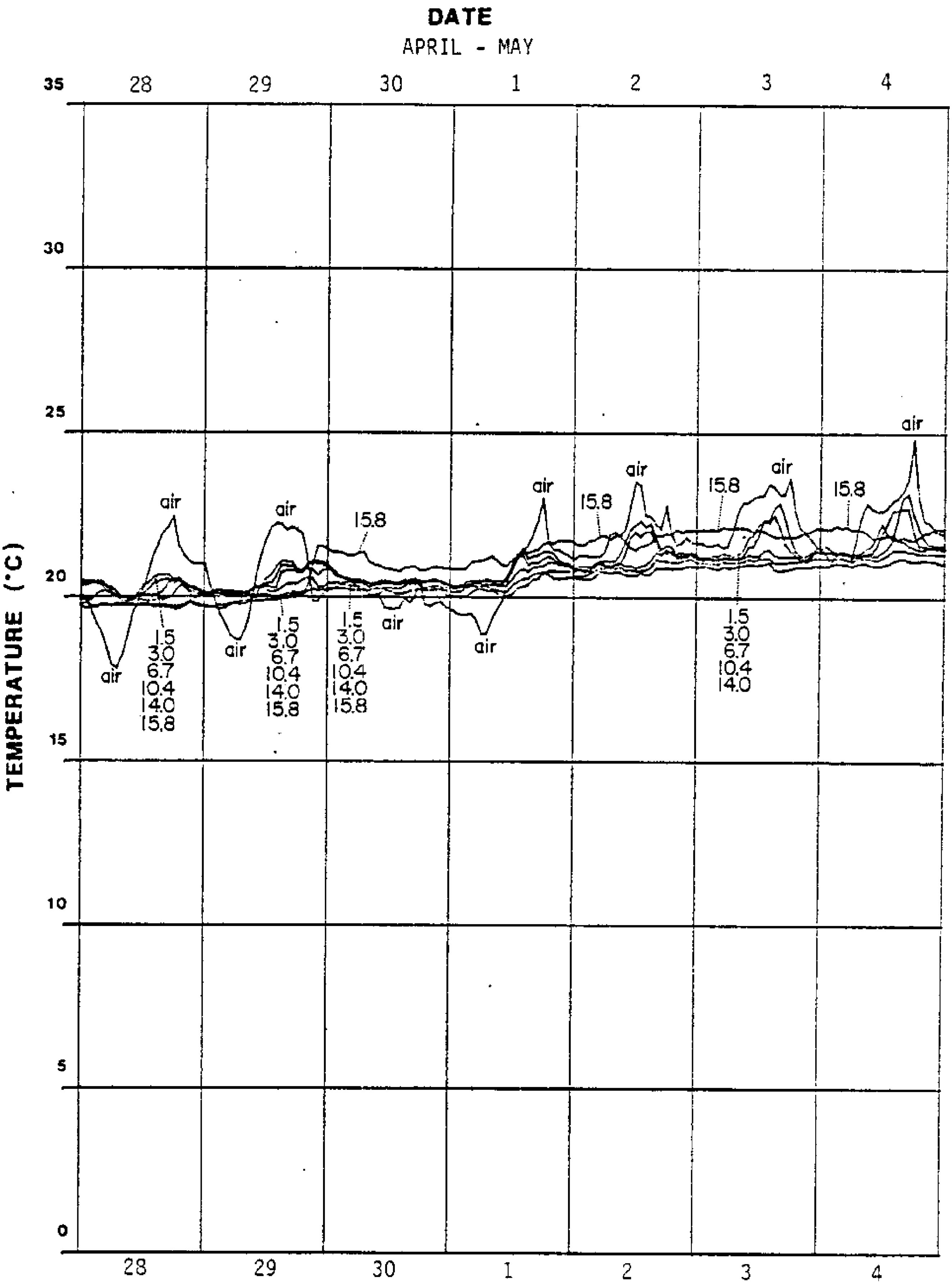

Figure 23. Air and ocean temperature from 28 April - 4 May 1977. Numbers identify depth in meters. Hourly values are plotted.

