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James River seed oyster bed project : physical data report, I, 1984-1987

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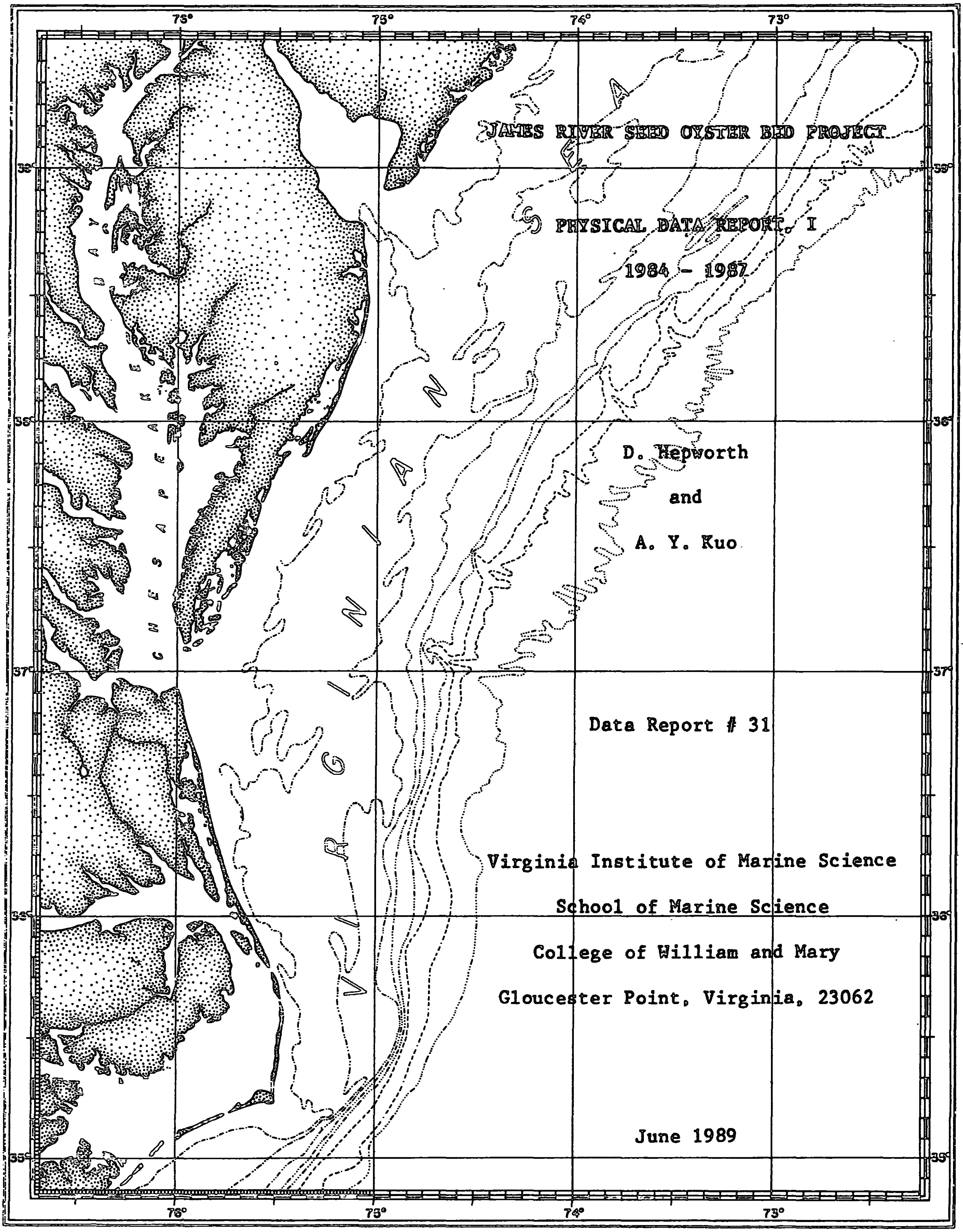

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PHYSICAL DATA REPORT, I

1984 - 1987

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and
A. Y. Kuo

Data Report # 31

Virginia Institute of Marine Science
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INTRODUCTION

The Virginia Institute of Marine Science initiated a study of the "James River Seed Oyster Beds" in July 1984. This was a multi-disciplinary program involving all aspects of marine science: physical, biological, geological, and chemical. The study of river circulation spanned the time period from 1984 to 1987.

Oysters spawn in the James River in summer and early fall. Their larvae stay suspended in the water column and drift with the currents for about 10 to 20 days at which time they attach to a hard surface for permanent residence. The paths of water mass movement during the planktonic stage is thus crucial for oyster recruitment. In fact the pioneer work of estuarine circulation was conducted in the James River (Pritchard, 1952) for the purpose of understanding oyster recruitment processes.

The objective of this circulation study was to delineate the transport pathways of oyster larvae between spawning and settling. Knowledge of larval transport pathways may in turn provide information that can aid in (a) the determination of the primary causes of the decline of oyster production and (b) the rehabilitation of the oyster industry once the causes for decline are determined. In order to attain this objective, it is imperative to understand the movement of water in the three spatial dimensions and be able to trace these movements through time. Tools with sufficient resolution are not available to resolve the problem with a single stroke. Accordingly, this study was pursued in terms of four projects, which, when integrated, would provide the estimate sought. The first project examined the movement of water masses in the horizontal plane. The second project addressed the variability of the gravitational circulation and water density (salinity) structure in the vertical plane. The third project studied smaller scale motion, such as estuarine fronts and vertical mixing, which were recognized as being potentially important to the concentration (or in some cases dispersion) of oyster larvae. The fourth project addressed the micro-circulation and the sedimentation processes occurring on one of the most important seed rocks, Wreck Shoal.

This data report describes the field measurements and provides graphical presentations of the data of the first two projects, which aimed at the gross scale, sub-tidal circulation. The numerical values of the data are archived and stored on magnetic tapes, which may be retrieved through the VIMS computer system. Some of the results synthesized from these data have been submitted for publication in professional literature.

I. CURRENT MEASUREMENTS

A. Equipment and Deployment

Currents were measured at several locations and at various depths in order to gather information on the three dimensional flow field. The different types of current meters used were the General Oceanic Model 6011, InterOcean Model S4, Endeco Model 105, and a modification of one made by Braincon. The specifics of each type of meter and where they were located are presented in Table 1. From 1984 through 1987, the general periods of successful deployment were:

1. October and November 1984

James River Bridge Area: A string of current meters was deployed in the channel upstream from the James River Bridge at Station B (Figure 1).

2. June and July 1985

(a) Fort Eustis Area: A station was located in the channel at Buoy J30 (designated as 'FE' in Figure 1), about 40 km from the mouth. The maximum depth at this location was about 10 m below mean low water, as can be seen in the cross sectional profile (Figure 2).

(b) James River Bridge Transect: These five stations were located on a transect across the river approximately 22 km upstream from the mouth (Figure 1). The maximum depth of about 10 m below mean low water was at Station B (Figure 3).

3. June through November 1985

James River Bridge Transect: A long term deployment at Station B was maintained for 6 months. This string of current meters was located in the channel portion of the transect.

4. June and July 1986

Burwell Bay Area: Current meters were deployed at a total of 6 stations on 2 transects (Figure 1). Instrument malfunctions, however, limited the usable data sets to only 5 stations. Maximum depths of about 8 m below mean low water were found in the dredged channel in both transects.

5. June and July 1987

Burwell Bay Area: In a deployment similar to the one in 1986, usable data was collected at 4 stations. Station locations were the same as in 1986.

B. Data Analysis

The currents observed in the James River are primarily along distinct ebb and flood axes. Because of irregular channel topography these axes can vary with location in the estuary, with depth at the same location, and are not necessarily opposing. The ebb and flood currents can be seen in the stickplots of observed velocities (Appendix A). These vectors (and all others reported in this study) were adjusted from magnetic north to true north by the annual local magnetic variation, which was about 9° west from 1984 through 1987. Currents were edited for wild points before further analysis.

In order to determine the major axis of flow, it is necessary to find the principal axis along which the longitudinal components are maximized. This axis was determined for each location as follows:

$$A = 0.5 \tan^{-1} \frac{(2\overline{NE})}{(\overline{N^2} - \overline{E^2})}$$

where A is the angle of principal axis relative to true north, N is the north-south component, E is the east-west component, and overbars indicate averaging over all data points. The data points were then split into two groups by a line perpendicular to the principal axis. Ebb and flood axes were determined by calculating the average vector direction for each group of data respectively. The angles of the principal, ebb, and flood axes are presented in Table 2. The relationships between these axes and the observed currents are evident in the scatterplots. Some examples of scatterplots are presented in Appendix B.

Current velocities were resolved into longitudinal and transverse components relative to the principal axis. These components are strongly influenced by the semidiurnal tides, which can be seen in the time series component plots (Appendices C and D). Since the transverse components of velocity are usually small, only a few samples are presented in Appendix D. Some of the current measurements showed relatively large transverse flows. These appear to have resulted from malfunctions and problems with some of the compasses in the InterOcean meters.

In order to study mean circulation it is necessary to remove the tidal variation from the data. One approach is to apply a low pass filter, which removes variations with frequencies higher than a specified cutoff value. The low pass filtered value for any data point can be generated by applying numerical weights to the sequences of observations extending from that point. With truncation of the sequence at a finite value, the low pass time series can be constructed from:

$$Y_i = \sum_{k=-N}^{N} w_k \, X_{i+k}$$

where Y_i is the low pass filtered value, N is the length of the sequence known as the span of the filter, w_k is the filter weight, and X_{i+k} are the observations. The low pass filter used for analysis was a modification of one designed by Godin (1972) with weights calculated as follows:

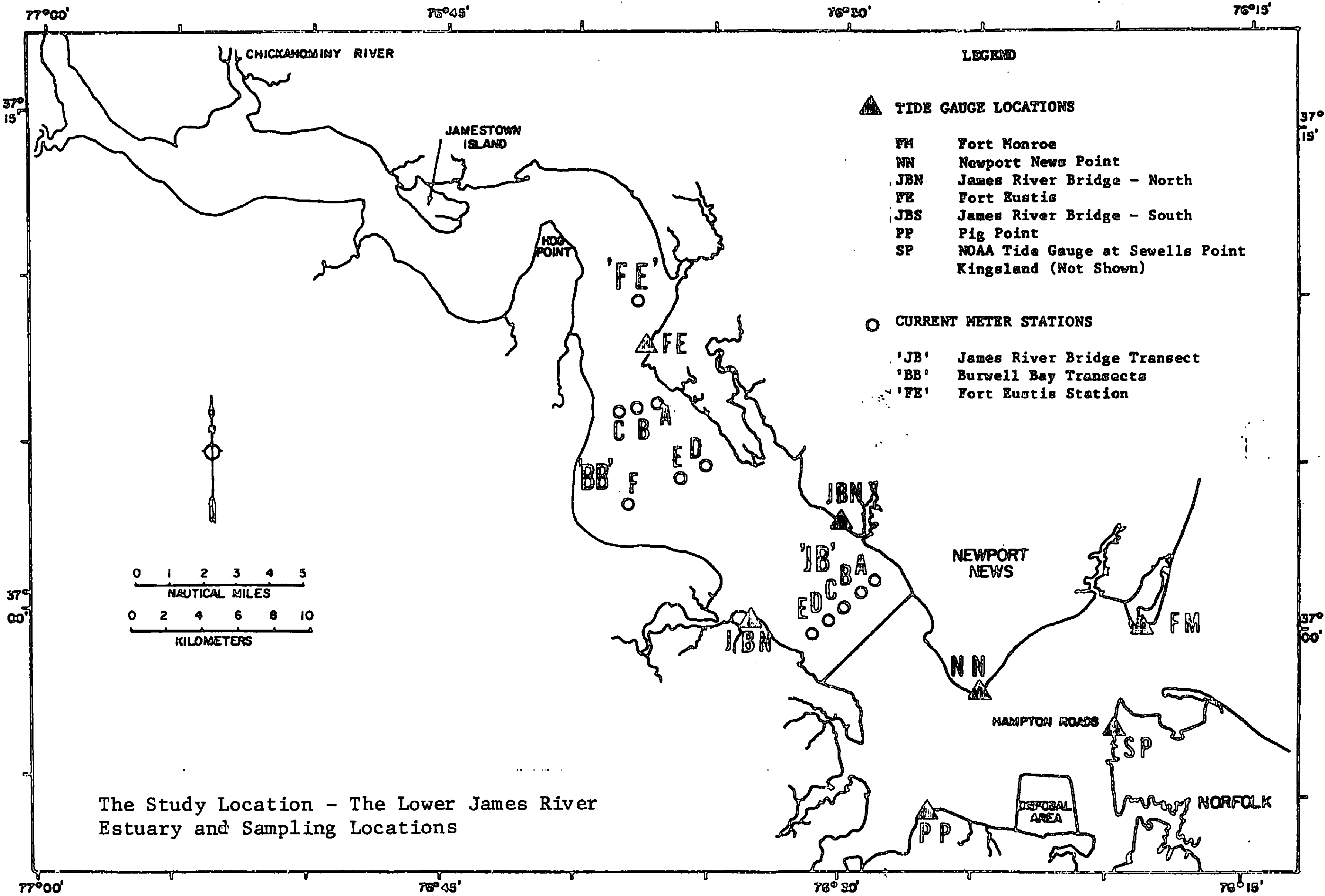
$$w_k = \frac{\sin\,(2\pi k\omega \cdot \Delta t)}{(2\pi k\omega \cdot \Delta t)} \cdot \frac{\sin\,(\frac{2\pi k}{2N+1})}{(\frac{2\pi k}{2N+1})}$$

for k = -N to N

where ω is the cutoff frequency, and Δt is the sampling interval. A sequence of filter weights with 2N+1 terms was generated and applied to the data. For this study, N was equal to the number of samples in 48 hours, and was 0.0278 h^{-1} or a cutoff period of 36 h.

In the lower part of the James River, the low pass filtered longitudinal components generally exhibited a seaward surface flow and landward bottom flow (Appendix E). Variations from this mean pattern were largely the result of meteorological forcing especially by wind and freshwater inputs. Some of these meteorologically driven changes in circulation were examined by Hepworth (1988). The filtered along-channel flows are greater than the transverse components, and only a few of the transverse component plots are presented in Appendix F. Exceptions are apparently due to compass problems. The observed and low pass filtered longitudinal components of flow in the channel near the James River Bridge are displayed for the whole period of deployment (June through November 1985) in Appendix G.

Figure 1.



The Study Location - The Lower James River Estuary and Sampling Locations

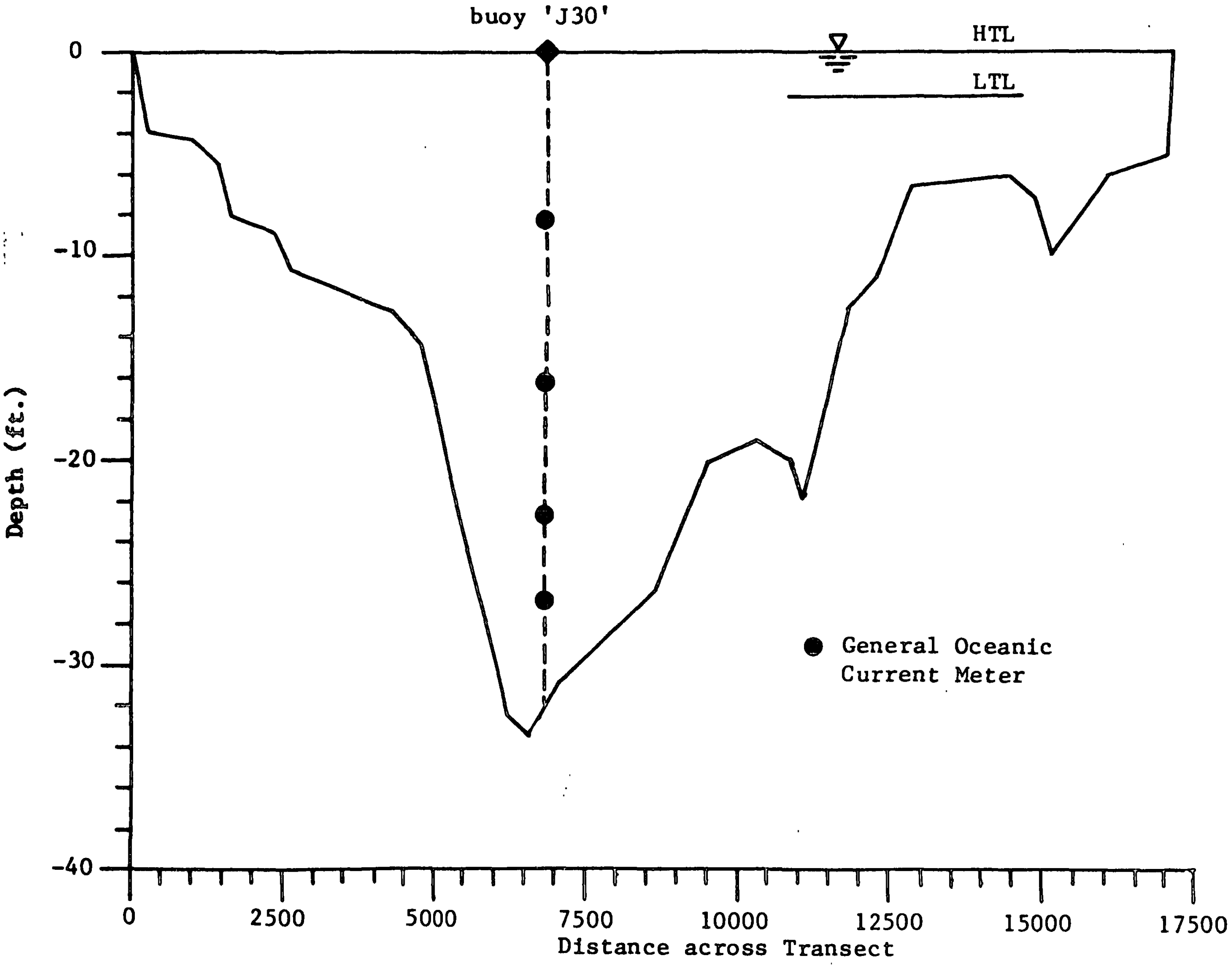


Figure 2. Cross-sectional profile (facing downstream) and current meter locations at Ft. Eustis transect.

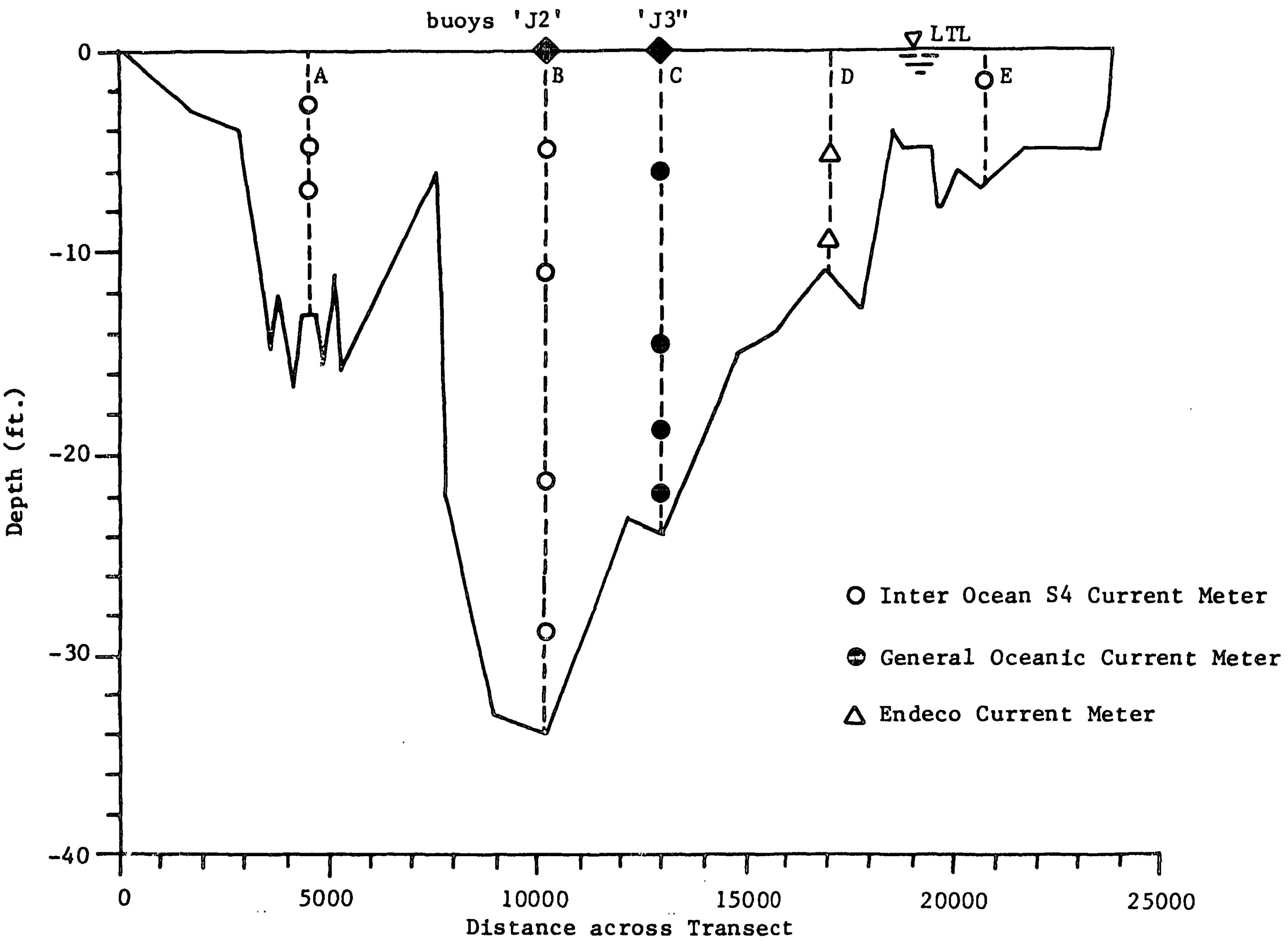


Figure 3. Cross-sectional profile (facing downstream) and current meter locations for transect near James River Bridge.

TABLE 1

TYPES AND LOCATIONS OF CURRENT METERS

General Oceanic	Inclinometer with data stored on magnetic tape.
InterOcean	Electromagnetic with solid state memory.
Endeco	Ducted axial propeller with data stored on film.
Braincon(modified)	Savonius rotor with film replaced by solid state memory.

LOCATION	STATION	DEPTH	INSTRUMENT TYPE	SAMPLES EVERY	USABLE DATA FROM - TO
			1984		
James River Bridge	B	2.4m	General Oceanic	15 min	10/20-11/15
		4.9	" "	"	10/25-11/22
		9.1	" "	"	10/19-11/17
			1985		
Fort Eustis	J30	1.8m	General Oceanic	30 min	5/26-6/24
		4.9	" "	"	6/ 1-7/ 1
		6.7	" "	"	"
		7.9	" "	"	"
James River Bridge	A	0.7m	InterOcean S4	30 min	7/ 2-7/30
		1.9	"	"	7/ 2-8/ 8
	B	1.2	"	"	6/ 1-11/27
		3.1	"	"	"
		6.3	"	"	"
		8.5	"	"	"
	C	1.5	General Oceanic	"	7/ 1-8/ 5
		4.3	" "	"	7/ 1-8/ 7
		5.6	" "	"	7/ 1-8/ 8
		6.6	" "	"	"
	D	1.2	Endeco	"	"
		2.4	"	"	"
	E	0.2	InterOcean S4	"	7/ 2-7/12
			1986		
Burwell Bay	A	1.5m	InterOcean S4	30 min	6/24-7/ 6
	B	3.0	Braincon	34.1 min	6/24-7/24
		5.5	"	"	"
	C	1.8	InterOcean S4	30 min	6/24-7/10
		7.6	"	"	6/24-7/12
	E	1.5	"	"	6/24-7/ 9
		3.4	Braincon	34.1 min	6/24-7/24
	F	1.5	InterOcean S4	30 min	6/24-7/10
			1987		
Burwell Bay	A	1.7m	Braincon	34.1 min	6/24-7/23
	B	1.8	InterOcean S4	30 min	6/24-7/27
		2.9	Braincon	34.1 min	"
		4.9	InterOcean S4	30 min	"
		6.9	"	"	"
	C	1.8	"	"	"
		3.5	Braincon	34.1 min	"
		5.4	"	"	"
	D	1.5	"	"	6/25-7/23

TABLE 2

PRINCIPAL AXES AND AVERAGE VELOCITY COMPONENTS

(a) 1984 CURRENT METER DATA

JAMES RIVER BRIDGE

LATE OCTOBER THROUGH LATE NOVEMBER

STATION/DEPTH/		AXES			AVERAGE		COMMENTS
START-END	DATES	PRINCIPAL	EBB	FLOOD	LONGITUDINAL	TRANSVERSE	
B 2.4m	10/20-11/15	97	100	275	6.2 cm/s		1,2
B 4.9m	10/25-11/22	108	105	290	-1.5		1,2
B 9.1	10/19-11/17	114	117	289	-8.9		1,2

COMMENTS

1 LONGITUDINAL COMPONENT ALONG PRINCIPAL AXIS IS WITH EBB POSITIVE

2 AVERAGE TRANSVERSE COMPONENTS WERE NOT CALCULATED BUT WERE OF ORDER OF 1 CM/S

TABLE 2 (cont'd.)

(b) 1985 CURRENT METER DATA

FORT EUSTIS

JUNE

STATION/DEPTH/ START-END	DATES	AXES PRINCIPAL	EBB	FLOOD	AVERAGE LONGITUDINAL	TRANSVERSE	COMMENTS
FE 1.8m	5/26-6/24	174	171	12	16.7 cm/s	3.1 cm/s	1,2
FE 4.9m	6/ 1-7/ 1	204	204	25	4.6	1.2	1,2
FE 6.7m	"	216	217	35	2.6	-0.1	1,2
FE 7.9m	"	204	201	28	0.8	1.5	1,2

JAMES RIVER BRIDGE TRANSECT

JULY THROUGH EARLY AUGUST

STATION/DEPTH/ START-END	DATES	AXES PRINCIPAL	EBB	FLOOD	AVERAGE LONGITUDINAL	TRANSVERSE	COMMENTS
A 0.7m	7/ 2-7/30	128	131	305	1.3 cm/s	-1.5 cm/s	1,2
A 1.9m	7/ 2-8/ 8	126	128	304	0.1	-0.9	1,2
B 1.2m	7/ 1-8/ 8	127	128	306	9.0	-0.3	1,2
B 3.1m	"	120	121	300	2.3	0.3	1,2
B 6.3m	"	105	106	284	-6.6	-0.9	1,2
B 8.5m	"	101	107	279	-7.4	-1.6	1,2
C 1.5m	7/ 1-8/ 5	112	105	307	11.7	7.0	1,2
C 4.3m	7/ 1-8/ 7	115	119	289	3.1	-3.1	1,2
C 5.6m	7/ 1-8/ 8	108	98	301	0.8	4.6	1,2
C 6.6m	"	111	104	299	-0.3	2.2	1,2
D 1.2m	"	109	112	284	5.1	-2.1	1,2
D 2.4m	"	111	114	287	1.5	-1.7	1,2
E 0.2m	7/ 2-7/12	126	129	302	0.3	-1.4	1,2

COMMENTS

1 LONGITUDINAL COMPONENT ALONG PRINCIPAL AXIS IS WITH EBB POSITIVE

2 TRANSVERSE COMPONENT POSITIVE BETWEEN NORTH AND PRINCIPAL AXIS (FOR THIS DATA, POSITIVE TOWARDS THE EAST)

TABLE 2 (cont'd.)

(b) 1985 CURRENT METER DATA (CONTINUED)

JAMES RIVER BRIDGE TRANSECT STATION B

STATION/DEPTH/		AXES			AVERAGE		COMMENTS
START-END	DATES	PRINCIPAL	EBB	FLOOD	LONGITUDINAL	TRANSVERSE	
JUNE							
B 1.2m	6/ 1-6/22	128	127	309	6.4 cm/s	0.2 cm/s	1,2
B 3.1m	6/ 1-7/ 1	121	123	300	0.1	-0.7	1,2
B 6.3m	6/ 1-6/12	106	111	284	-7.1	-1.8	1,2
B 8.5m	6/ 1-7/ 1	95	97	274	-5.5	0.1	1,2
JULY THROUGH EARLY AUGUST							
B 1.2m	7/ 1-8/ 8	127	128	306	9.0	-0.3	1,2
B 3.1m	"	120	121	300	2.3	0.3	1,2
B 6.3m	"	105	106	284	-6.6	-0.9	1,2
B 8.5m	"	101	107	279	-7.4	-1.6	1,2
EARLY AUGUST THROUGH EARLY SEPTEMBER							
B 1.2m	8/ 8-9/ 6	131	130	313	7.7 cm/s	-0.1 cm/s	1,2
B 3.1m	8/ 8-9/ 8	110	94	305	-0.6	9.0	1,2
B 6.3m	8/ 8-9/12	105	114	281	-8.0	-2.8	1,2
B 8.5m	8/ 8-8/25	97	91	279	-6.3	1.0	1,2
MID SEPTEMBER THROUGH MID OCTOBER							
B 1.2m	9/12-10/11	122	120	306	7.4 cm/s	1.8 cm/s	1,2
B 3.1m	"	109	86	312	0.5	11.8	1,2
B 6.3m	"	109	112	287	-6.4	-1.3	1,2
B 8.5m	"	94	75	283	-5.7	3.7	1,2
MID OCTOBER THROUGH MID NOVEMBER							
B 1.2m	10/12-11/10	119	116	308	13.3 cm/s	2.0 cm/s	1,2
B 3.1m	"	97	77	313	7.2	13.3	1,2
B 6.3m	"	109	111	287	-2.9	-1.2	1,2
B 8.5m	"	92	72	282	-4.4	4.0	1,2
MID THROUGH LATE NOVEMBER							
B 1.2m	11/11-11/27	124	120	313	8.9 cm/s	1.9 cm/s	1,2
B 3.1m	"	106	72	313	-2.1	17.7	1,2
B 6.3m	"	107	109	286	-9.2	-0.5	1,2
B 8.5m	"	100	65	286	-8.6	4.0	1,2

COMMENTS

1 LONGITUDINAL COMPONENT ALONG PRINCIPAL AXIS IS WITH EBB POSITIVE

2 TRANSVERSE COMPONENT POSITIVE BETWEEN NORTH AND PRINCIPAL AXIS (FOR THIS DATA, POSITIVE TOWARDS THE EAST)

TABLE 2 (cont'd.)

(c) 1986 CURRENT METER DATA

BURWELL BAY

LATE JUNE THROUGH LATE JULY

STATION/DEPTH/ START-END	DATES	AXES PRINCIPAL	EBB	FLOOD	AVERAGE LONGITUDINAL	TRANSVERSE	COMMENTS
A 1.5m	6/24-7/ 6	132	127	318	-0.6 cm/s	2.7 cm/s	1,2
B 3.0	6/24-7/24	139	135	321	-2.7	1.4	3
B 5.5	"	137	135	318	-8.3	0.2	3
C 1.8	6/24-7/10	172	176	345	5.3	-2.8	
C 7.6	6/24-7/12	163	164	342	-4.0	-0.9	
E 1.5	6/24-7/ 9	143	141	326	2.8	1.1	
E 3.4	6/24-7/24	140	138	321	2.7	0.0	3
F 1.5	6/24-7/10	138	139	315	4.2	-0.8	

COMMENTS

1 LONGITUDINAL COMPONENT ALONG PRINCIPAL AXIS WITH EBB POSITIVE

2 TRANSVERSE COMPONENT POSITIVE BETWEEN NORTH AND PRINCIPAL AXIS (FOR THIS DATA, POSITIVE TOWARDS THE EAST)

3 DATA AT 2048 SECOND INTERVAL (AS OPPOSED TO 30 MINUTES)

TABLE 2 (cont'd.)

(d) 1987 CURRENT METER DATA

BURWELL BAY

LATE JUNE THROUGH LATE JULY

STATION/DEPTH/		AXES			AVERAGE		COMMENTS
START-END	DATES	PRINCIPAL	EBB	FLOOD	LONGITUDINAL	TRANSVERSE	
A 1.7m	6/24-7/23	134	138	310	-0.6 cm/s	-1.6 cm/s	1,2,3
B 1.8	6/24-7/27	146	144	330	3.4	1.6	4,5
B 2.9	"	142	138	326	-1.2	2.6	3
B 4.9	"	147	145	328	-10.0	0.8	
B 6.9	"	148	172	323	-11.1	-4.8	
C 1.8	"	162	160	347	6.7	0.9	4
C 3.5	"	160	166	332	3.5	-3.6	3
C 5.4	"	168	171	345	-0.4	-2.0	3
D 1.5	6/25-7/23	132	131	315	6.1	0.7	3

COMMENTS

1 LONGITUDINAL COMPONENT ALONG PRINCIPAL AXIS WITH EBB POSITIVE

2 TRANSVERSE COMPONENT POSITIVE BETWEEN NORTH AND PRINCIPAL AXIS (FOR THIS DATA, POSITIVE TOWARDS THE EAST)

3 DATA AT 2048 SECOND INTERVAL (AS OPPOSED TO 30 MINUTES)

4 DATA QUALITY WAS POOR, FILE WAS CONSIDERABLY EDITED

5 DUE TO POOR DATA, COMPONENTS NOT LOW PASS FILTERED

II. SURFACE ELEVATION MEASUREMENTS

A. Equipment and Deployment

Surface elevation was measured at several locations in the lower James River (Figure 1). The tide gauges used were the Fischer & Porter Model 35C, which records water level at 6-min intervals on a paper tape. These gauges were mounted along the shoreline near Fort Monroe, Newport News Point, the James River Bridge (upriver on both shores), Fort Eustis, and Pig Point. Another gauge was located much further upriver at Kingsland near Richmond. Owning to a variety of circumstances, the records at some stations are not continuous (Table 3).

B. Data Analysis

All gauges were surveyed at the time of installation so elevations could be related to the National Geodetic Vertical Datum (NGVD), which lies relatively close to Mean Sea Level (MSL) in the lower James River. Surface elevation measurements on the hour were determined by computing the five point average for the 6-min readings centered on that hour. In addition to the observed surface elevations, a low pass filter with the same characteristics as the one applied to current measurements was used to examine the mean or nontidal surface elevations. The observed and low pass filtered surface elevations at sites with useable data are found in Appendix H.

TABLE 3

AVAILABLE SURFACE ELEVATION DATA

(a) 1984

LOCATION	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
FORT EUSTIS 19 OCTOBER - 2 DECEMBER										XXXXXXX		

TABLE 3 (cont'd.)

AVAILABLE SURFACE ELEVATION DATA

(b) 1985

LOCATION	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
FORT MONROE					X	X	X	X	X	X	X	X
8 MAY - 23 SEPTEMBER												
10 OCTOBER - 18 OCTOBER												
20 OCTOBER - 31 DECEMBER												
NEWPORT NEWS POINT										X	X	X
8 OCTOBER - 4 NOVEMBER												
8 NOVEMBER - 19 NOVEMBER												
20 NOVEMBER - 24 DECEMBER												
JAMES RIVER BRIDGE (NORTH)					X		X	X	X	X	X	X
22 MAY - 31 MAY												
5 JULY - 19 NOVEMBER												
20 NOVEMBER - 17 DECEMBER												
JAMES RIVER BRIDGE (SOUTH)						X	X	X	X	X	X	X
11 JUNE - 2 AUGUST												
28 AUGUST - 18 OCTOBER												
5 NOVEMBER - 17 DECEMBER												
FORT EUSTIS					X	X	X	X	X			
2 MAY - 25 MAY												
28 MAY - 1 SEPTEMBER												
4 SEPTEMBER - 24 SEPTEMBER												
PIG POINT												X X
4 DECEMBER - 13 DECEMBER												
18 DECEMBER - 31 DECEMBER												
KINGSLAND					X	X	X	X				
7 MAY - 30 JUNE												
3 JULY - 17 AUGUST												
17 AUGUST - 20 AUGUST												

TABLE 3 (cont'd.)

AVAILABLE SURFACE ELEVATION DATA

(c) 1986

```
LOCATION                    JAN FEB MAR APR MAY JUN JUL AUG SEP OCT NOV DEC

FORT MONROE                 XXXXXXXXXXXXXXXXXXXXXXXXXXXXXX  |   |   |   |
 1 JANUARY - 14 AUGUST      |   |   |   |   |   |   |   |   |   |   |   |

FORT EUSTIS                 |   |   |   |   |   | XXXXXX|   |   |   |   |
19 JUNE - 31 JULY           |   |   |   |   |   |   |   |   |   |   |   |

PIG POINT                   X XXXX  |   |  XXXXXXXXXXX  |   |   |   |   |
 1 JANUARY -  7 JANUARY     |   |   |   |   |   |   |   |   |   |   |   |
21 JANUARY - 16 FEBRUARY    |   |   |   |   |   |   |   |   |   |   |   |
23 APRIL - 20 JUNE          |   |   |   |   |   |   |   |   |   |   |   |
20 JUNE - 10 JULY           |   |   |   |   |   |   |   |   |   |   |   |
```

III. SALINITY MEASUREMENTS

A. Time Series Measurements

In addition to recording currents, the InterOcean S4 instruments also measured conductivity and temperature. These two parameters were converted to salinity in parts per thousand (ppt) using the Practical Salinity Scale 1978 (UNESCO, 1981). The locations and durations of useable data are presented in Table 4. One feature in the salinity records is the variation resulting from the semidiurnal tidal currents (Appendix I). These higher frequency fluctuations were superimposed on longer period changes, which were largely the result of variations in freshwater inputs and the influence of meteorological events. These longer term variations are revealed in the low pass filtered data (Appendix J). A long term record of salinities during summer and fall 1985 is found in Appendix K.

B. Slackwater Surveys

The synoptic gross scale distributions of salinity were obtained through a series of slackwater surveys. These surveys were part of a river-monitoring program jointly sponsored by the Virginia Institute of Marine Science and the State Water Control Board. From 1984 to 1986, the surveys were conducted monthly from March or April to November of each year. Each survey was conducted at a slackwater phase of the tide, slack before flood (SBF) or slack before ebb (SBE), as it propagated upstream from the estuary mouth. Temperature and conductivity were measured, or samples taken, at designated stations along the river. Station locations are shown in Figure 4. In this figure station designation (i.e., 0.00, 17.30, etc.) refers to the distance from the river mouth in kilometers.

In the 1986 surveys, temperature and conductivity were measured with an Applied Micro Systems CTD (Conductivity-Temperature-Depth Probe). Vertical profiles for these variables were recorded every meter from surface to bottom at each designated station. The readings were recorded automatically with a portable personal computer. Prior to 1986, measurements were made with an InterOcean Model 513 CTD. At each station the data were recorded manually every two meters from surface to bottom. Occasionally, water samples were collected for conductivity determination in the laboratory.

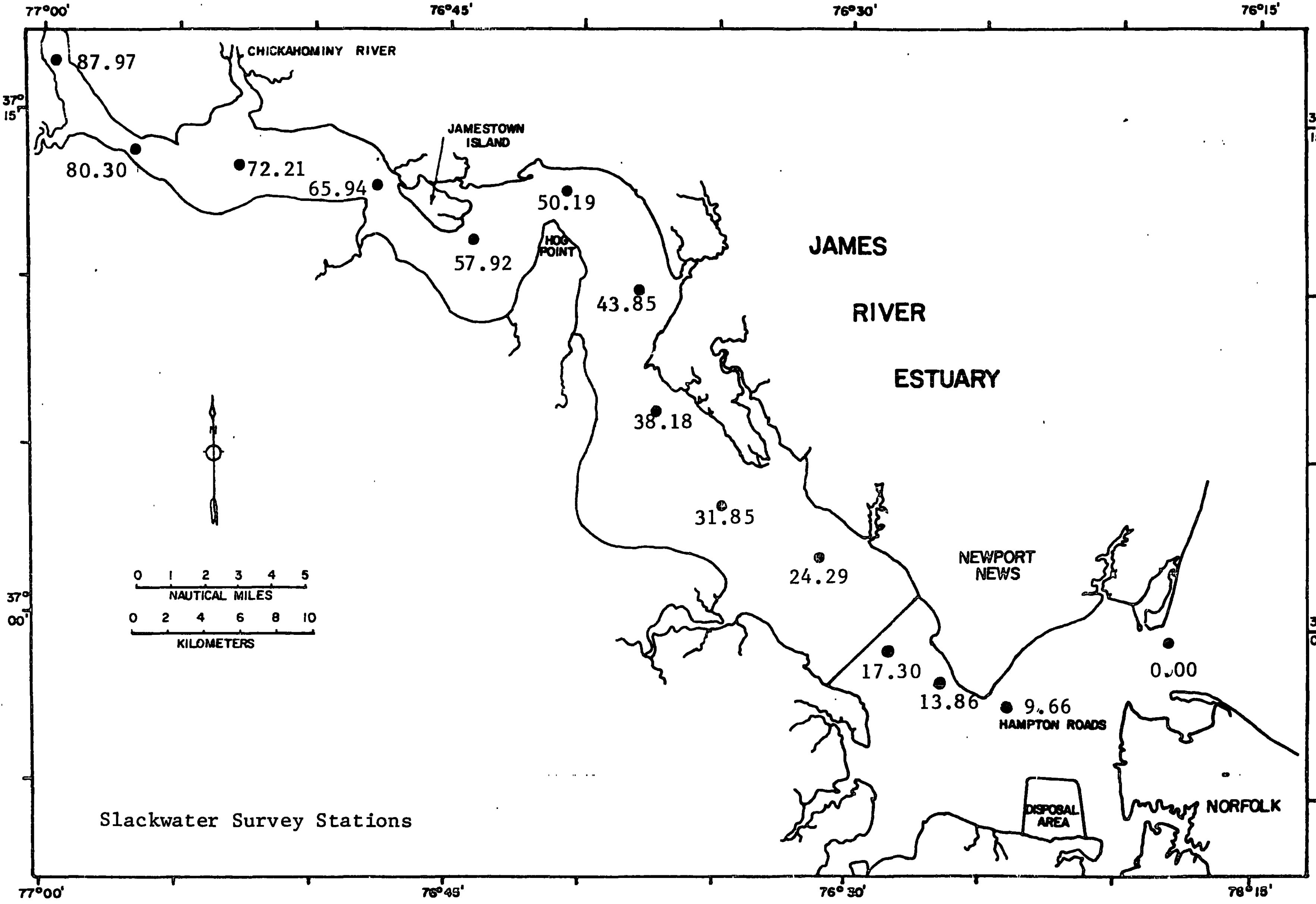
Conductivity measurements were converted to salinity employing the Practical Salinity Scale. The salinity distribution for each survey is displayed as isohaline contours in the vertical-longitudinal plane. These contour plots are presented in Appendix L.

TABLE 4

AVAILABLE SALINITY DATA

LOCATION	STATION	DEPTH	STARTING AND ENDING DATES
(a) James River Bridge 1985	A	0.7m	7/ 2-7/30
		1.9	7/ 2-8/ 8
	B	1.2	7/ 1-11/27
		3.1	"
		6.3	"
	E	0.2	7/ 2-7/12
(b) Burwell Bay 1986	A	1.5m	6/24-7/ 6
	C	1.8	6/24-7/10
		7.6	6/24-7/12
	E	1.5	6/24-7/ 9
	F	1.5	6/24-7/10
(c) Burwell Bay 1987	B	1.8m	6/24-7/27
		4.9	"
	C	1.8	"

Figure 4



Slackwater Survey Stations

REFERENCES

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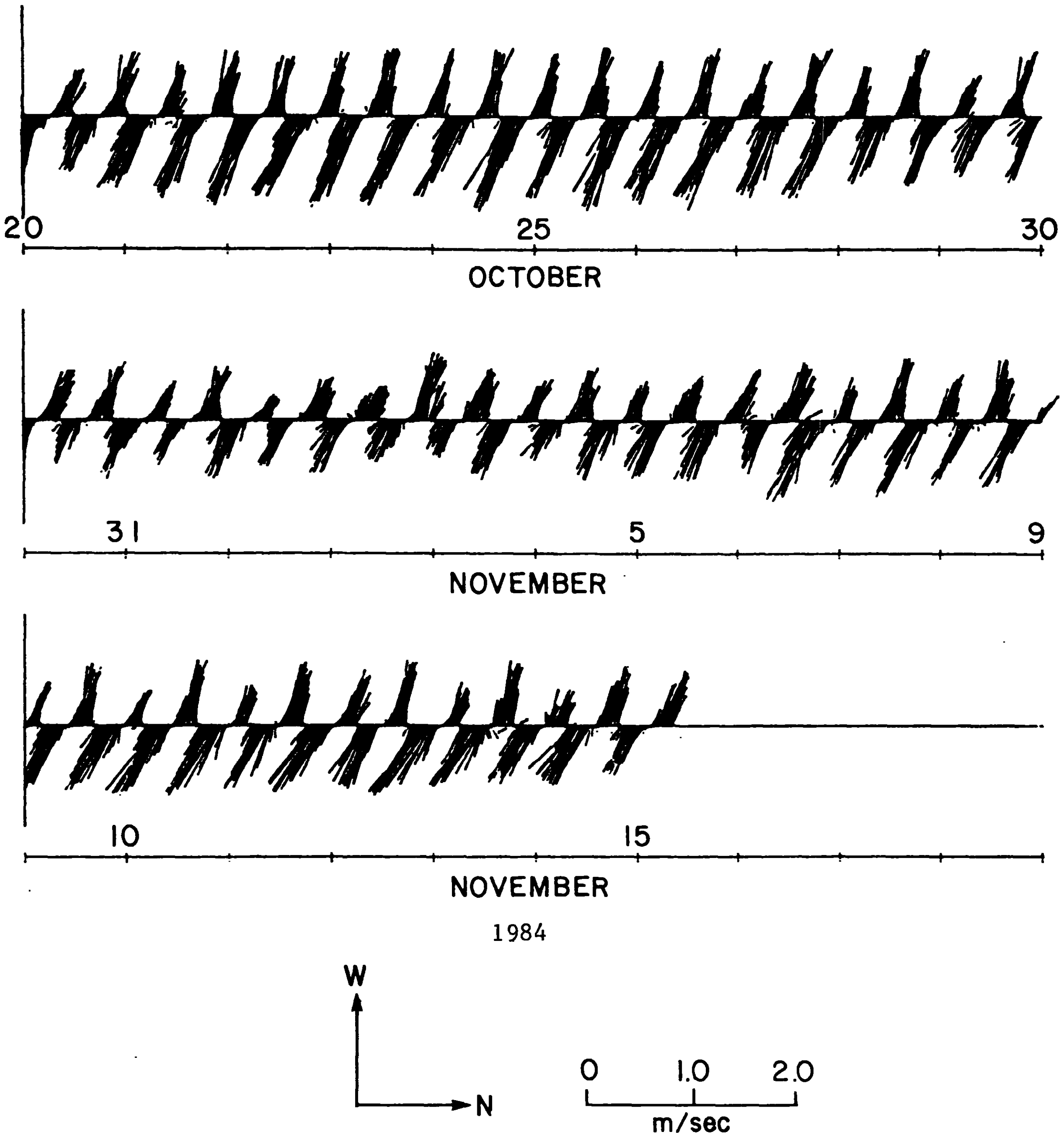
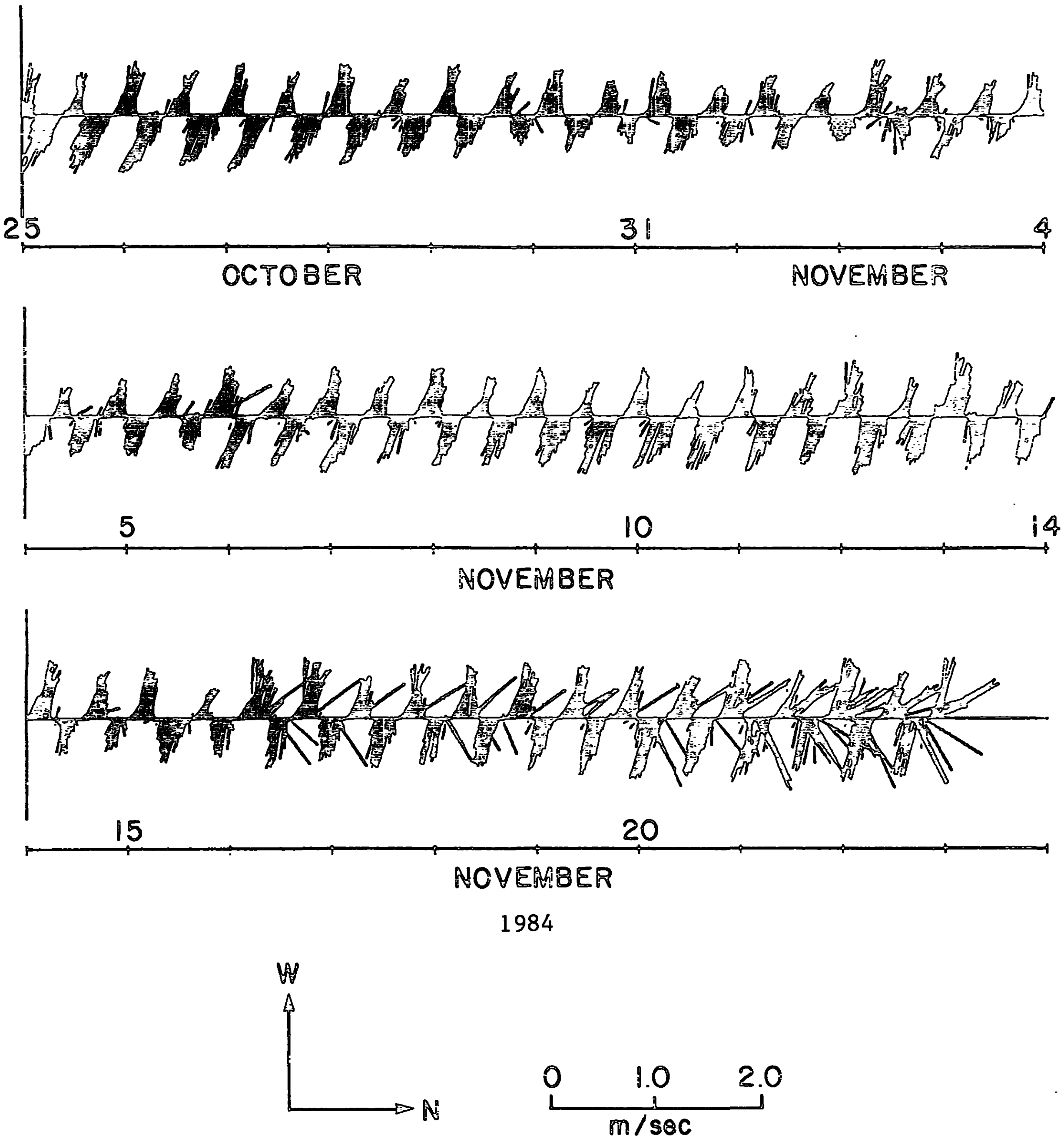
UNESCO, 1981. Technical Report 37. Practical Salinity Scale 1978.

APPENDIX A

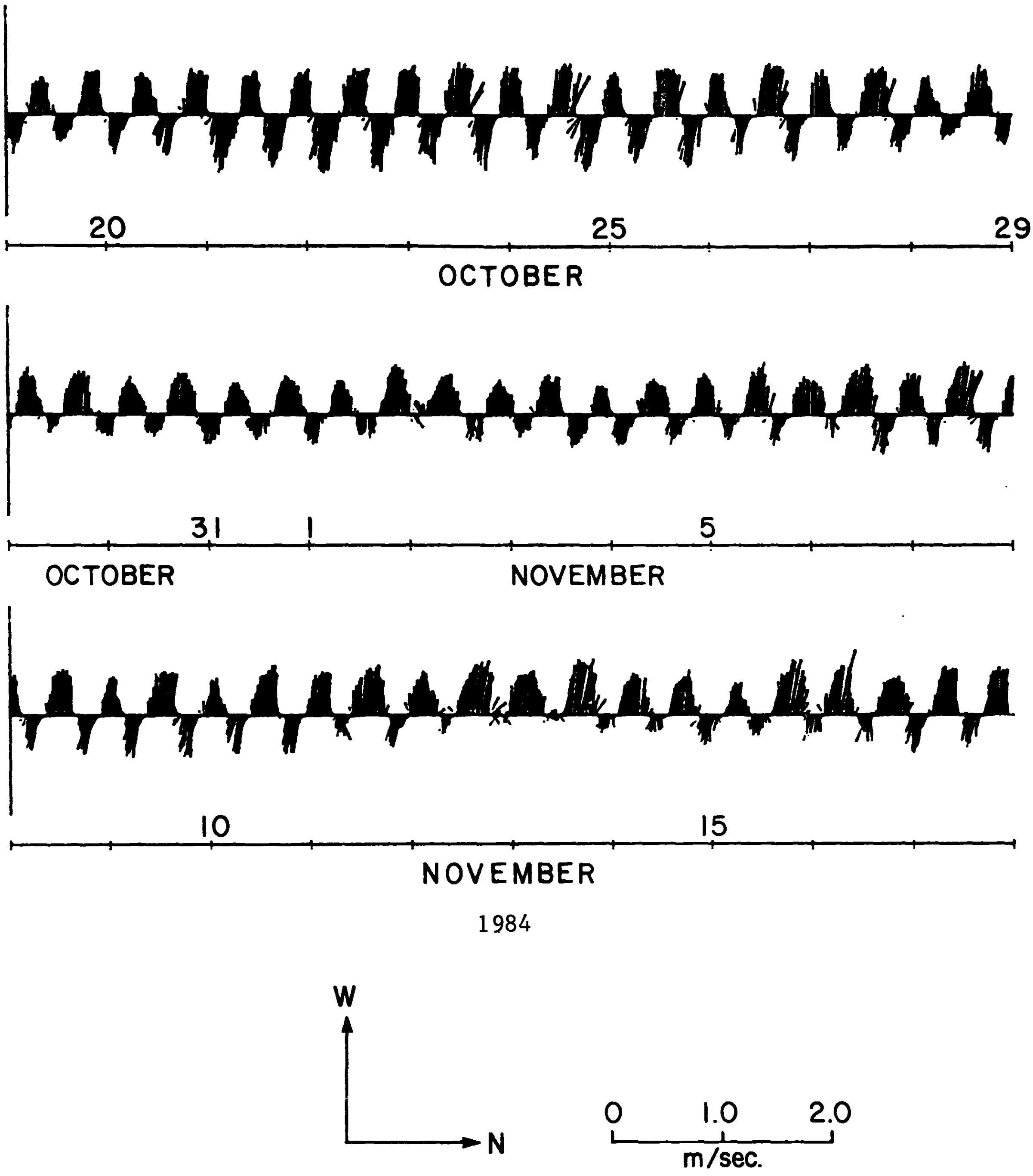
STICKPLOTS OF CURRENTS



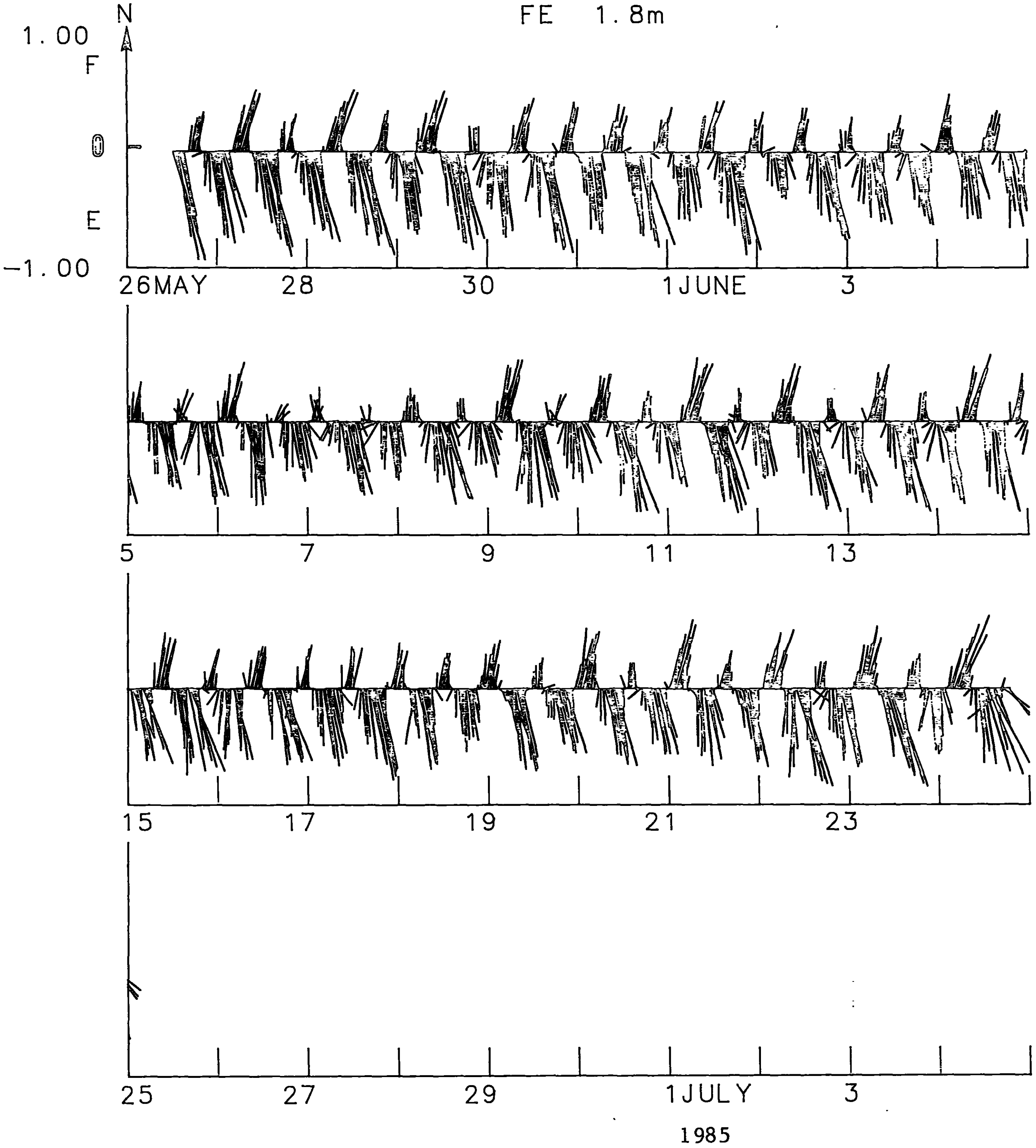
Hourly current at station 'J2', 2.4 m. below surface.



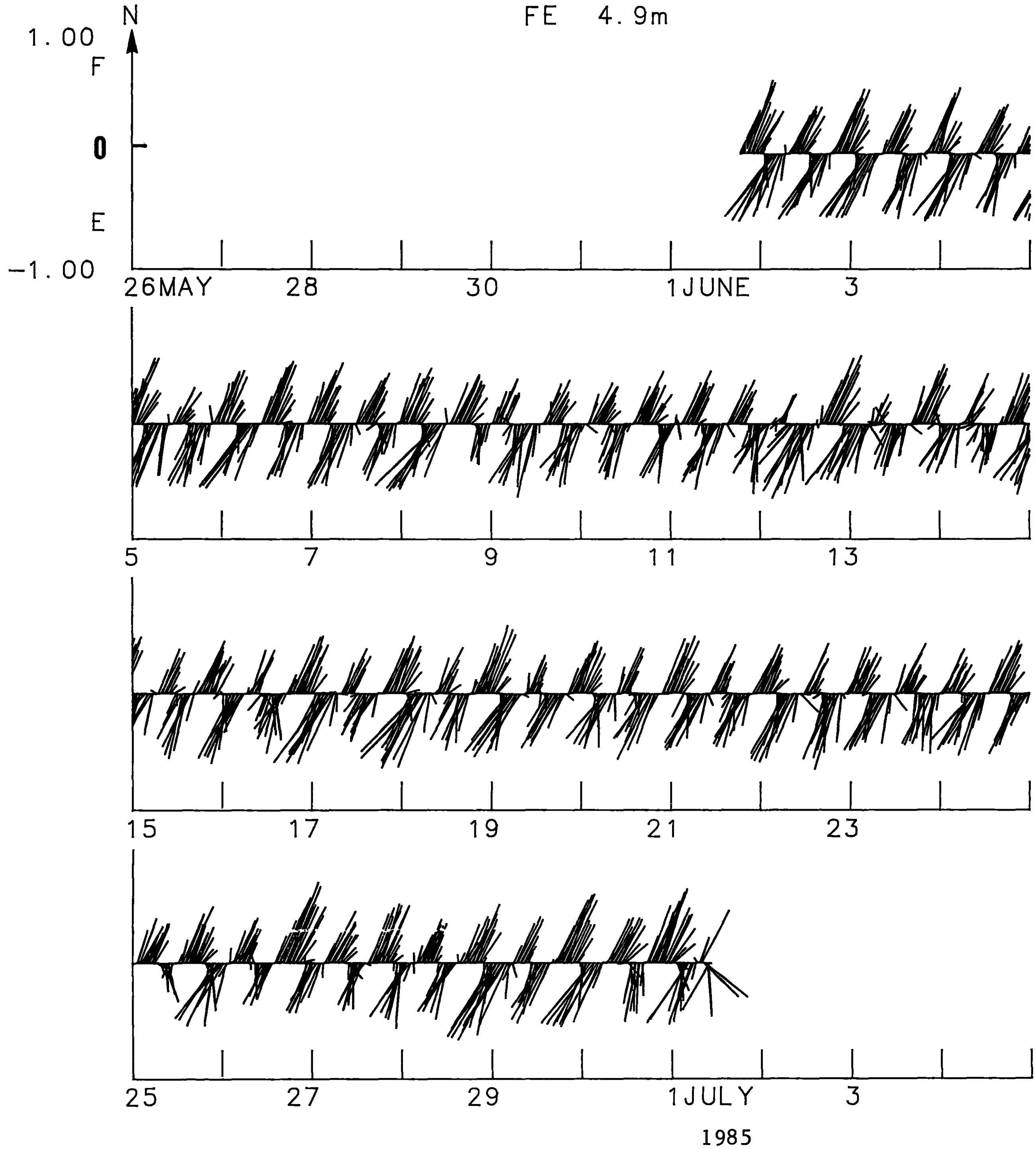
Hourly current at station 'J2', 4.9 m. below water surface.



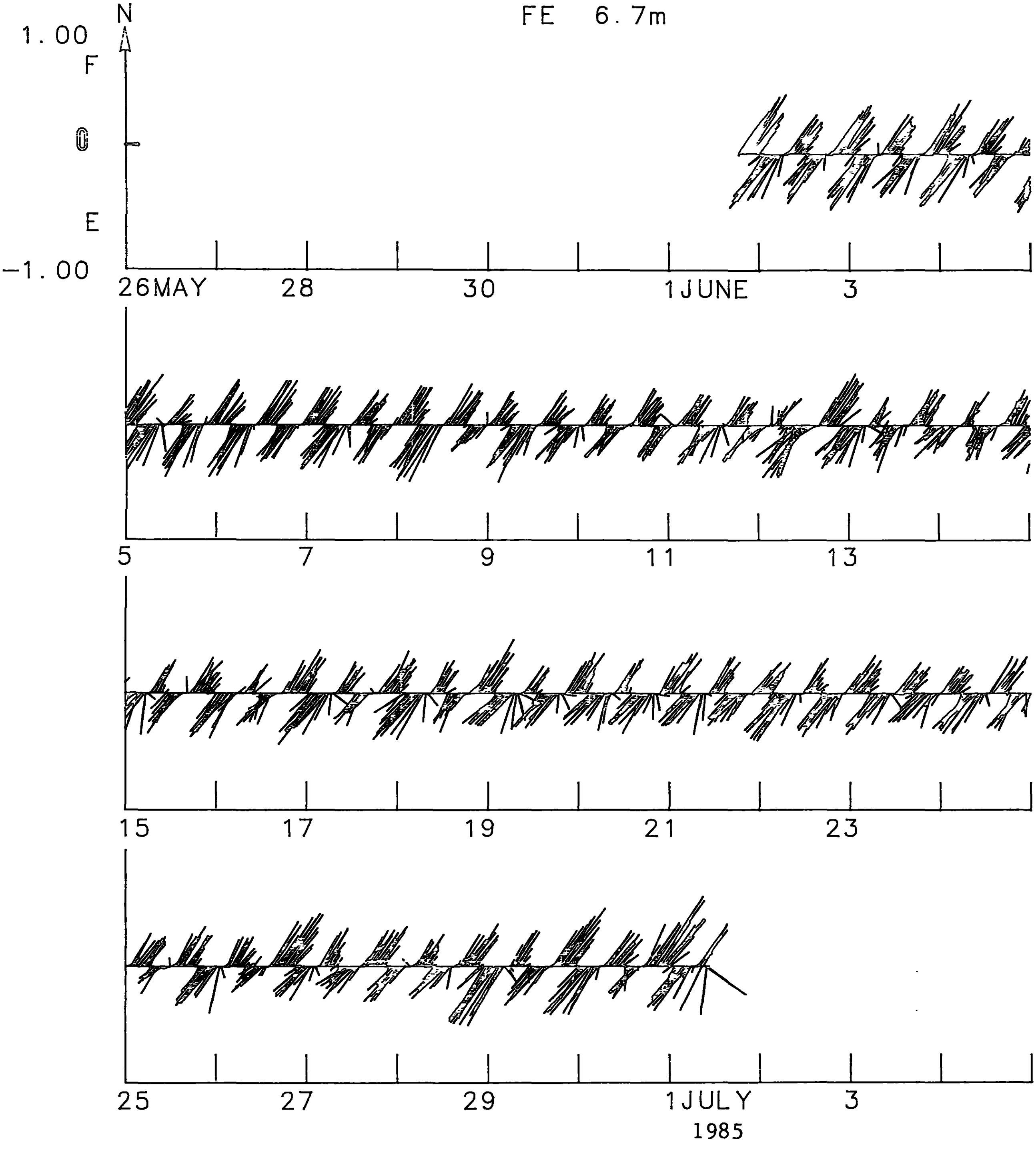
Hourly current at station 'J2', 9.1 m. below surface.



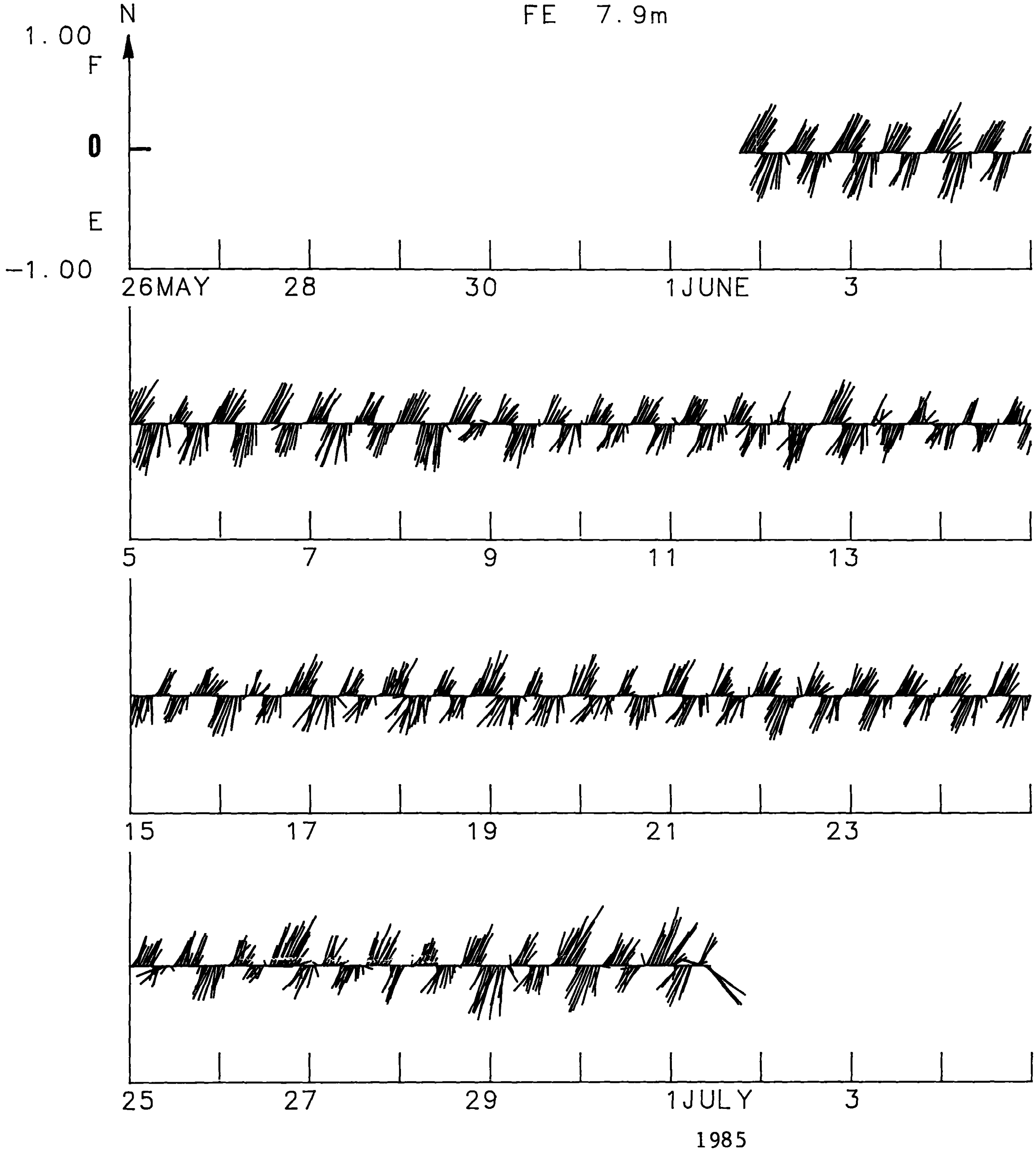
Fort Eustis, 1.8 m below surface, scale in m/sec



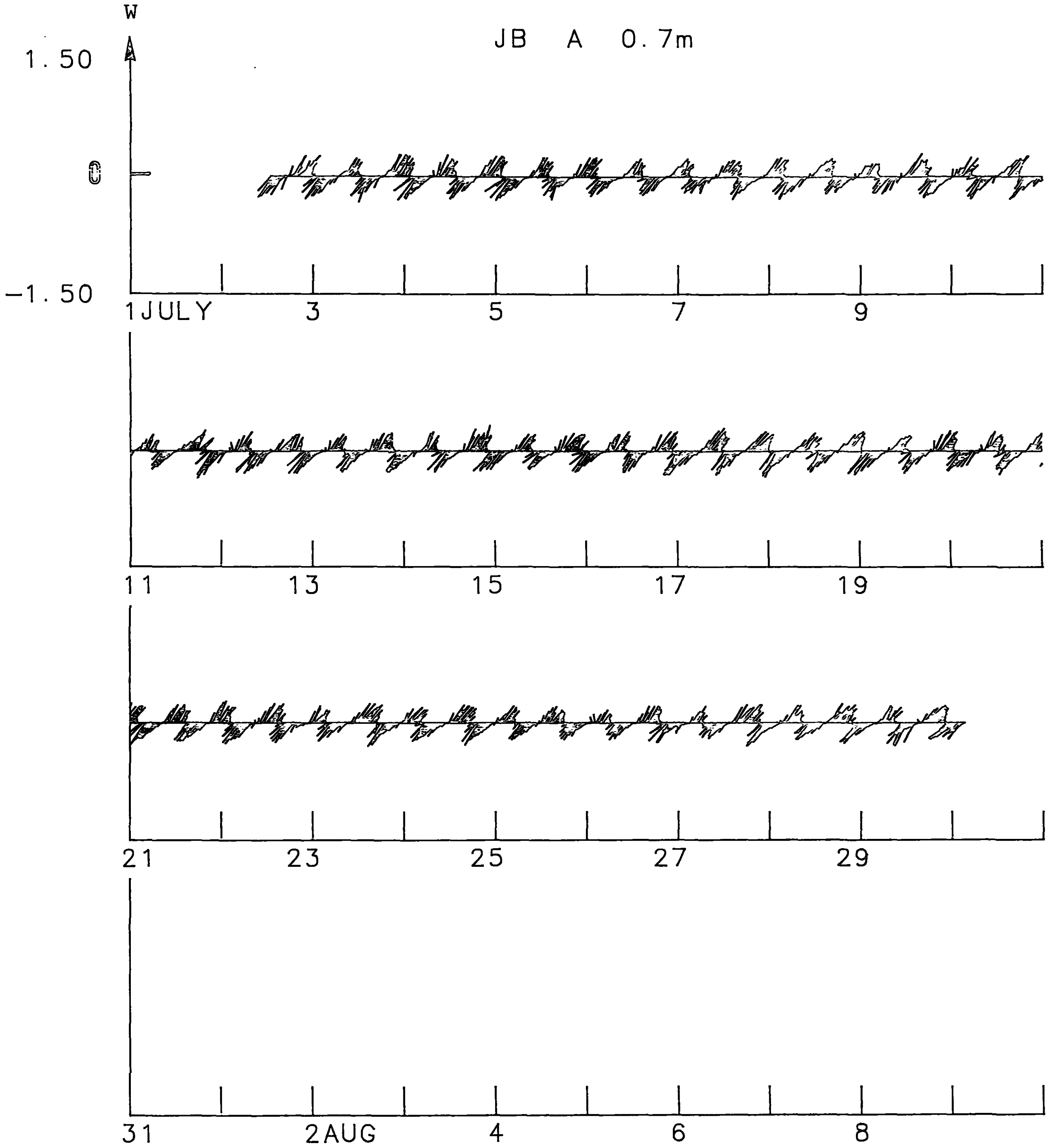
Fort Eustis, 4.9 m below surface, scale in m/sec



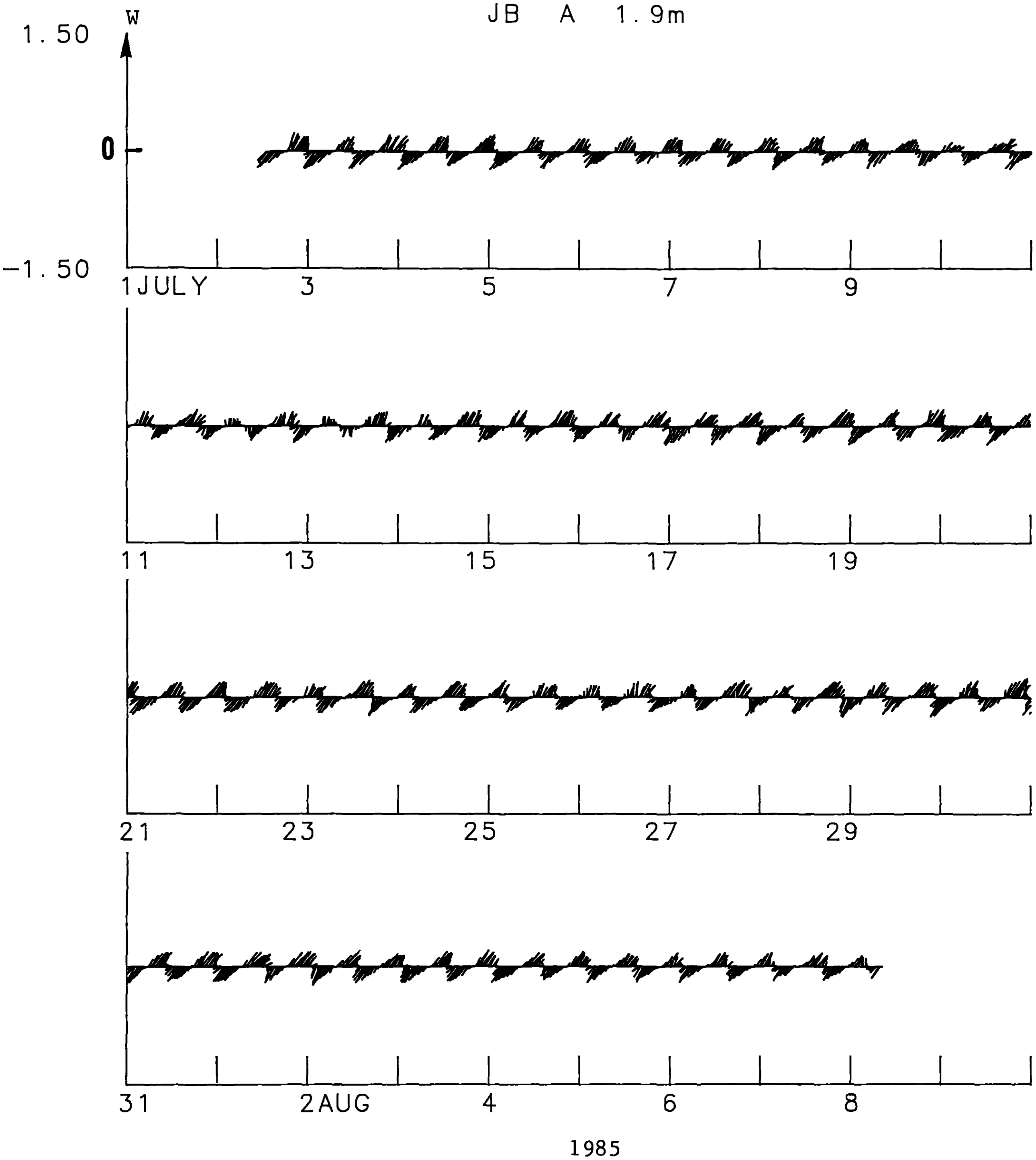
Fort Eustis, 6.7 m below surface, scale in m/sec



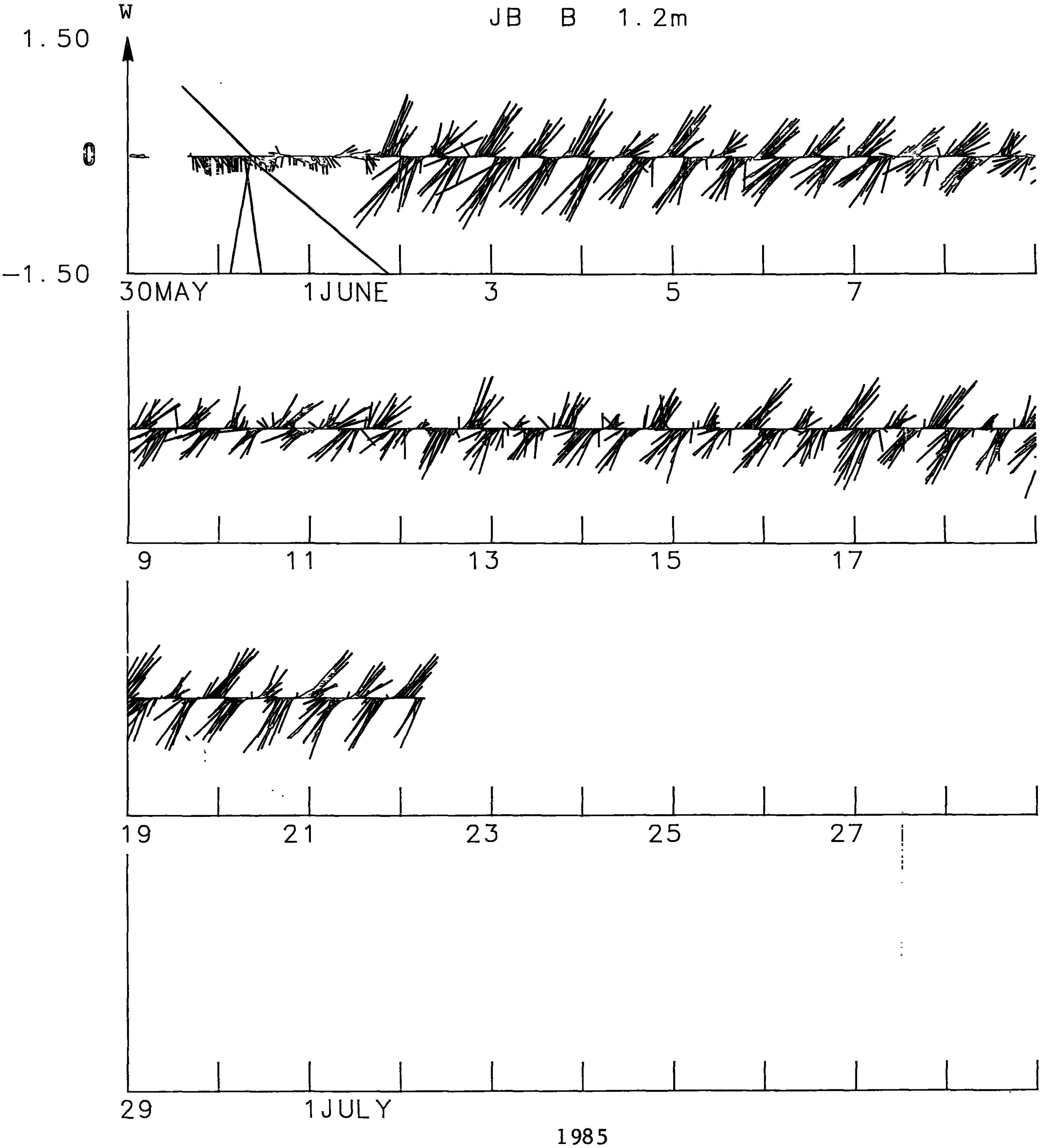
Fort Eustis, 7.9 m below surface, scale in m/sec



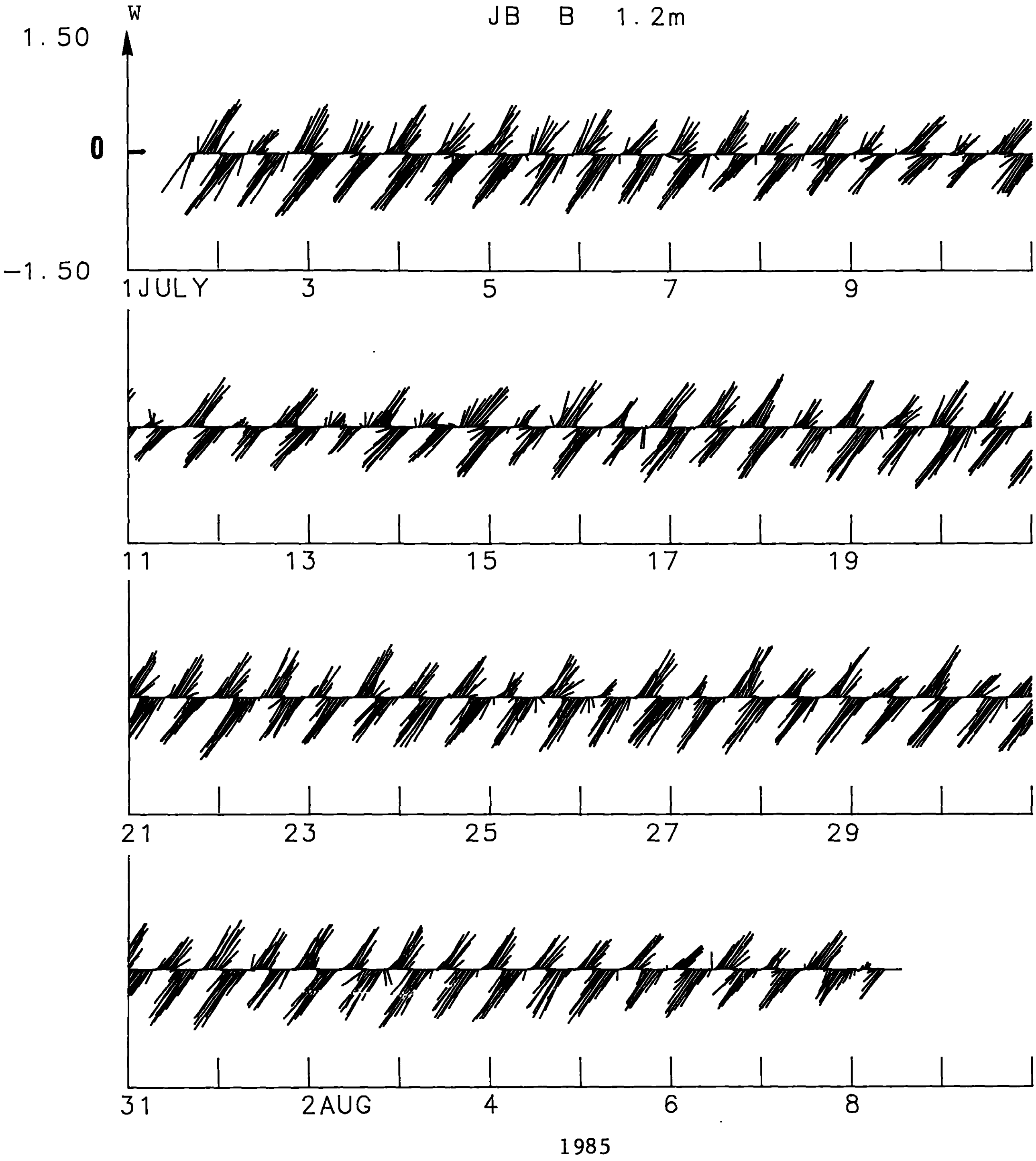
James River Bridge Station A, 0.7 m below surface, scale in m/sec



James River Bridge Station A, 1.9 m below surface, scale in m/sec



James River Bridge Station B, 1.2 m below surface, scale in m/sec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3
5
7
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23
25
27
29
31
2AUG
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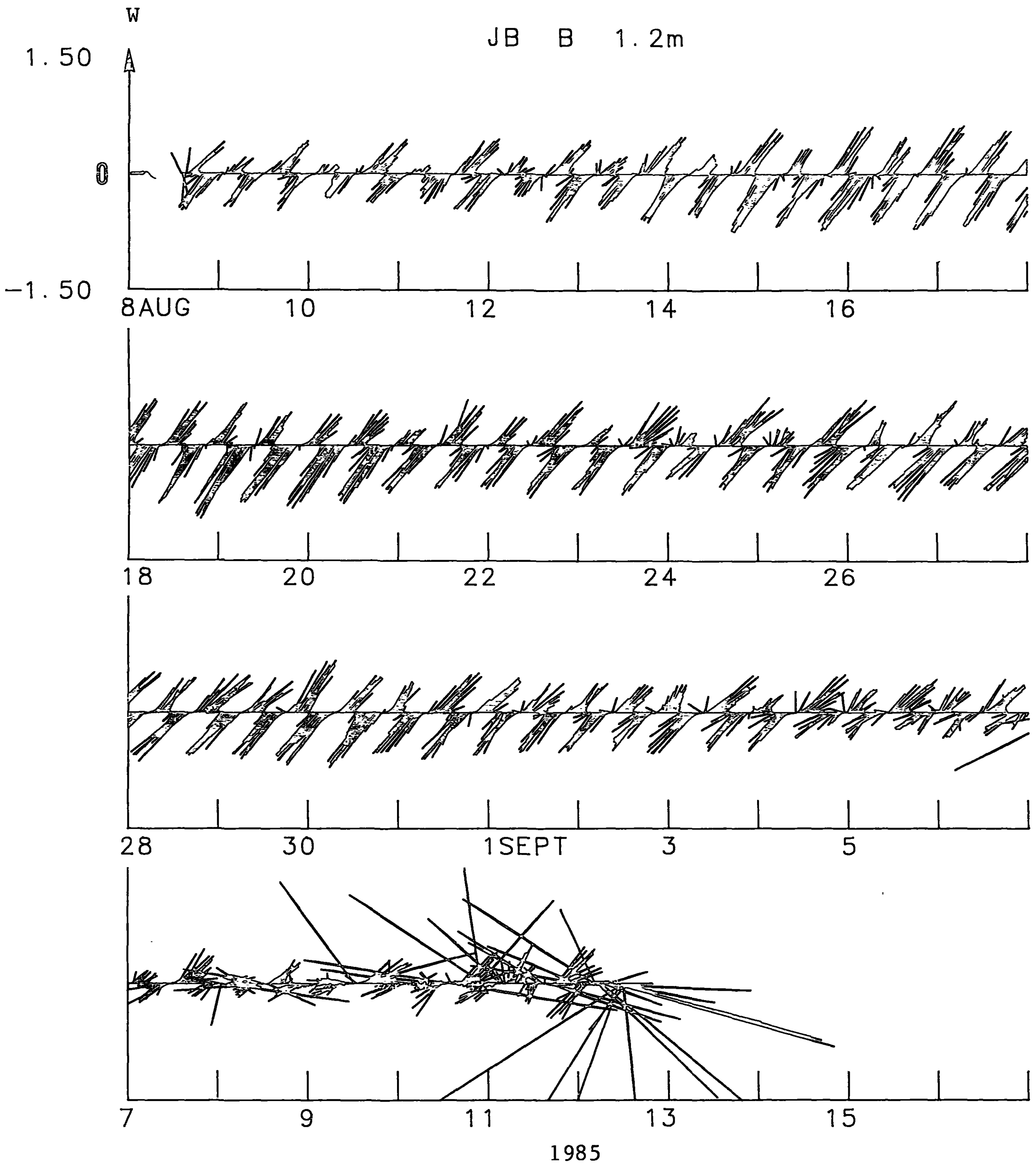
6
8
1985

(continued)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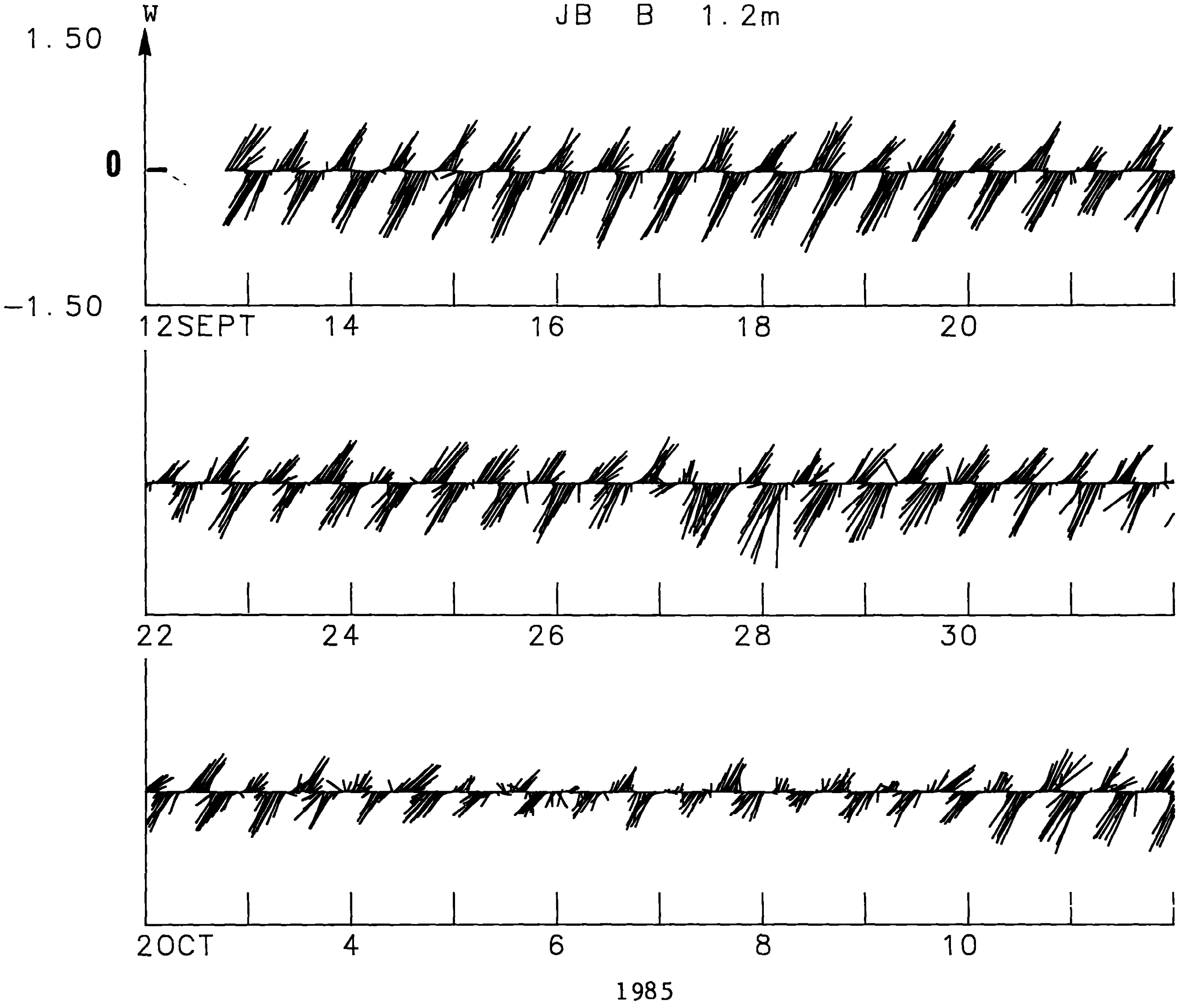
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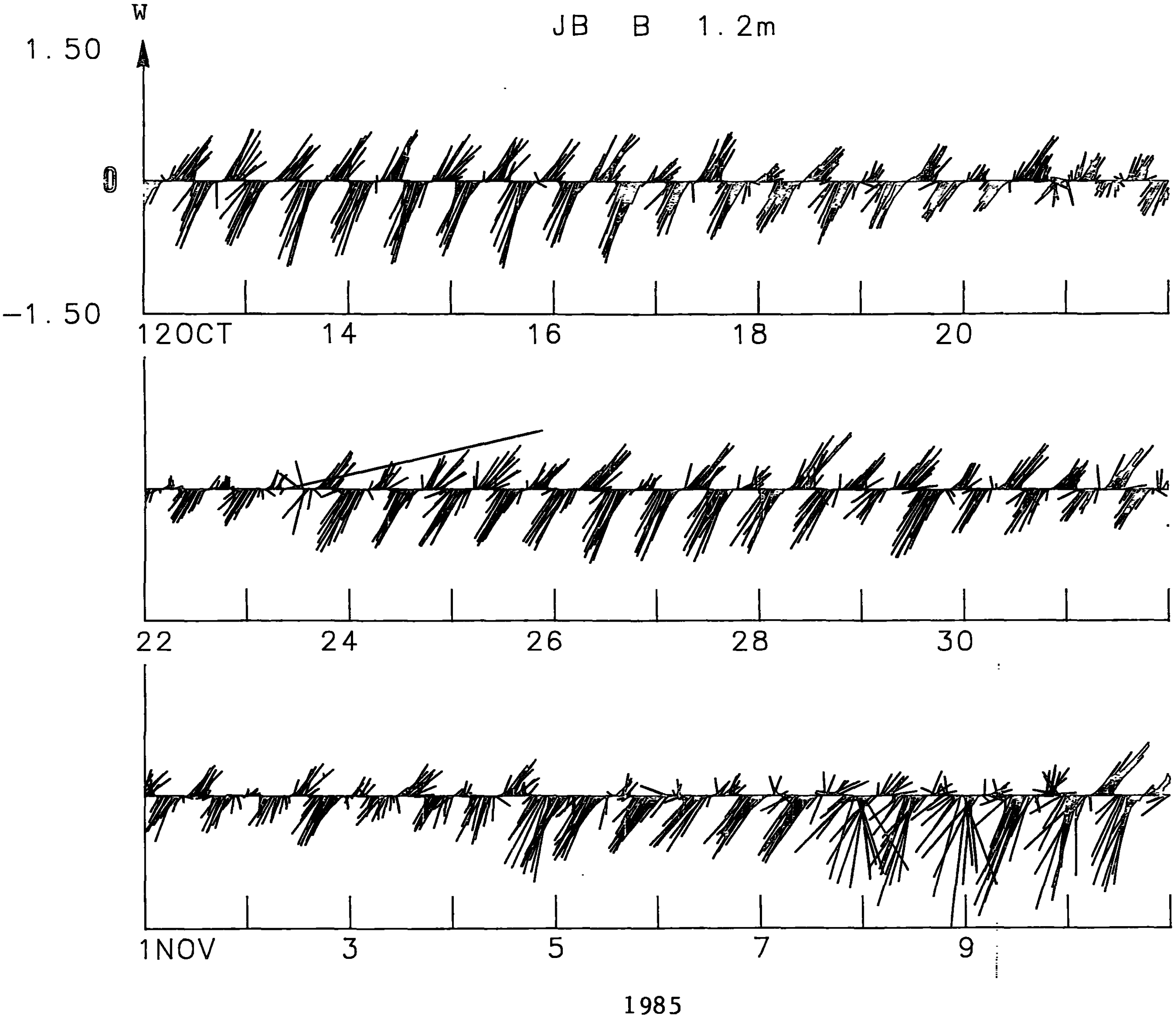