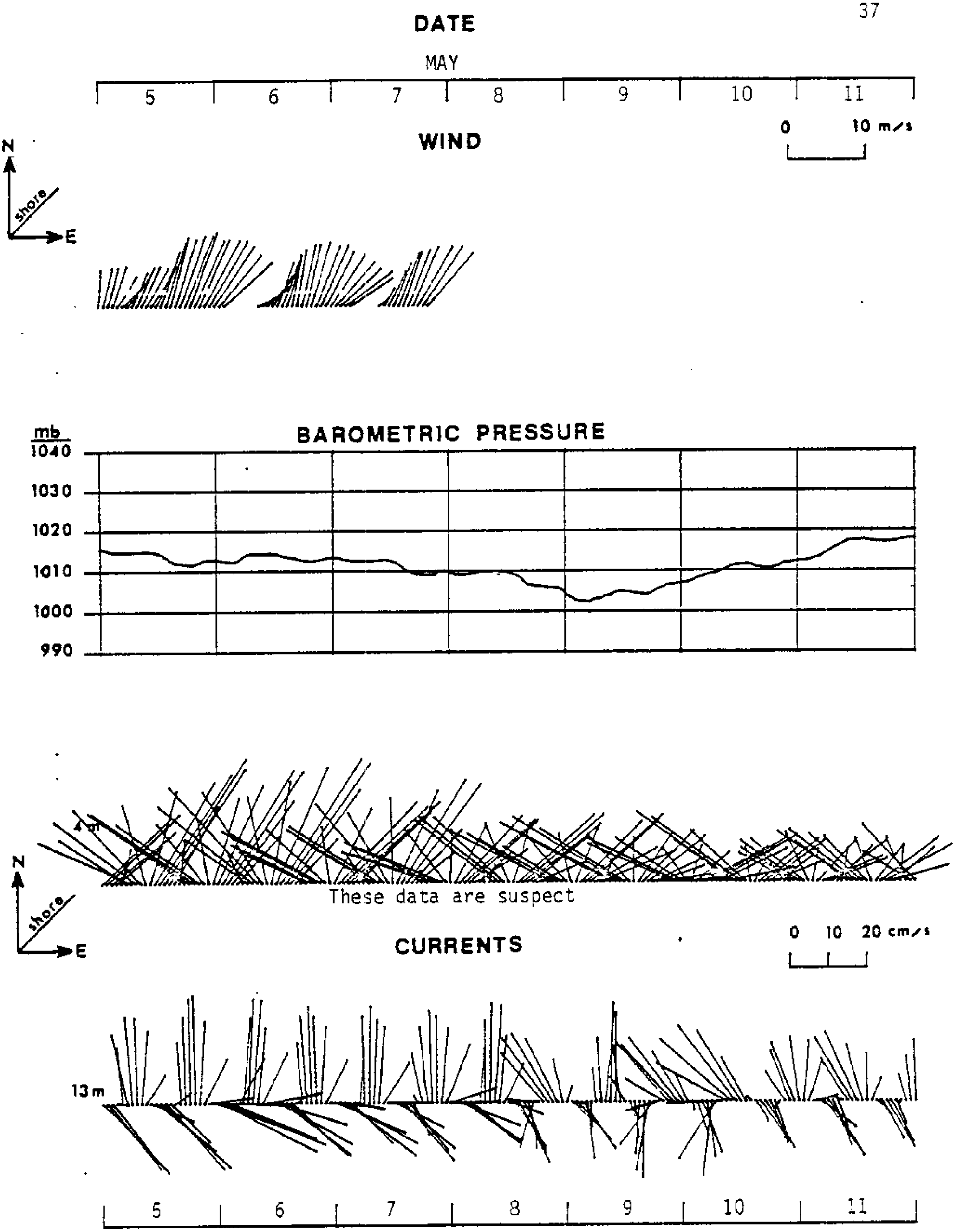

Figure 24. Wind, barometric pressure, and ocean currents from 5-11 May 1977. Hourly values are plotted.

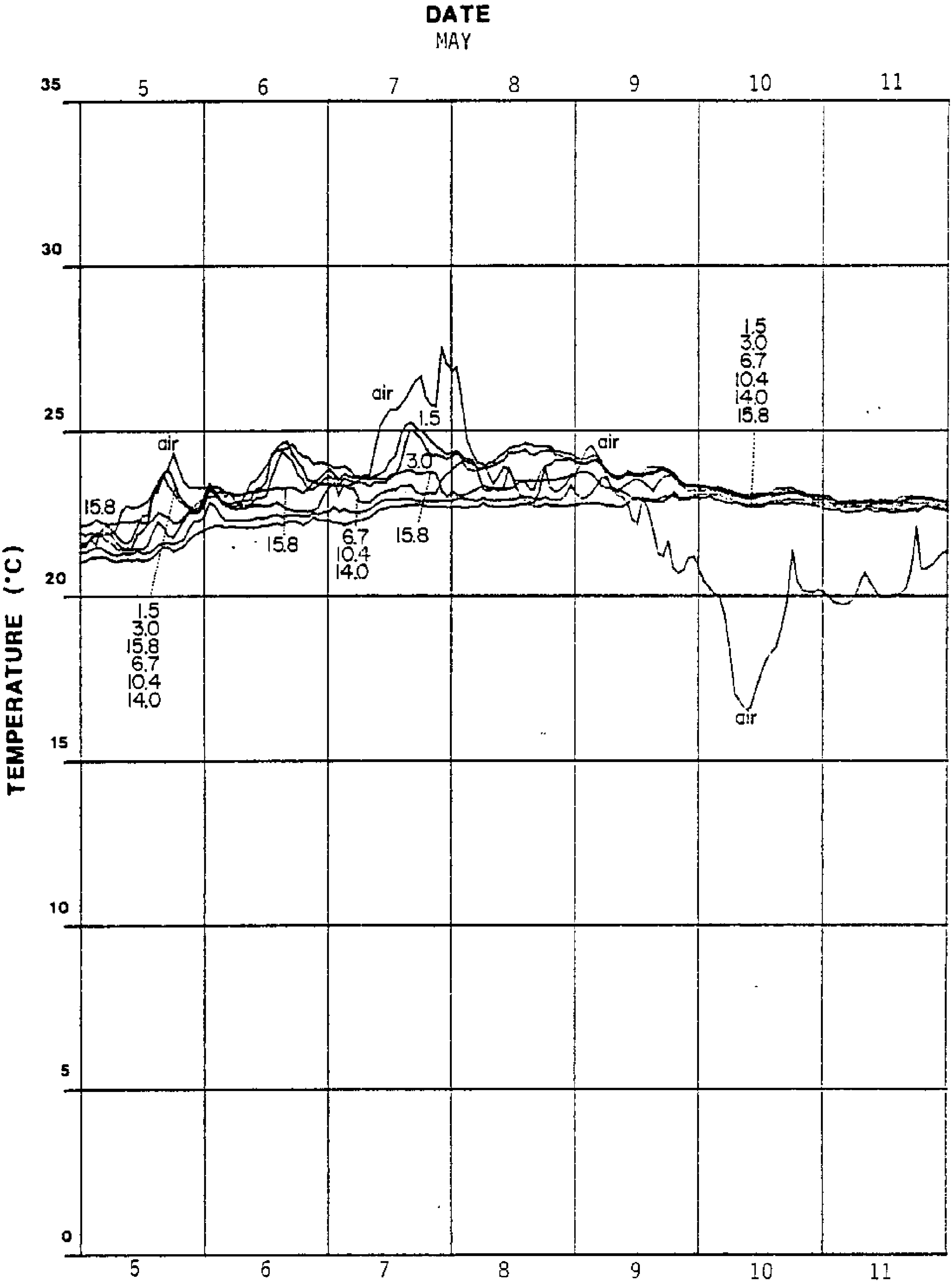

Figure 25. Air and ocean temperature from 5-11 May 1977. Numbers identify depth in meters. Hourly values are plotted.