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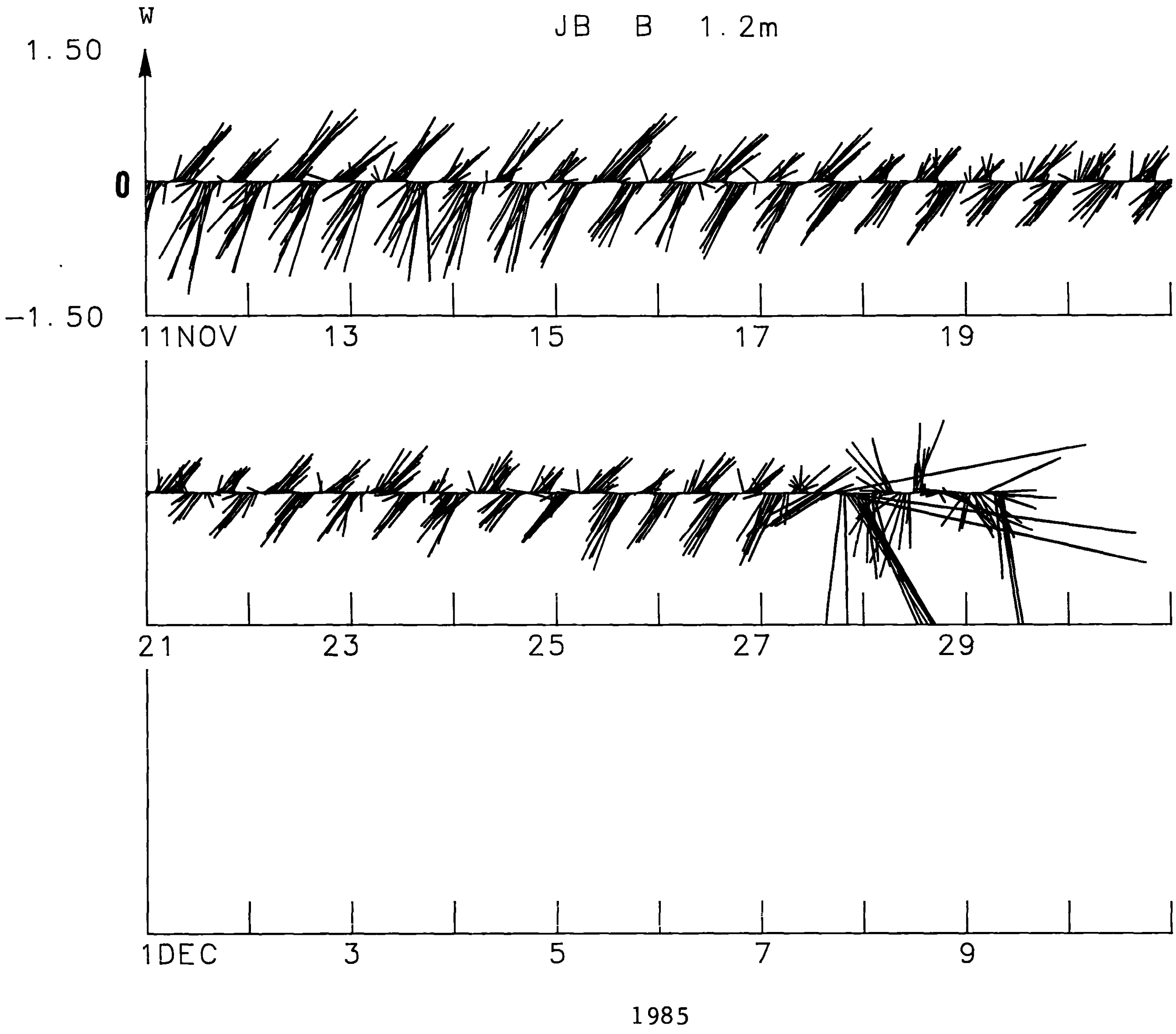

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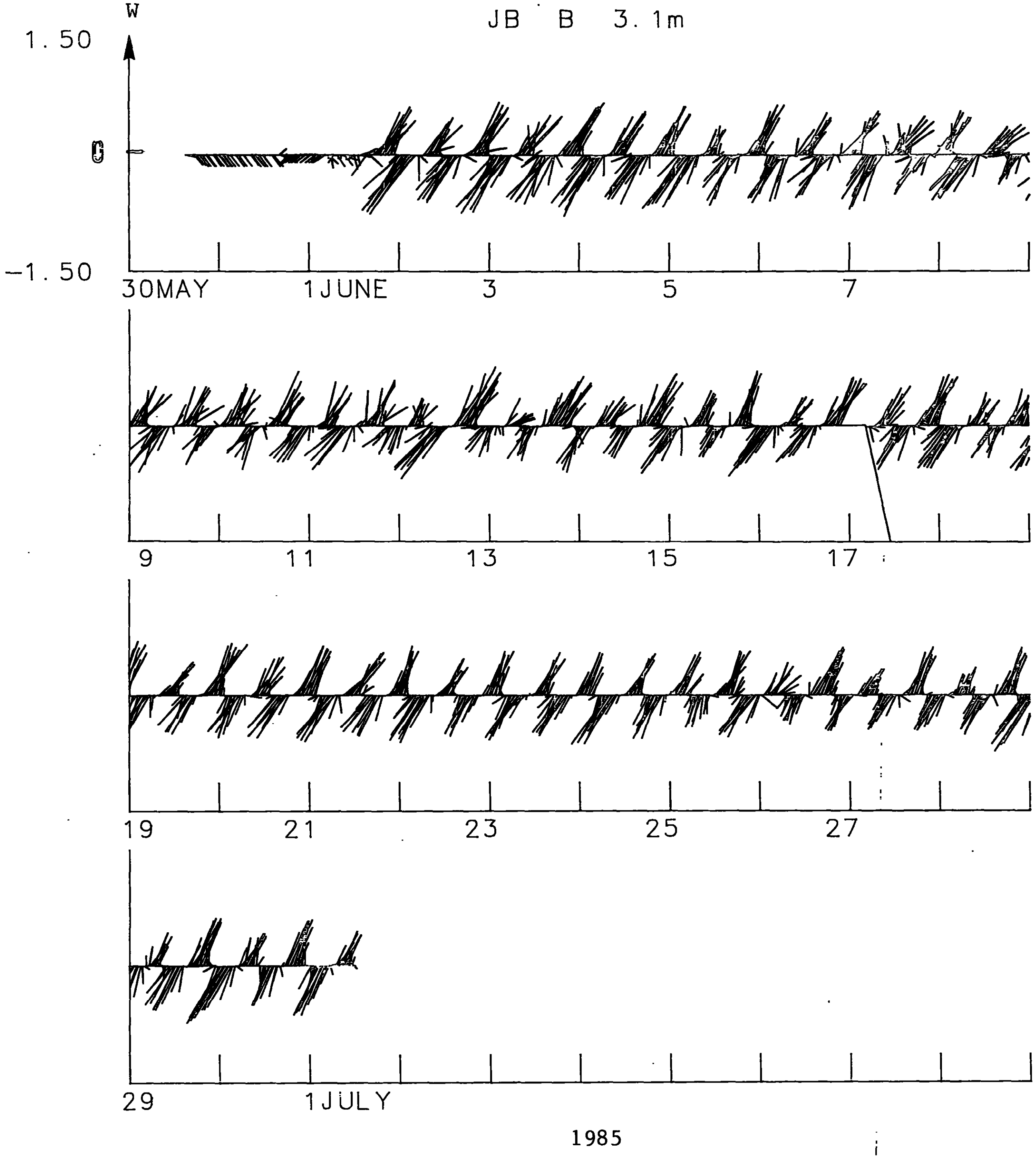
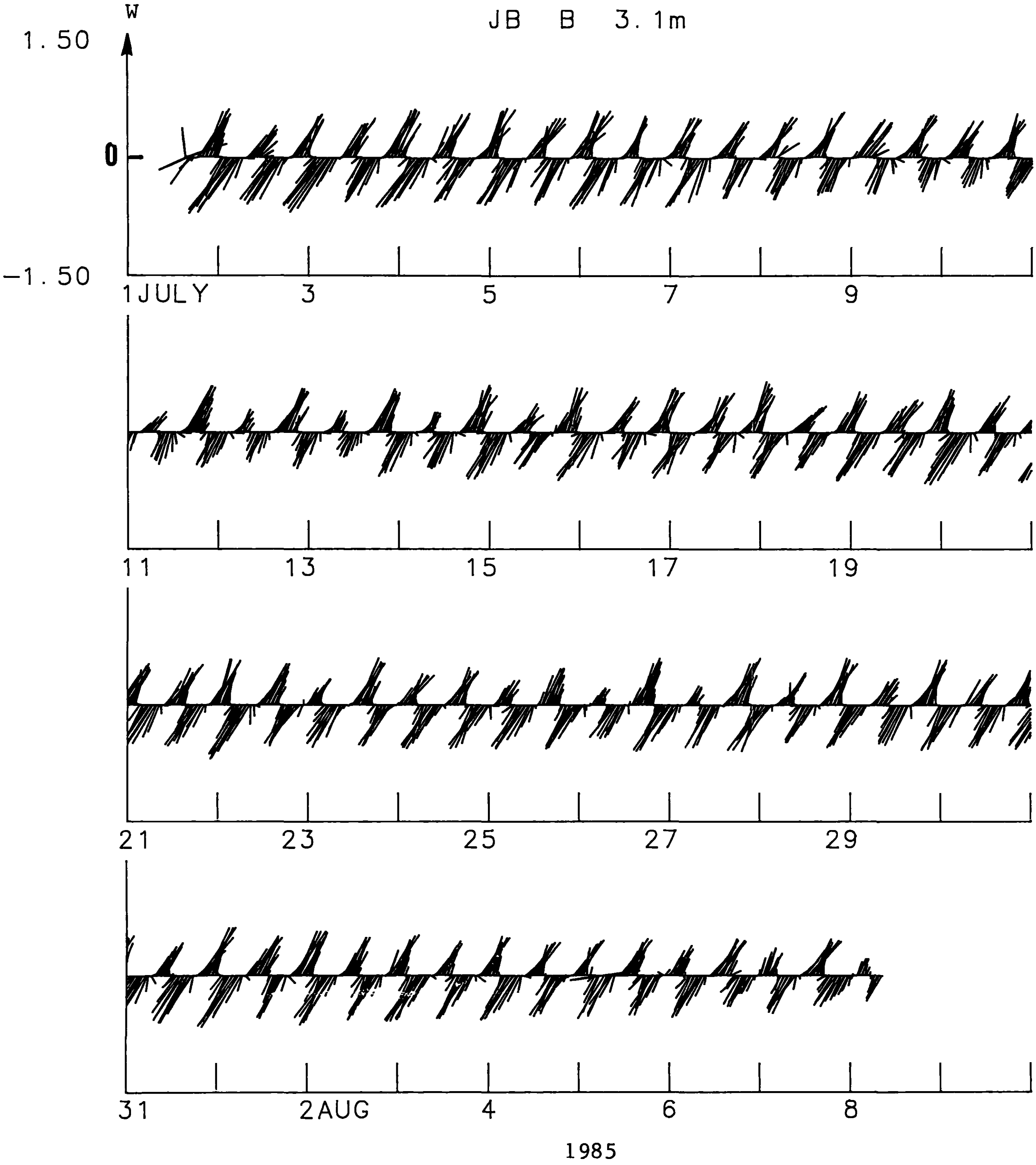


James River Bridge Station B, 3.1 m below surface, scale in m/sec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2AUG
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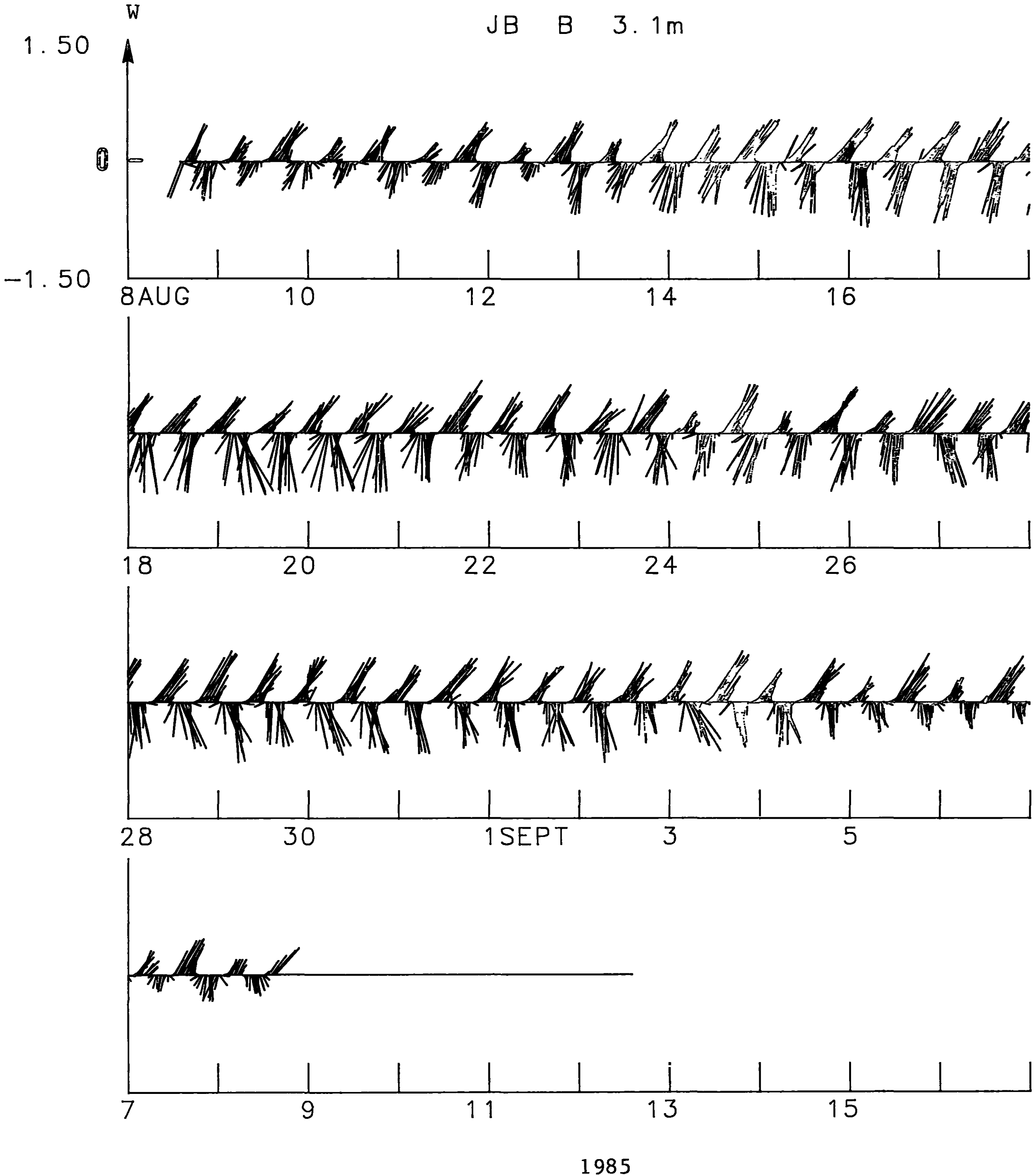
1985

(continued)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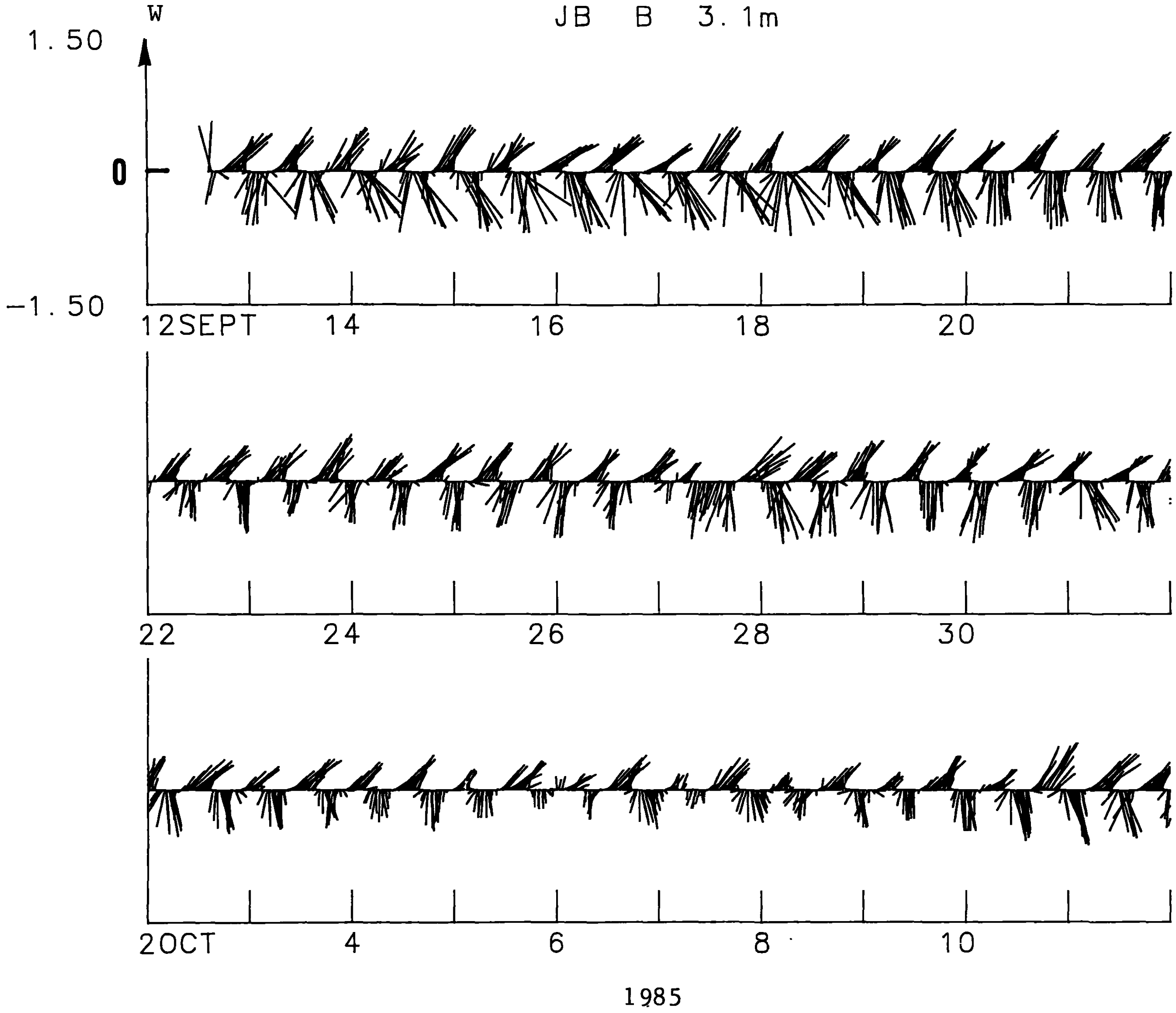
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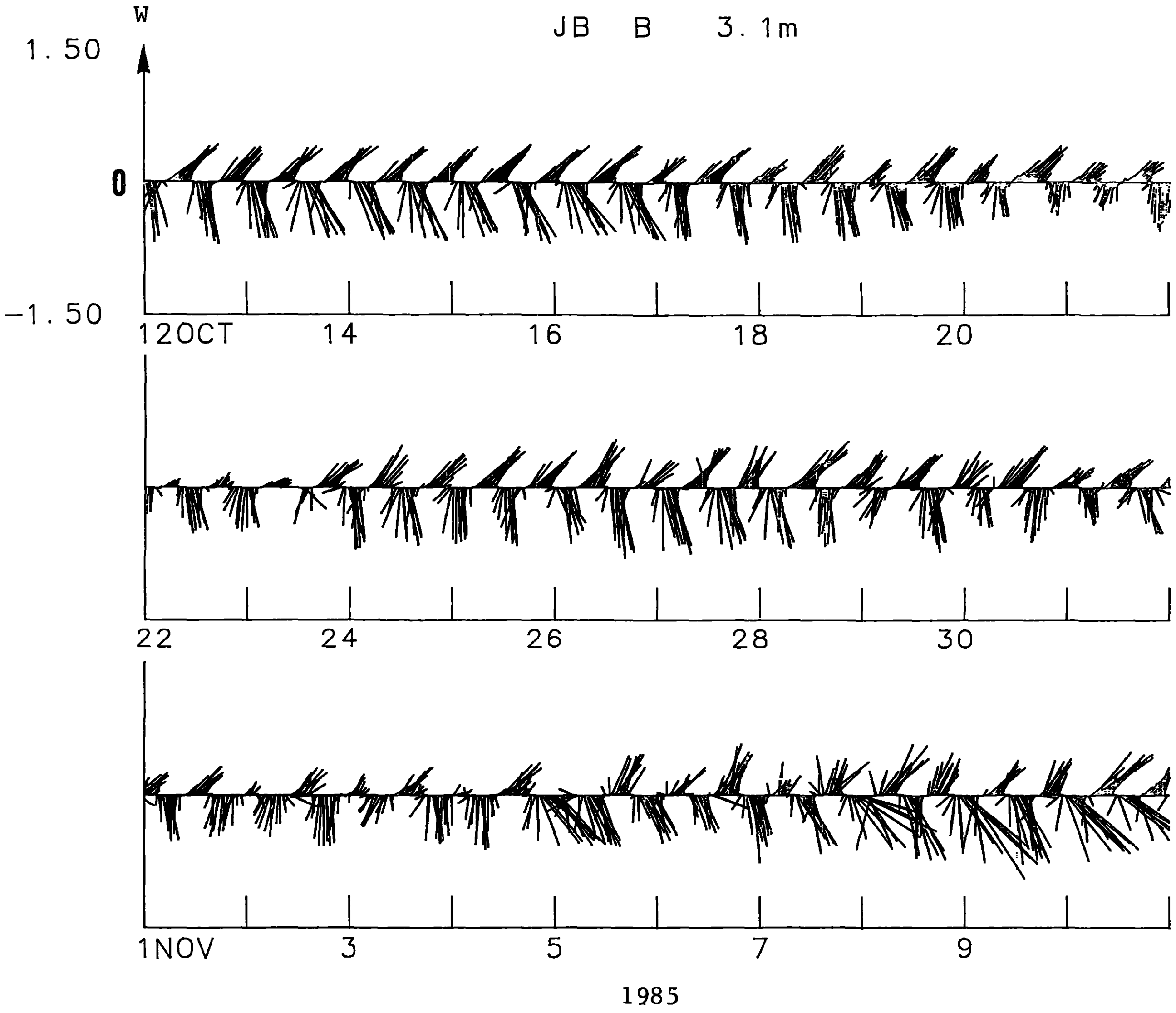

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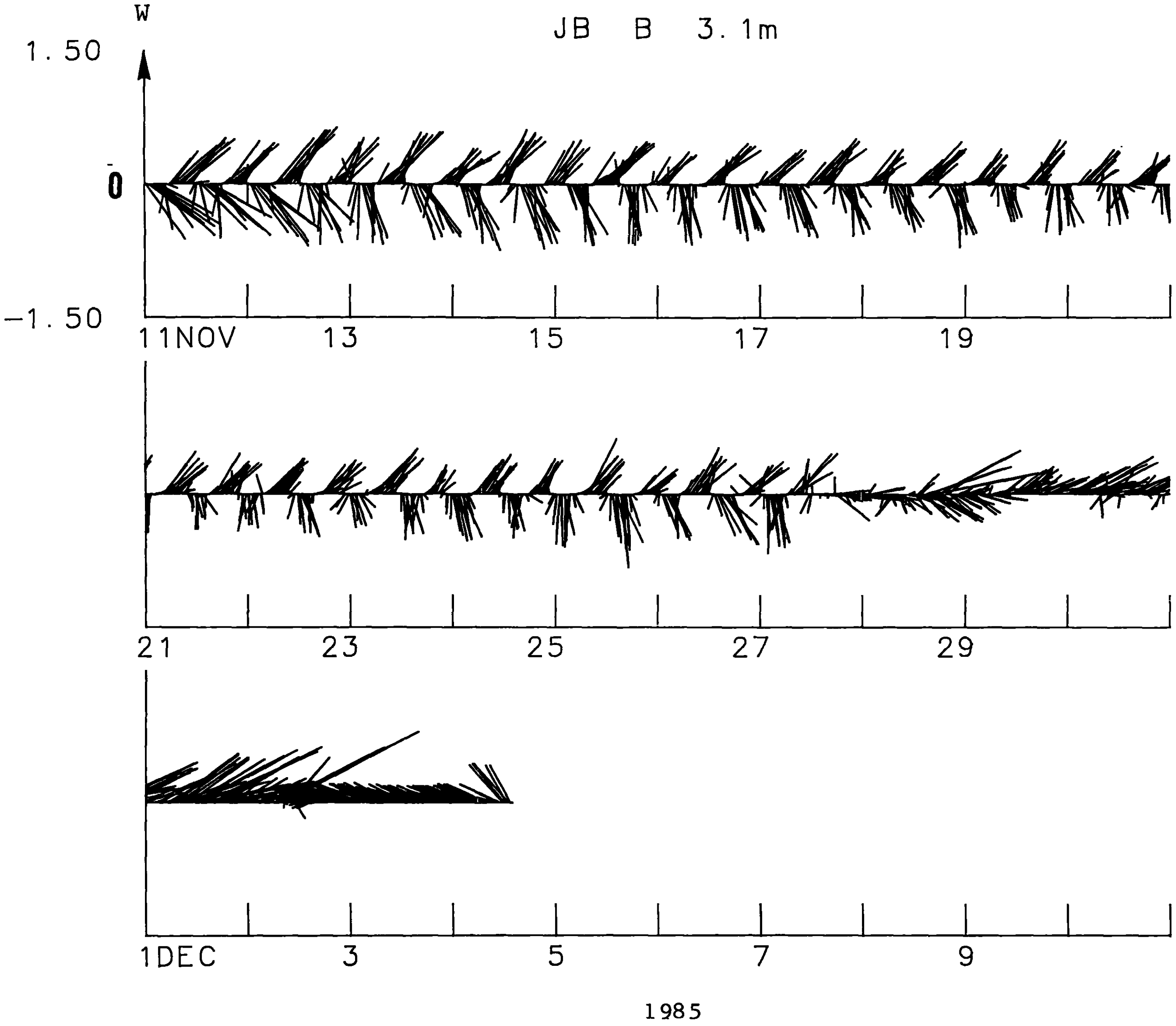

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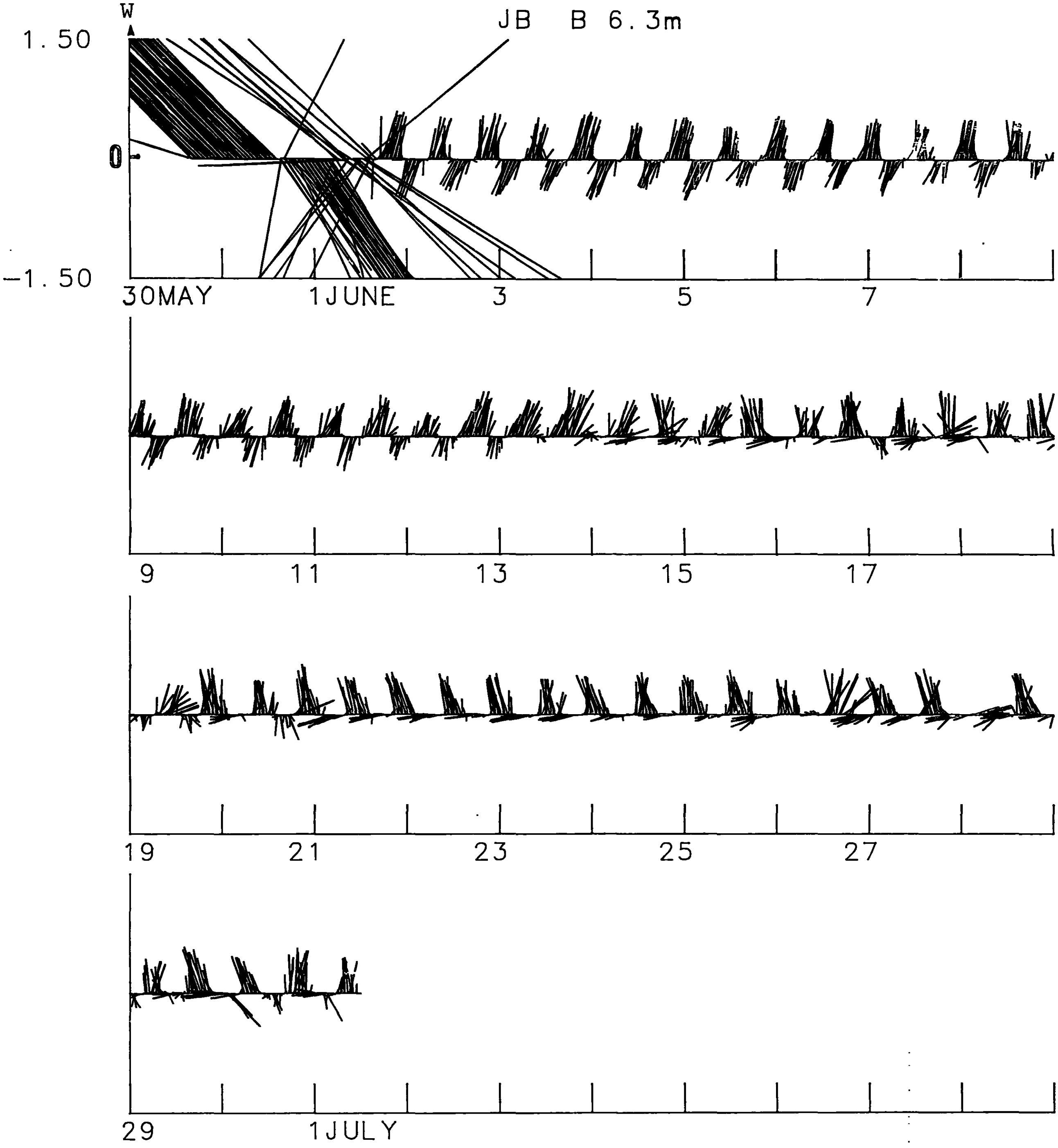
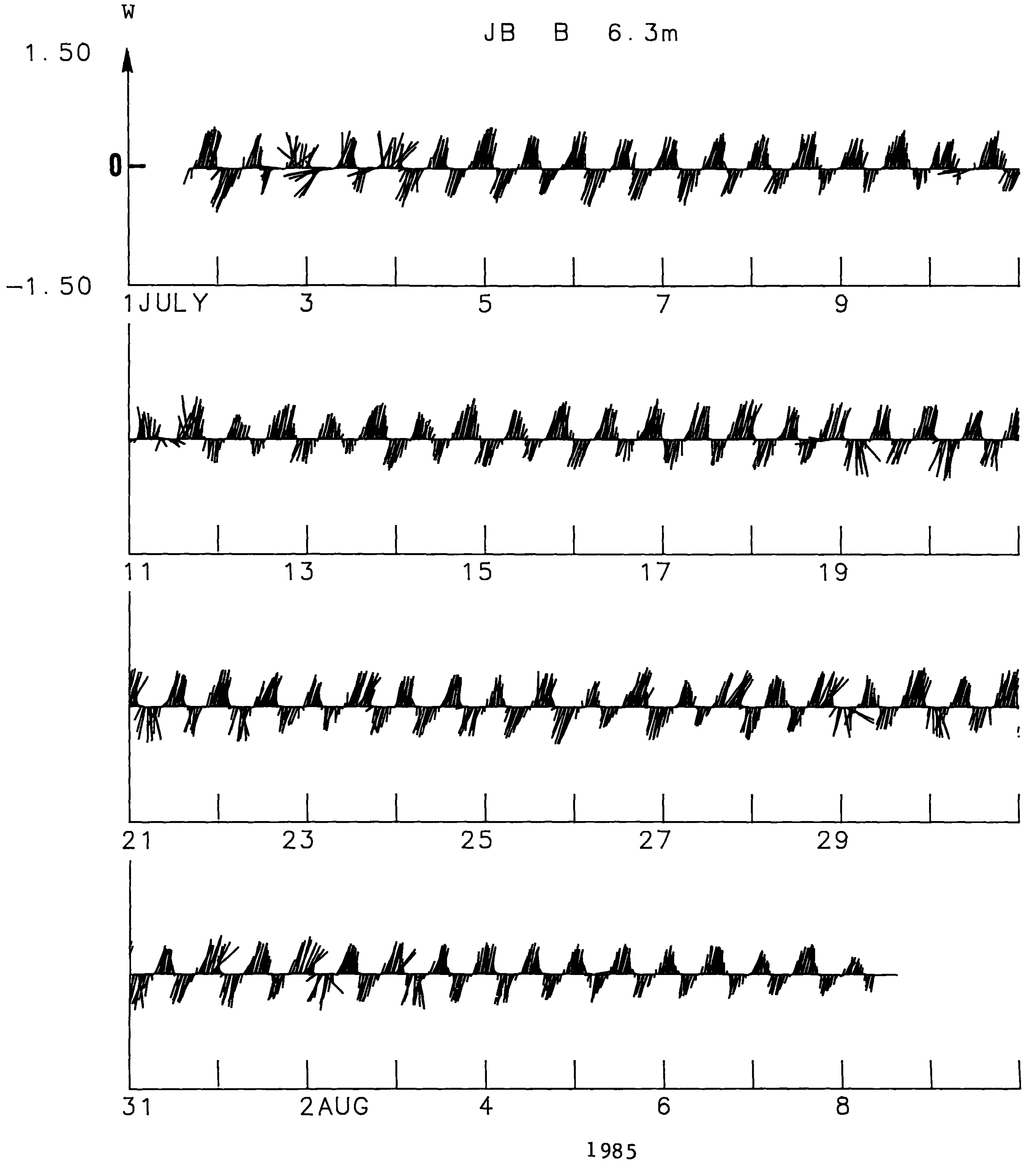


James River Bridge Station B, 6.3 m below surface, scale in m/sec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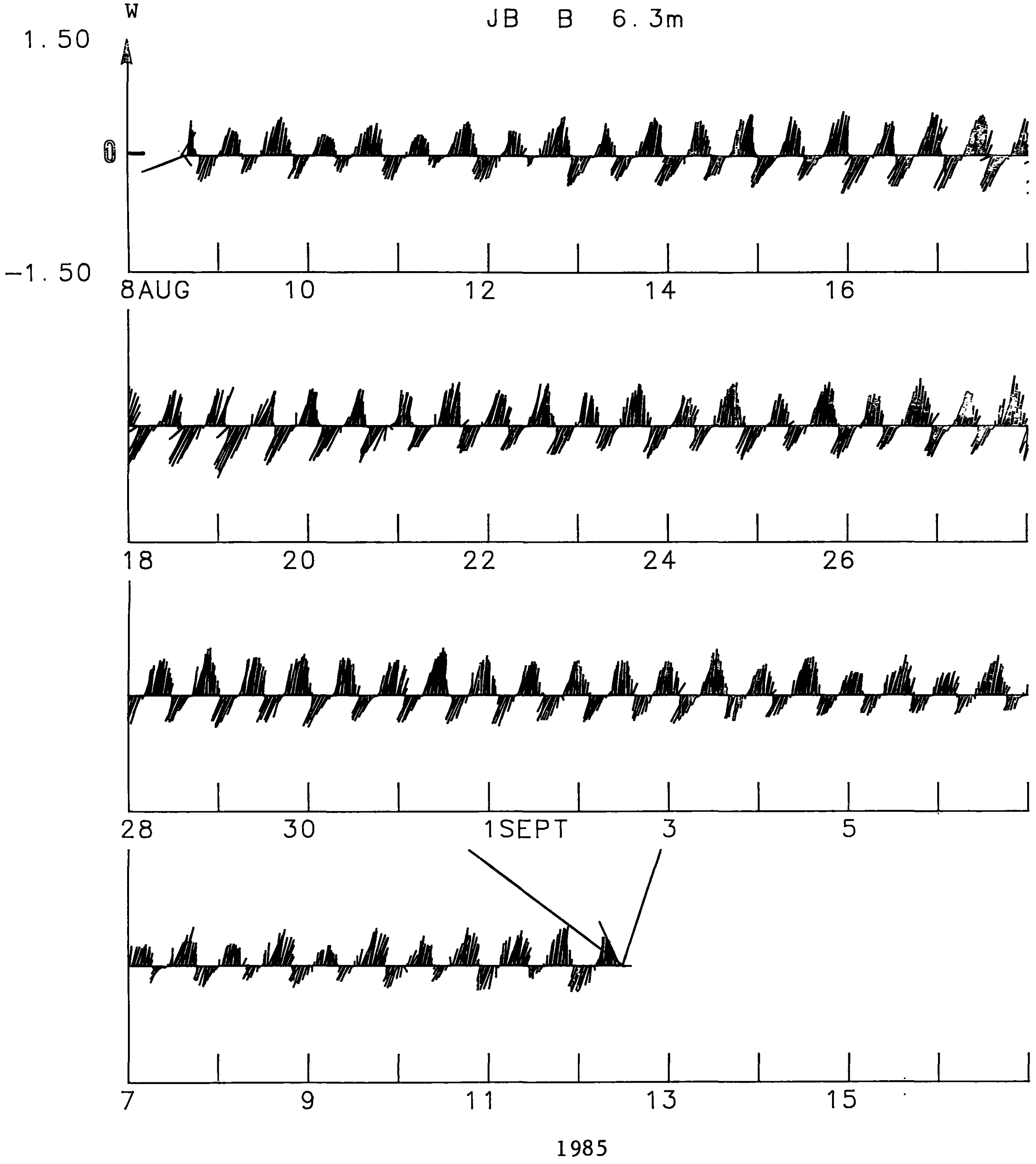
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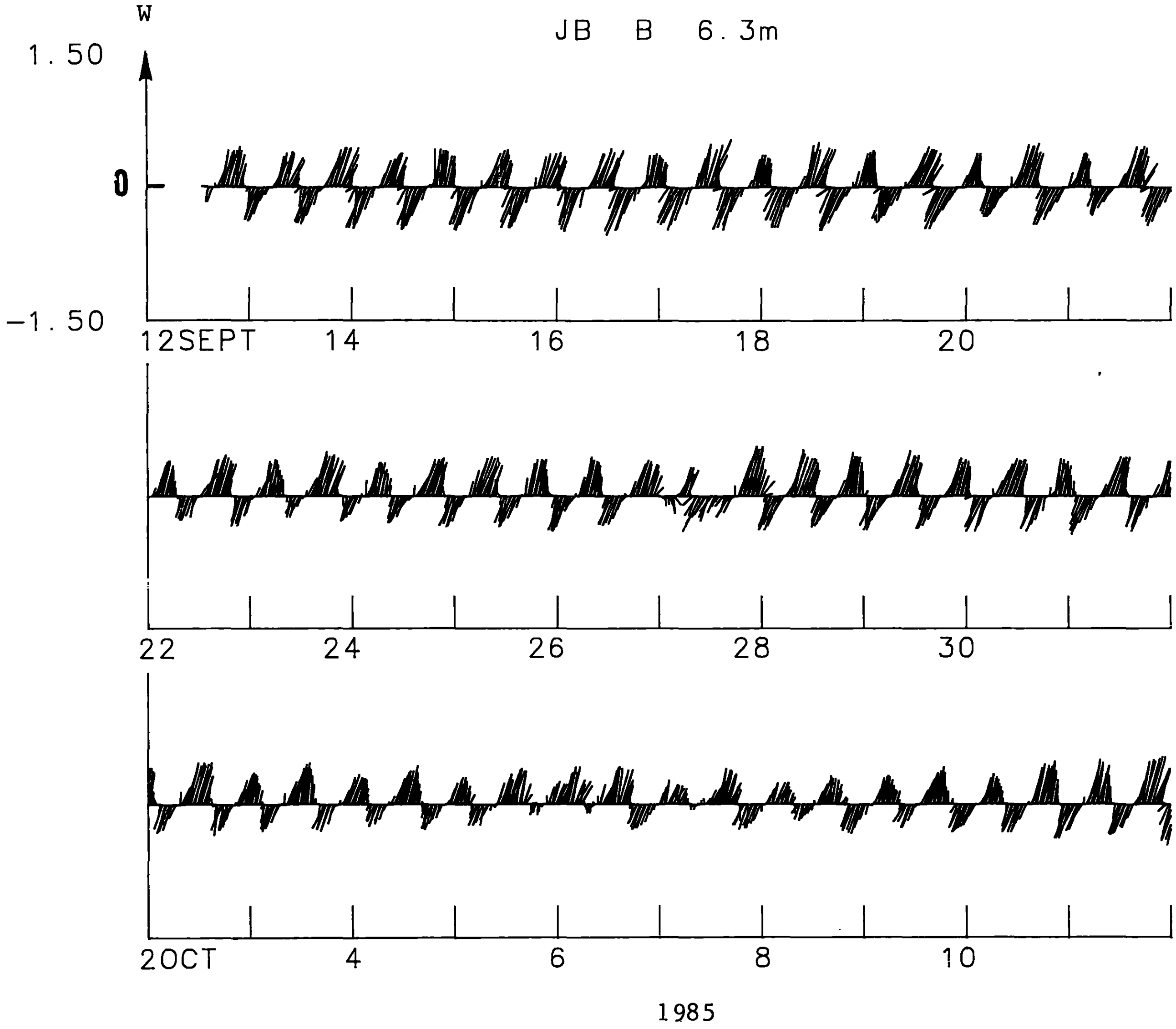
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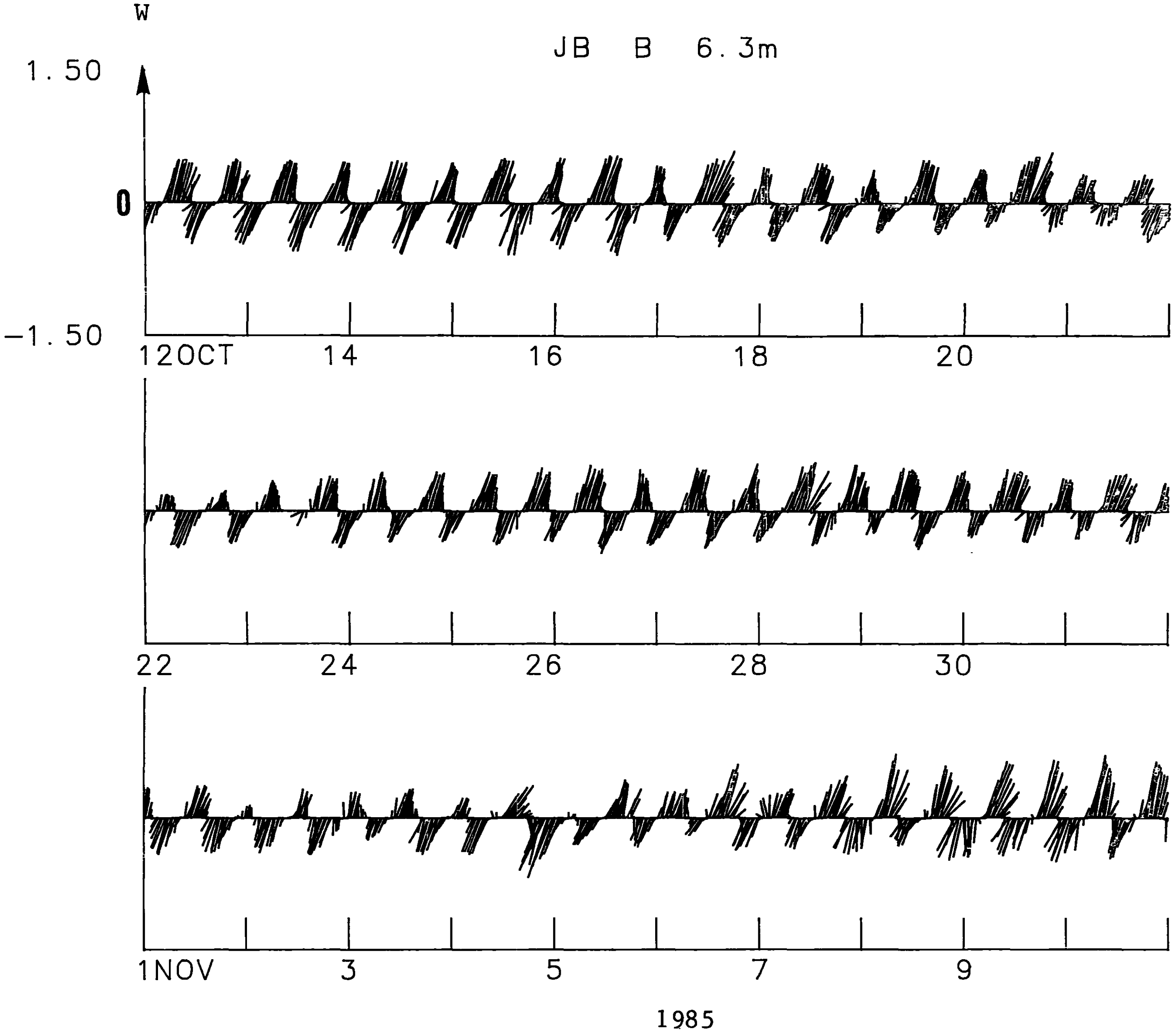