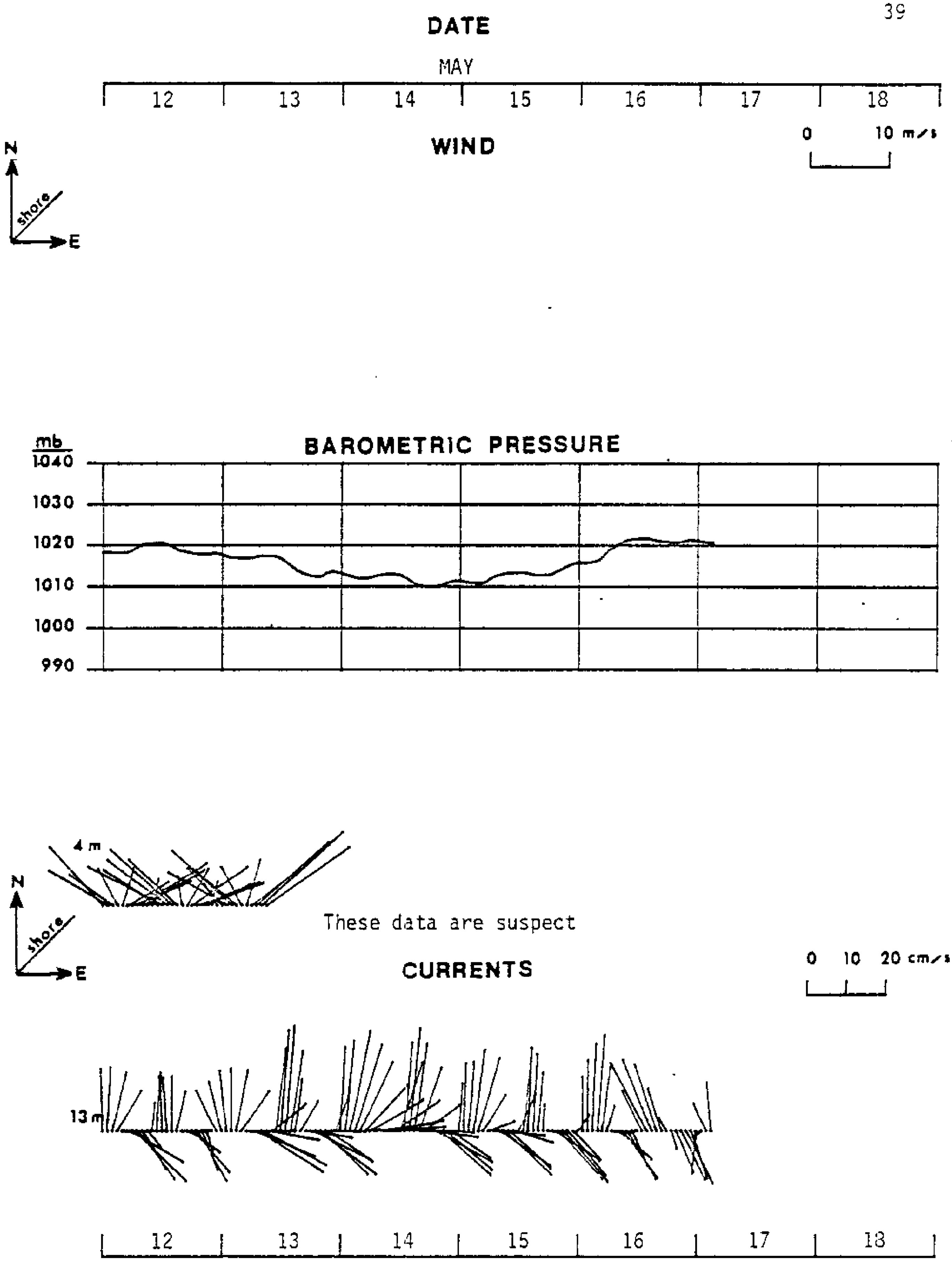

Figure 26. Barometric pressure and ocean currents from 12-18 May 1977. Hourly values are plotted.

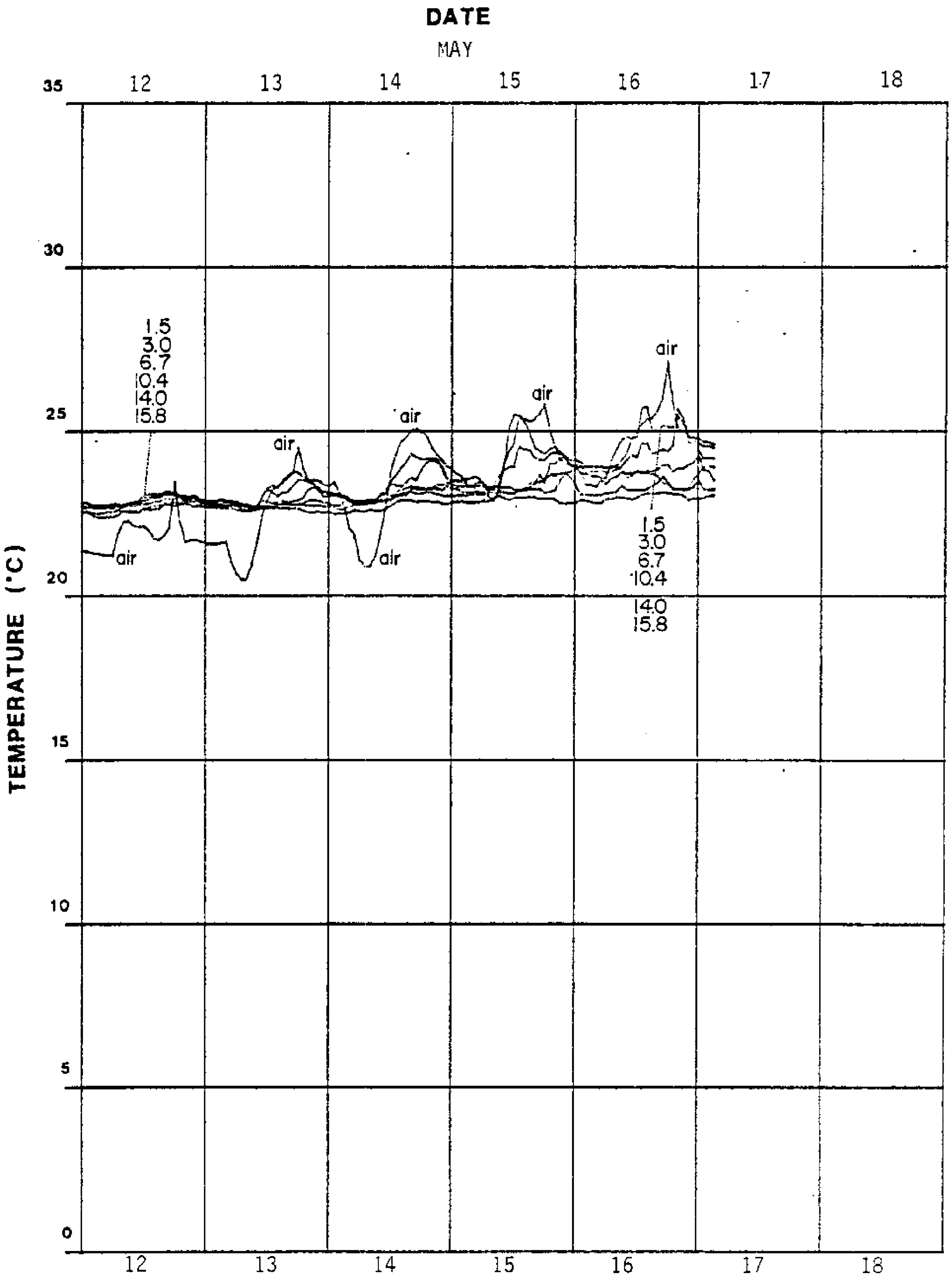

Figure 27. Air and ocean temperature from 12-18 May 1977. Numbers identify depth in meters. Hourly values are plotted.

THE DATA

Monthly Plots of 40-hour Low-pass Data

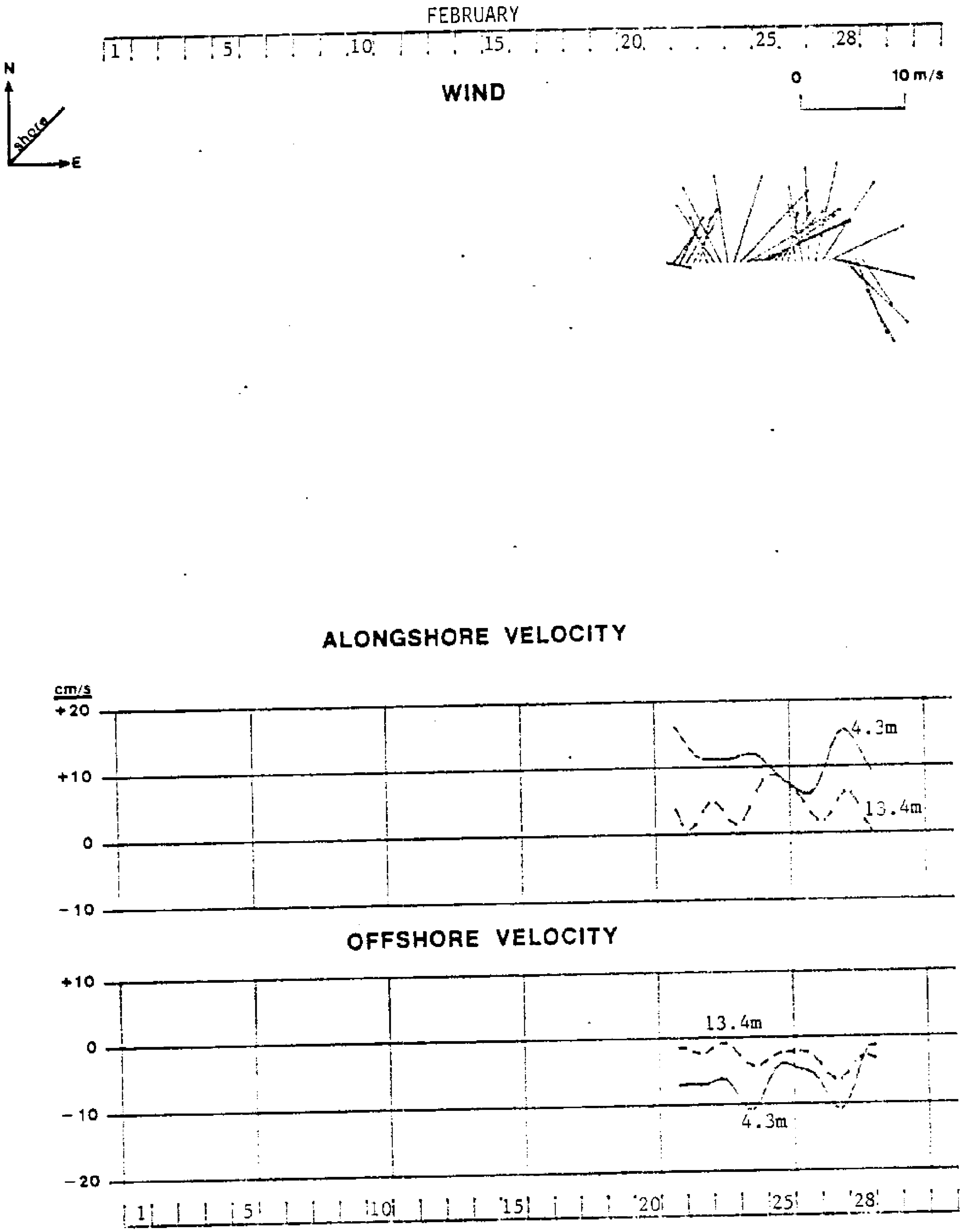

Figure 28. Wind and ocean currents for February 1977. Smoothed 6-hourly values are plotted. The accuracy of the 4.3 m velocity data is questionable.