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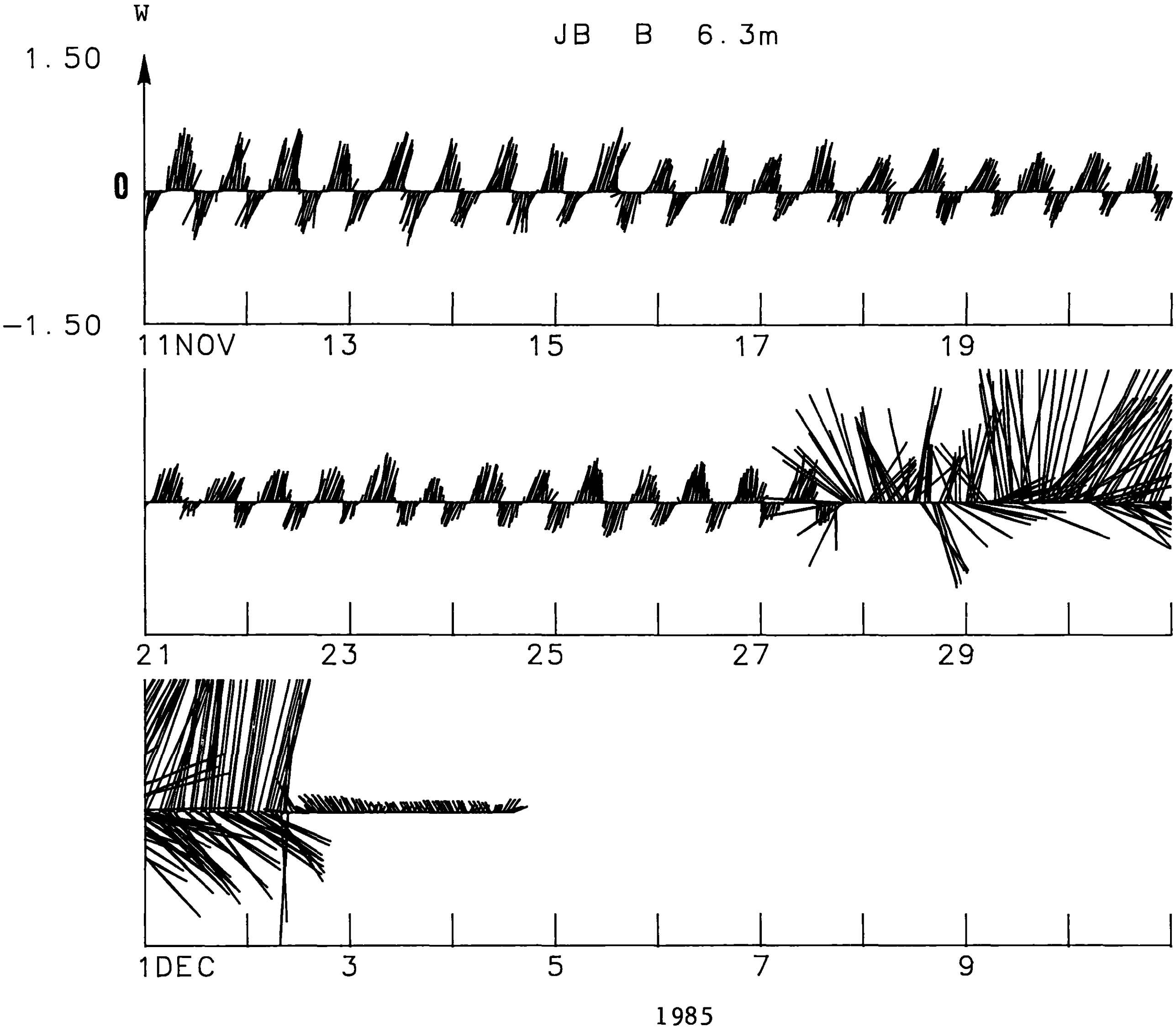

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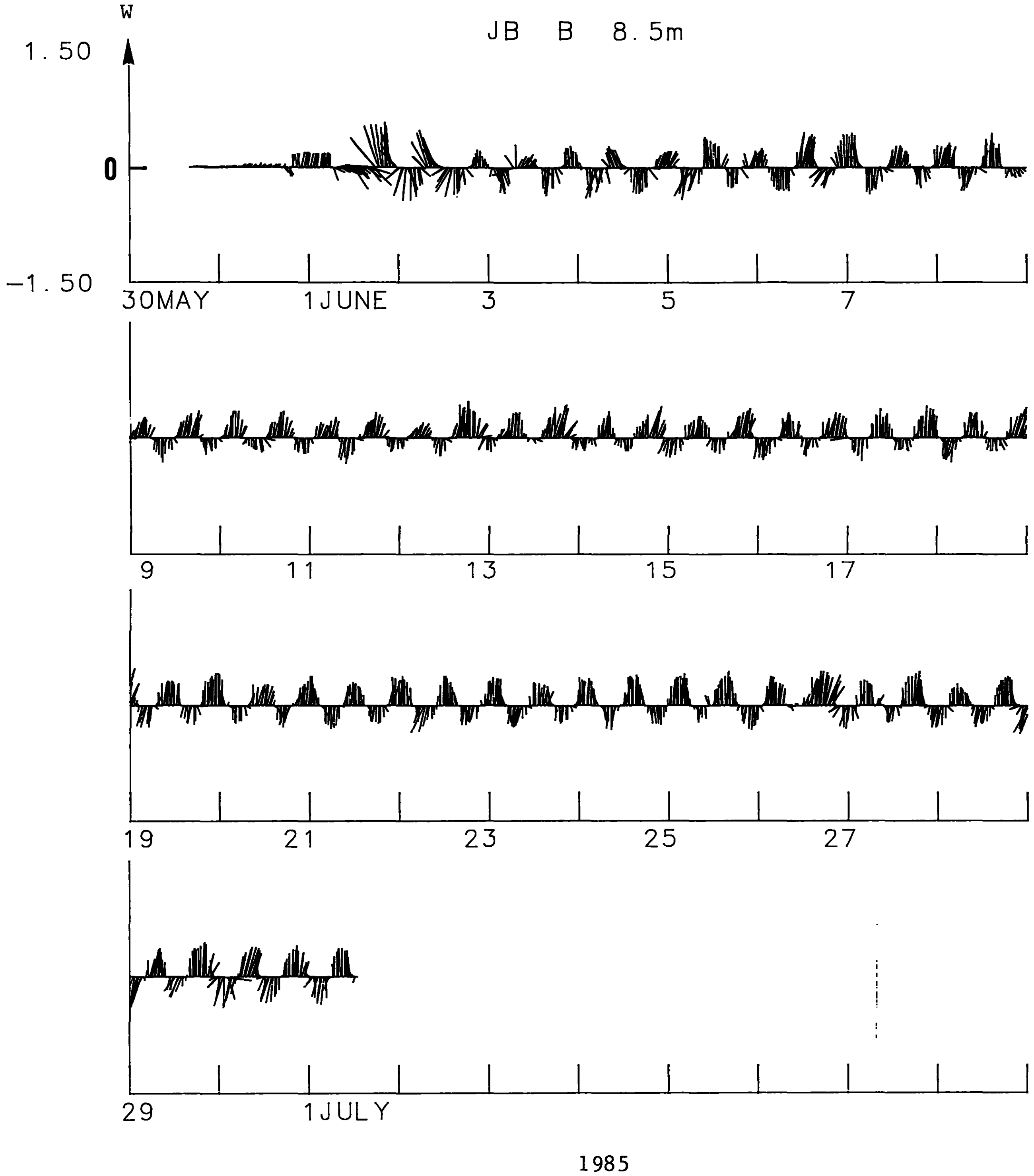
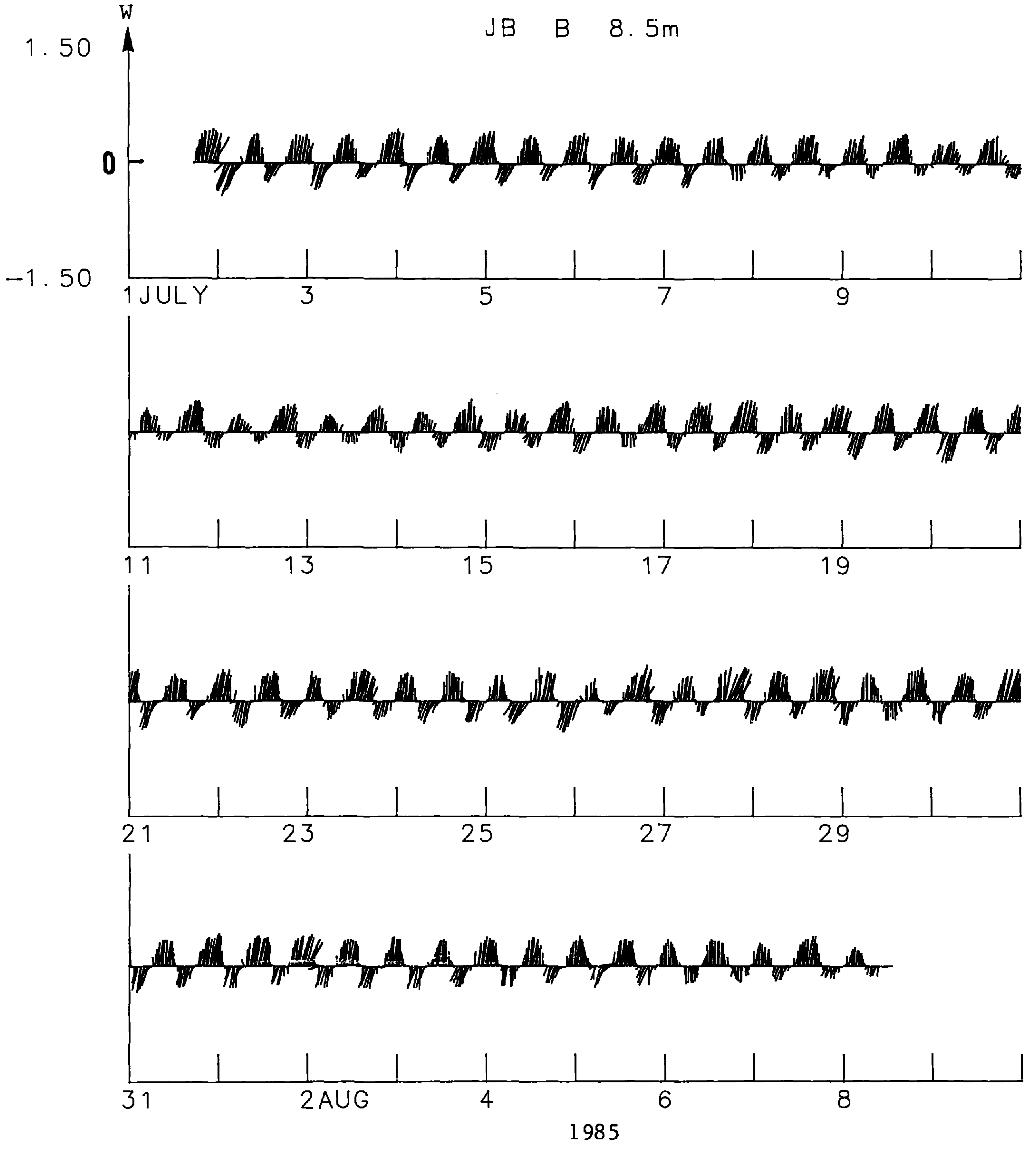


James River Bridge Station B, 8.5 m below surface, scale in m/sec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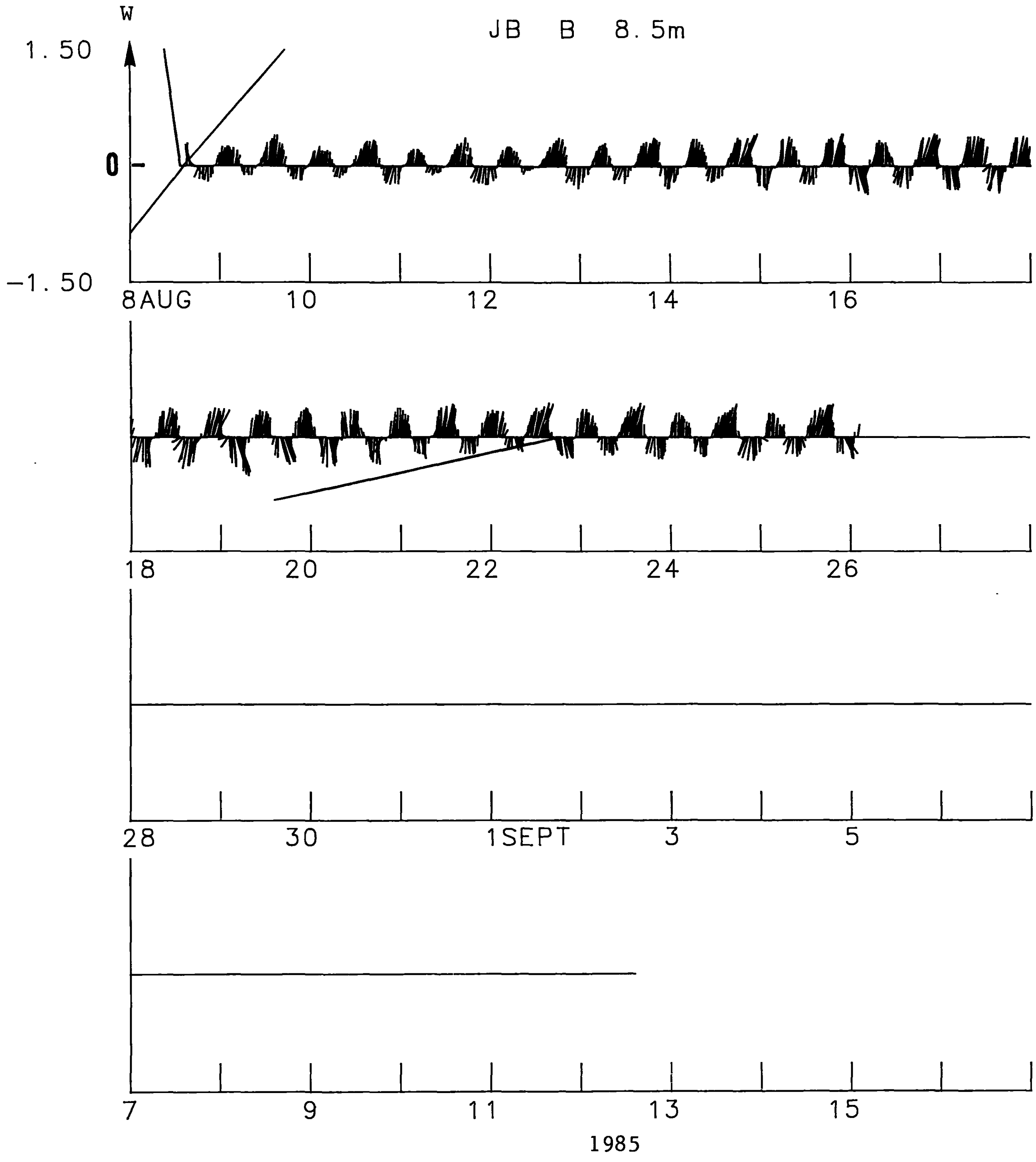
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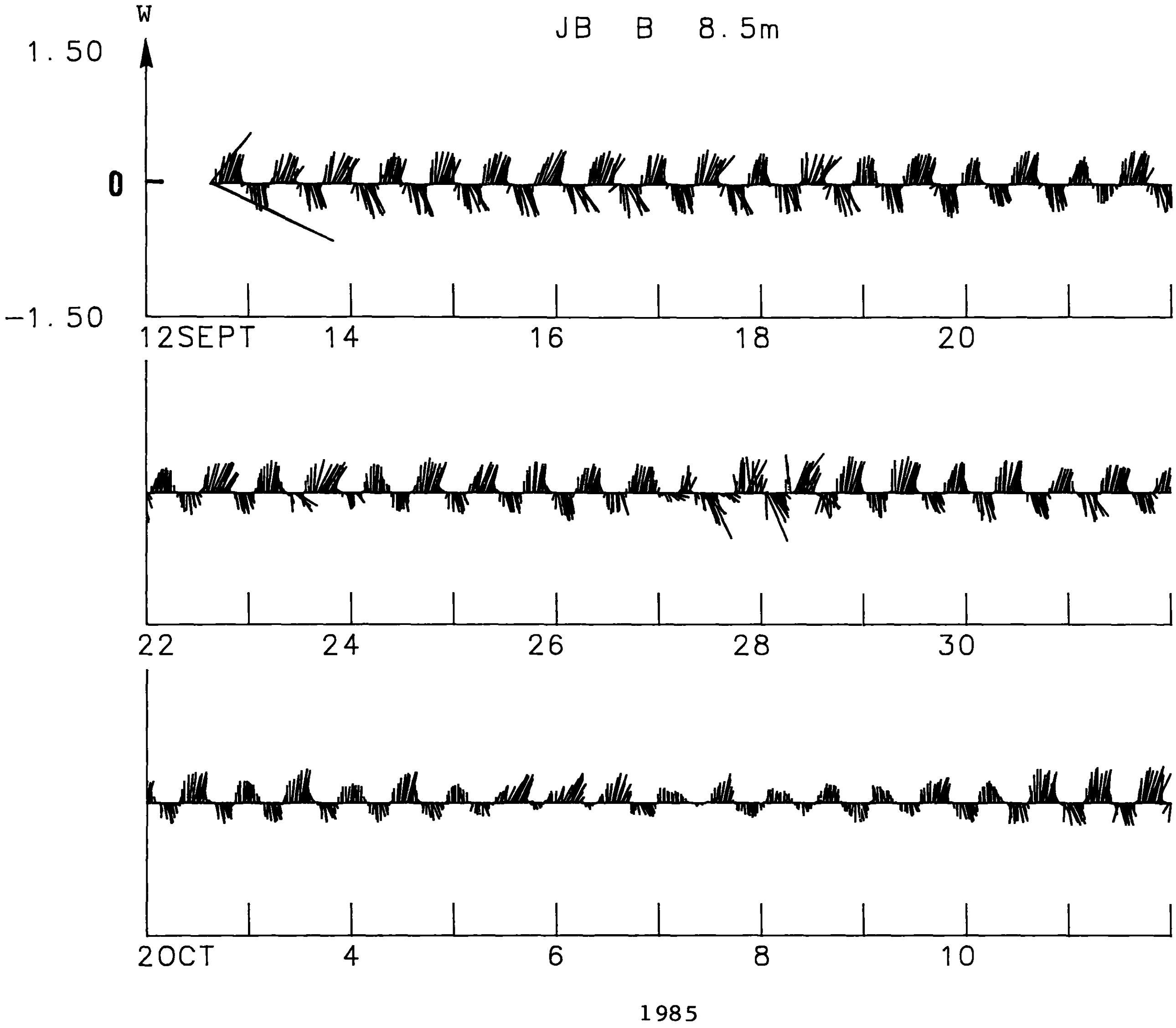
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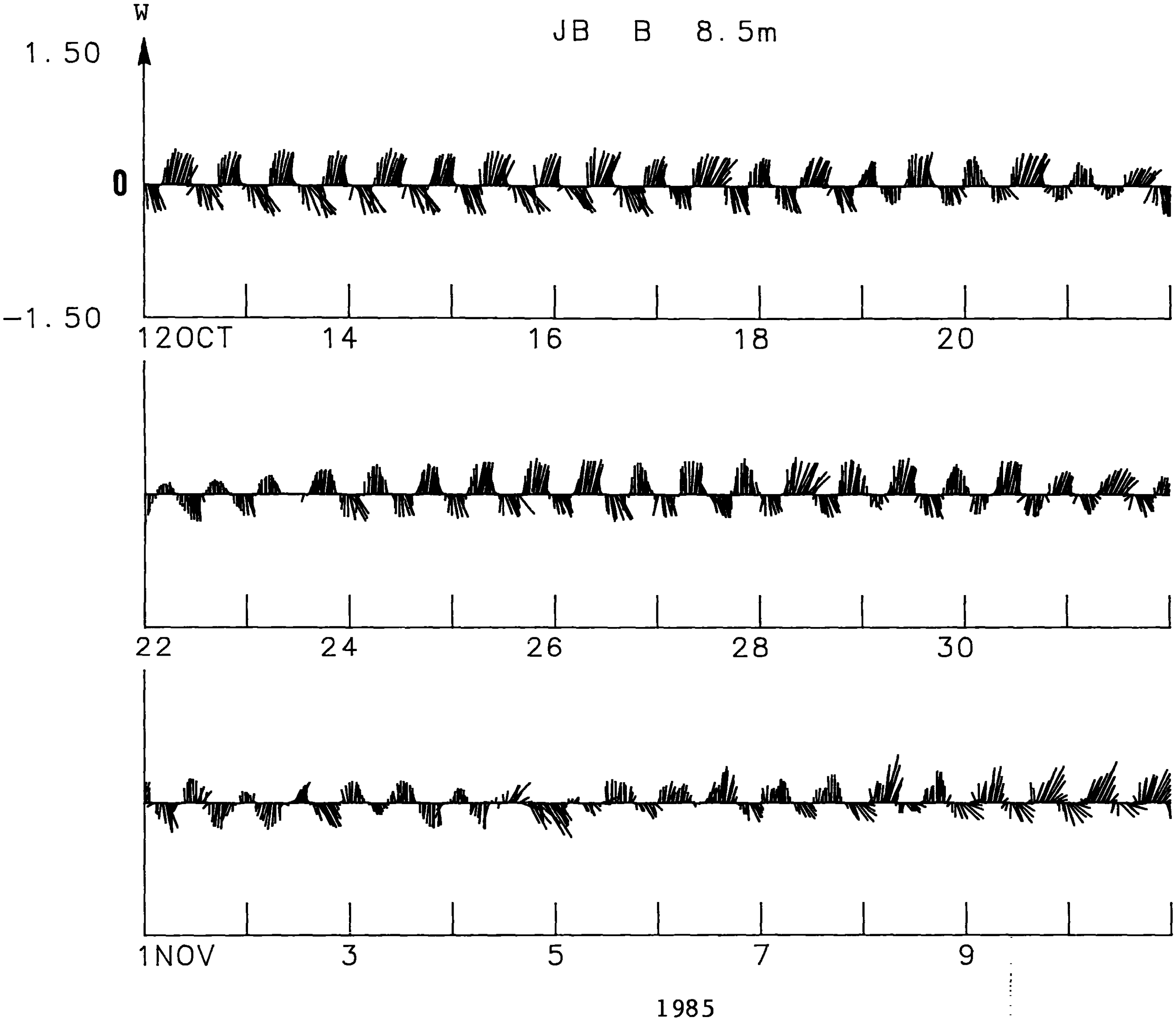

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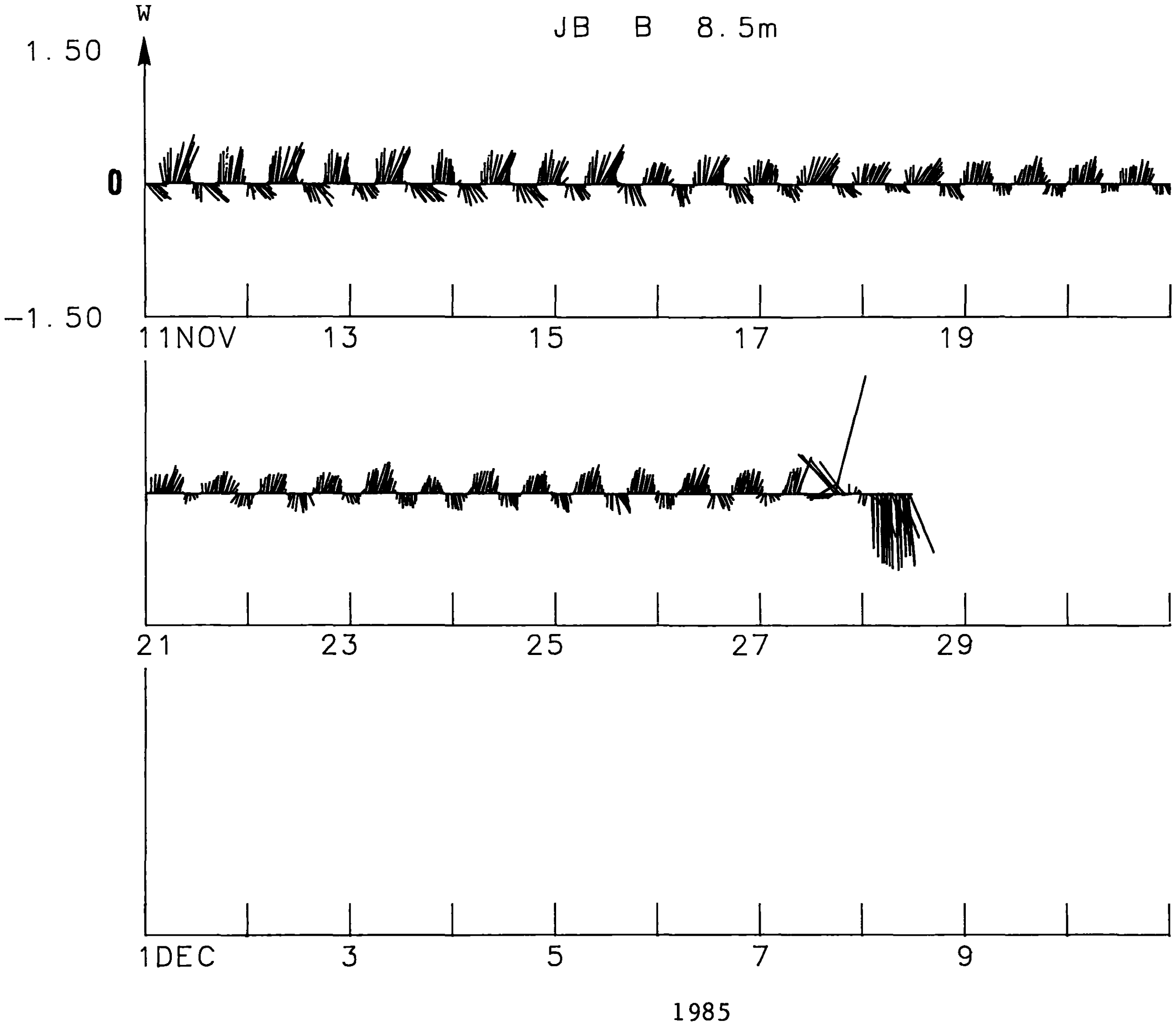

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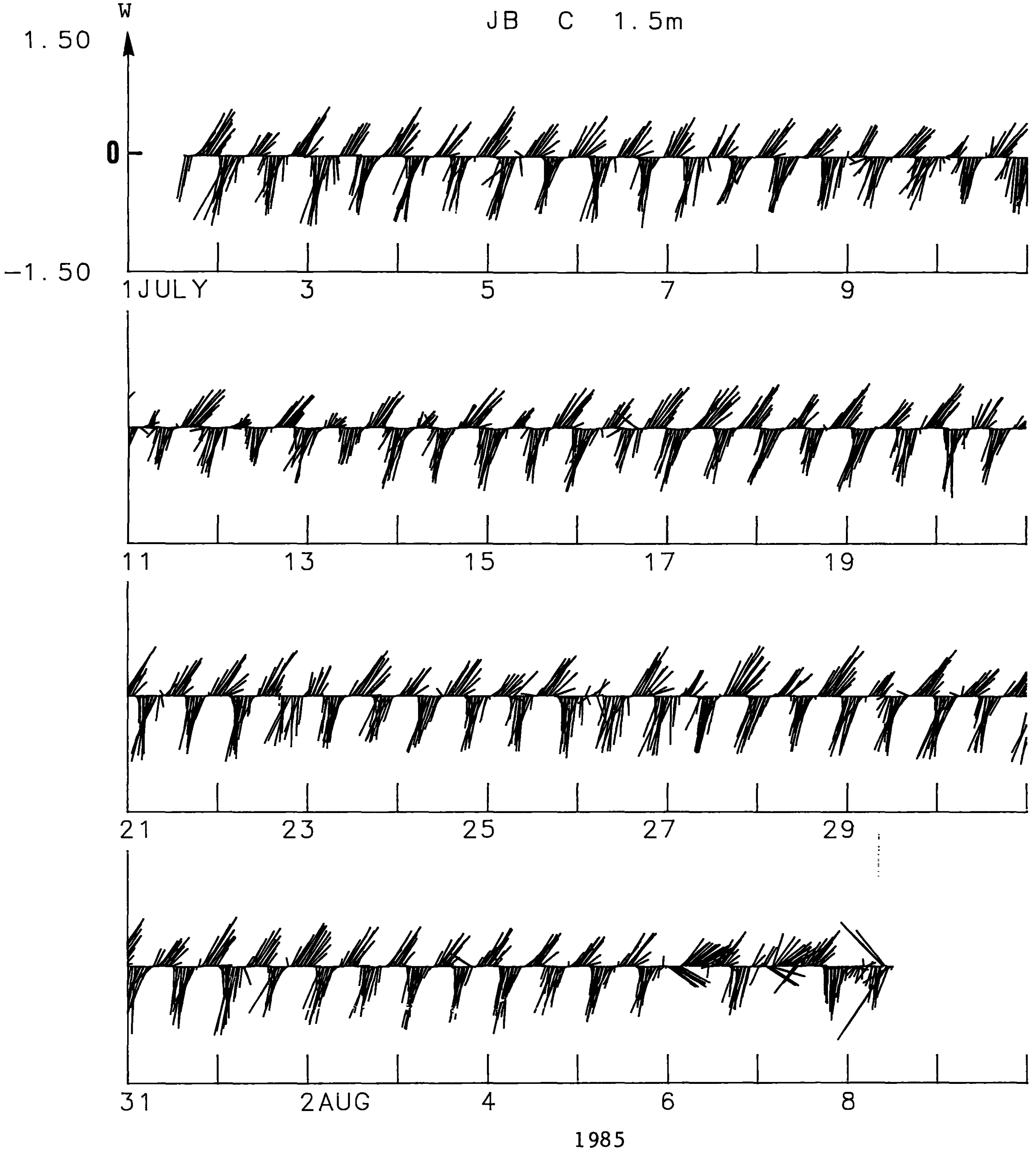
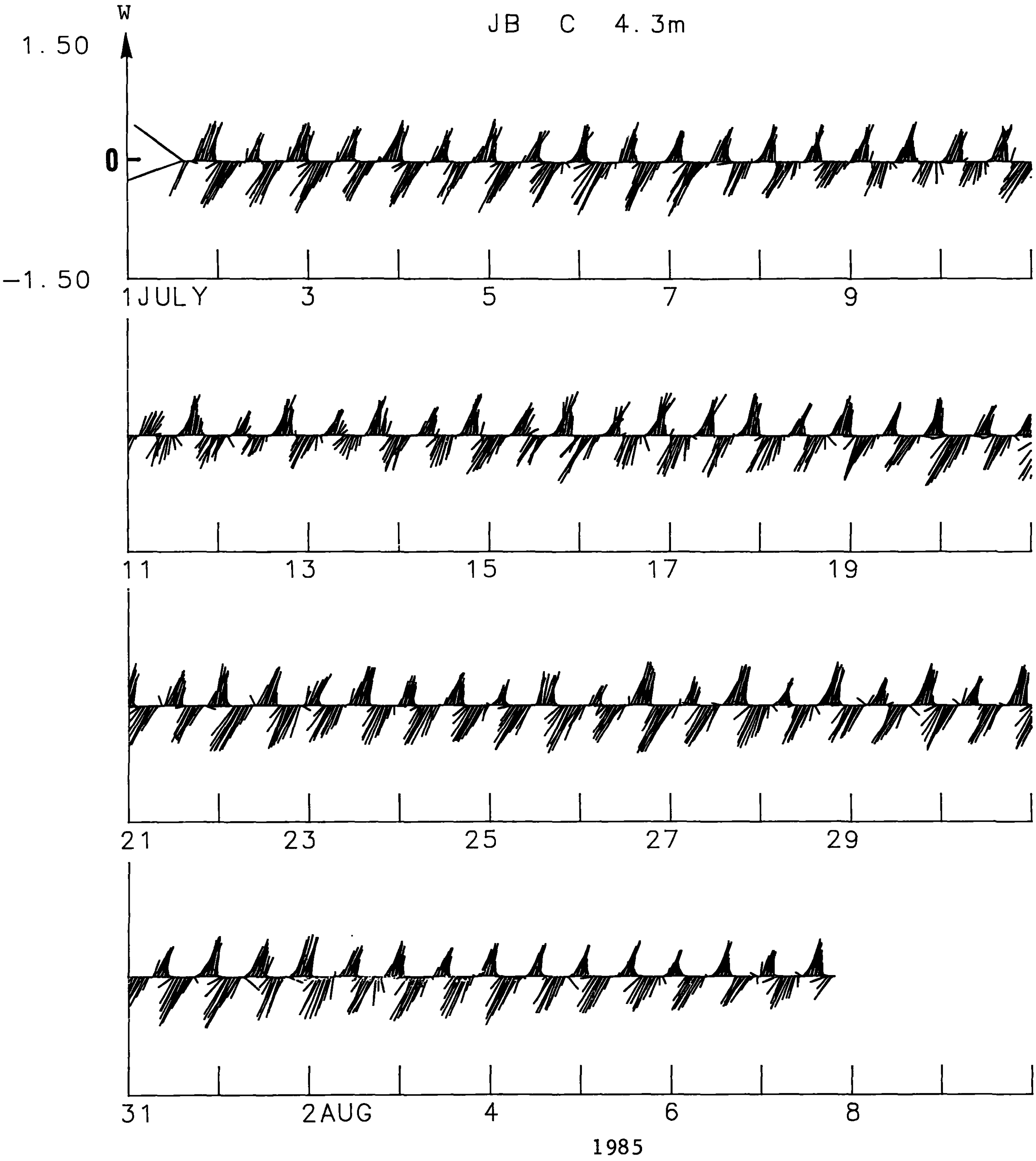
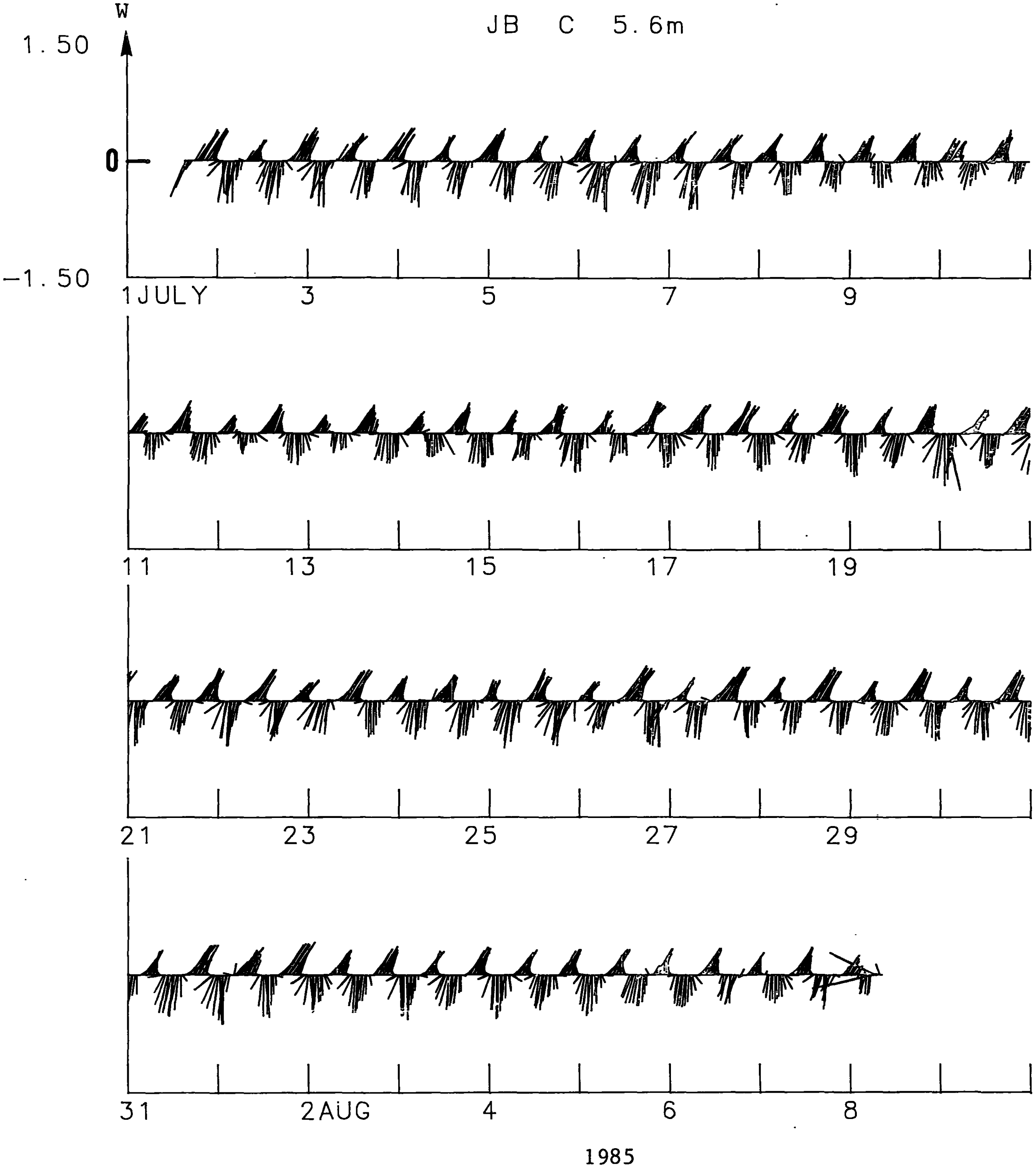


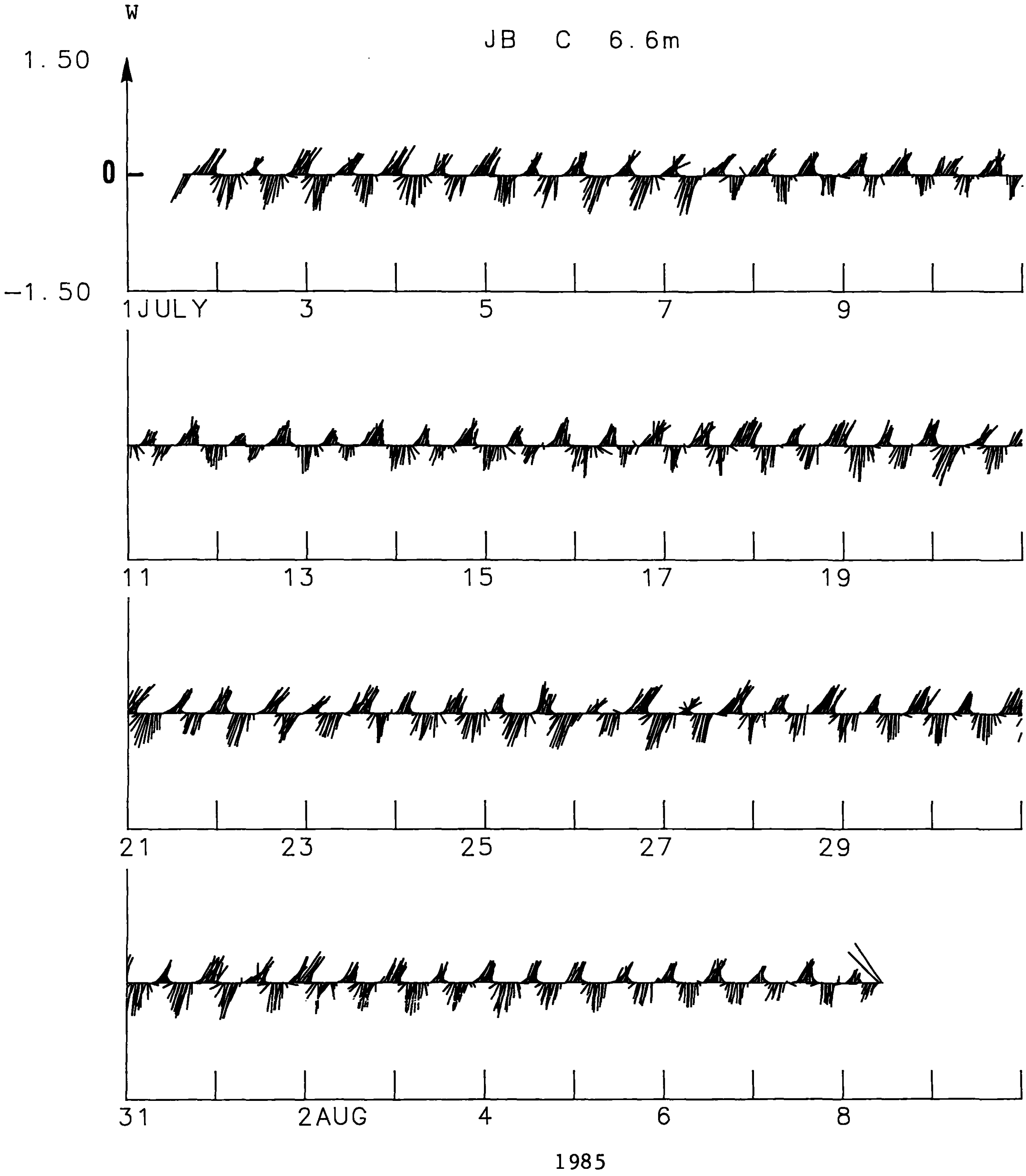
James River Bridge Station C, 1.5 m below surface, scale in m/sec



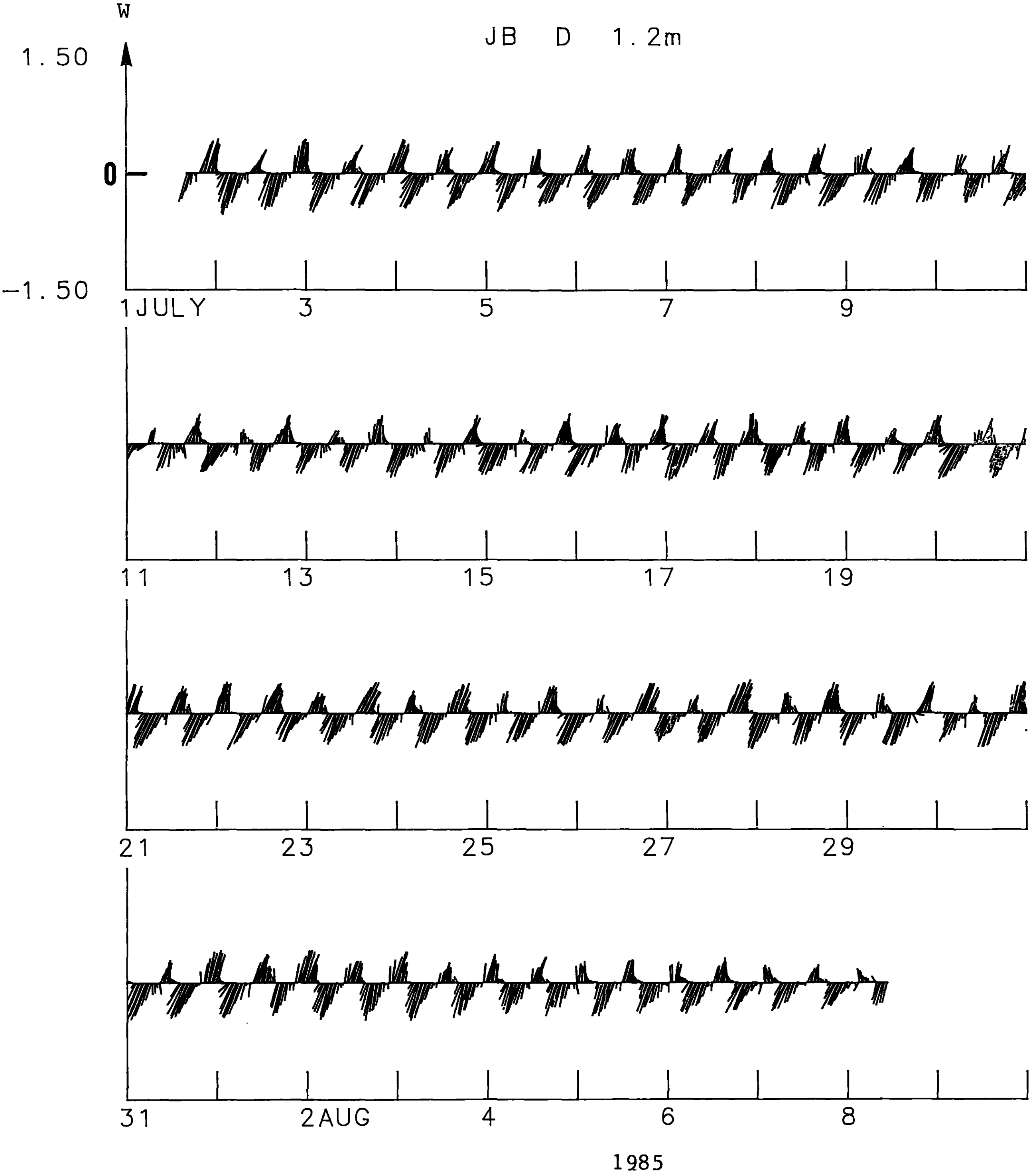
James River Bridge Station C, 4.3 m below surface, scale in m/sec



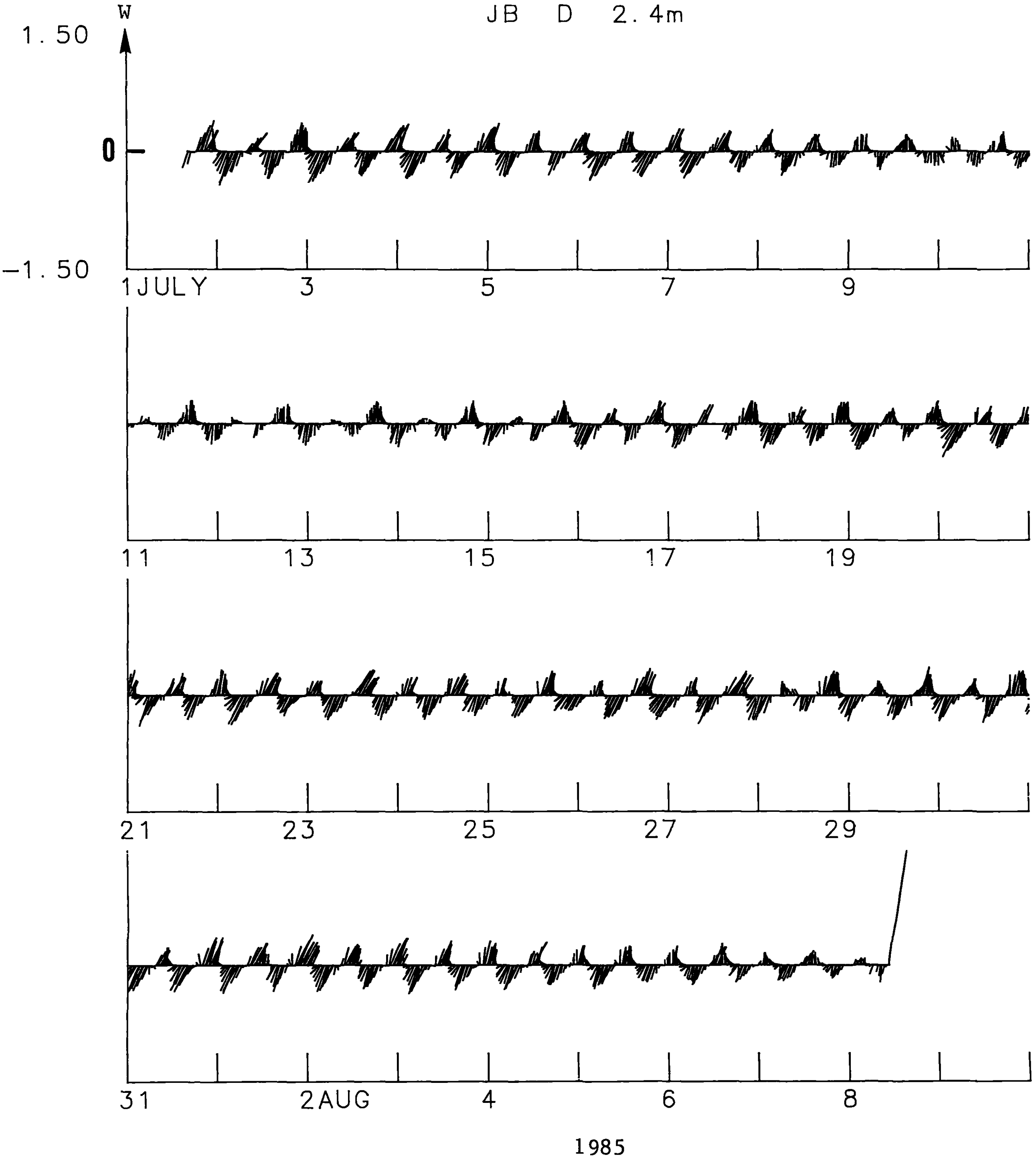
James River Bridge Station C, 5.6 m below surface, scale in m/sec