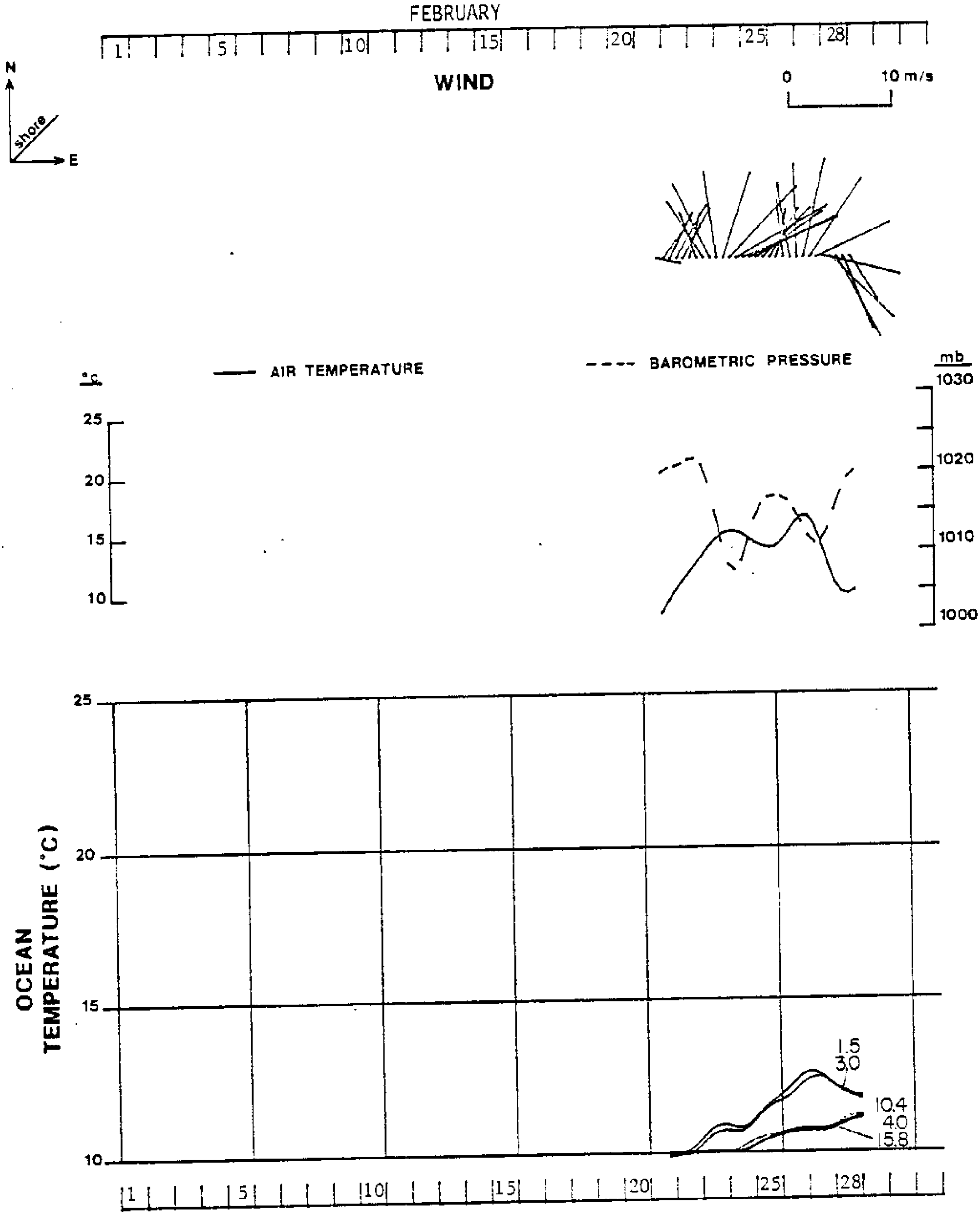

Figure 29. Wind, air temperature, barometric pressure, and ocean temperature for February 1977. Numbers identify depth in meters. Smoothed 6-hourly values are plotted.

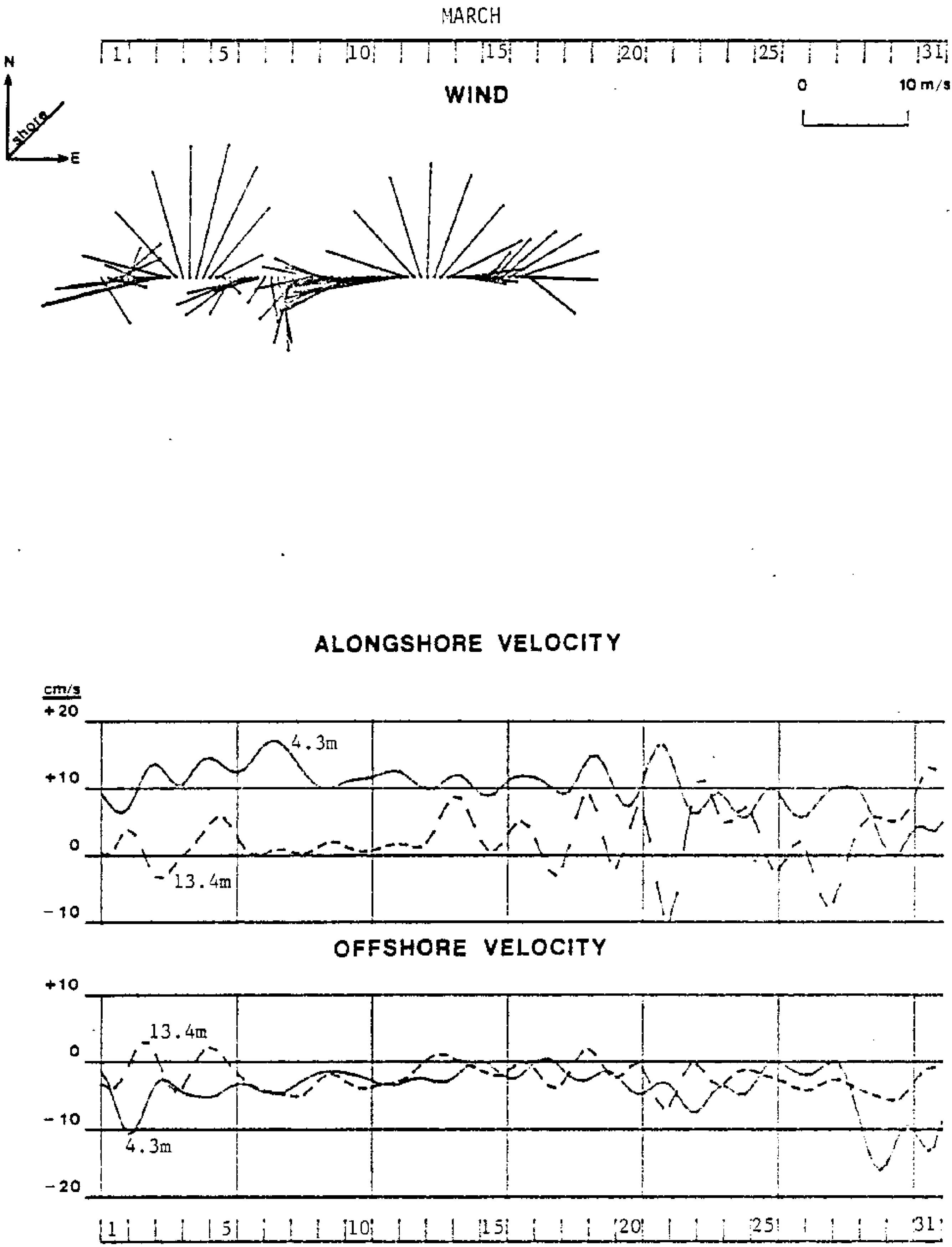

Figure 30. Wind and ocean currents for March 1977. Smoothed 6-hourly values are plotted. The accuracy of the 4.3 m velocity data is questionable.

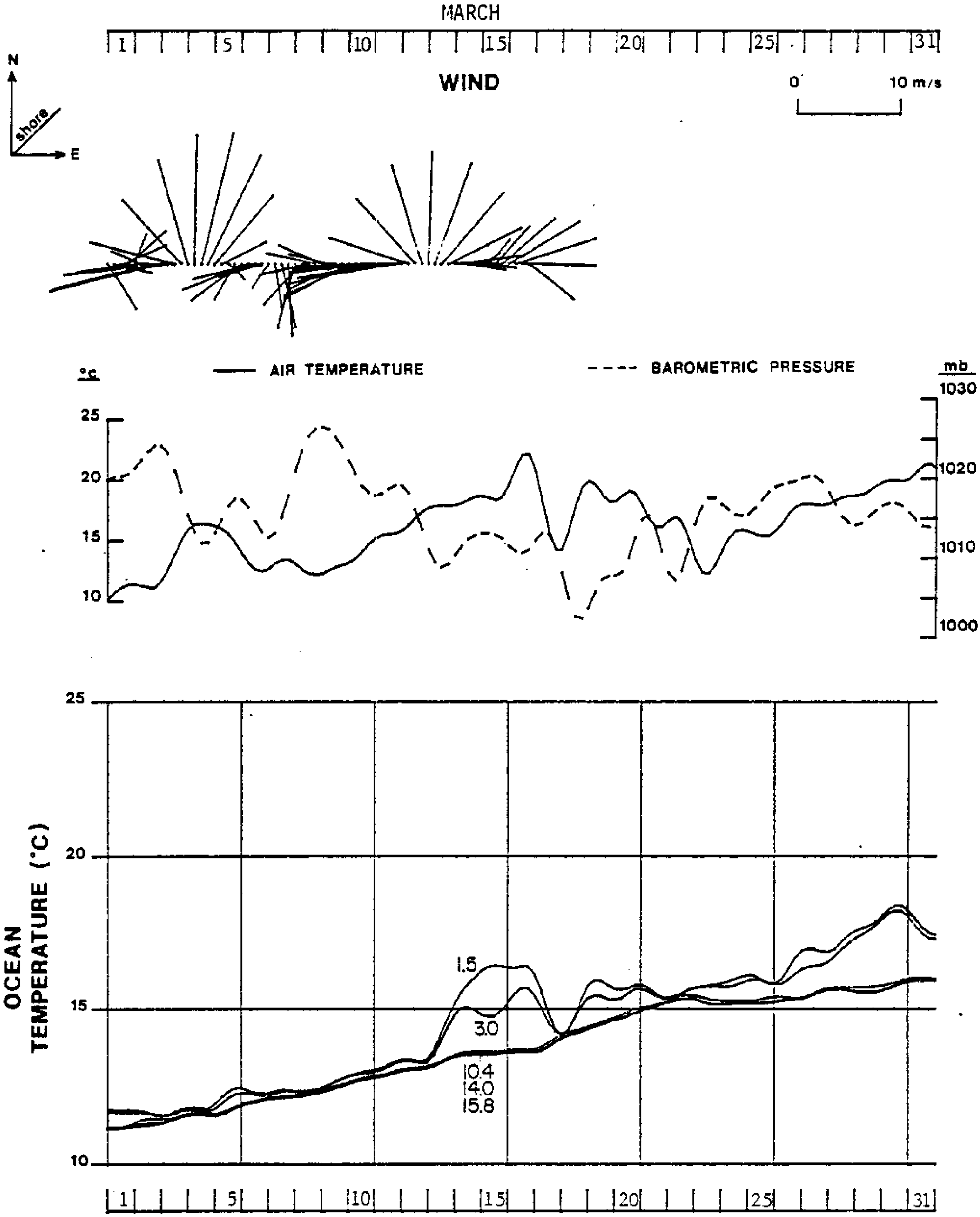

Figure 31. Wind, air temperature, barometric pressure, and ocean temperature for March 1977. Numbers identify depth in meters. Smoothed 6-hourly values are plotted.