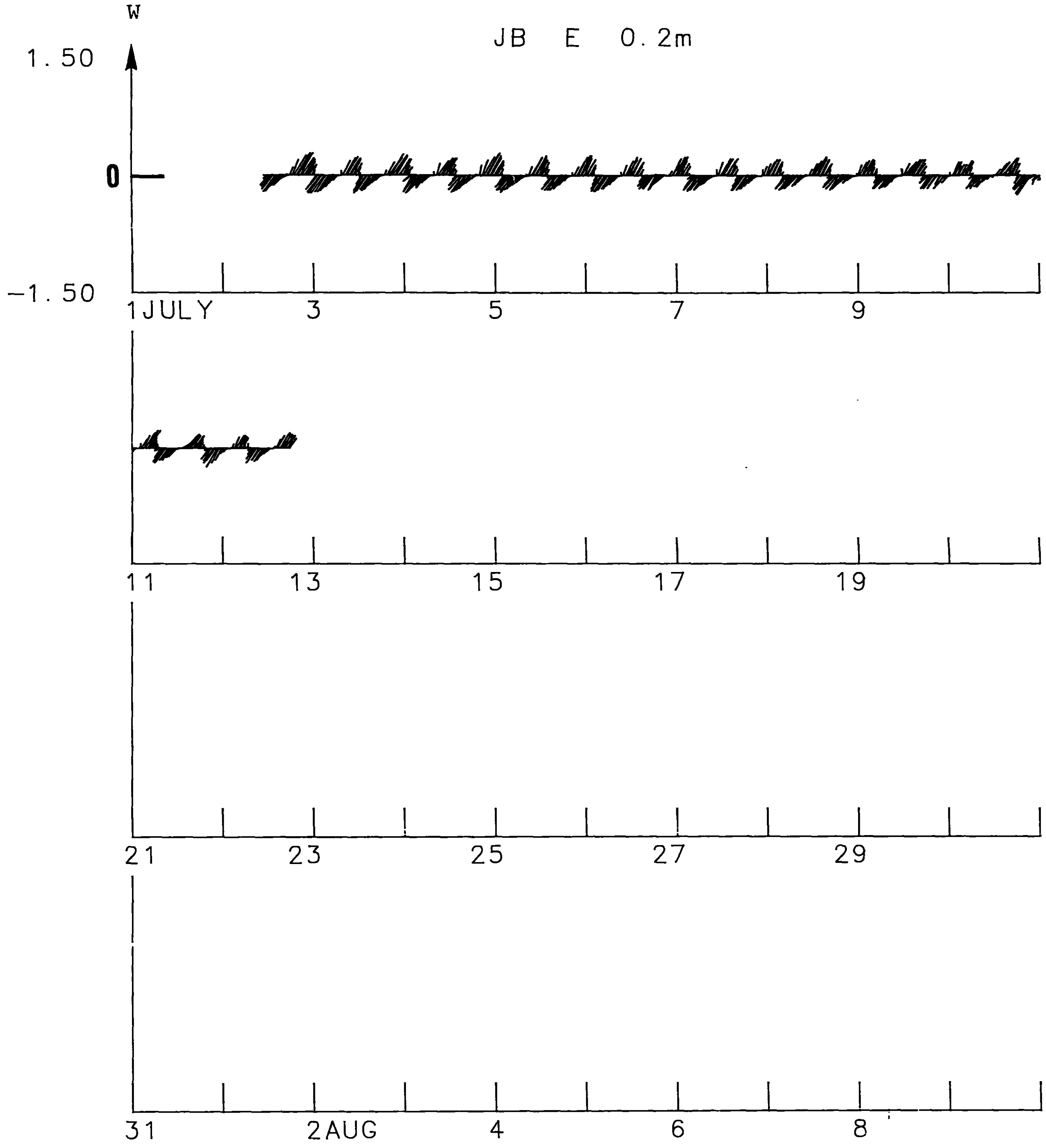
James River Bridge Station C, 6.6 m below surface, scale in m/sec



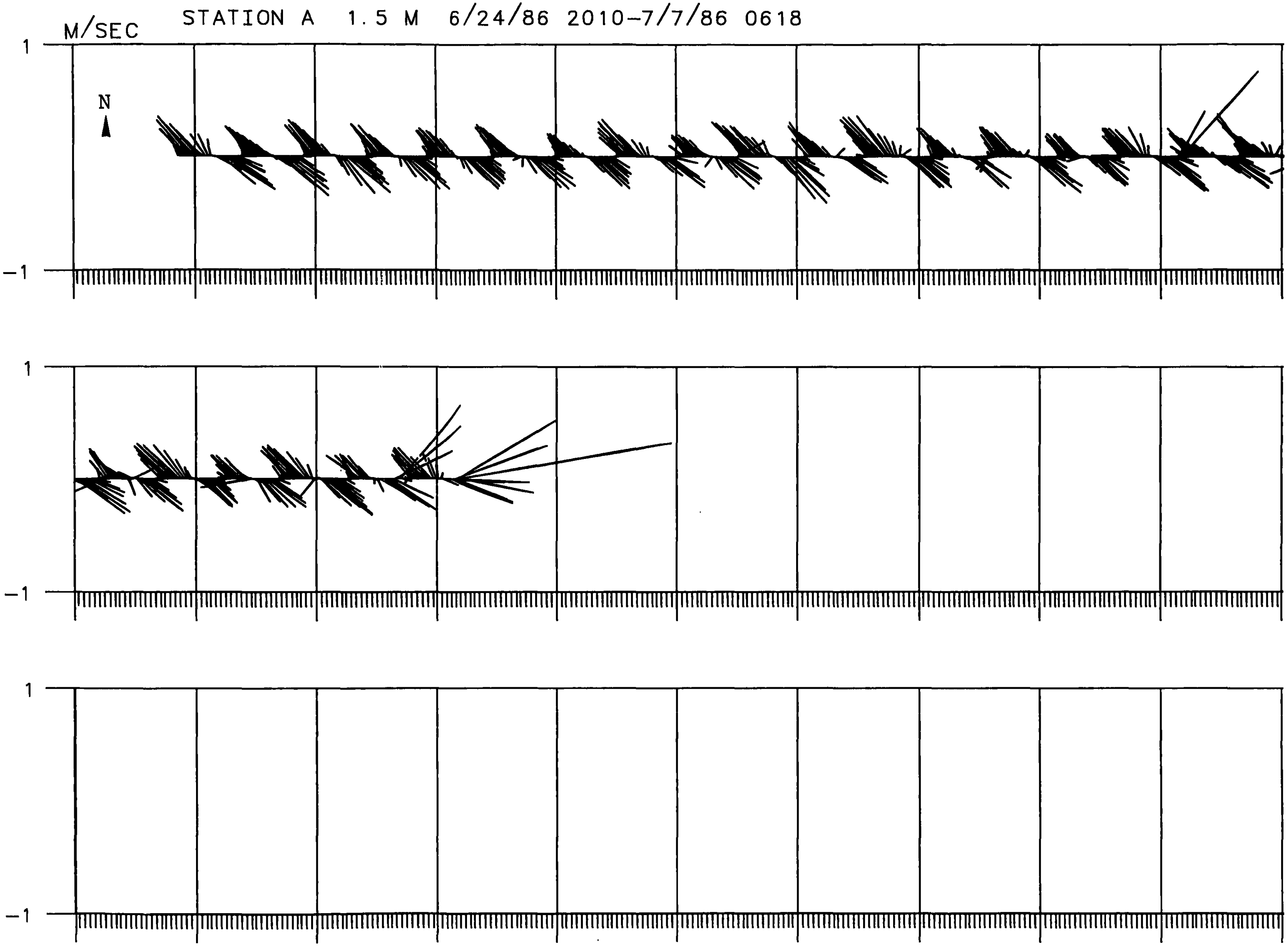
James River Bridge Station D, 1.2 m below surface, scale in m/sec



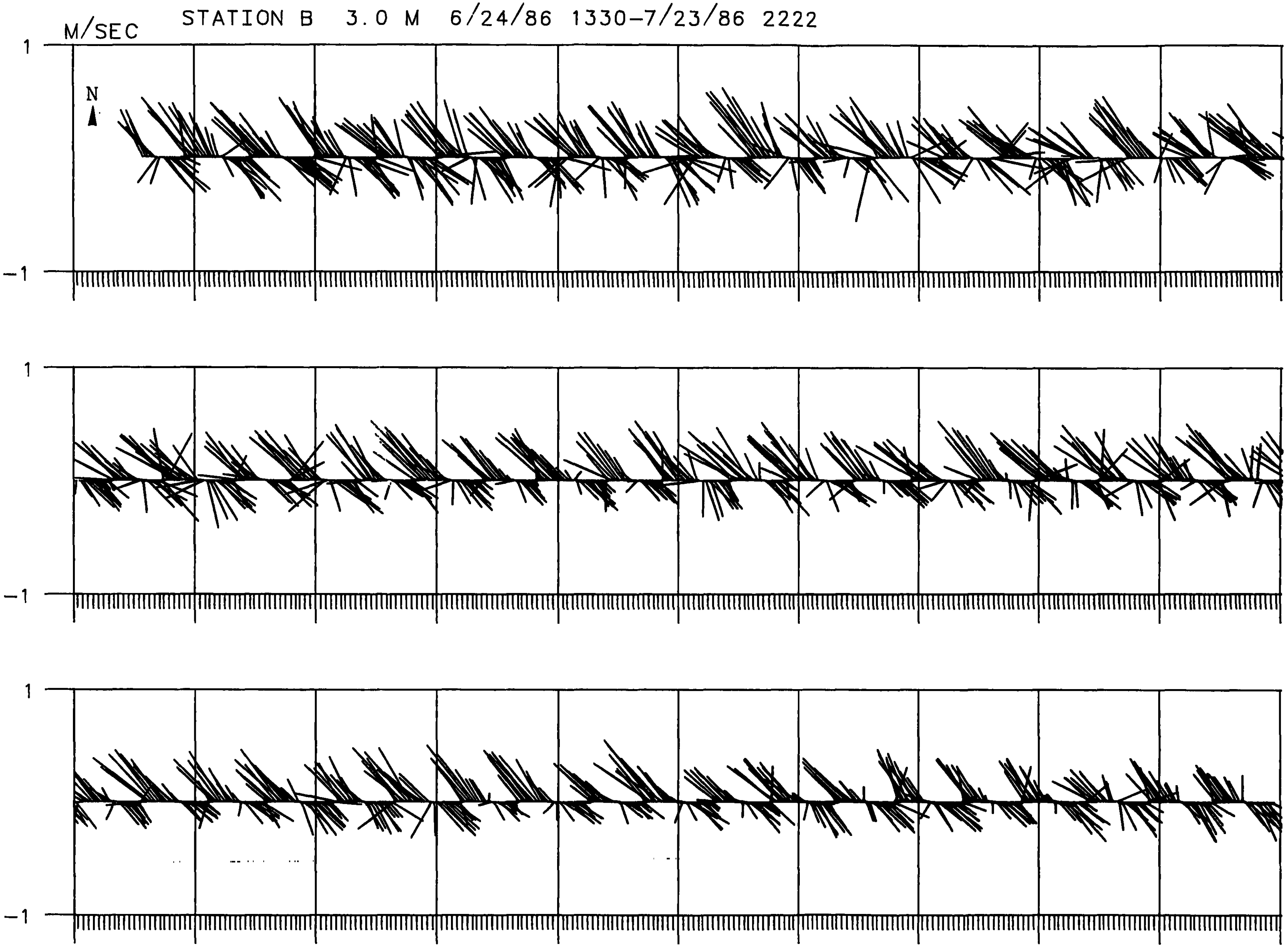
James River Bridge Station D, 2.4 m below surface, scale in m/sec



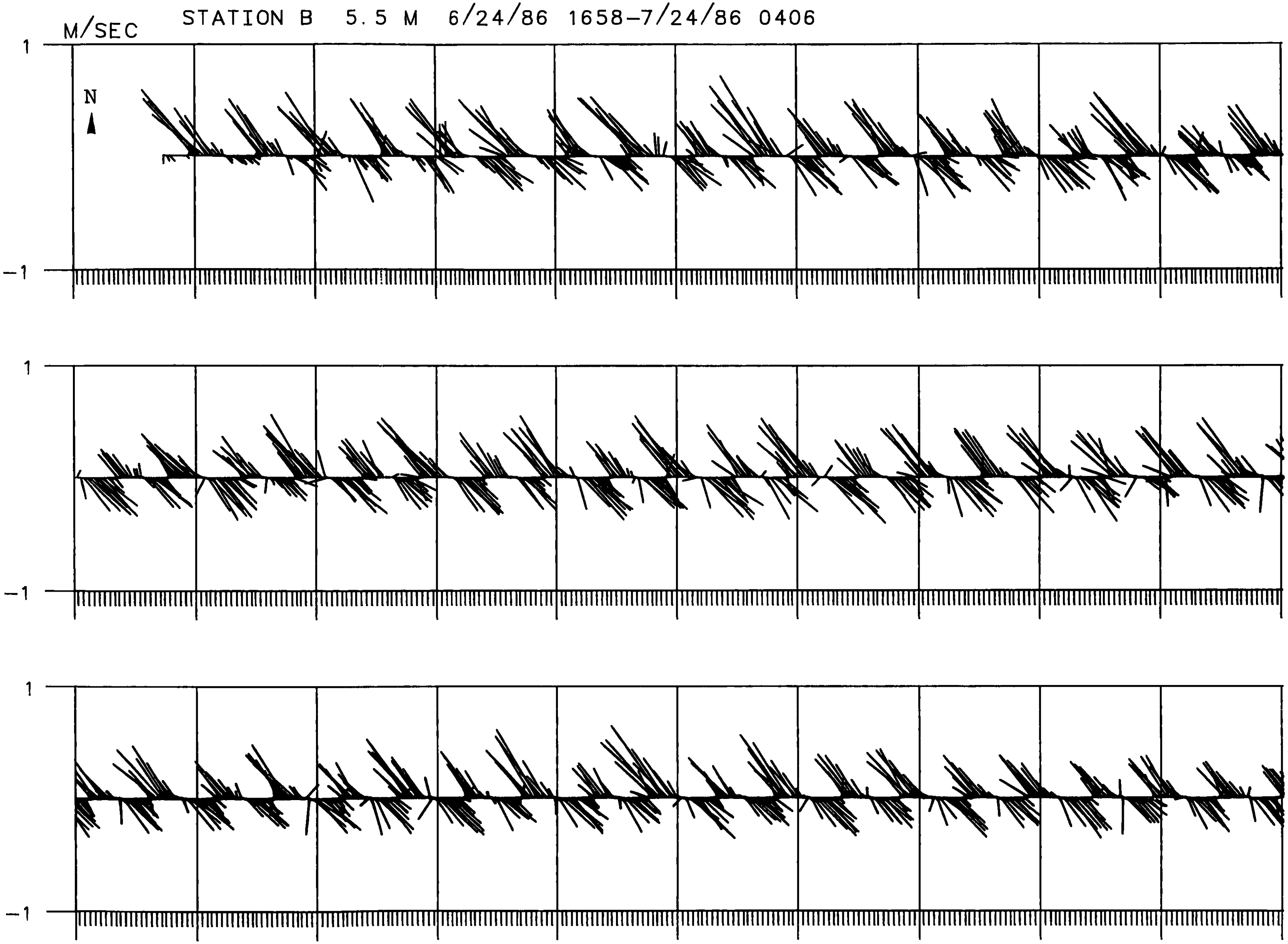
James River Bridge Station E, 0.2 m below surface, scale in m/sec



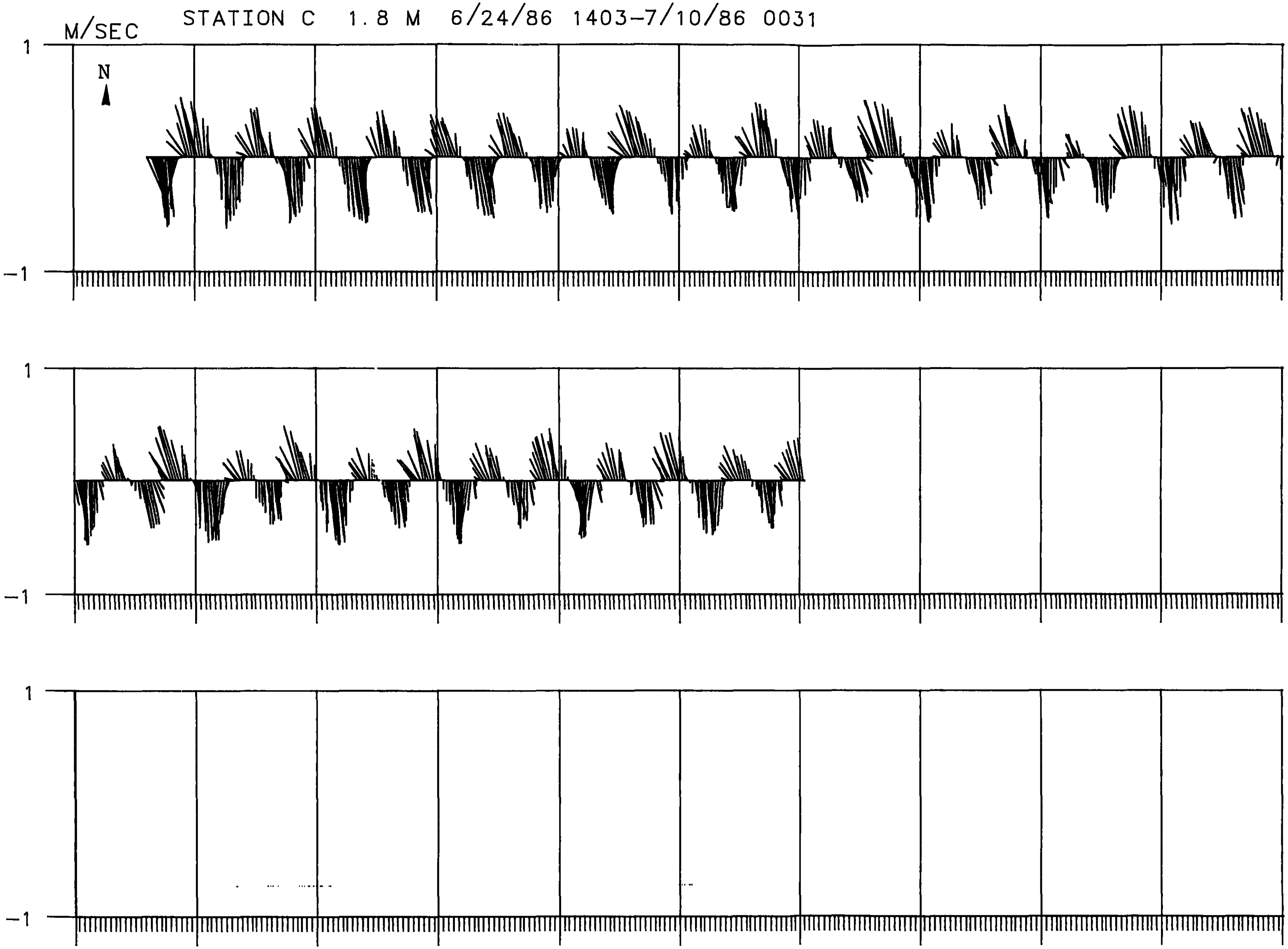
Burwell Bay Station A, 1.5 m below surface, scale in m/sec



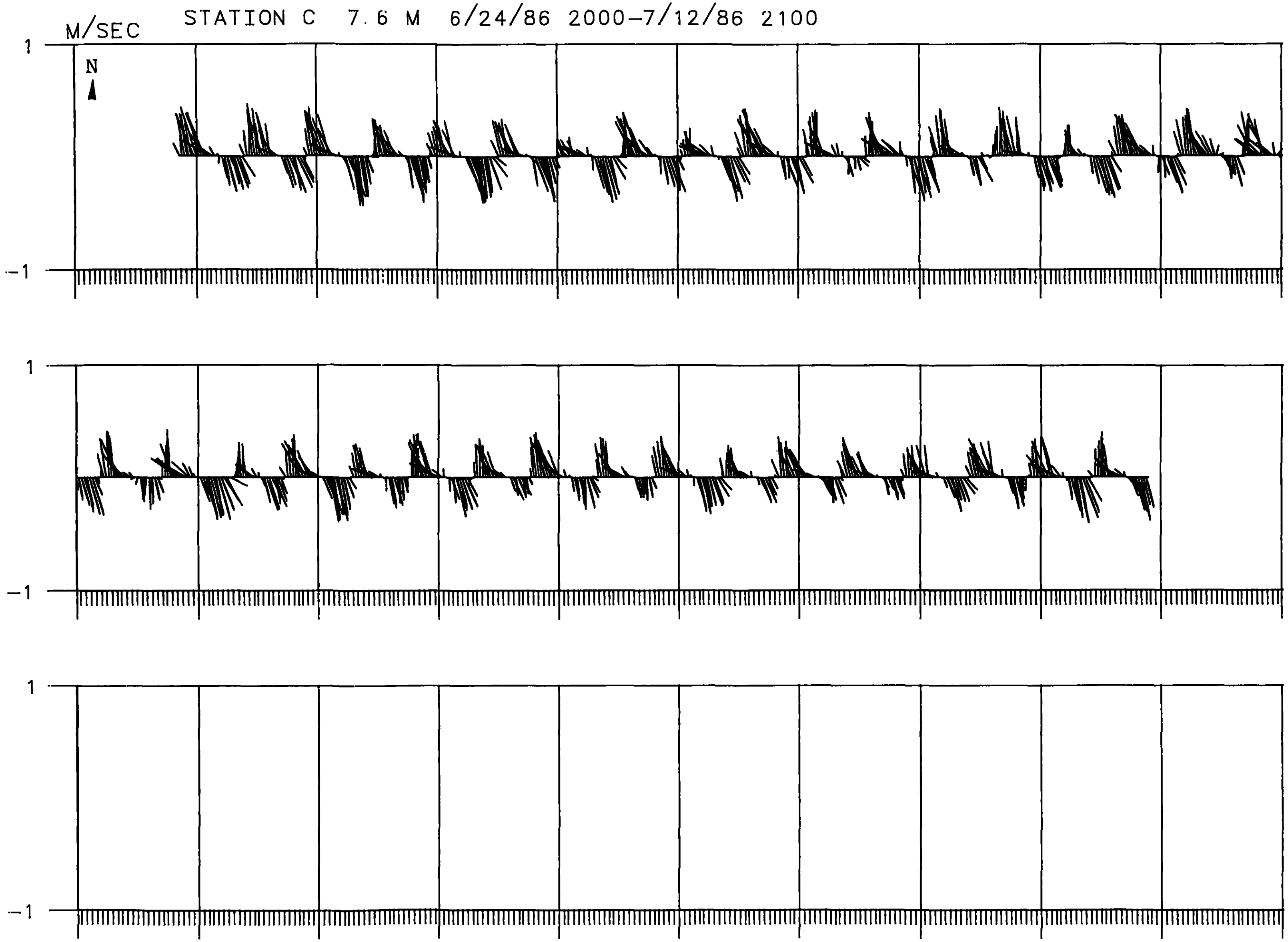
Burwell Bay Station B, 3.0 m below surface, scale in m/sec



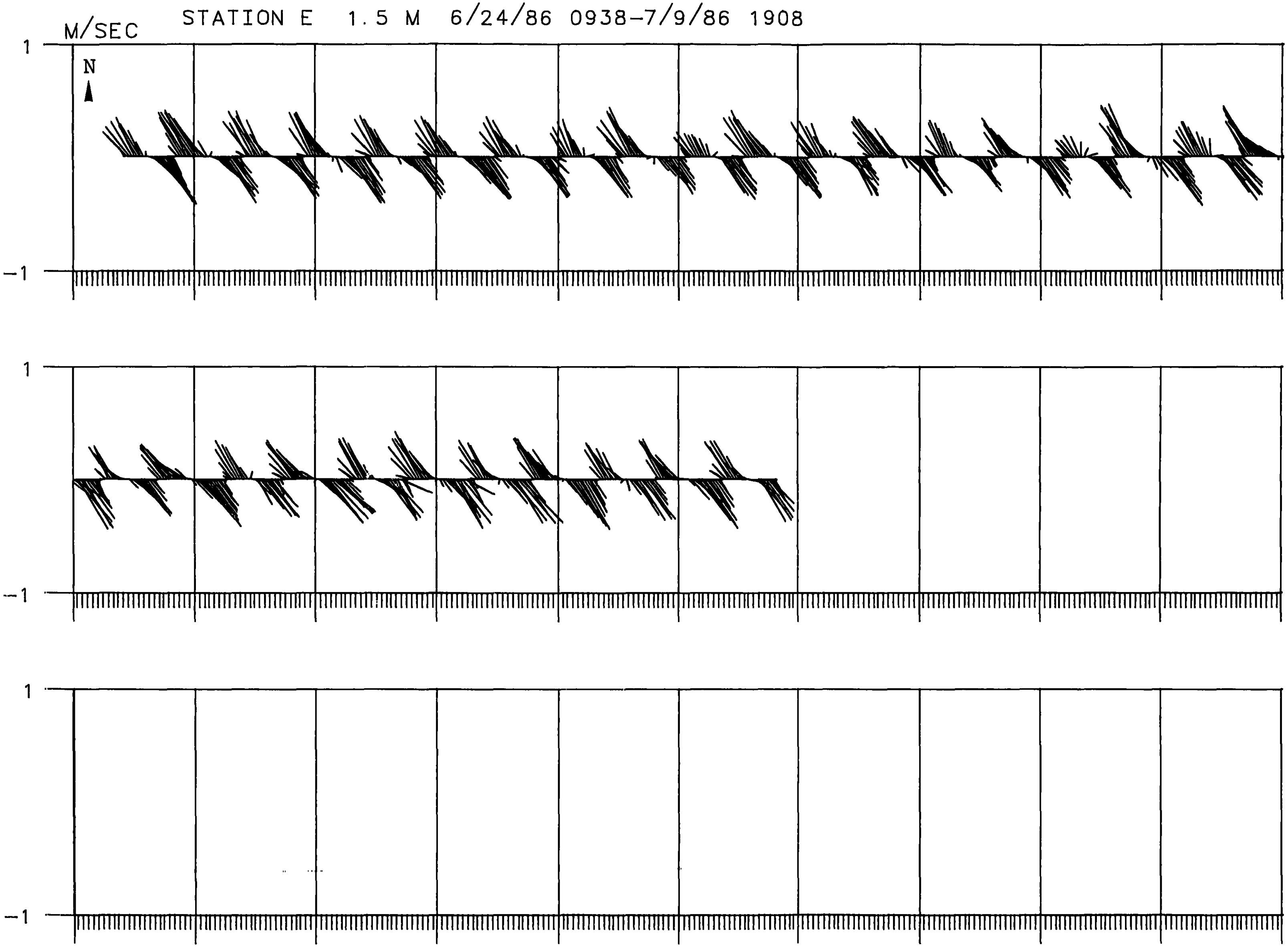
Burwell Bay Station B, 5.5 m below surface, scale in m/sec



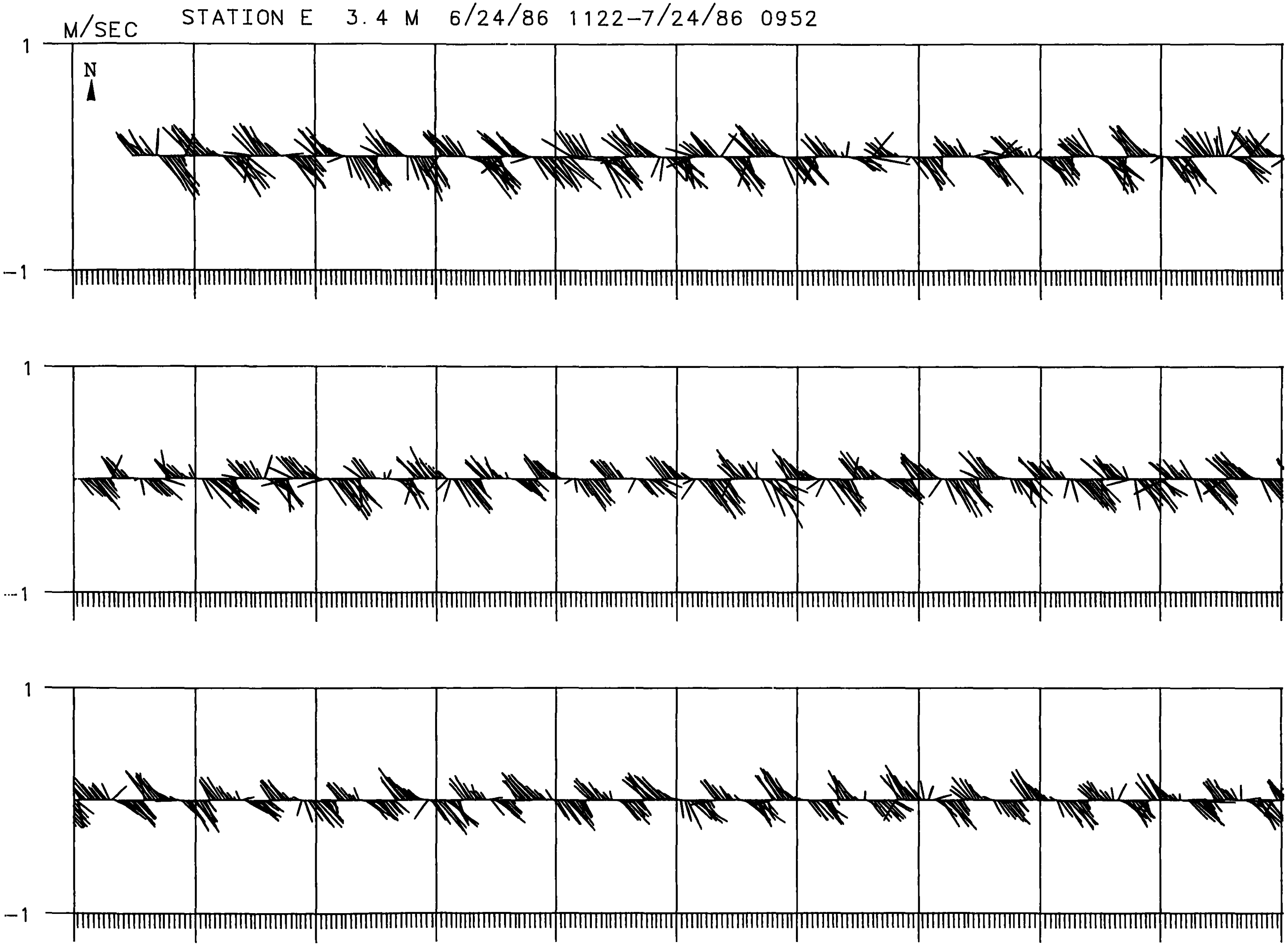
Burwell Bay Station C, 1.8 m below surface, scale in m/sec



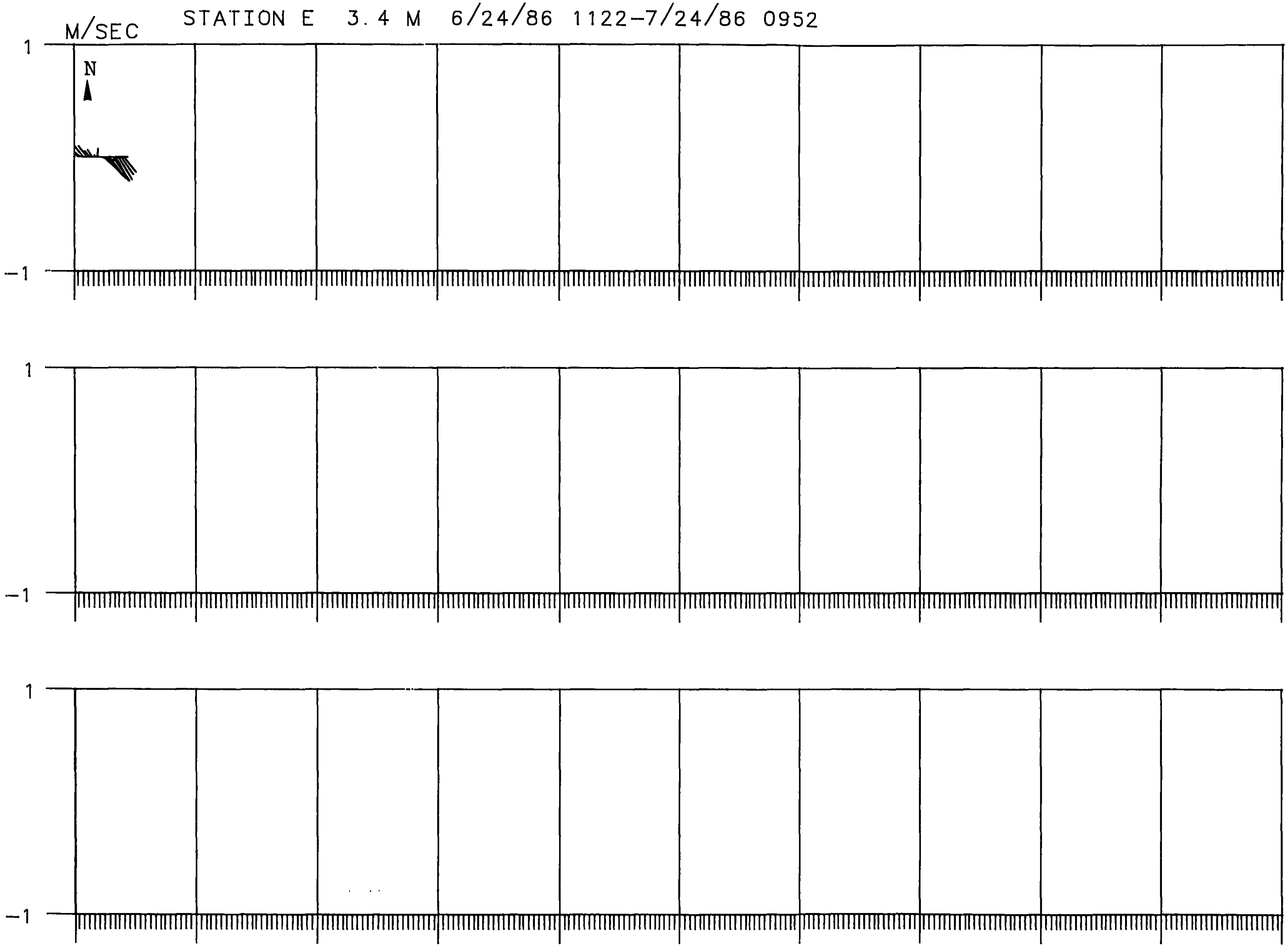
Burwell Bay Station C, 7.6 m below surface, scale in m/sec



Burwell Bay Station E, 1.5 m below surface, scale in m/sec



Burwell Bay Station E, 3.4 m below surface, scale in m/sec



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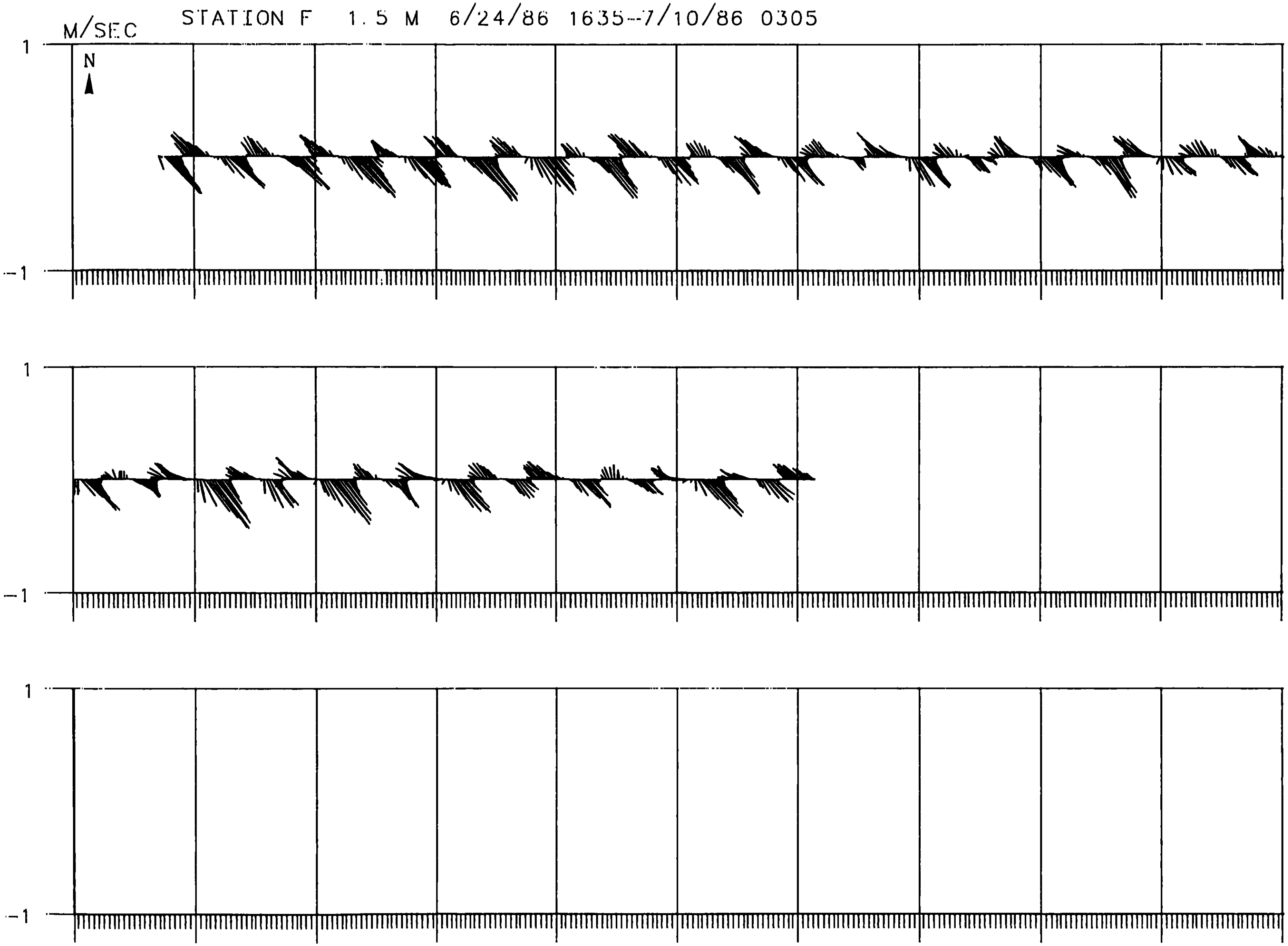
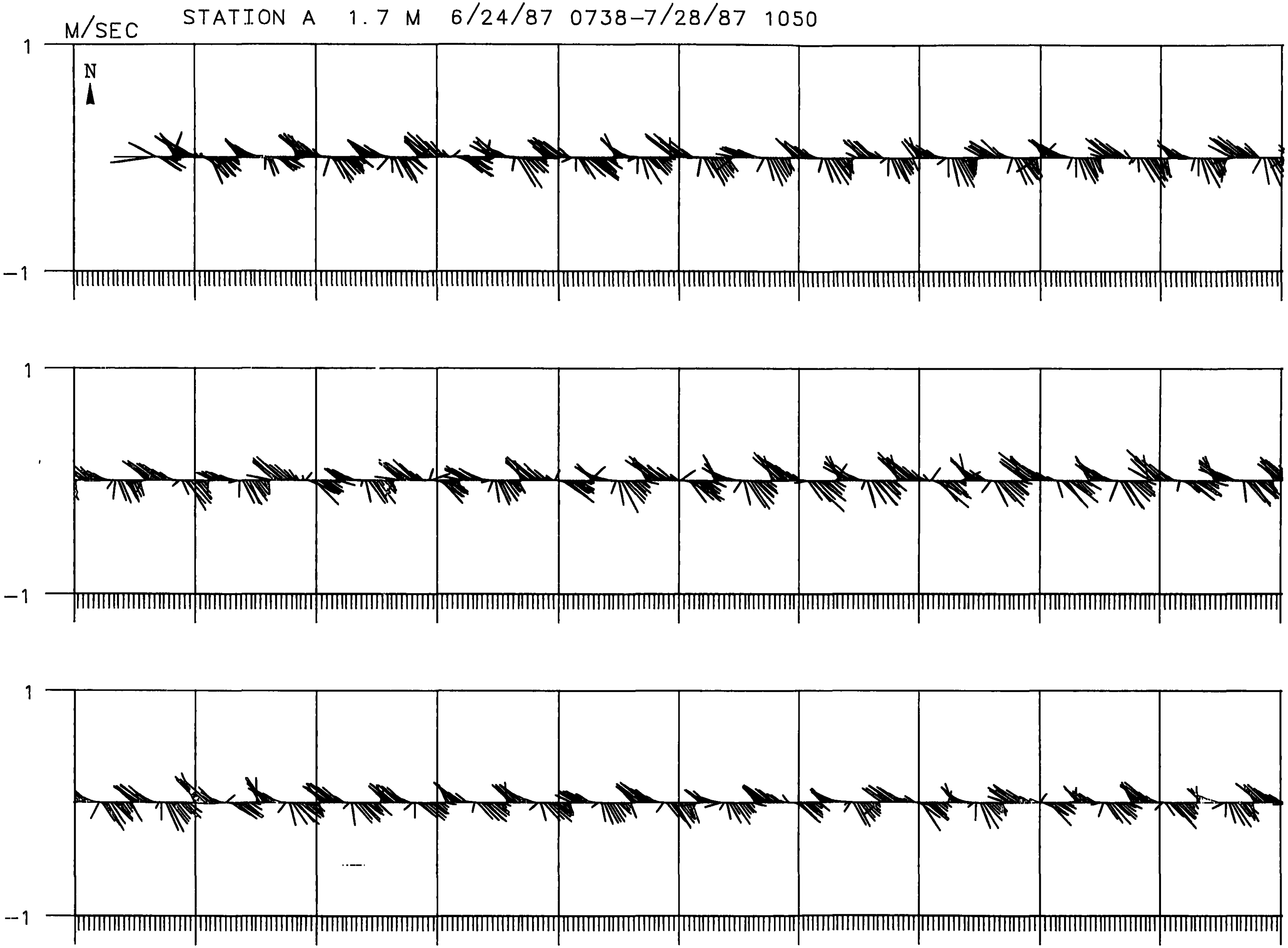
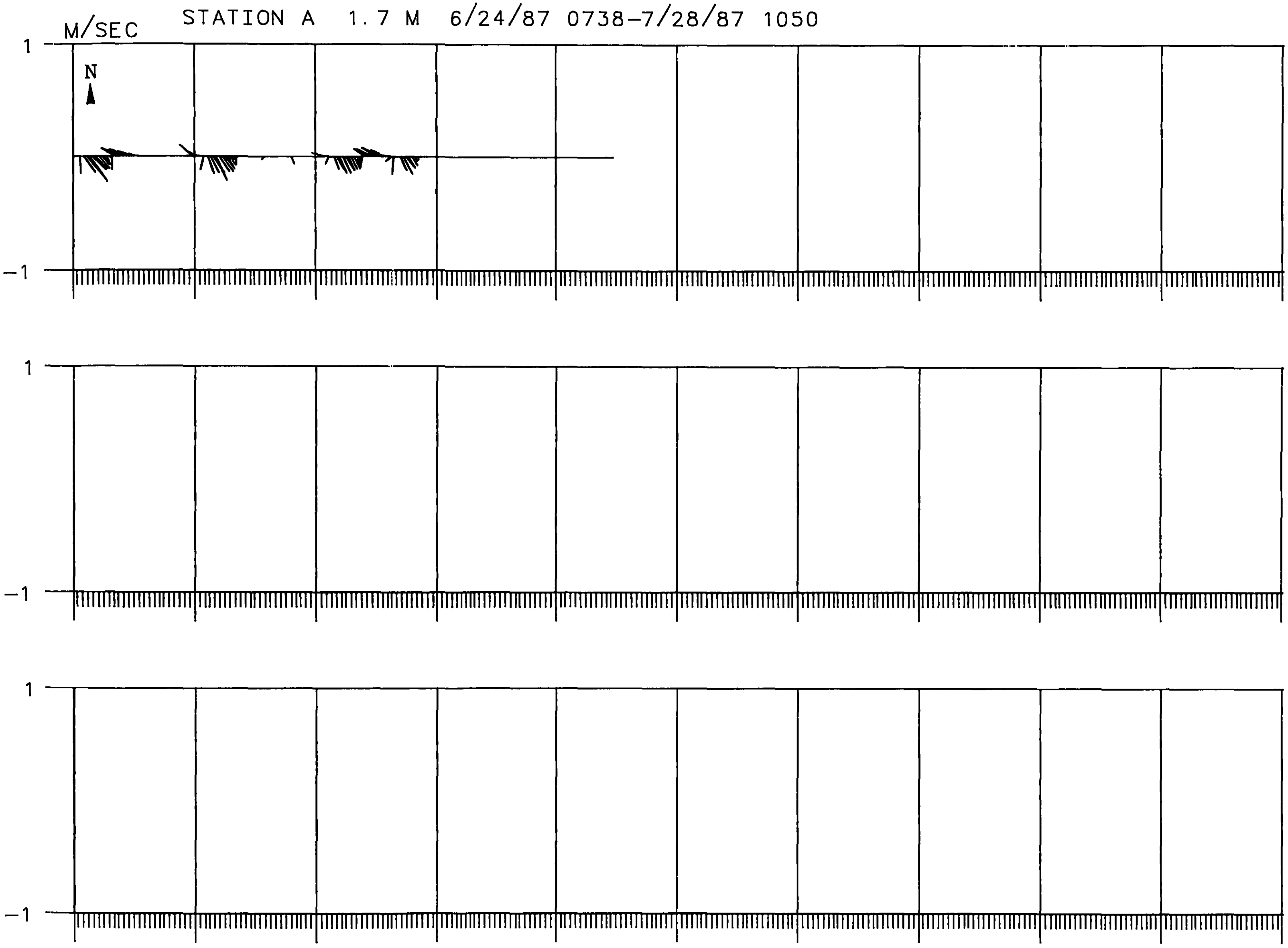


Burwell Bay Station F, 1.5 m below surface, scale in m/sec



Burwell Bay Station A, 1.7 m below surface, scale in m/sec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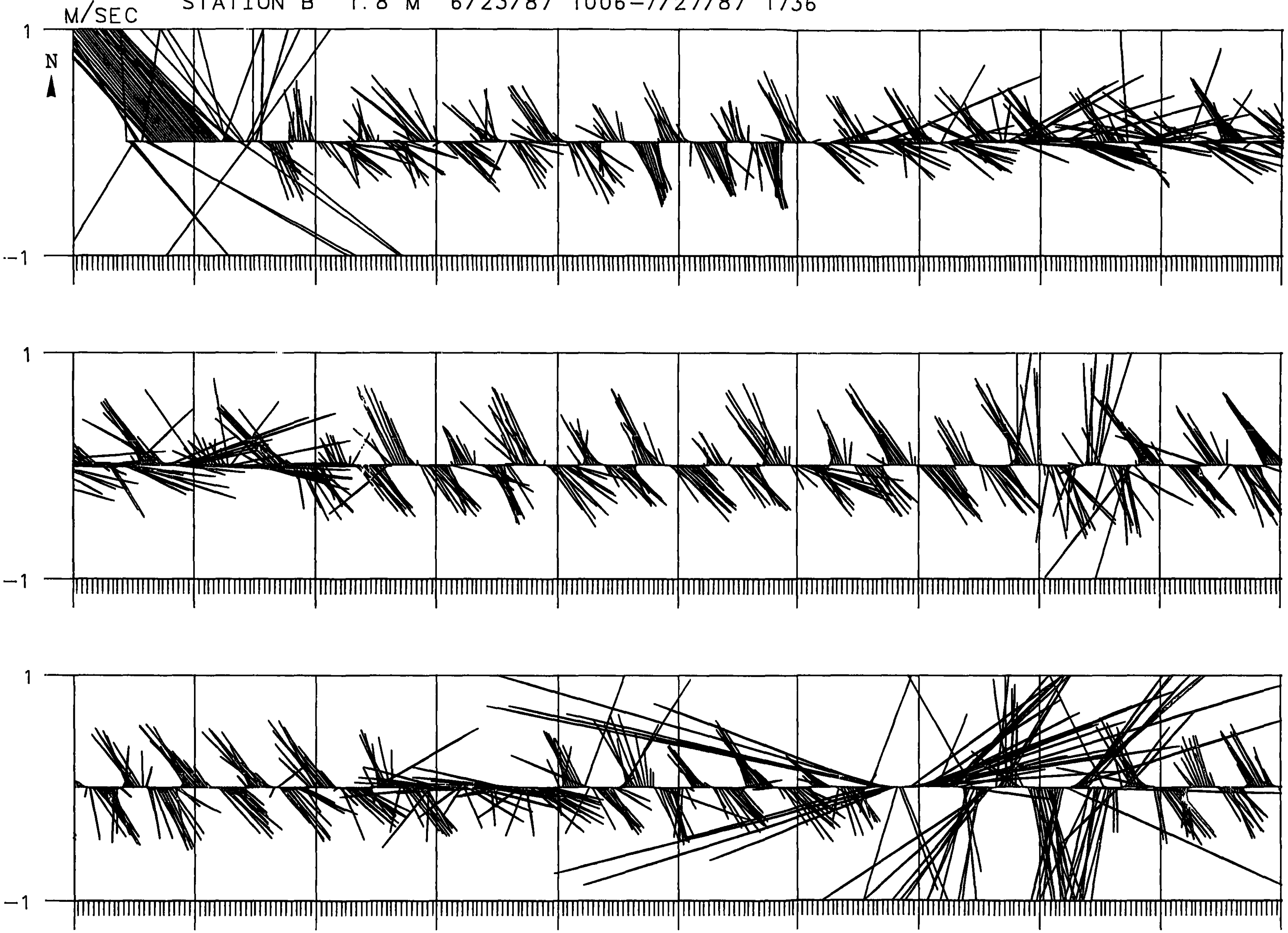
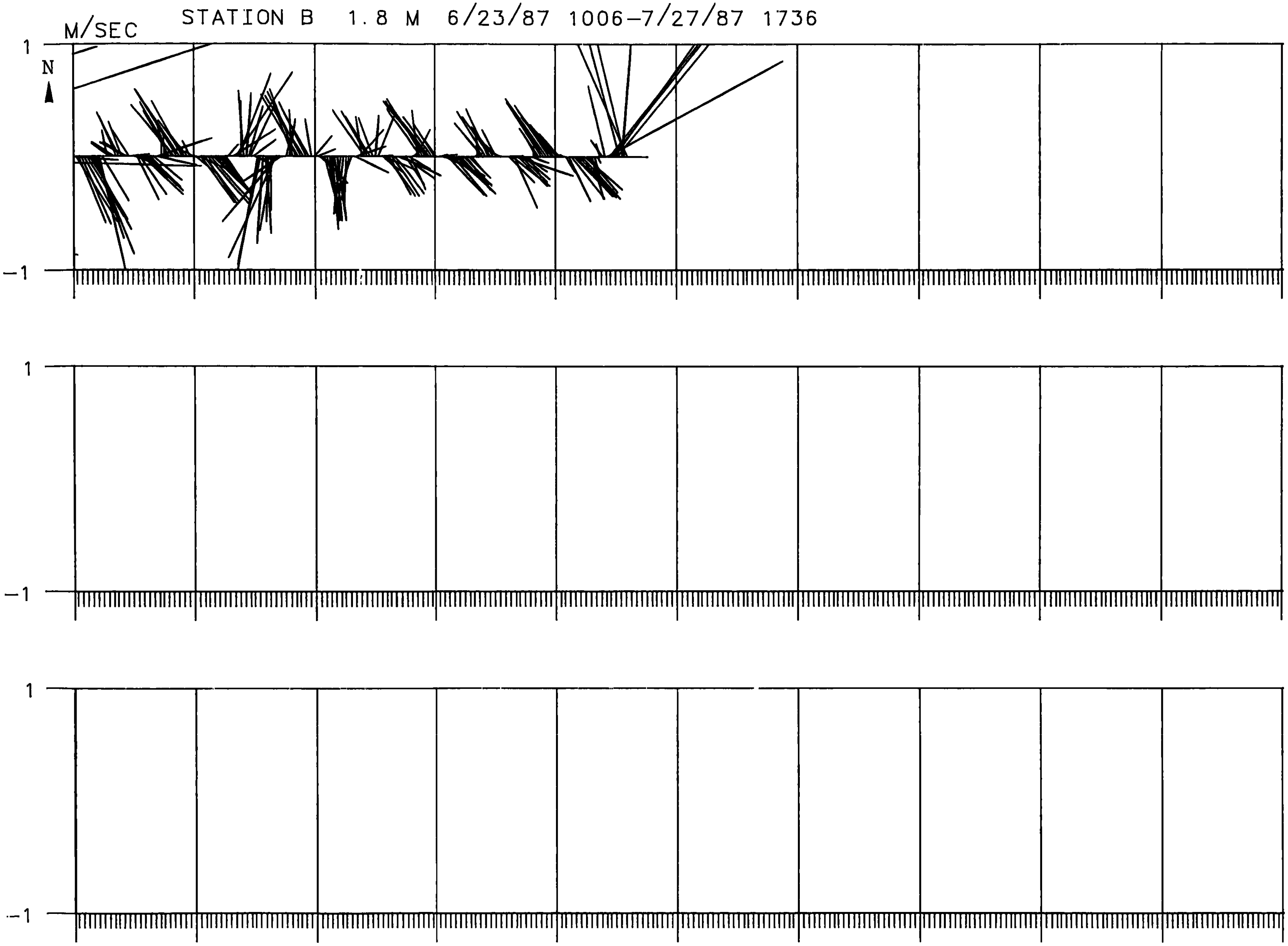


Burwell Bay Station B, 1.8 m below surface, scale in m/sec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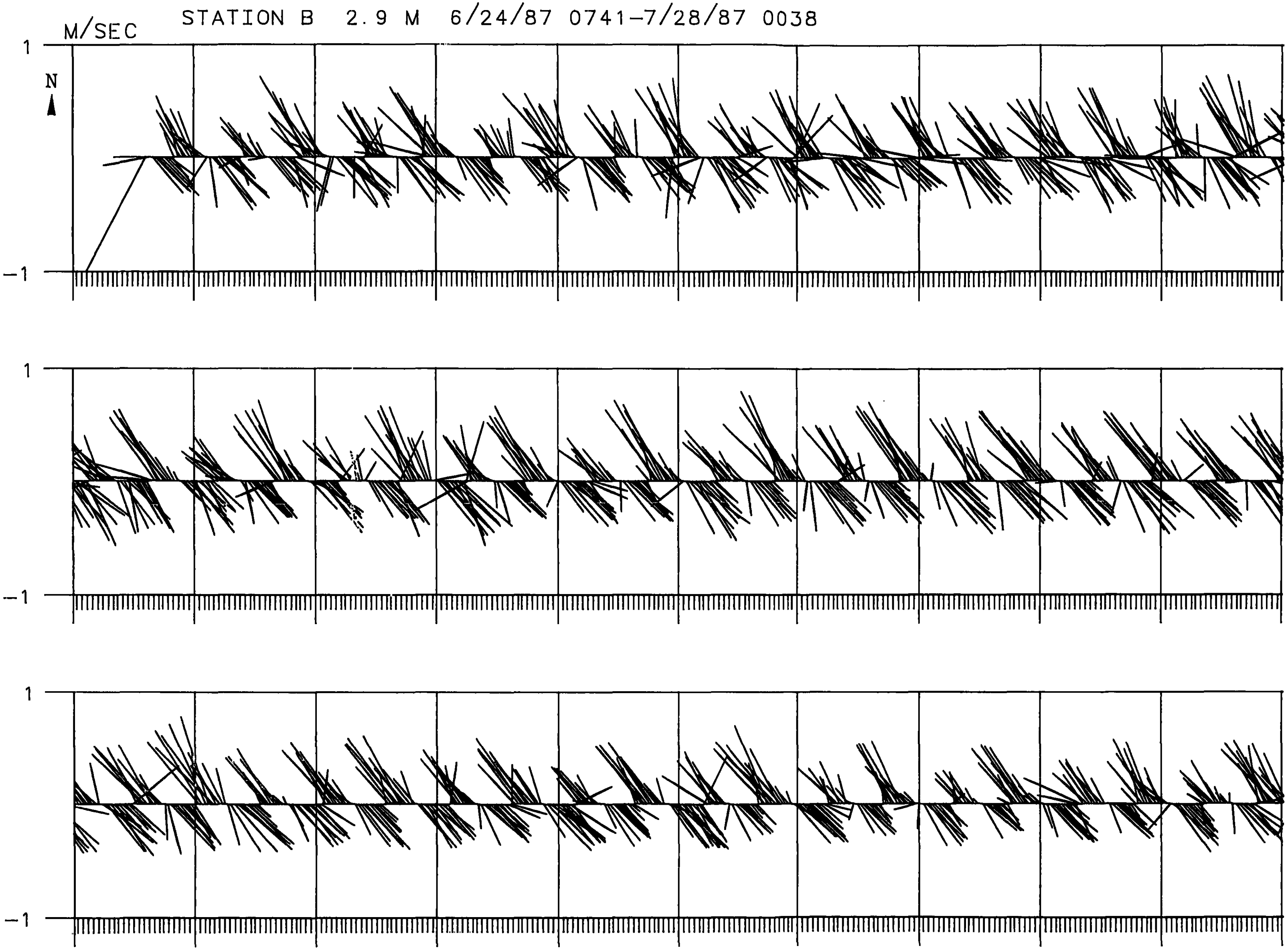
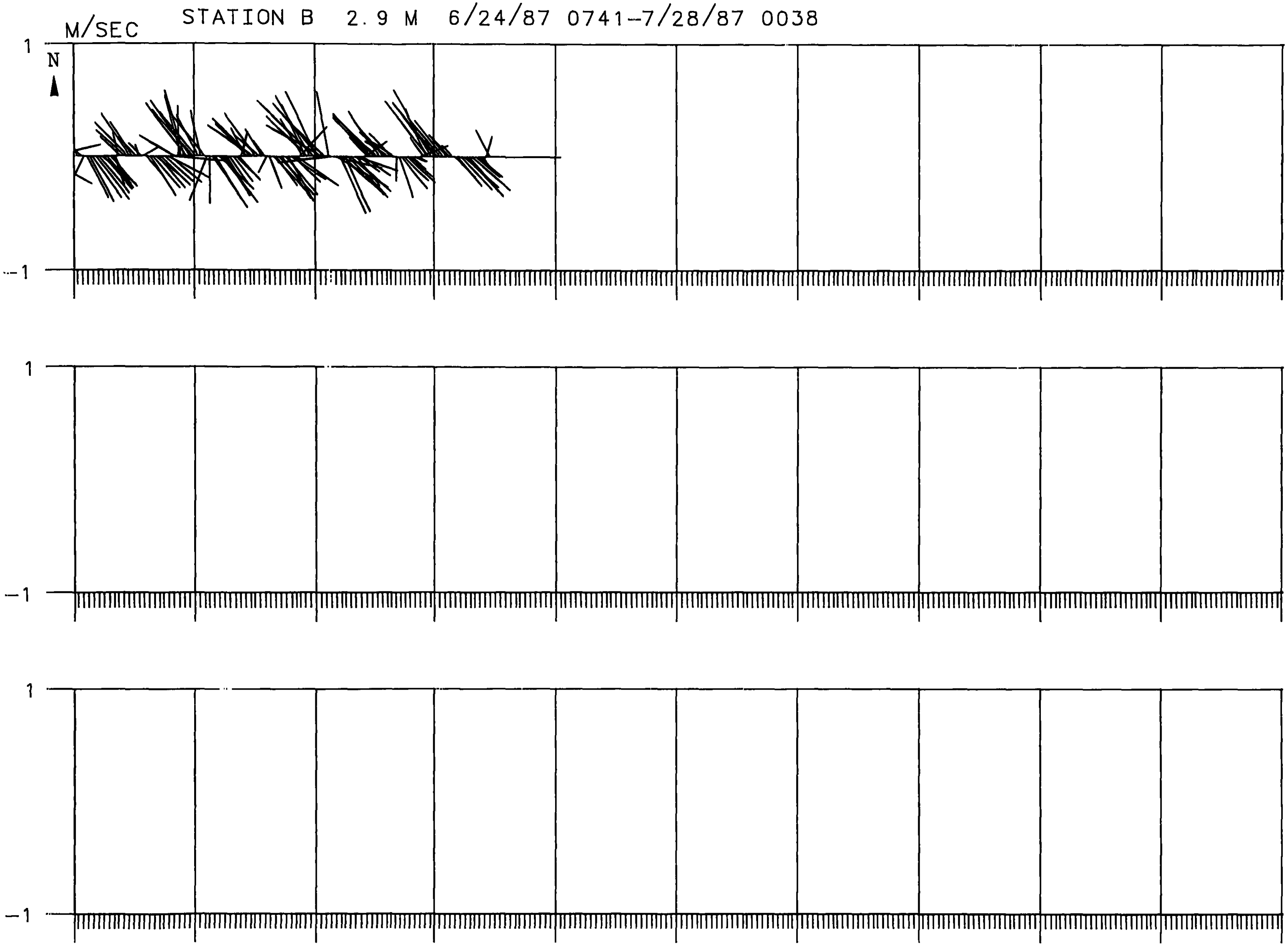


Burwell Bay Station B, 2.9 m below surface, scale in m/sec


STATION B 2.9 M 6/24/87 0741–7/28/87 0038

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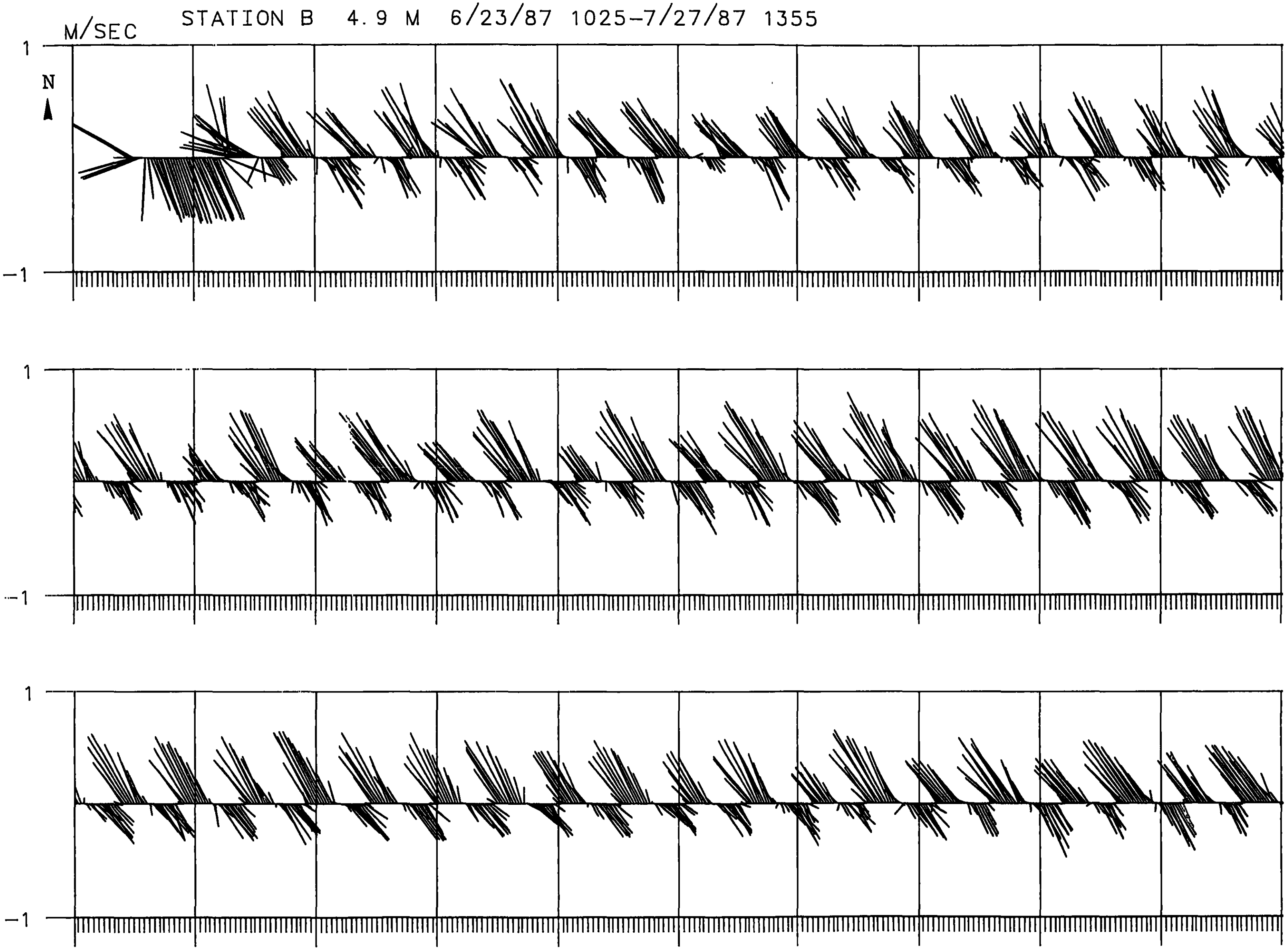
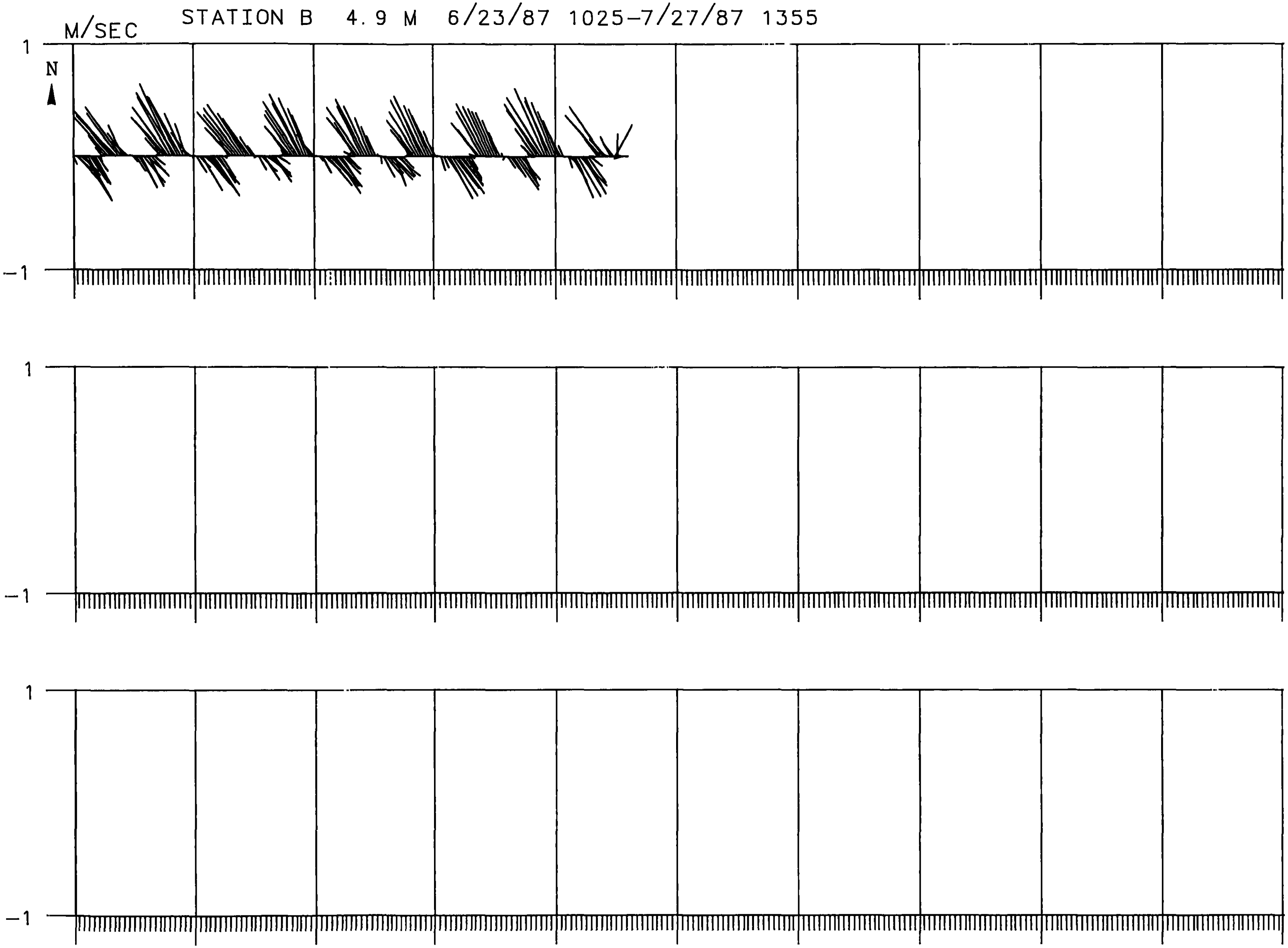
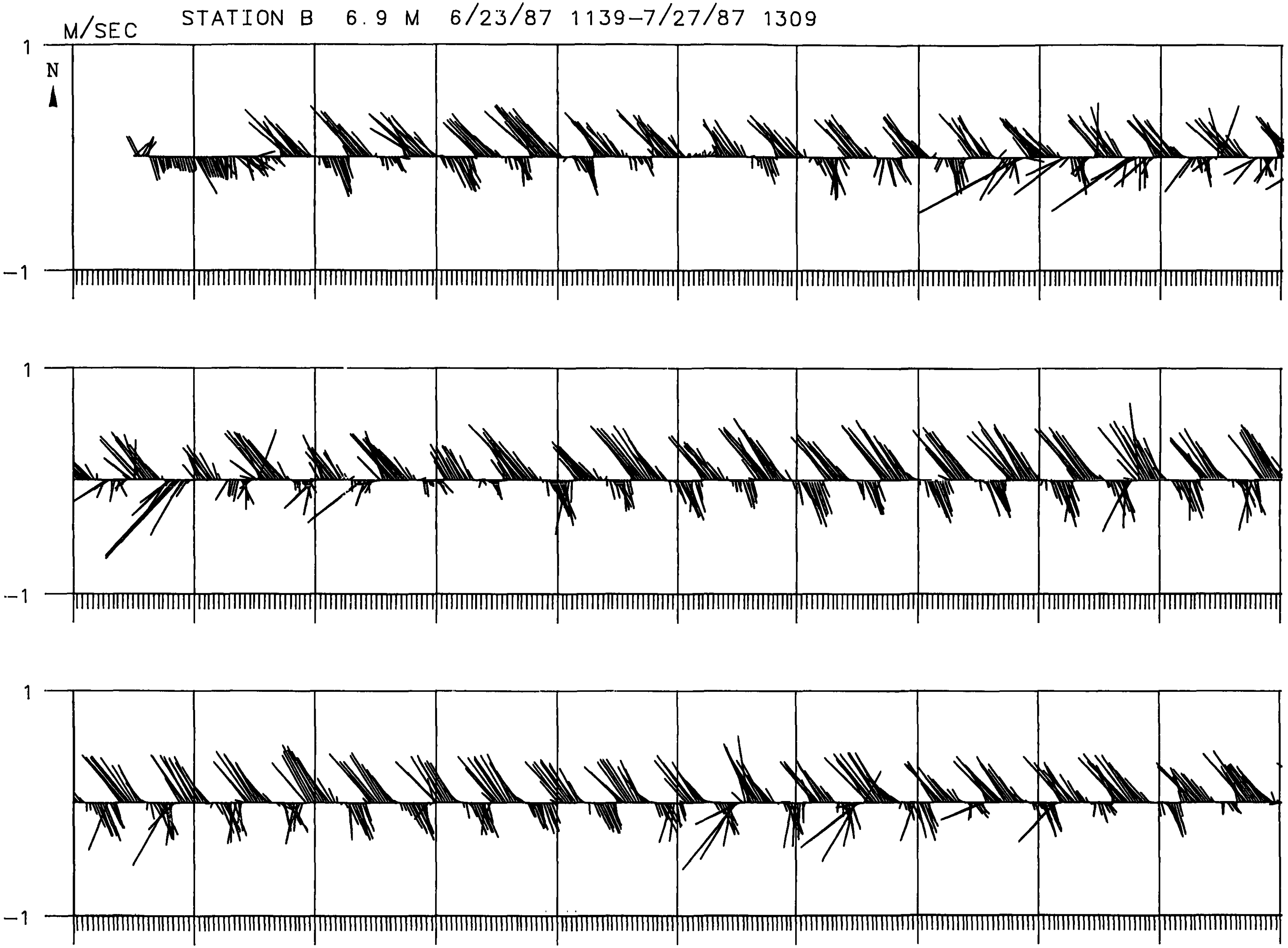


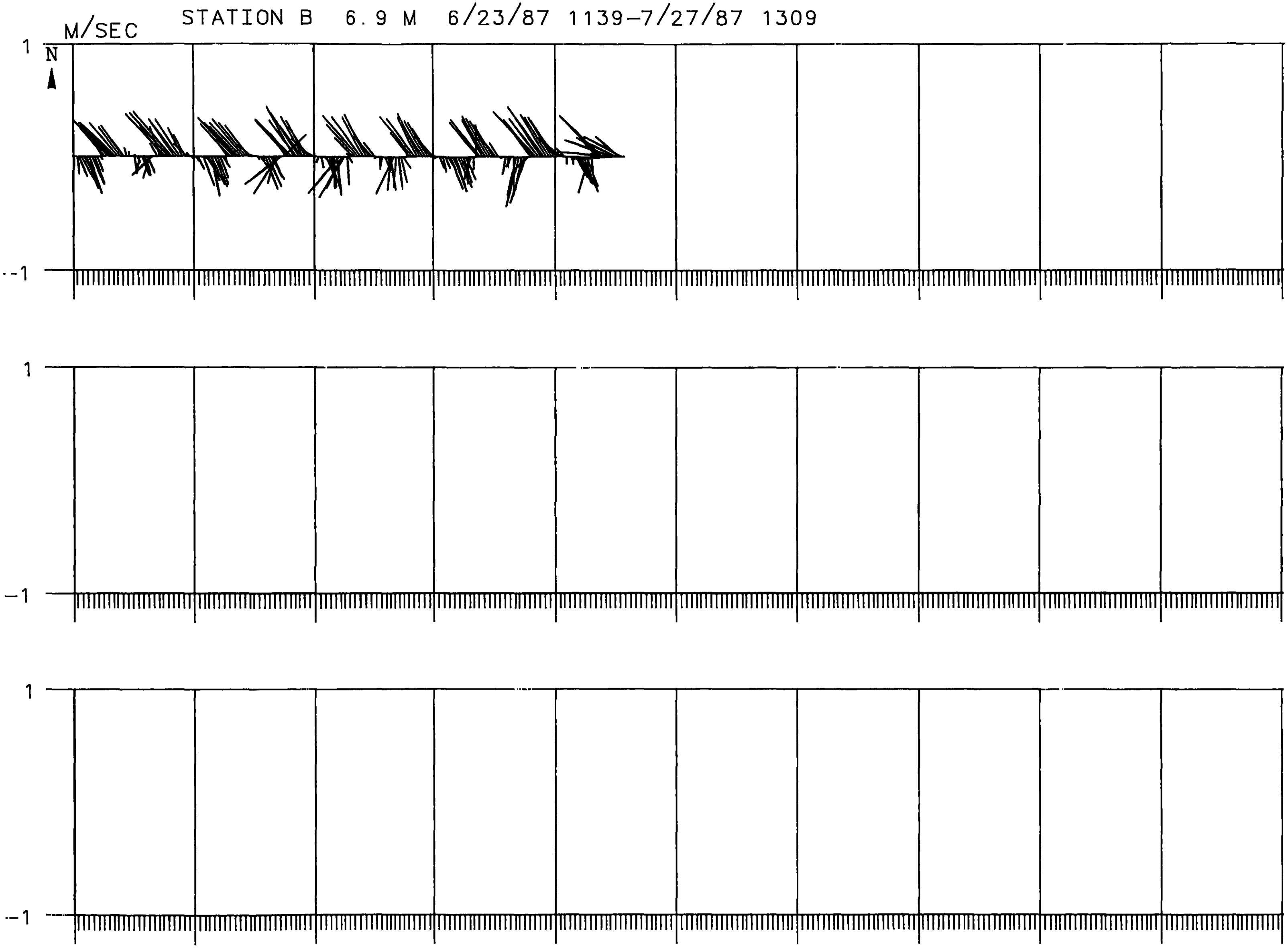
Burwell Bay Station B, 4.9 m below surface, scale in m/sec


STATION B 4.9 M 6/23/87 1025–7/27/87 1355

(continued)



Burwell Bay Station B, 6.9 m below surface, scale in m/sec



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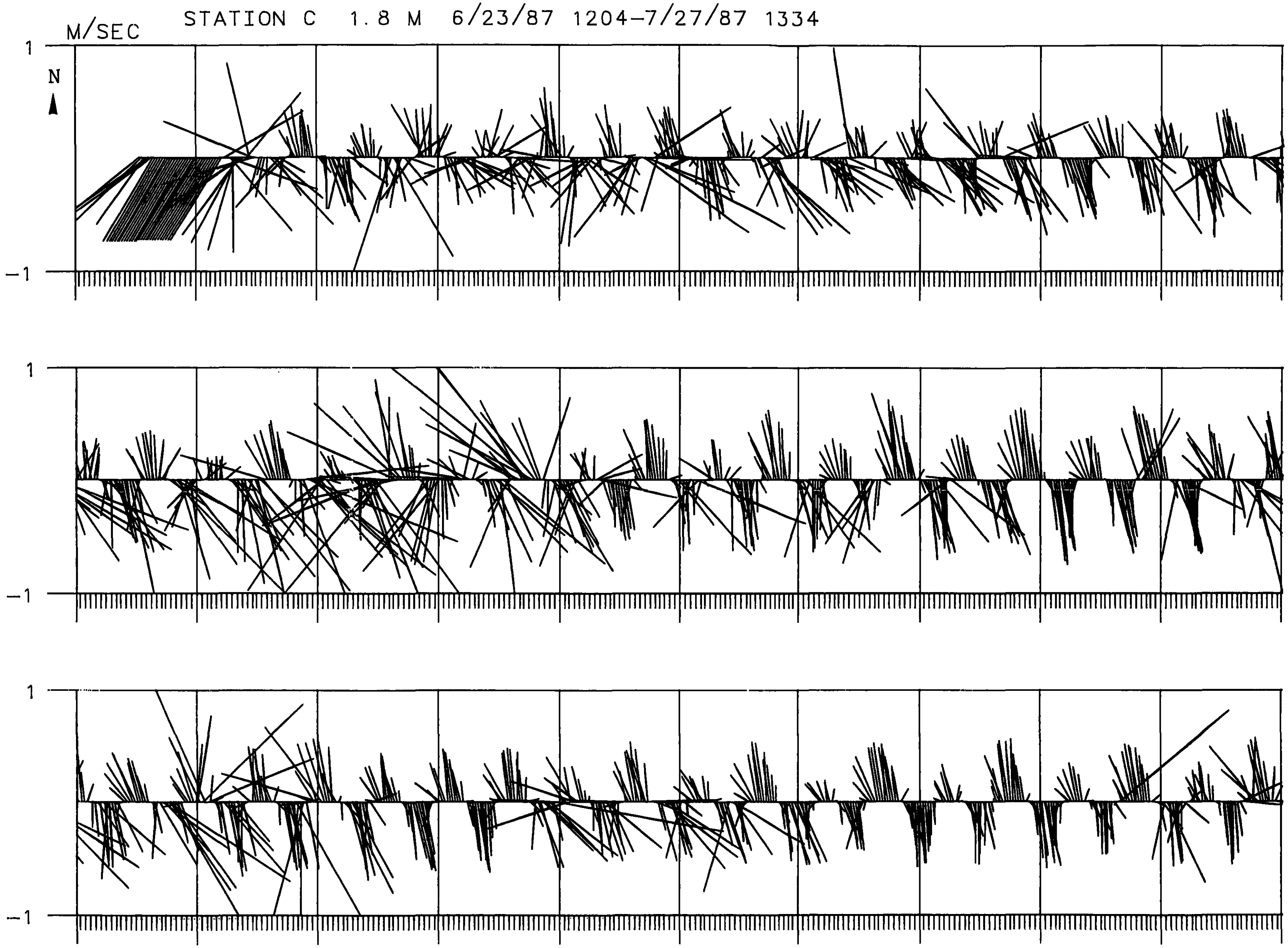
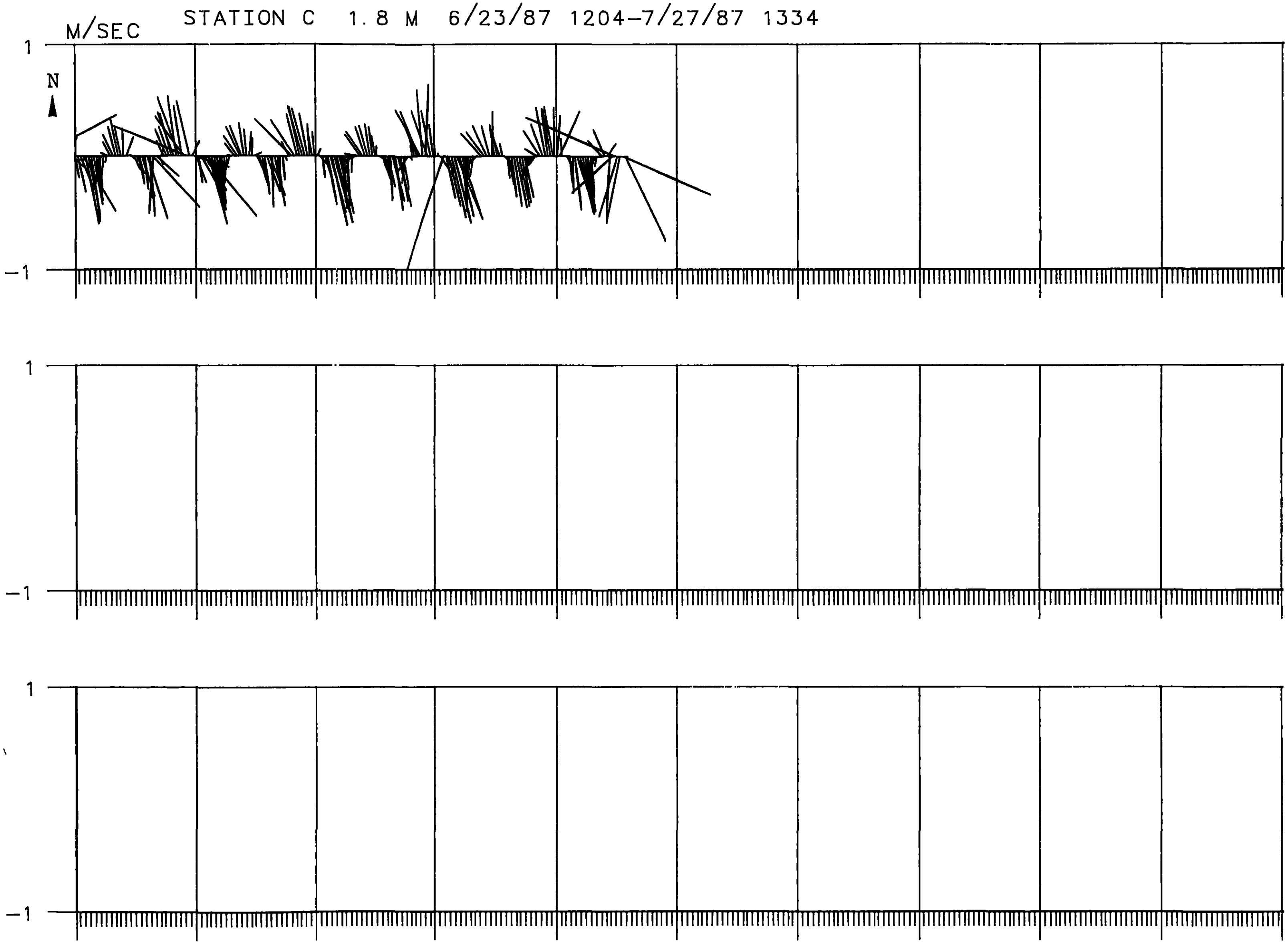


Burwell Bay Station C, 1.8 m below surface, scale in m/sec



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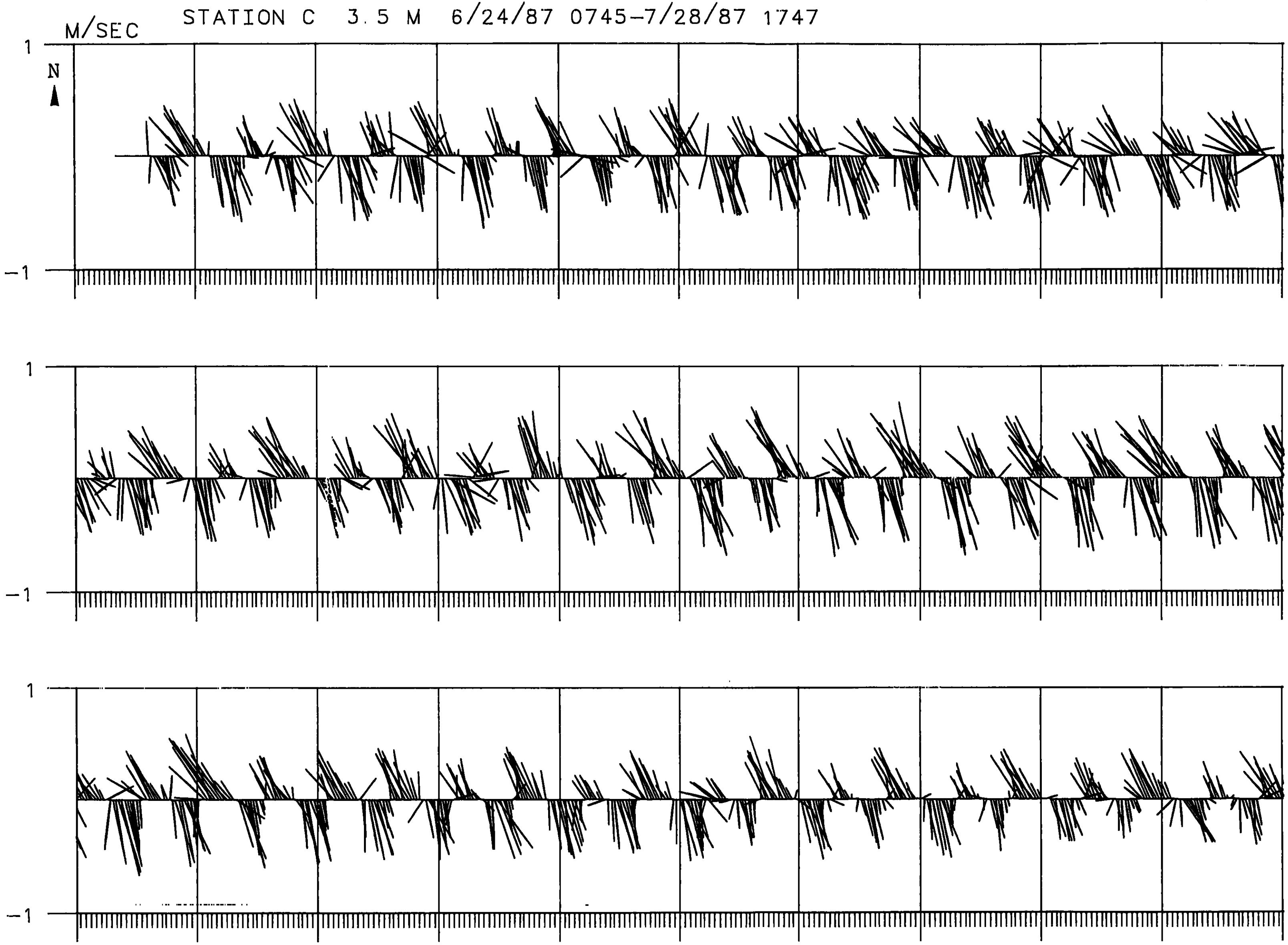
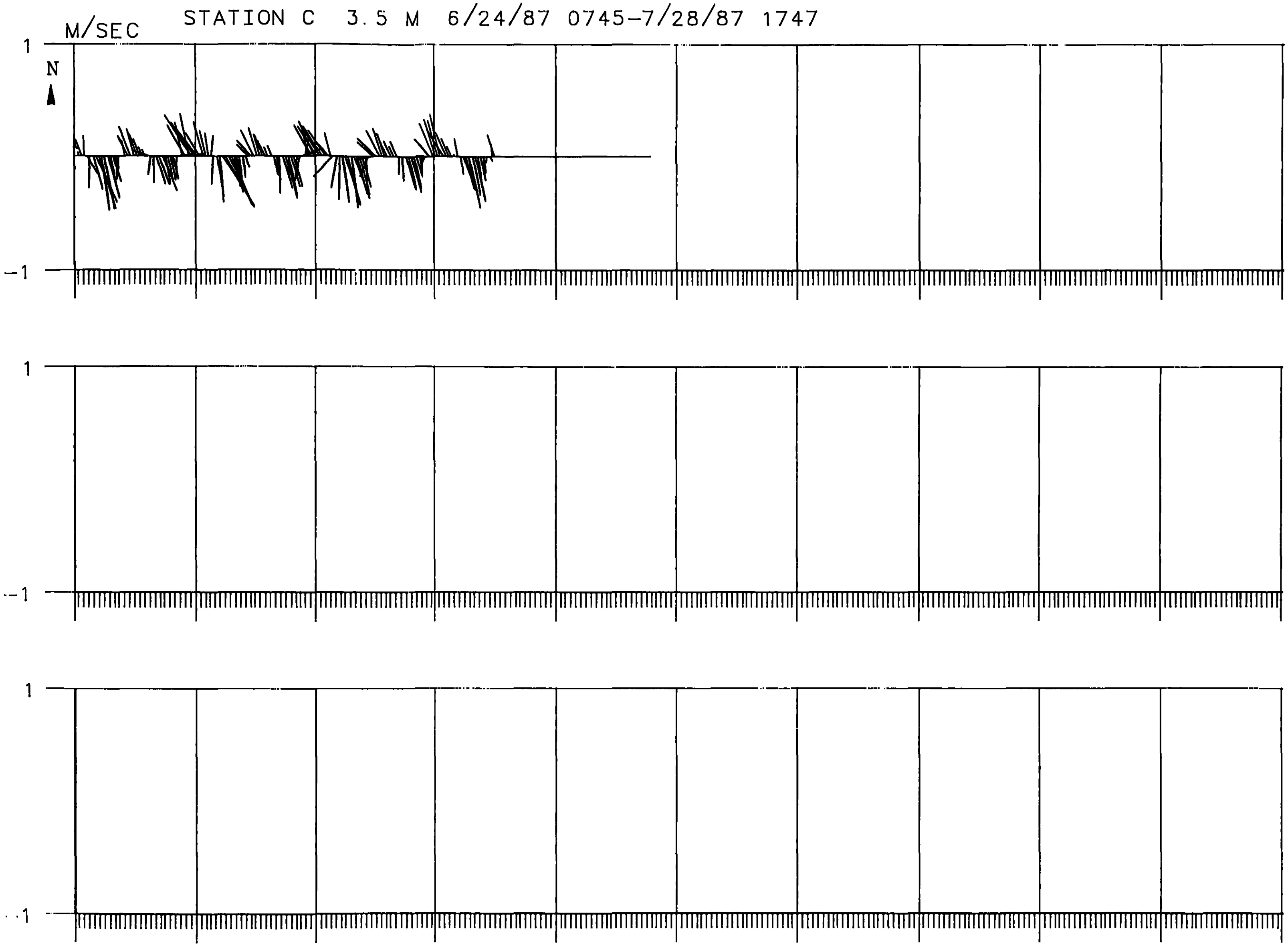