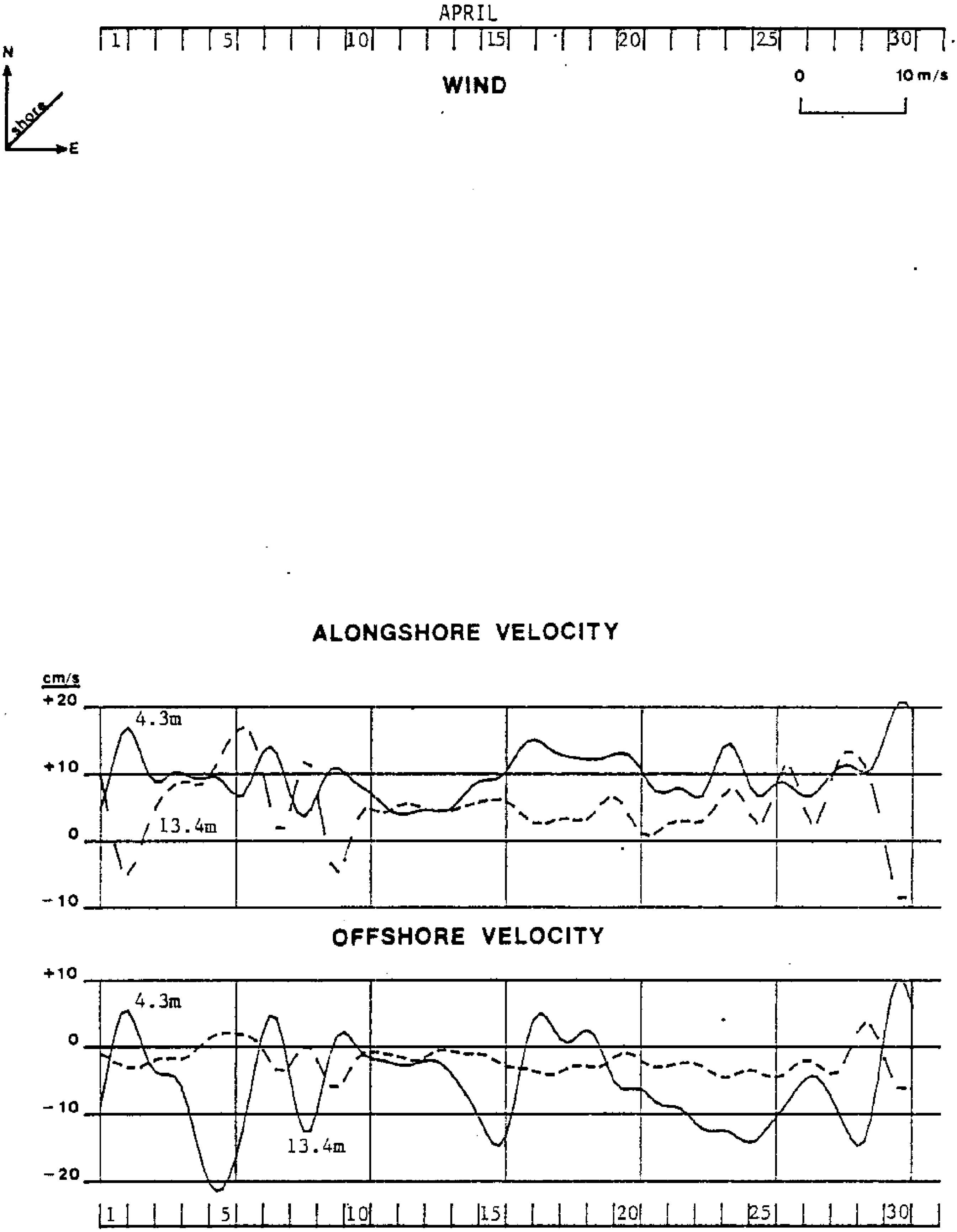

Figure 32. Ocean currents for April 1977. Smoothed 6-hourly values are plotted. The accuracy of the 4.3 m velocity data is questionable.

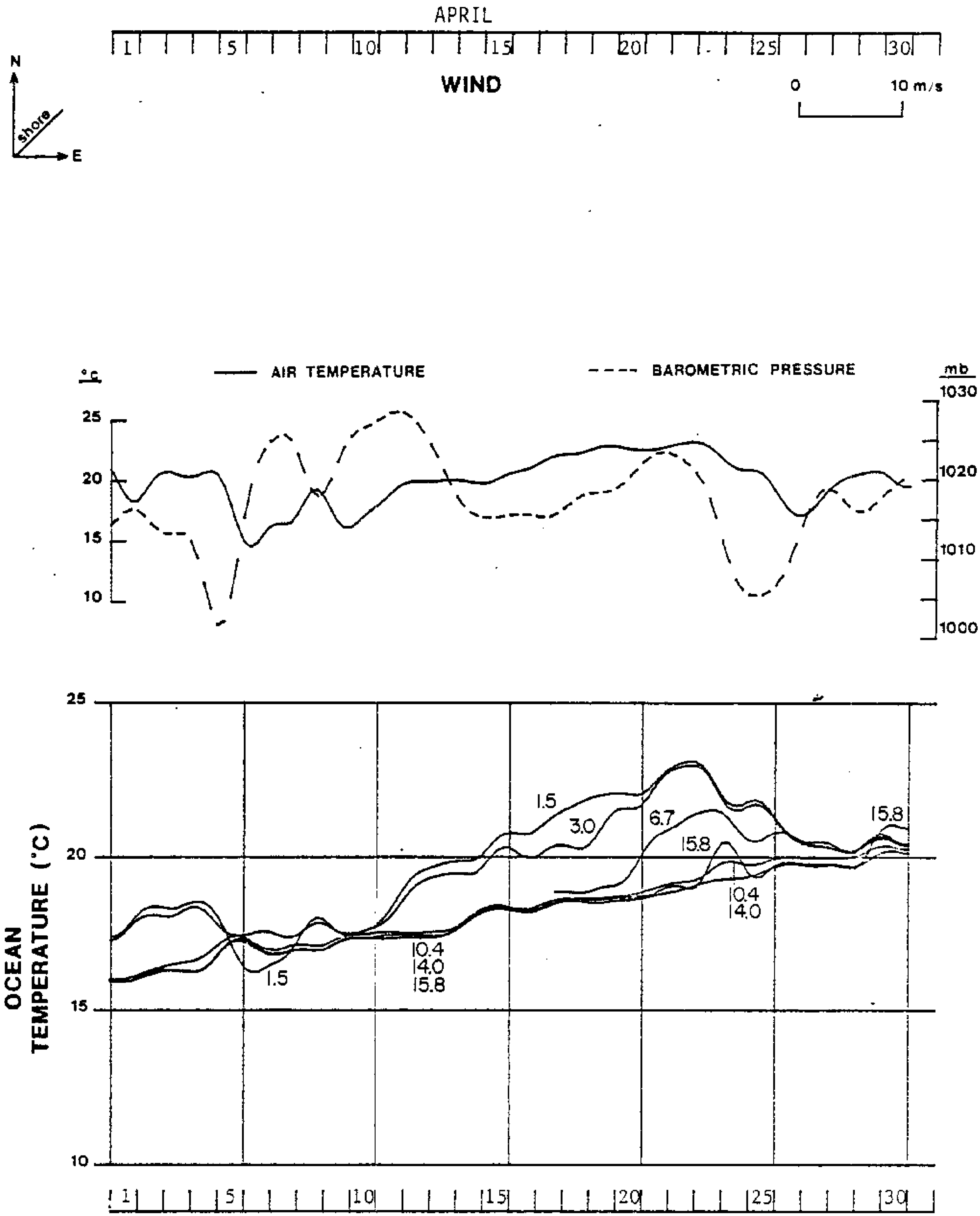

Figure 33. Air temperature, barometric pressure, and ocean temperature for April 1977. Numbers identify depth in meters. Smoothed 6-hourly values are plotted.