Burwell Bay Station C, 3.5 m below surface, scale in m/sec



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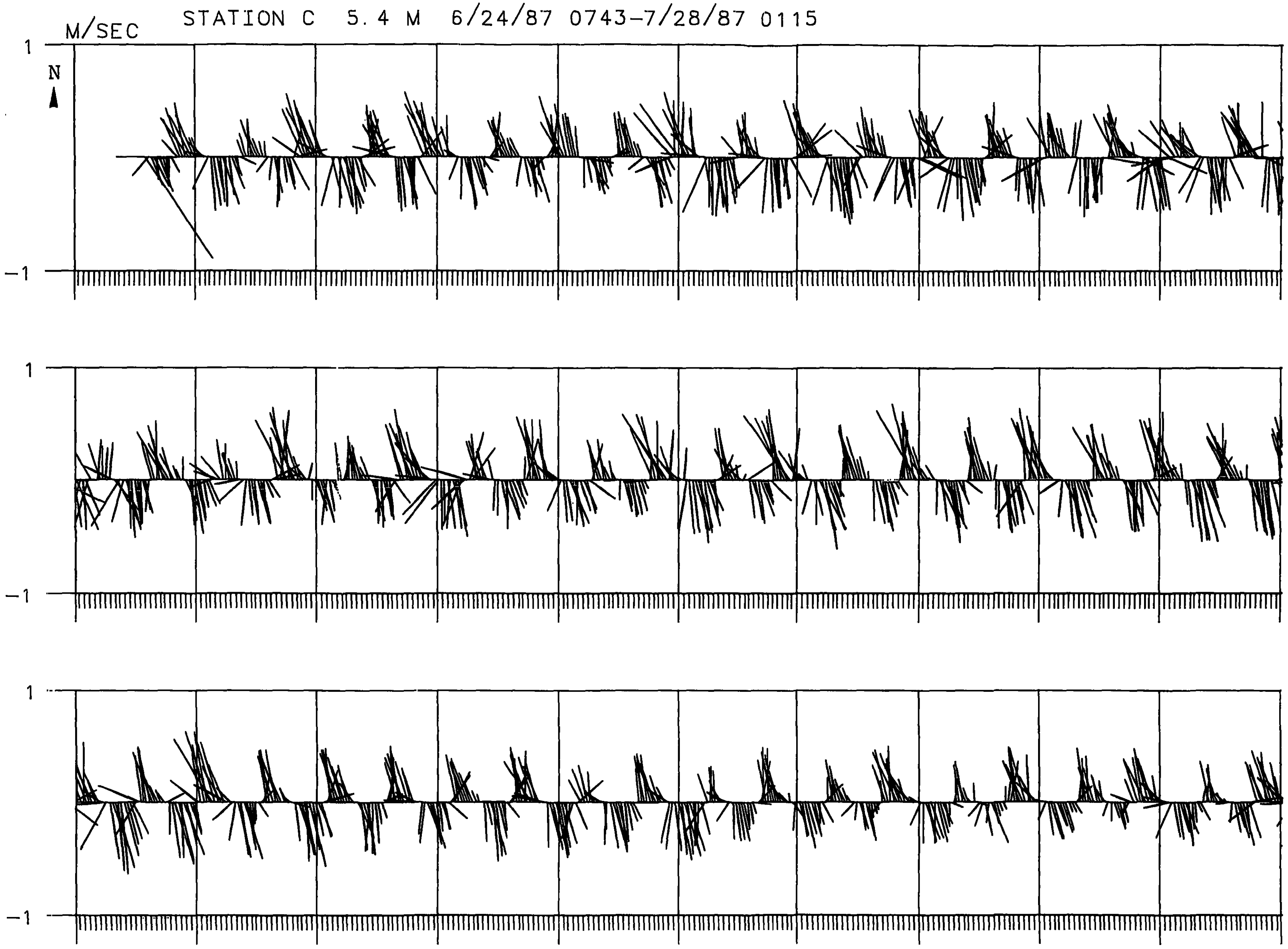
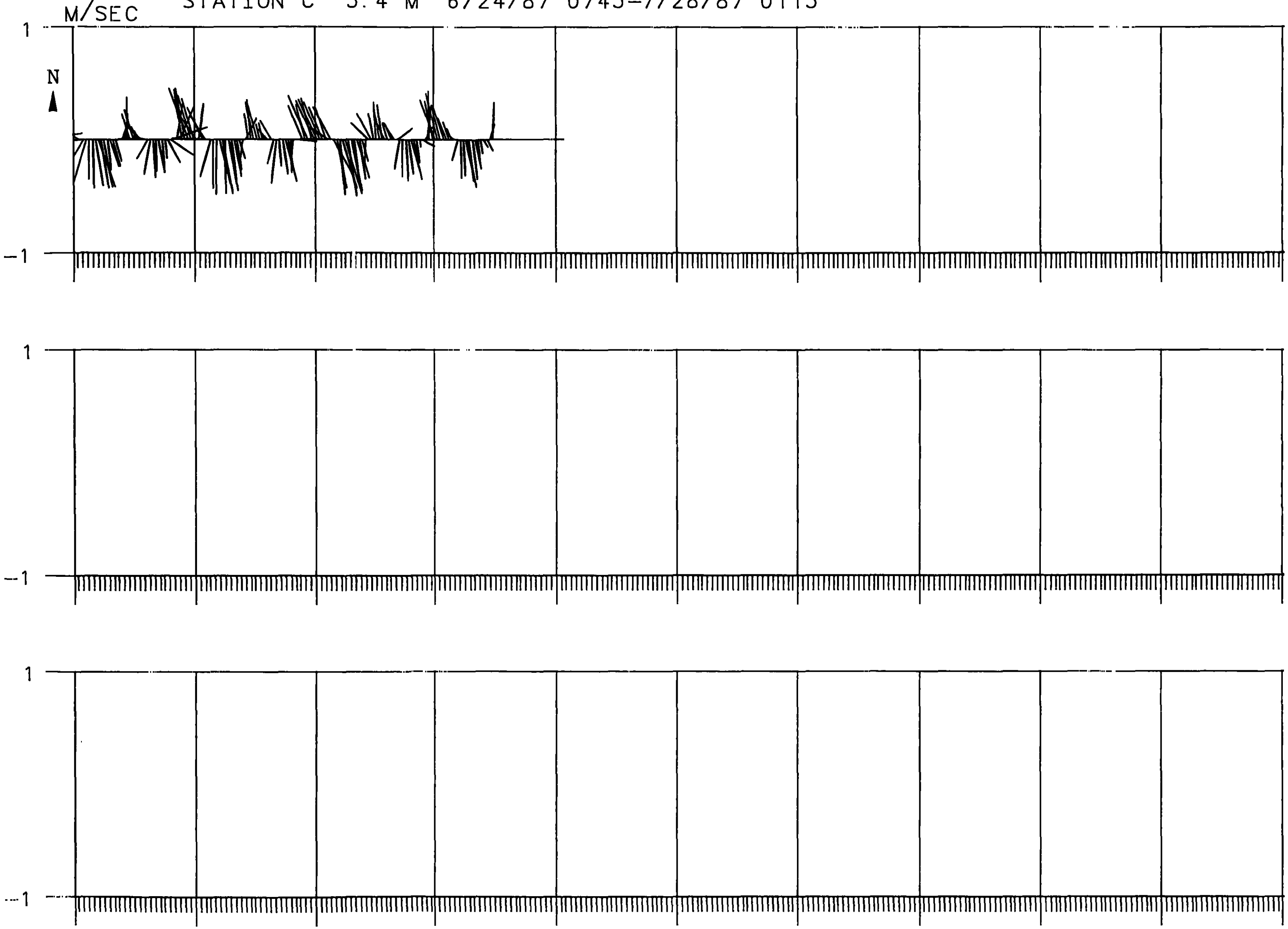
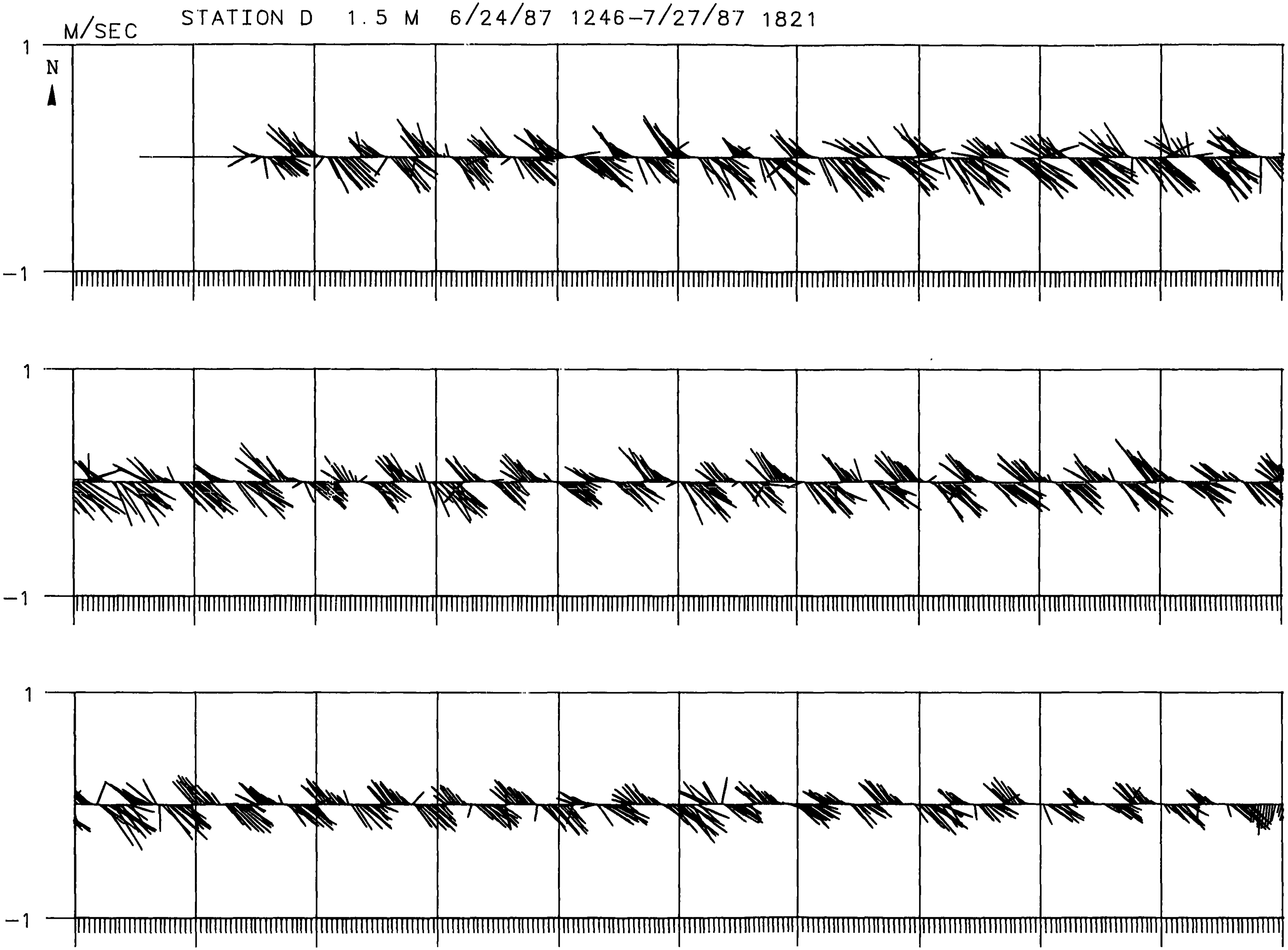


Burwell Bay Station C, 5.4 m below surface, scale in m/sec

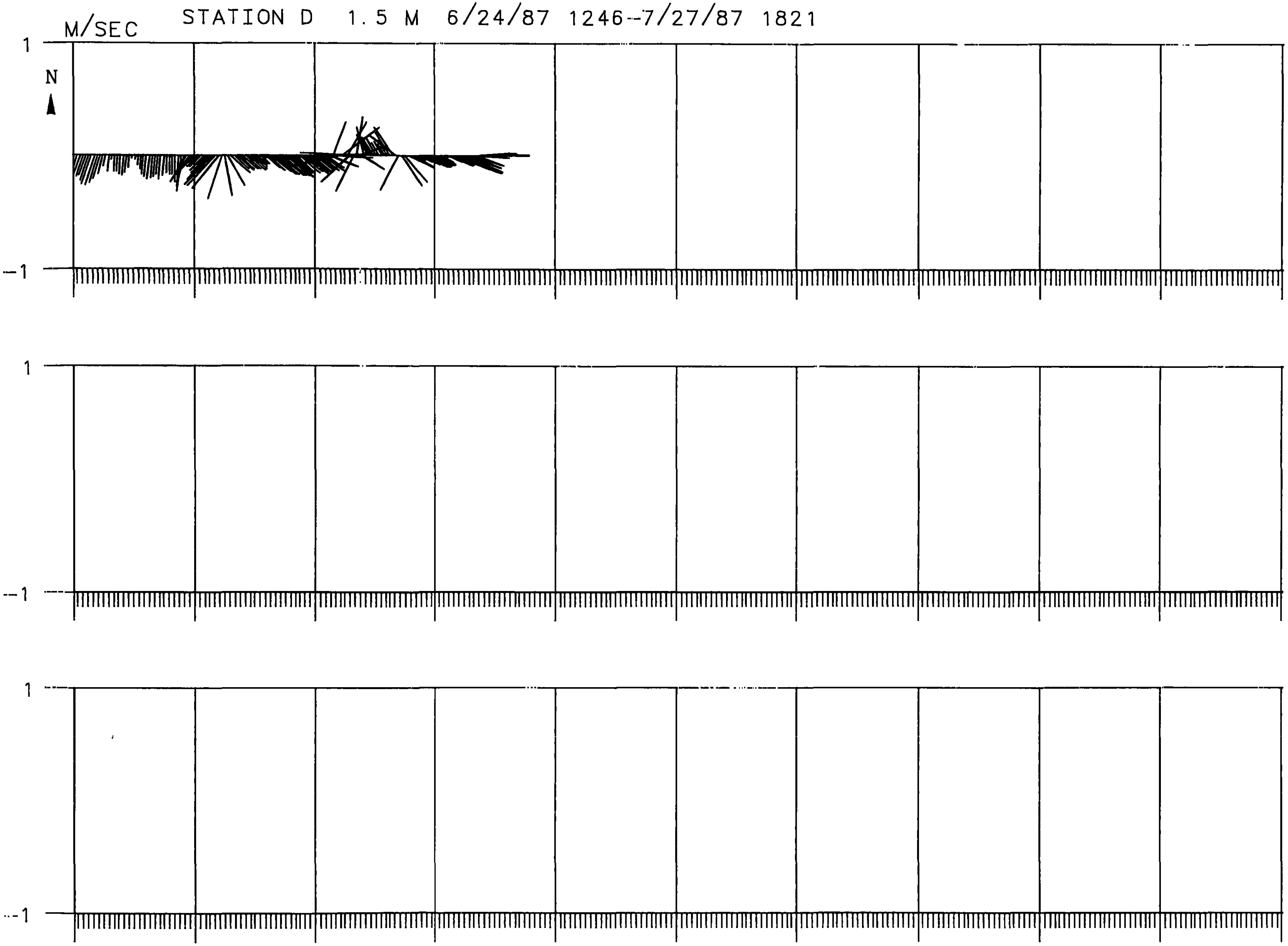
STATION C 5.4 M 6/24/87 0743–7/28/87 0115



(continued)



Burwell Bay Station D 1.5 m below surface, scale in m/sec



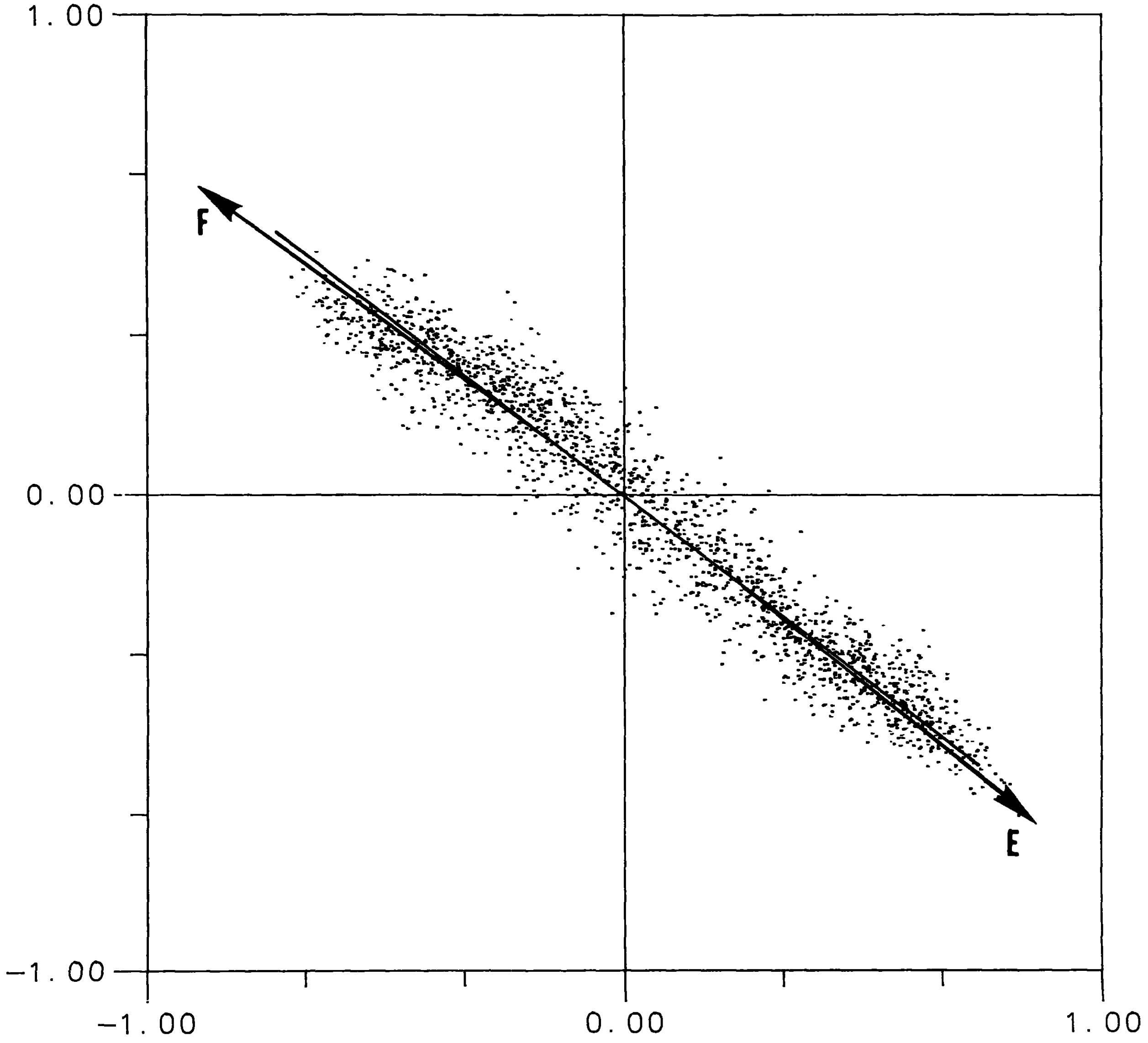
(continued)

APPENDIX B

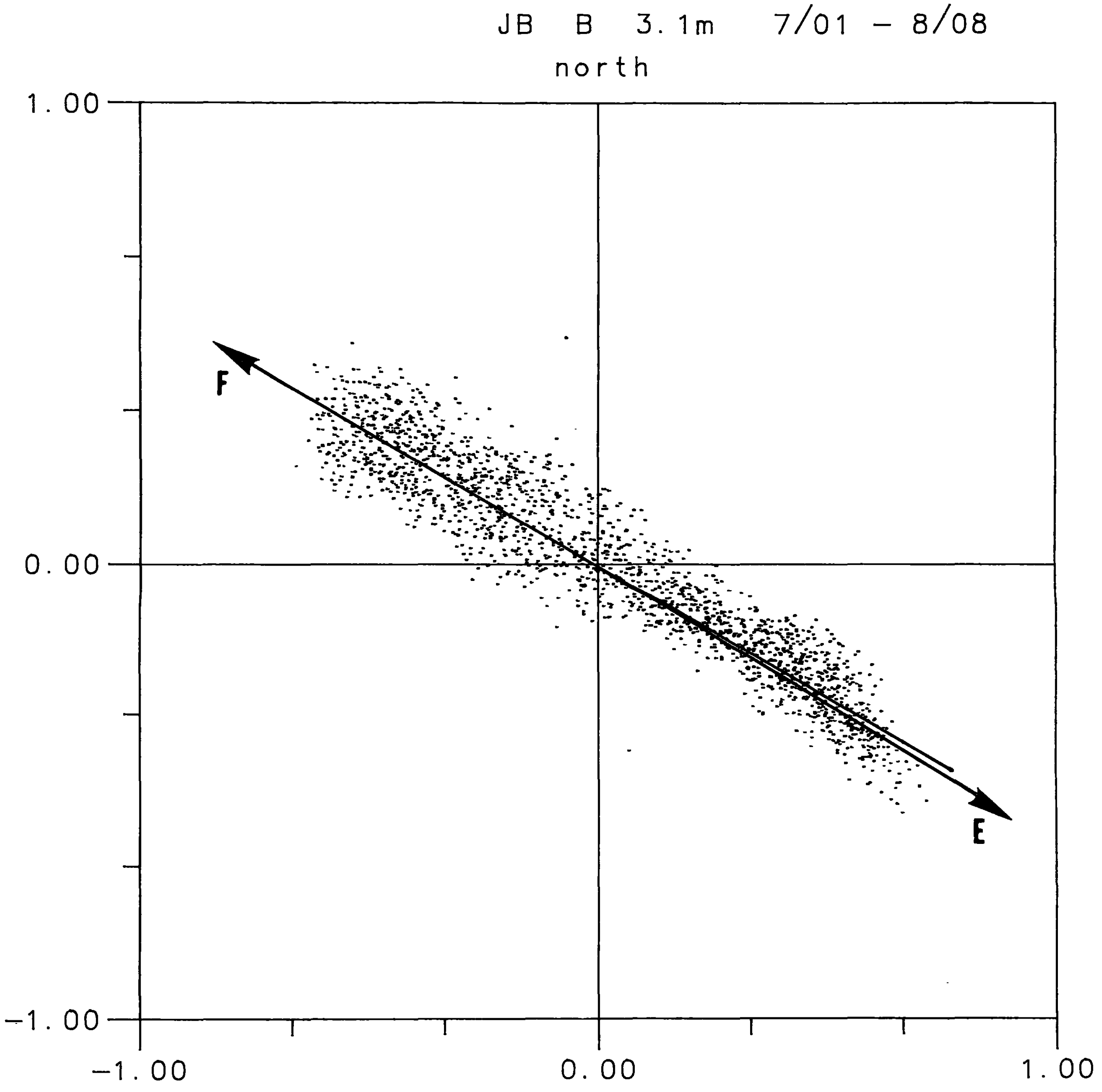
SCATTERPLOTS OF CURRENTS
JAMES RIVER BRIDGE, STATION B

JULY, 1985

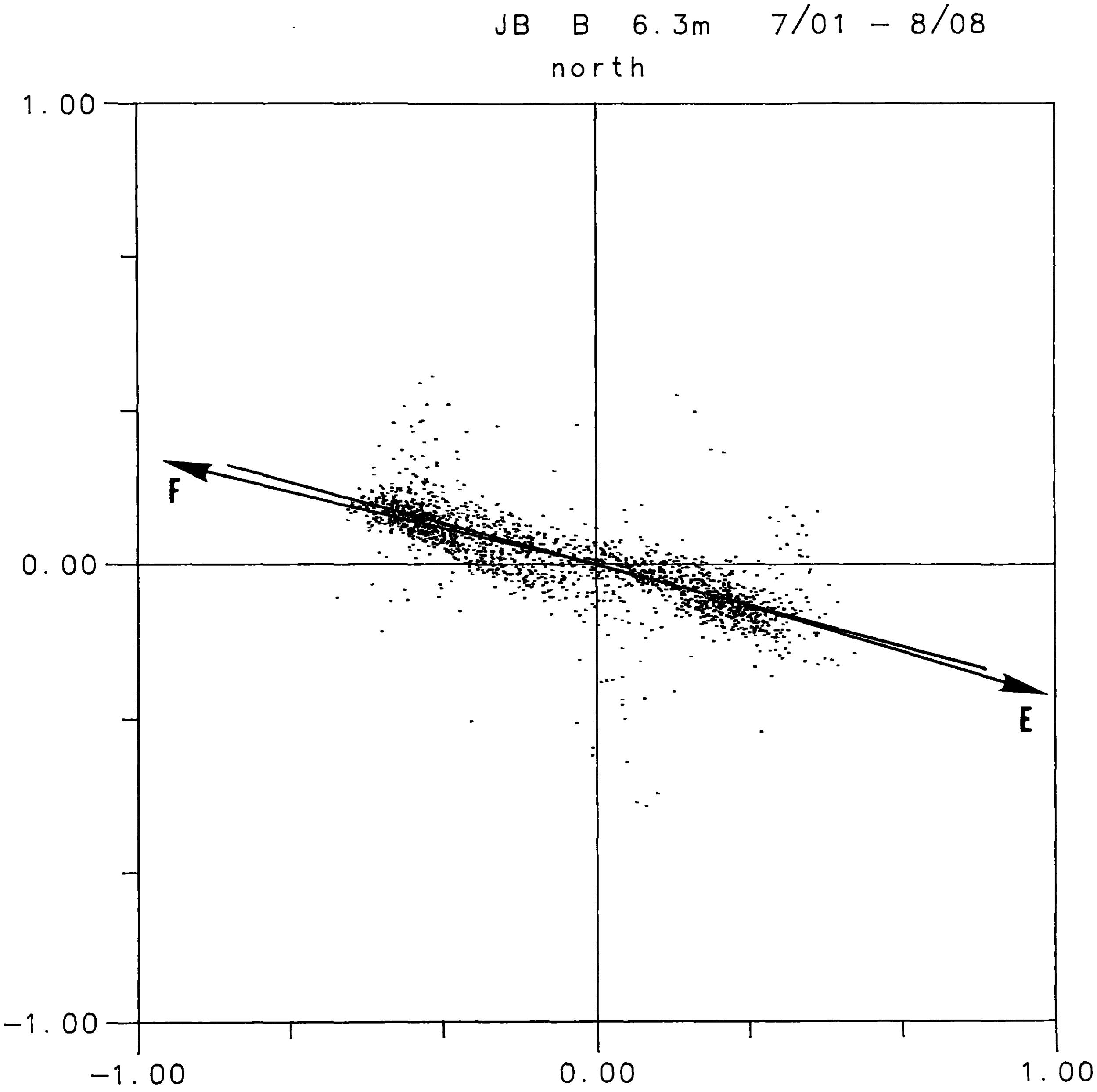
JB B 1.2m 7/01 - 8/08



Principal Axis: 127° Ebb Axis: 128° Flood Axis: 306°

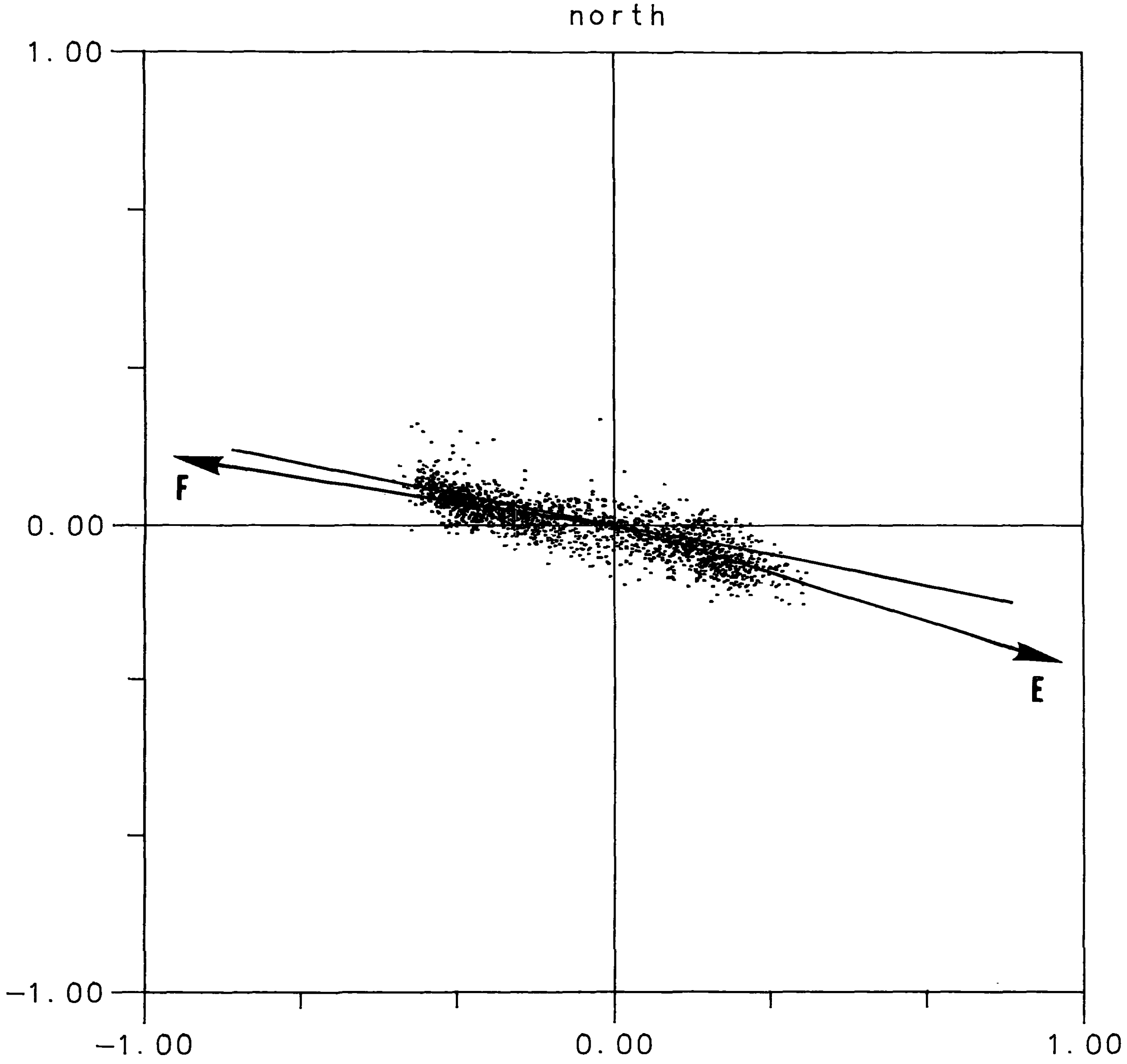


Principal Axis: 120° Ebb Axis: 121° Flood Axis: 300°



Principal Axis: 105° Ebb Axis: 106° Flood Axis: 284°

JB B 8.5m 7/01 - 8/08

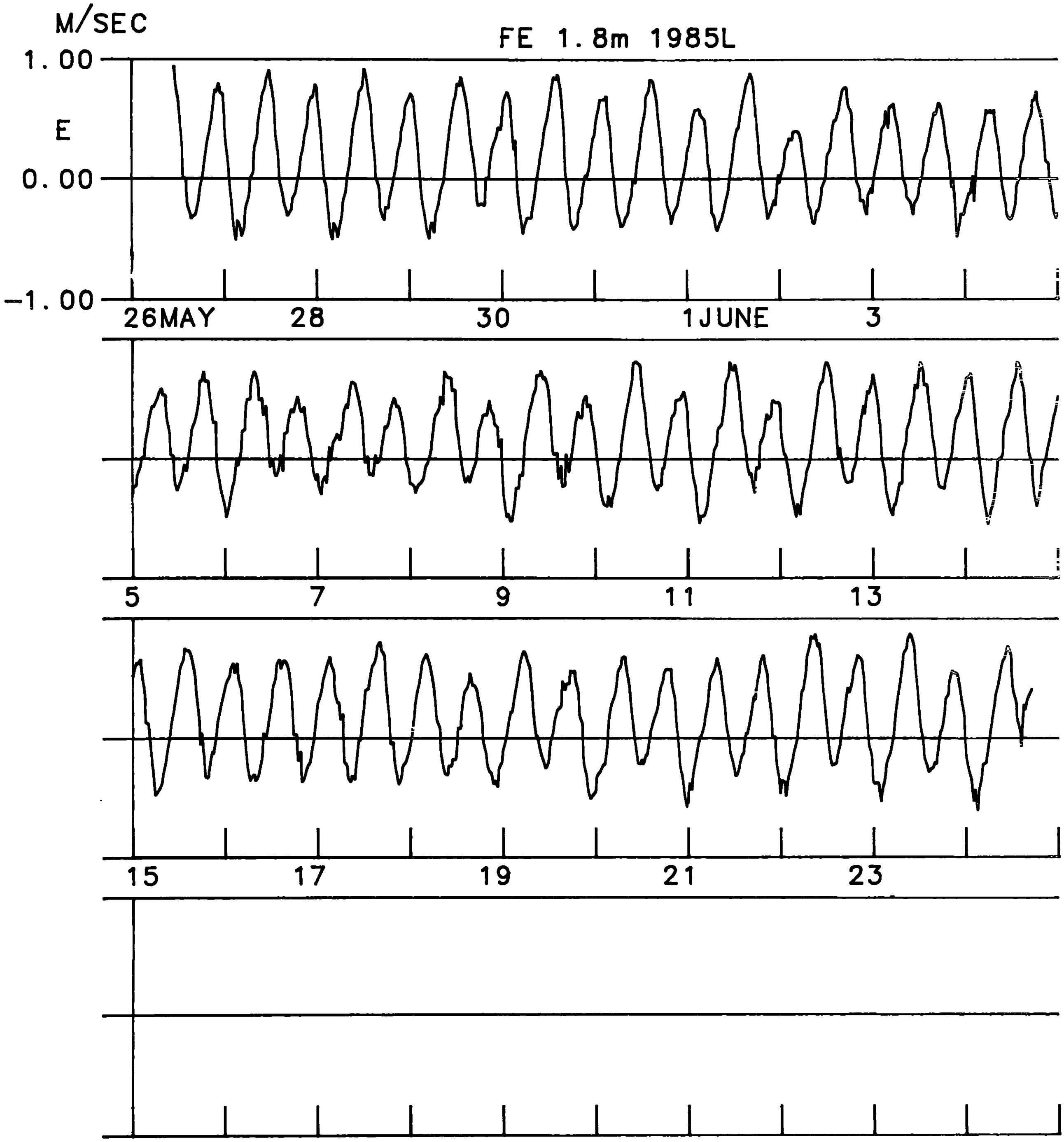


Principal Axis: 101° Ebb Axis: 107° Flood Axis: 279°

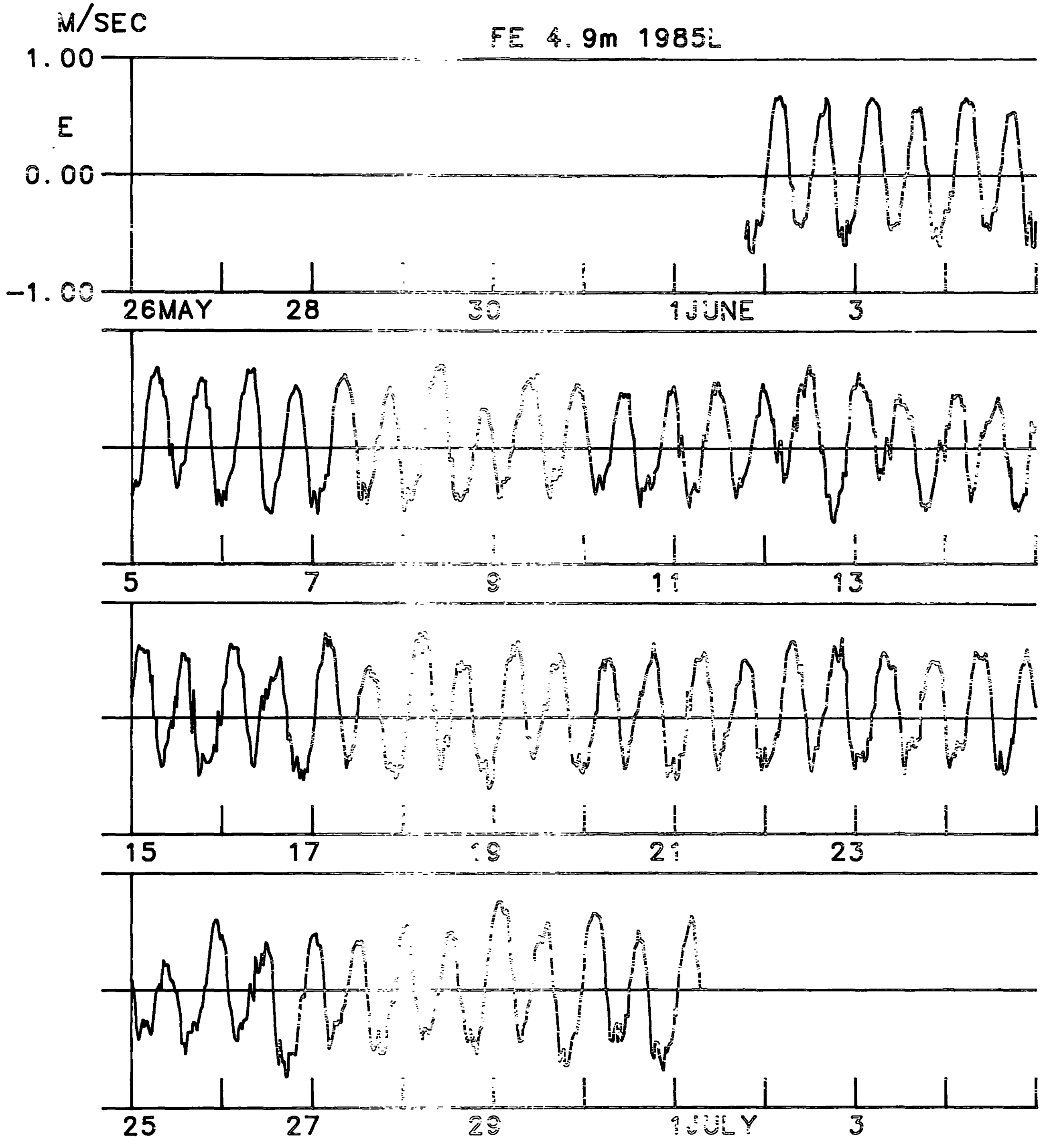
APPENDIX C

LONGITUDINAL COMPONENTS OF CURRENTS

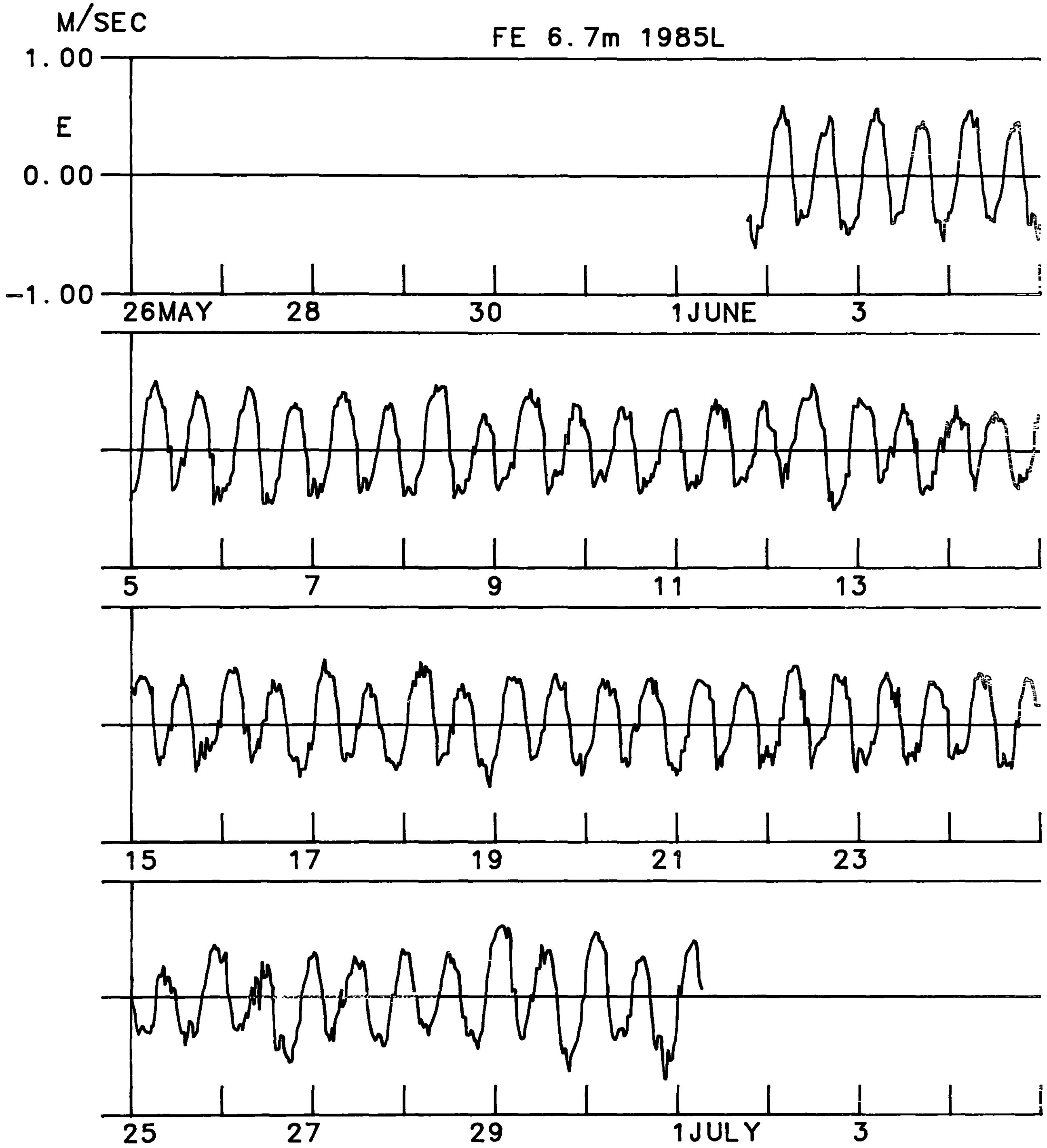
(E designates ebb direction)



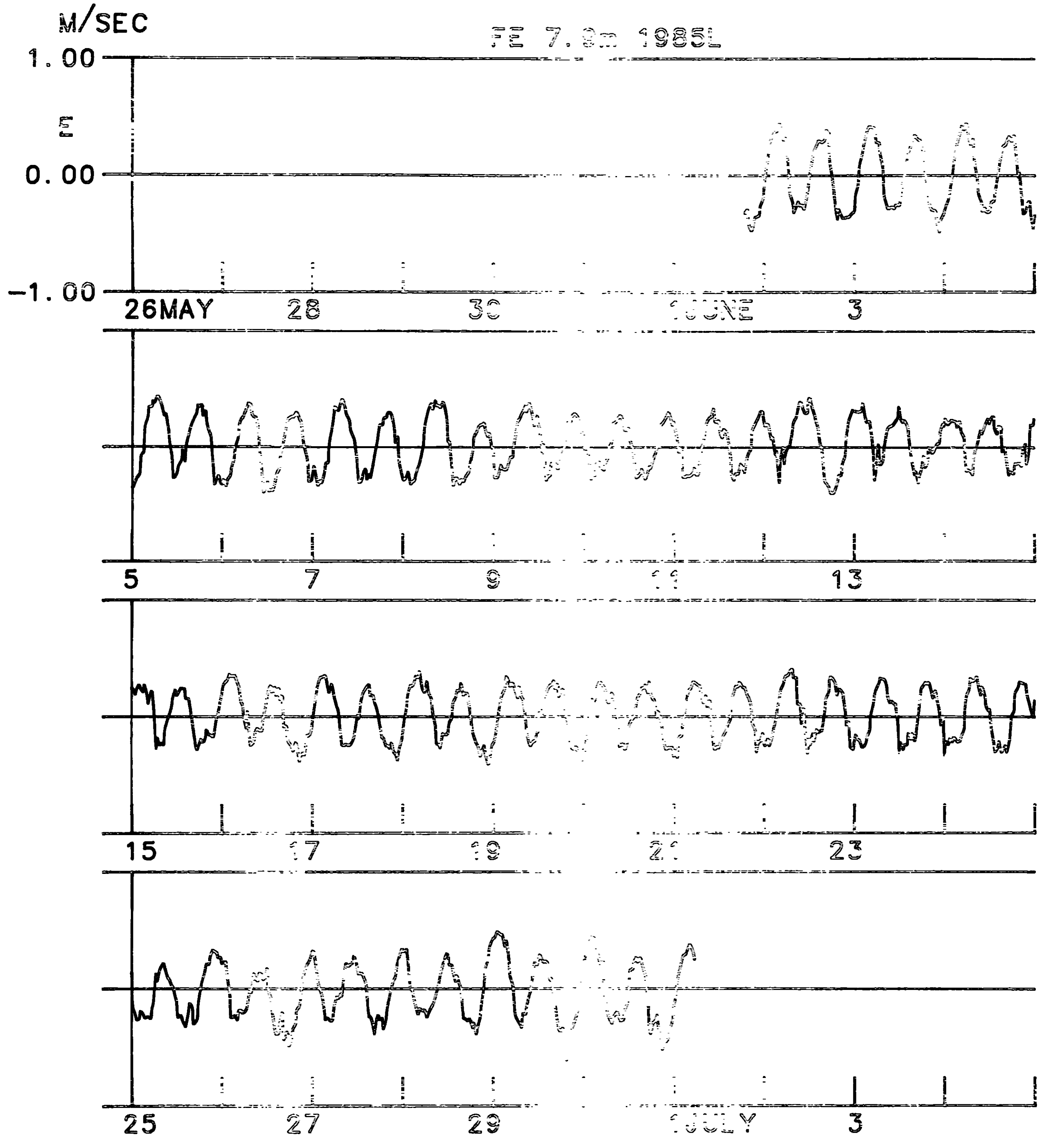
Fort Eustis Station, 1.8 m below surface



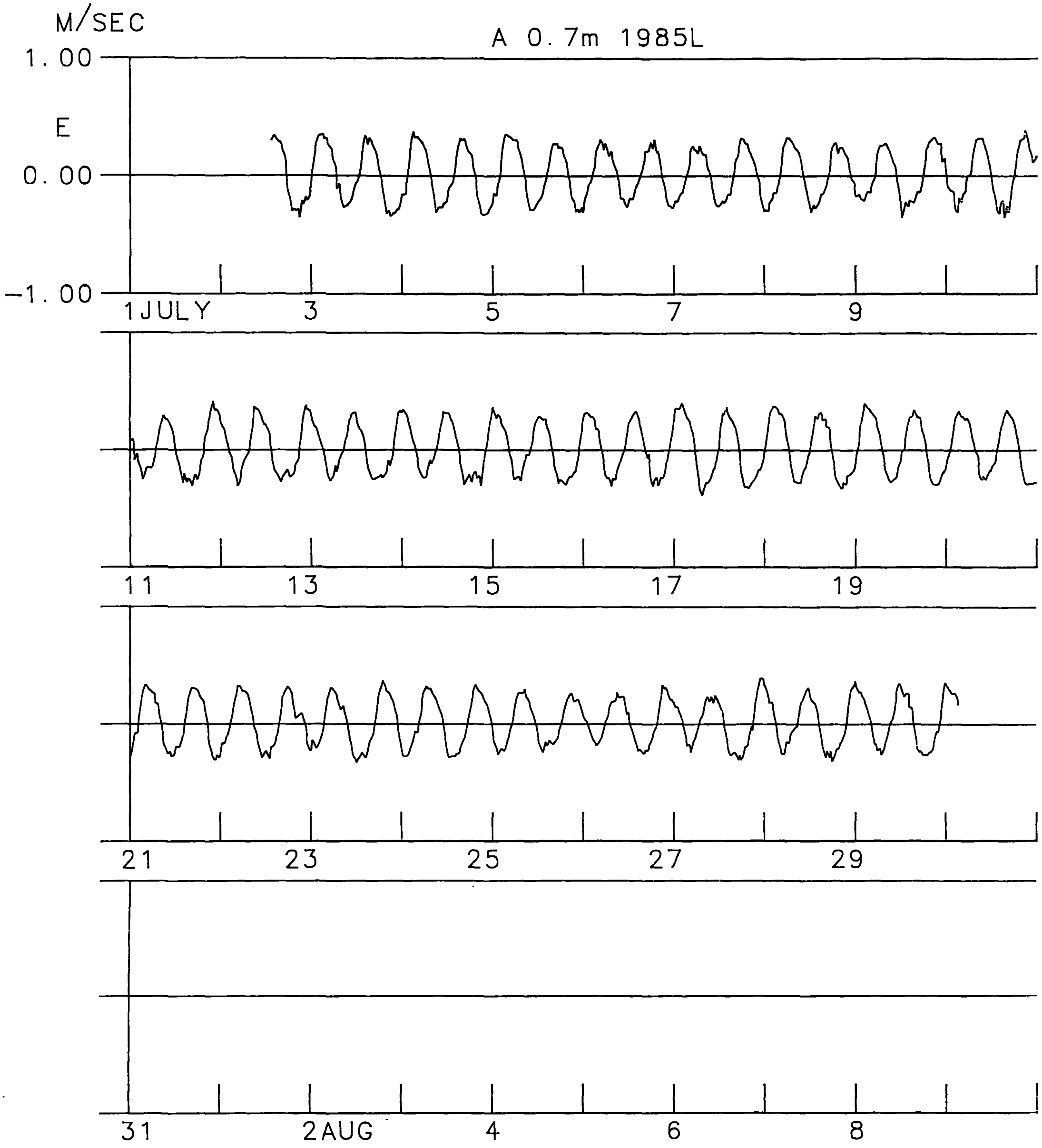
Fort Eustis Station, 4.9 m below surface