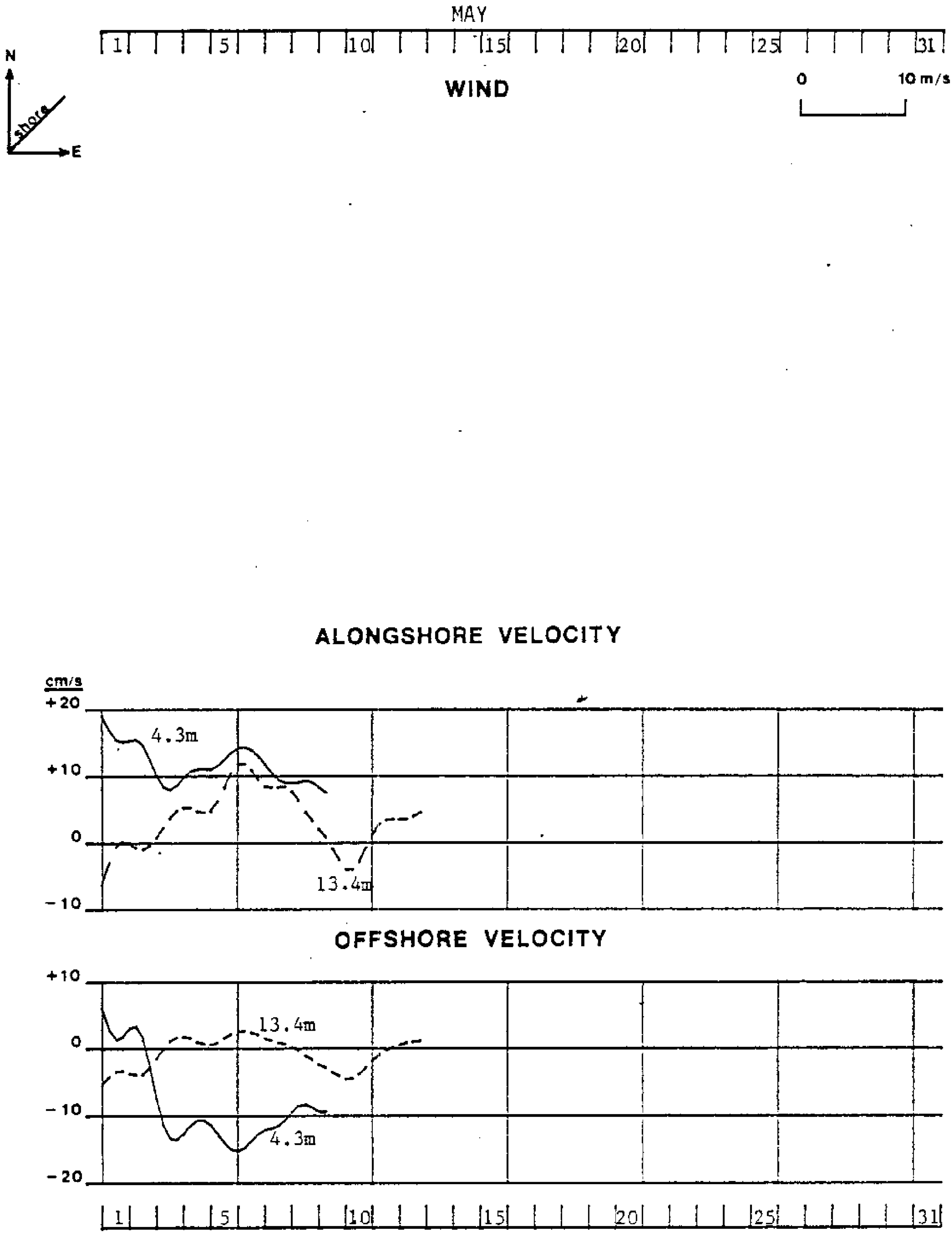

Figure 34. Ocean currents for May 1977. Smoothed 6-hourly values are plotted. The accuracy of the 4.3 m velocity data is questionable.

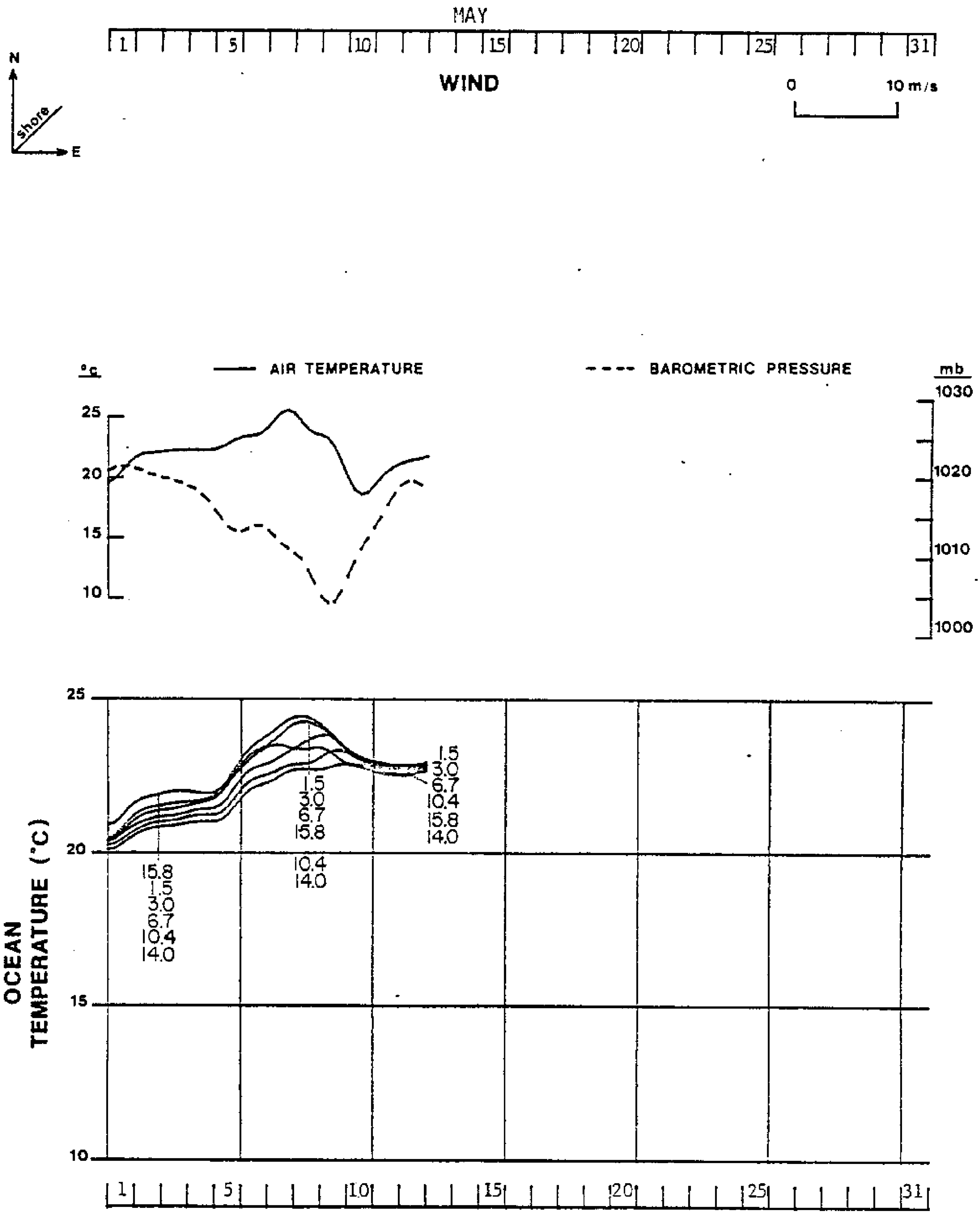

Figure 35. Air temperature, barometric pressure, and ocean temperature for May 1977. Numbers identify depth in meters. Smoothed 6-hourly values are plotted.