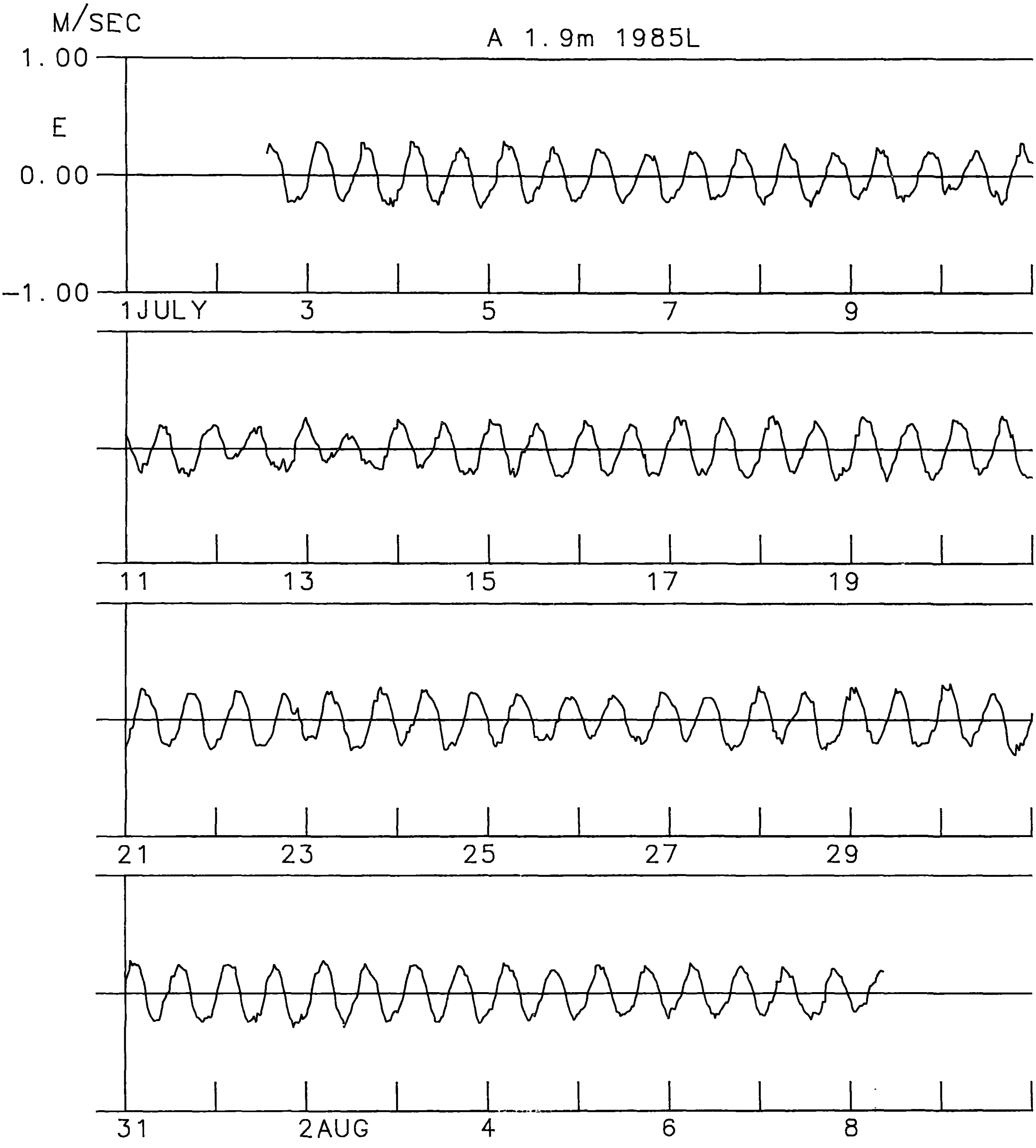
Fort Eustis Station, 6.7 m below surface



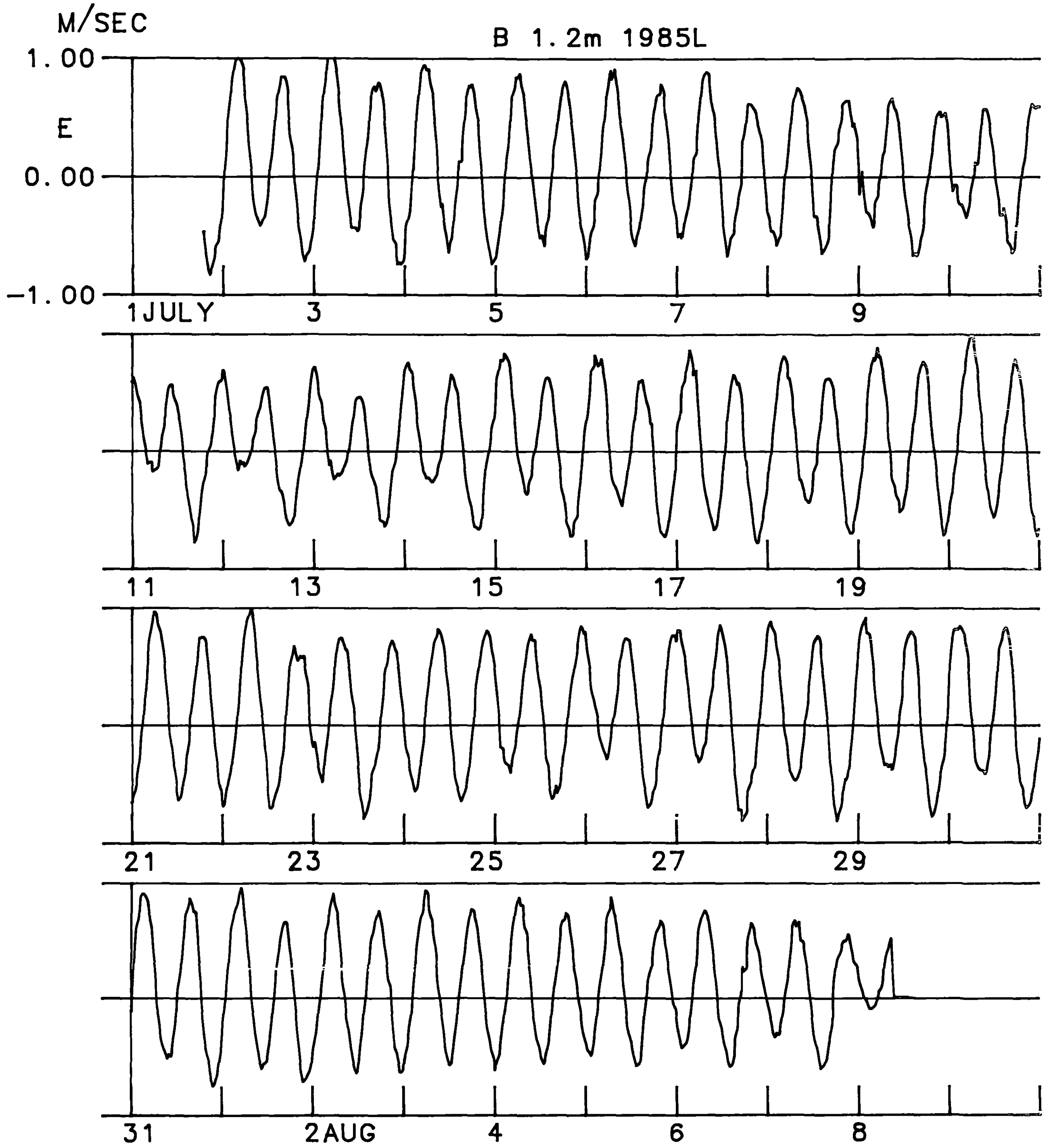
Fort Eustis Station, 7.9 m below [illegible]



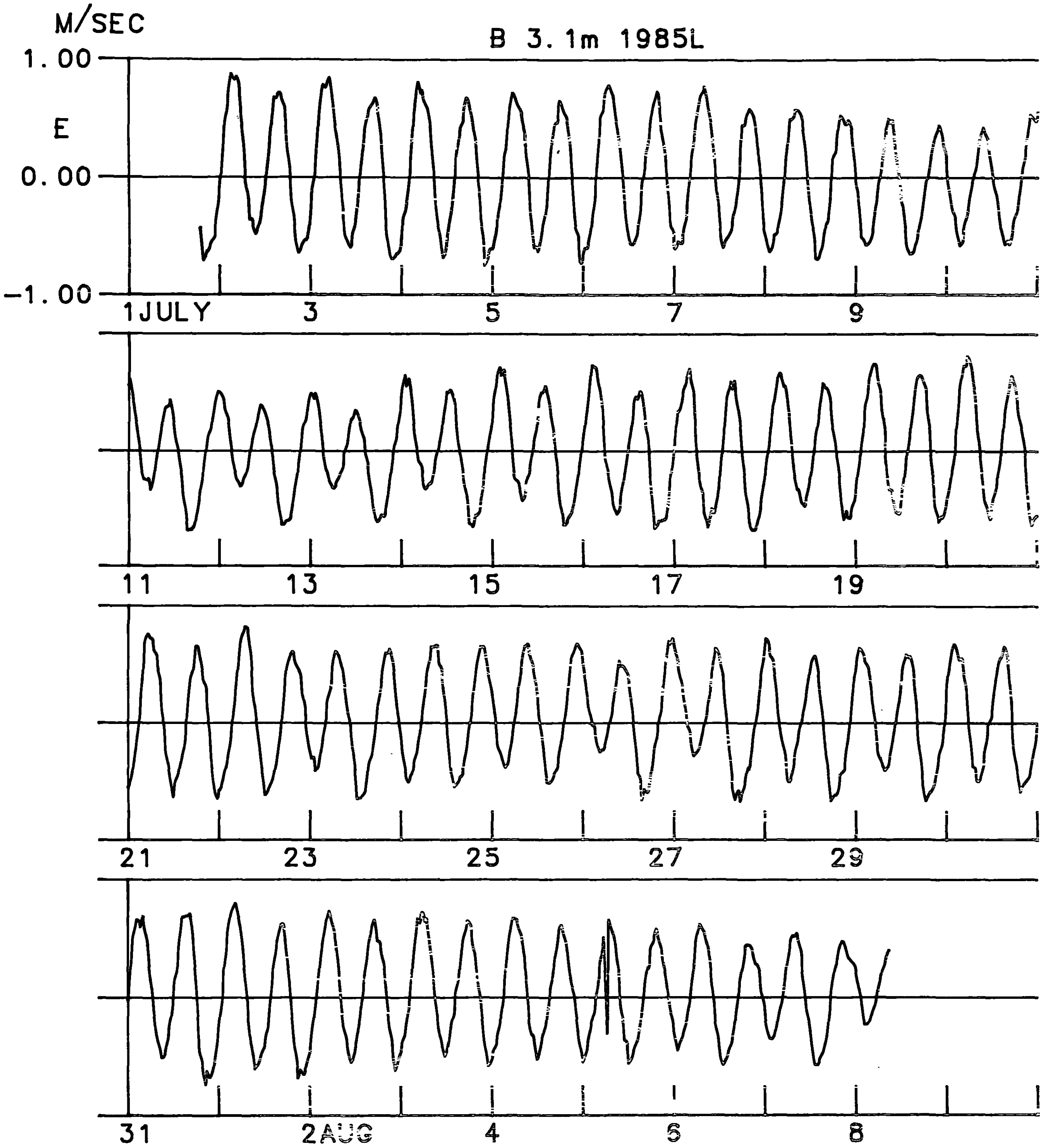
James River Bridge Station A, 0.7 m below surface



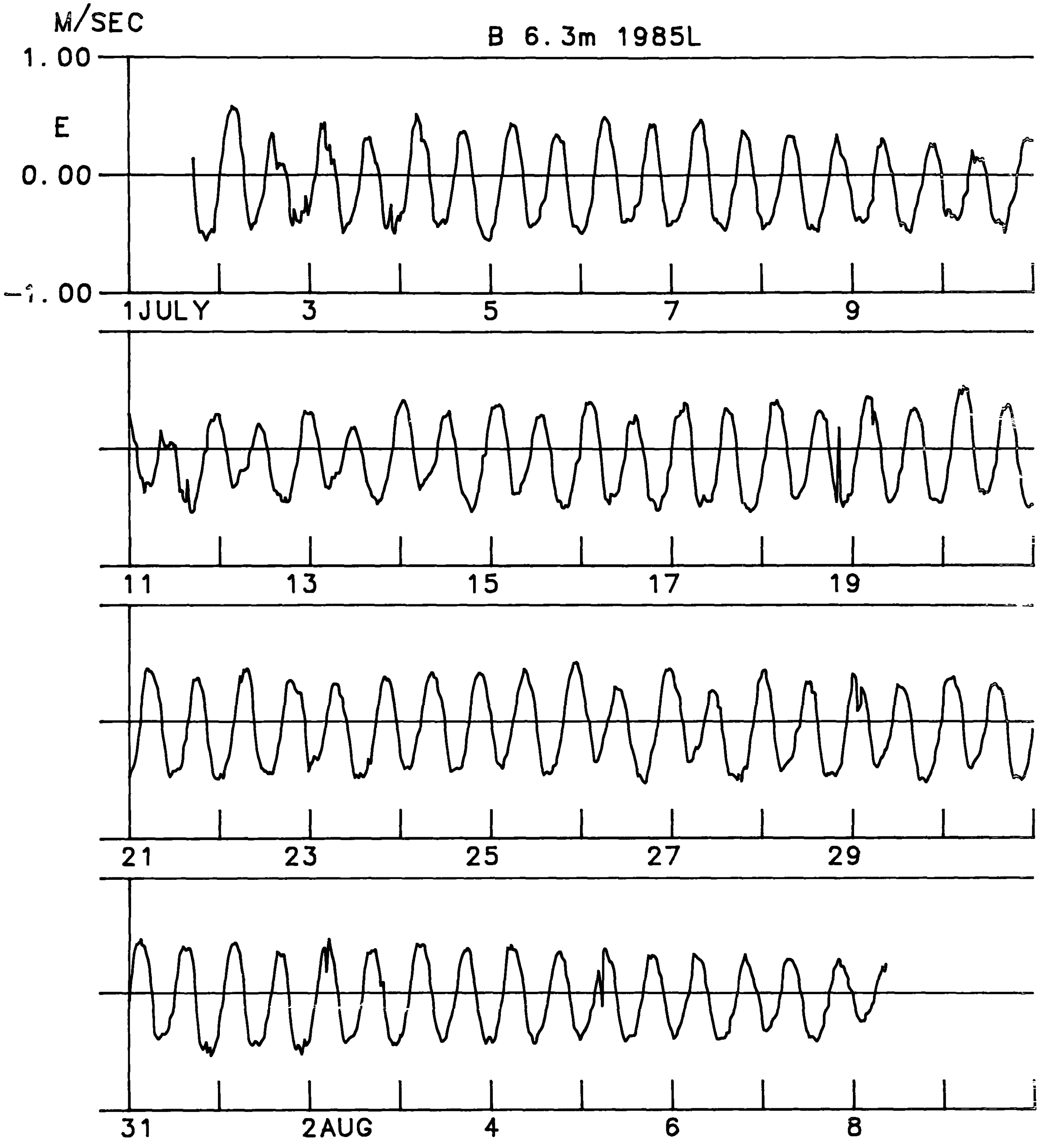
James River Bridge Station A, 1.9 m below surface



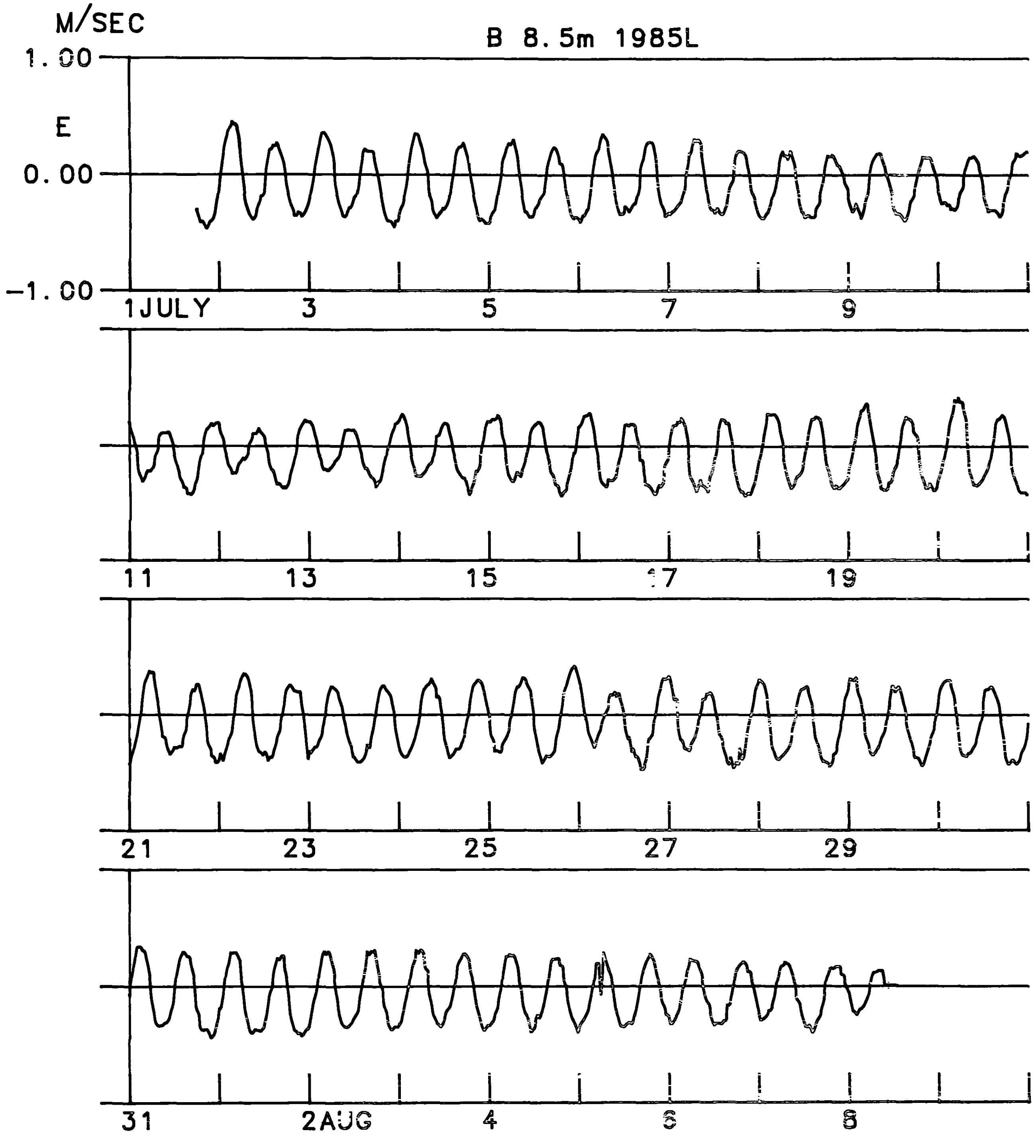
James River Bridge Station B, 1.2 m below surface



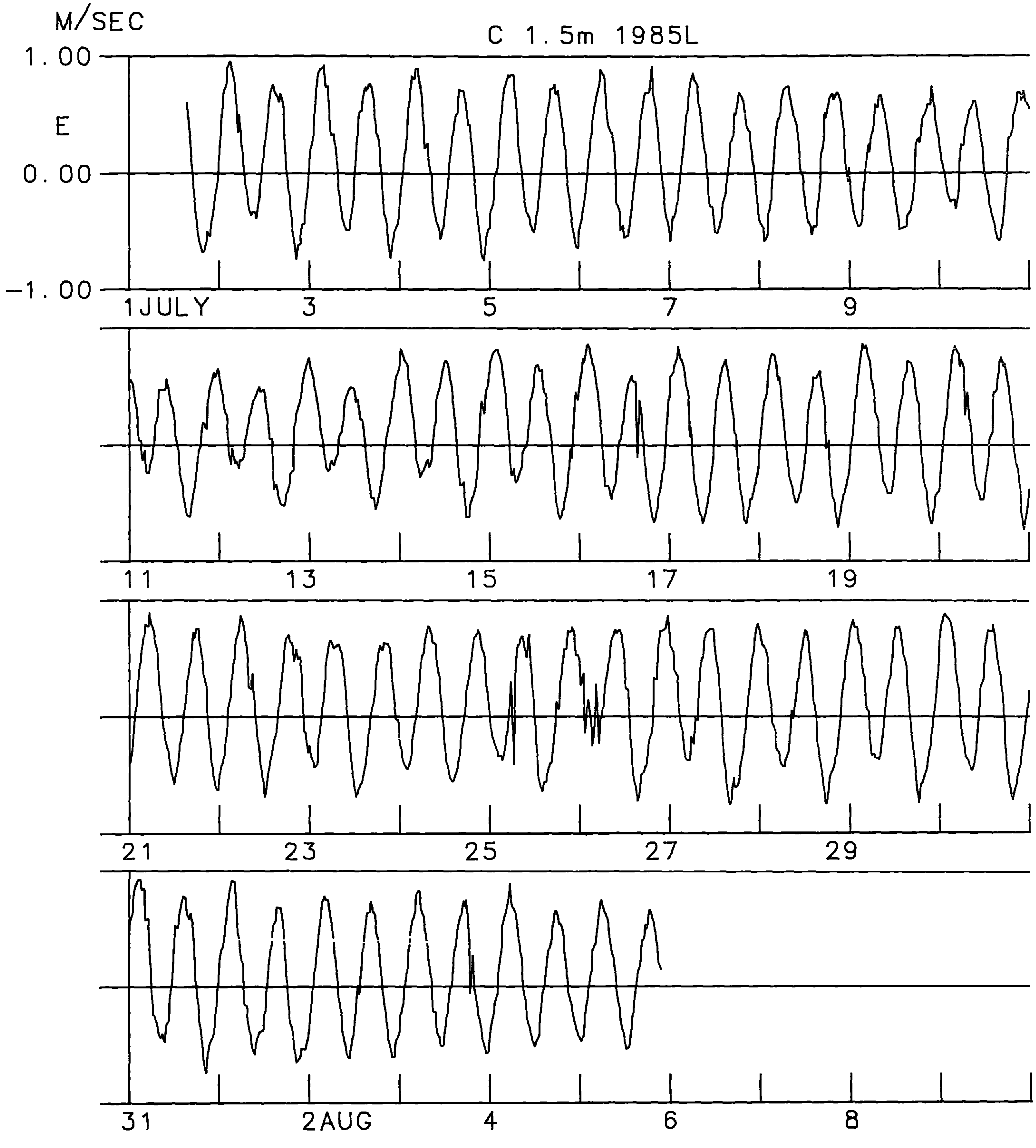
James River Bridge Station B, 3.1 m below surface



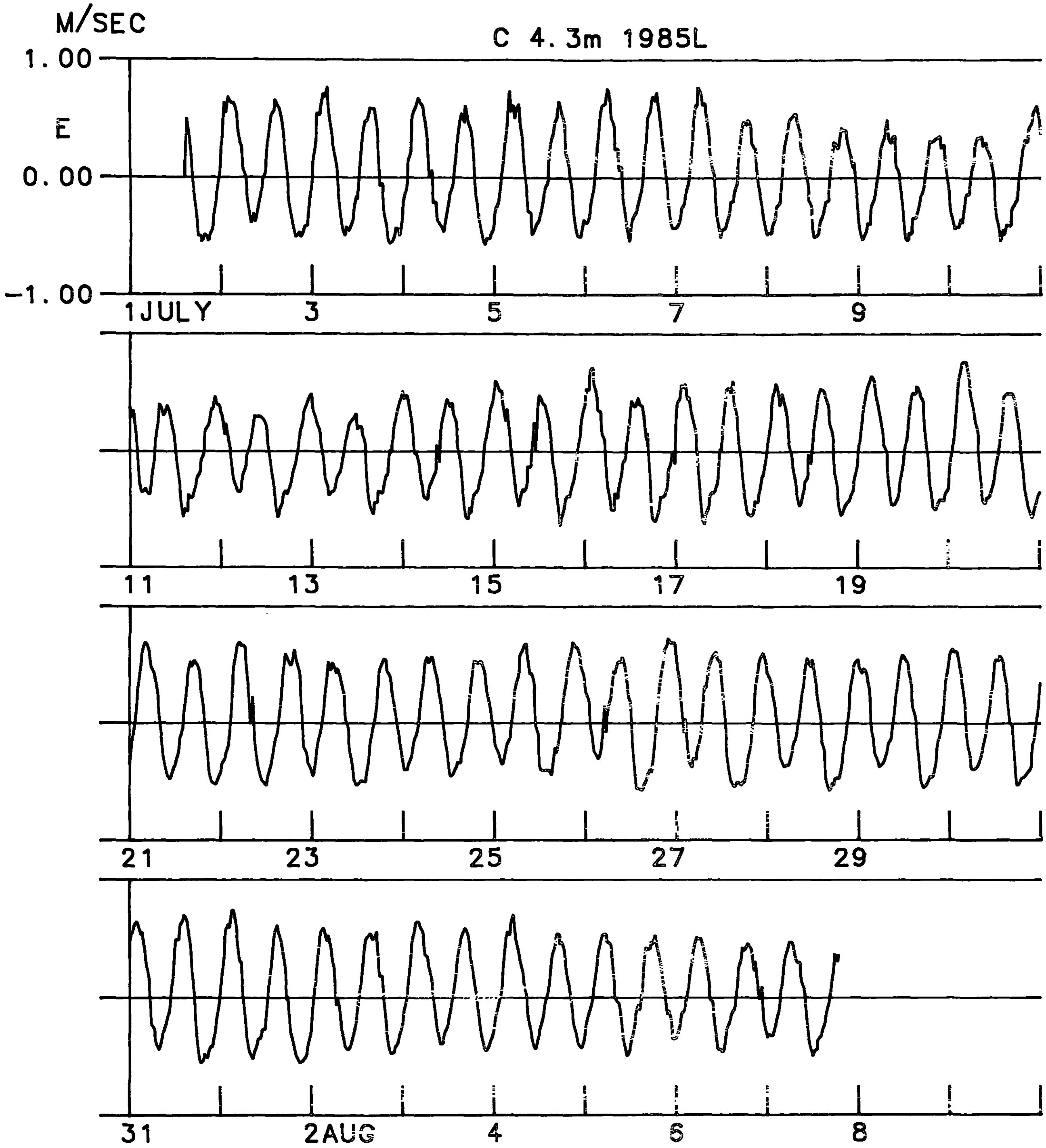
James River Bridge Station B, 6.3 m below surface



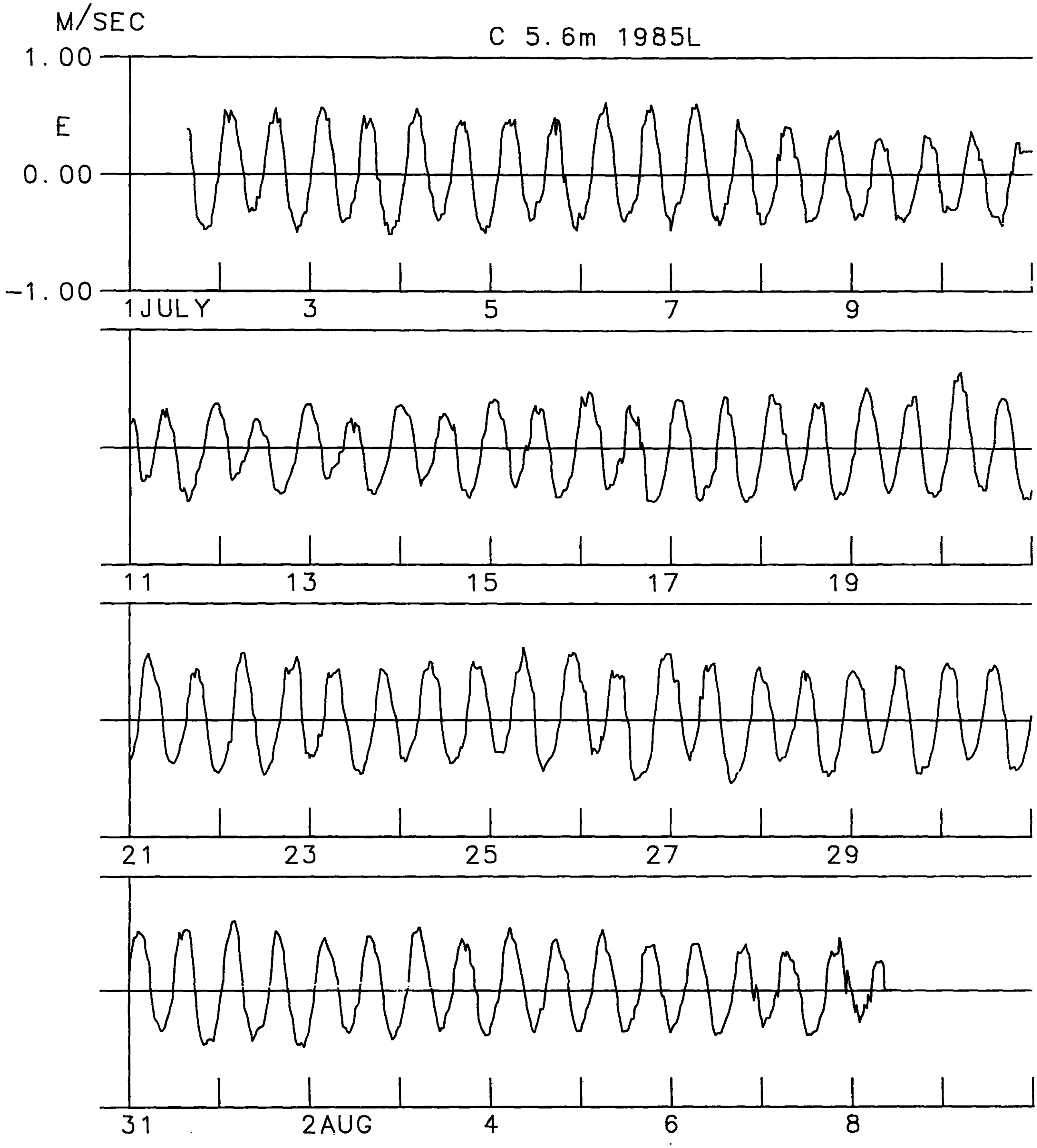
James River Bridge Station B, 8.5 m below surface



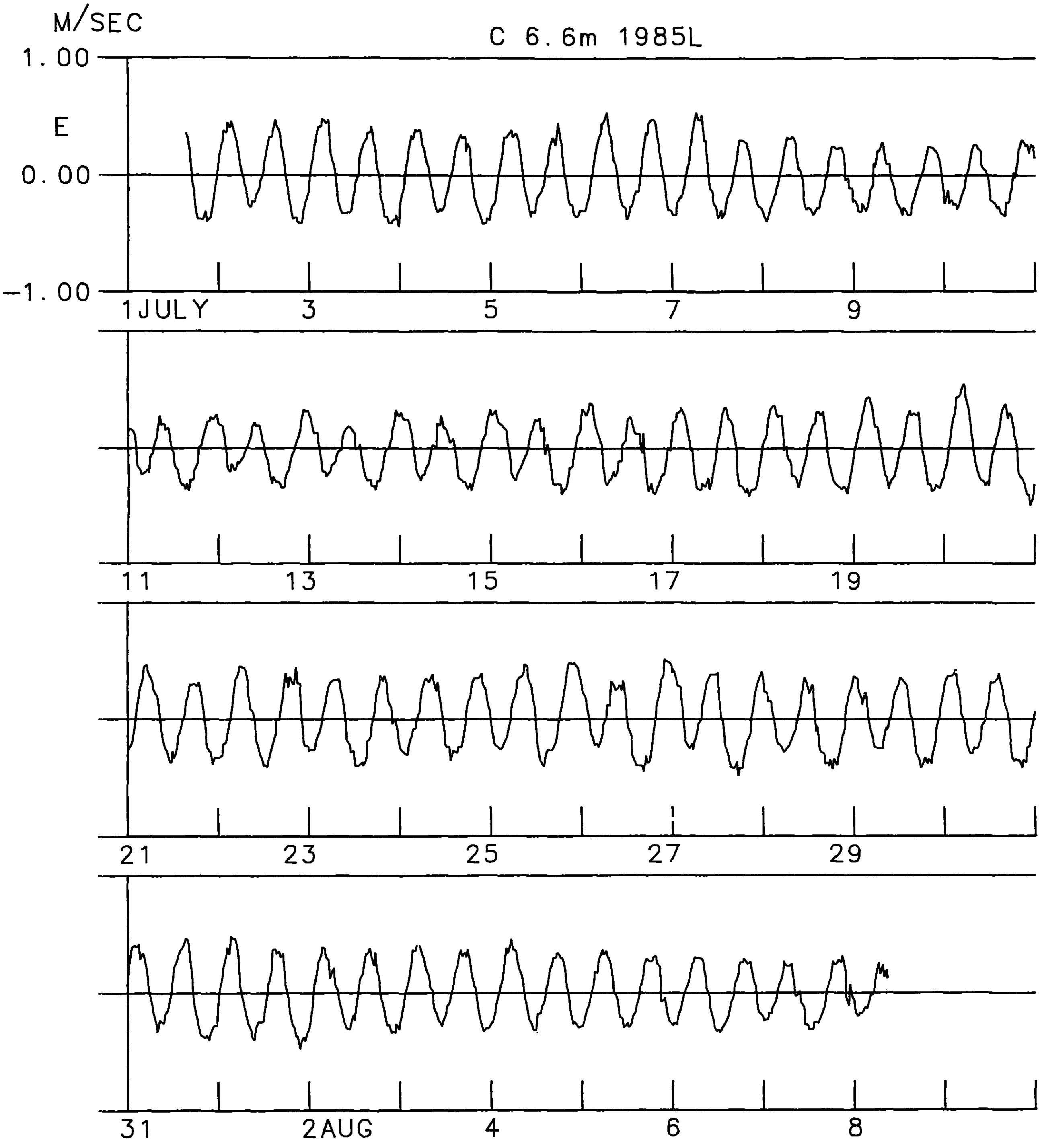
James River Bridge Station C, 1.5 m below surface



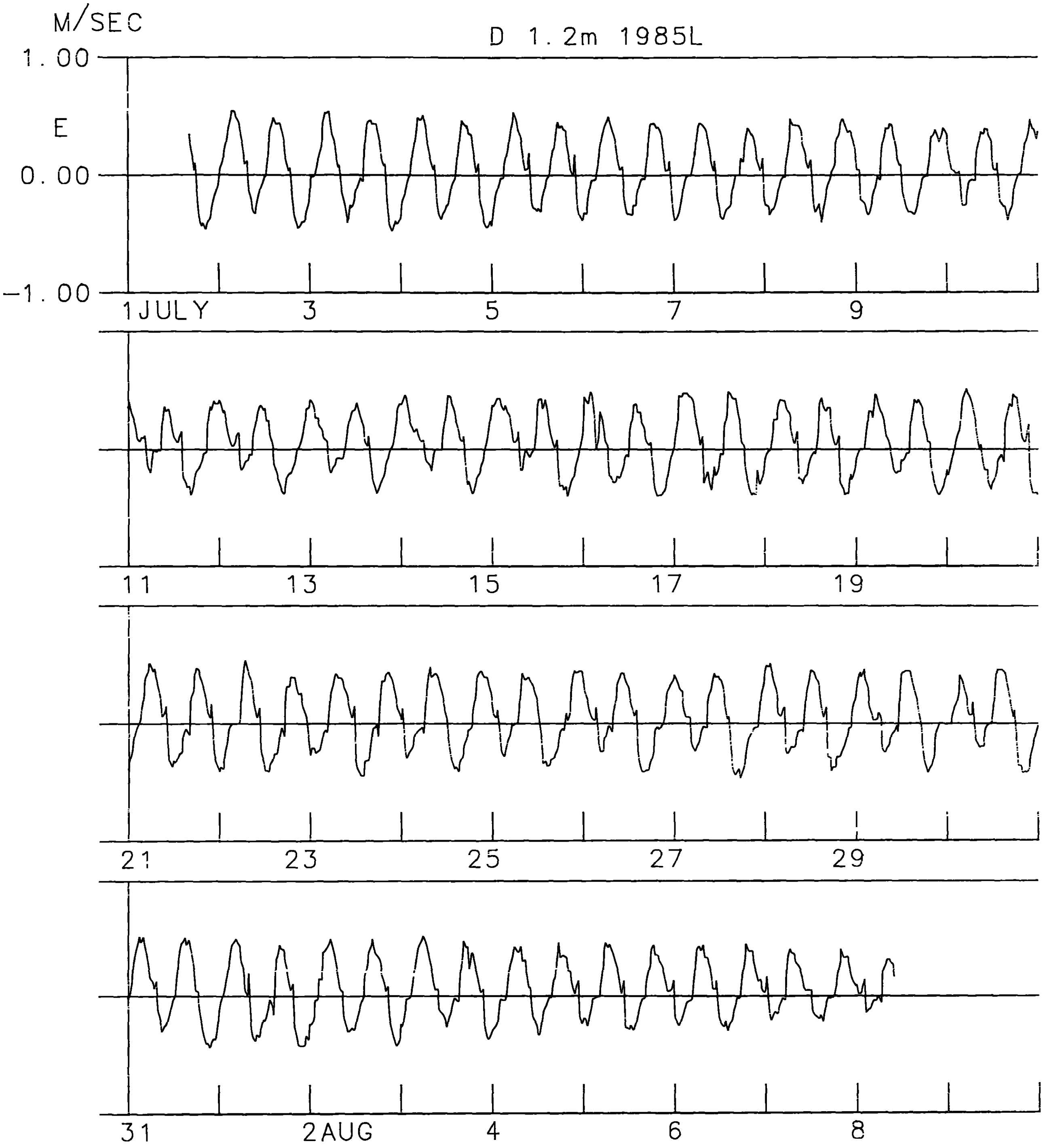
James River Bridge Station C, 4.3 m below surface



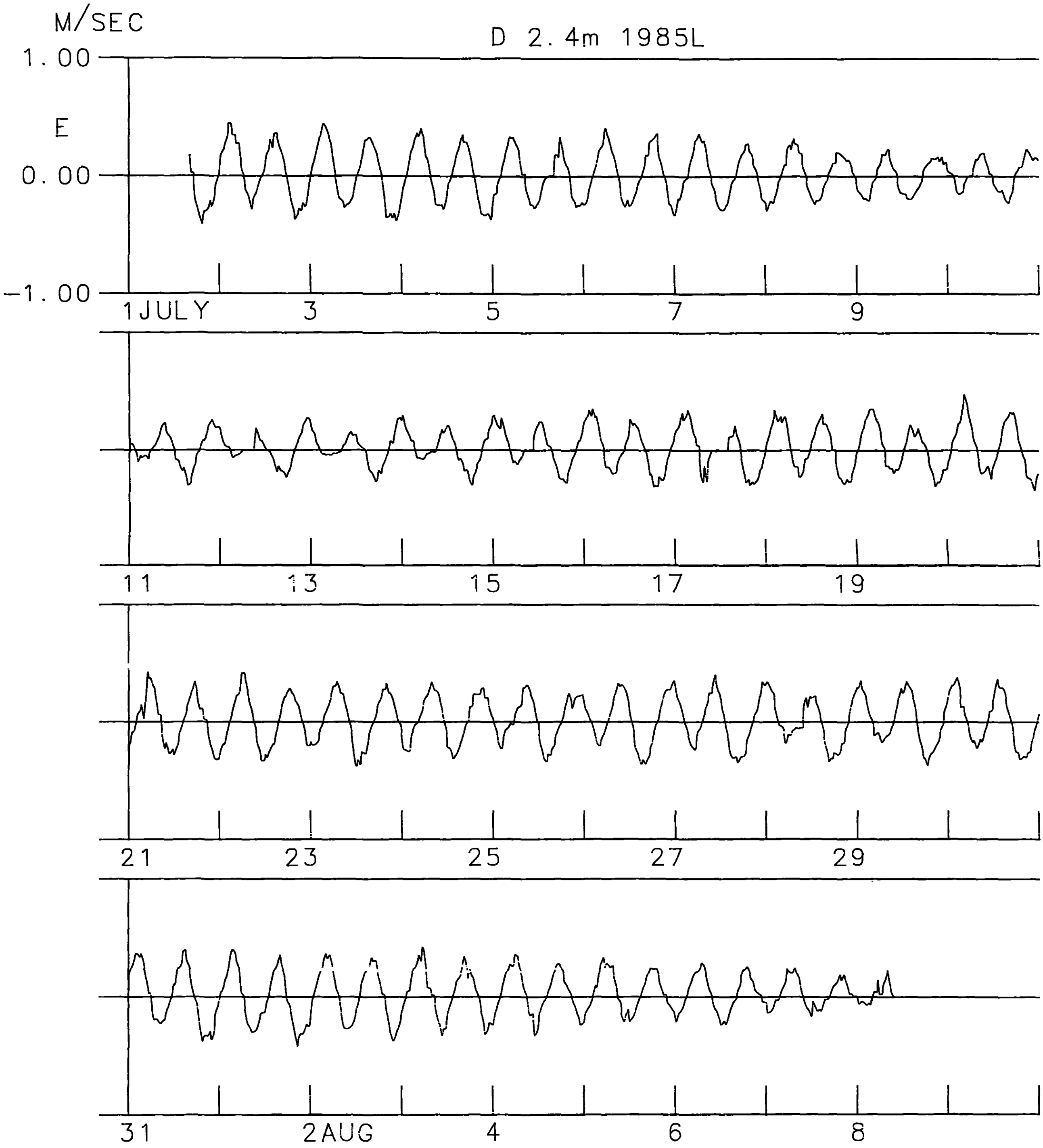
James River Bridge Station C, 5.6 m below surface



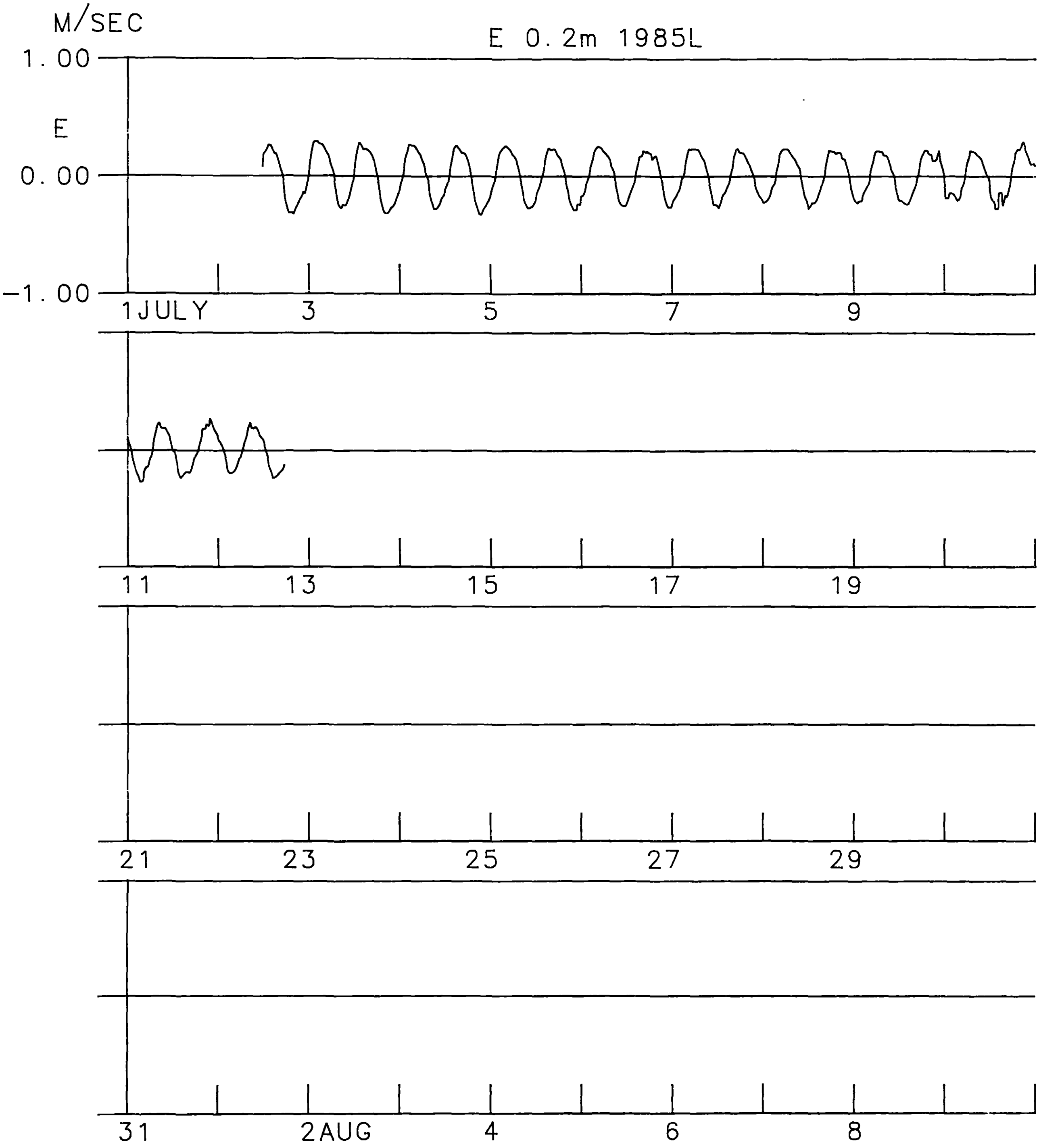
James River Bridge Station C, 6.6 m below surface



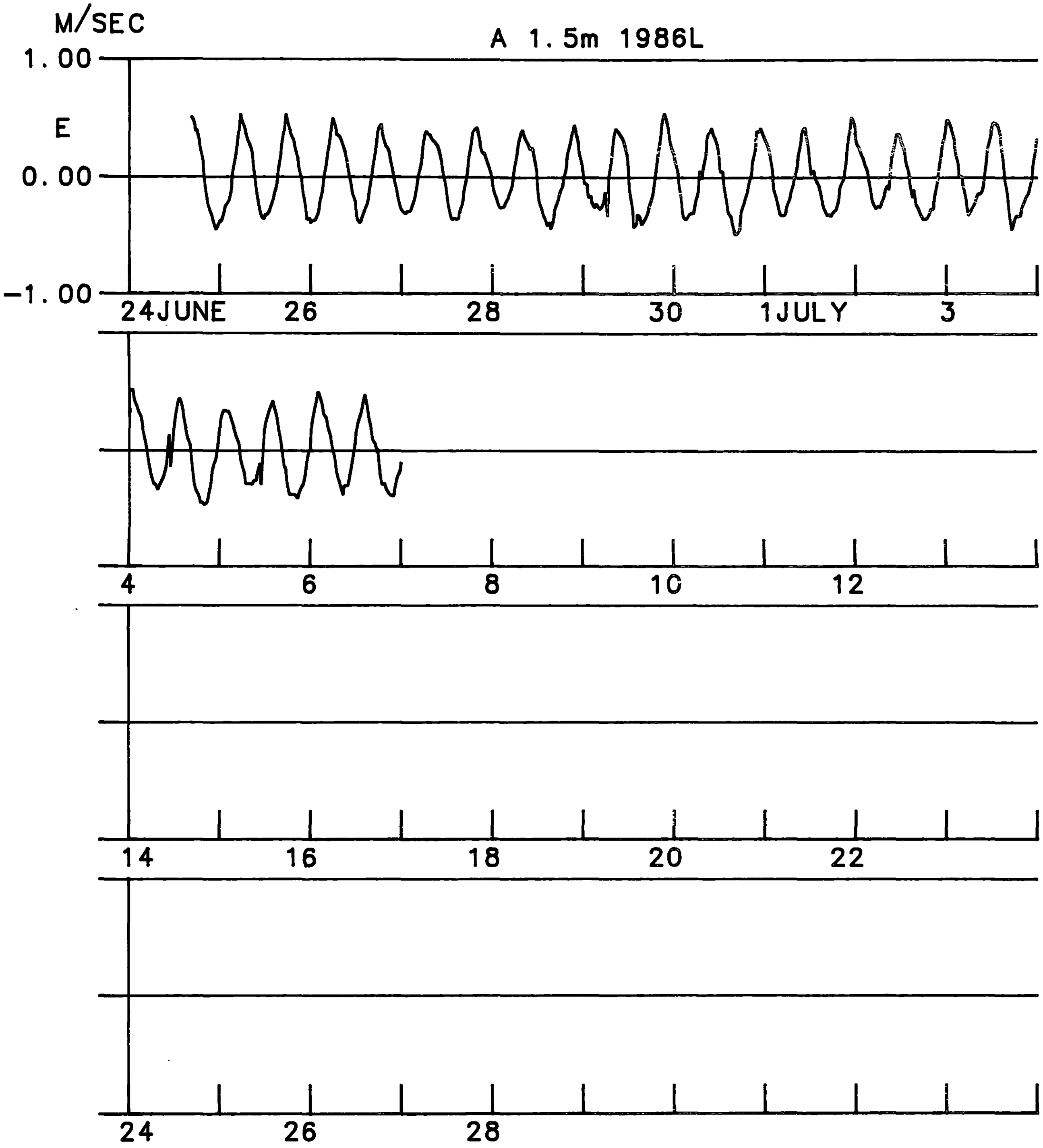
James River Bridge Station D, 1.2 m below surface



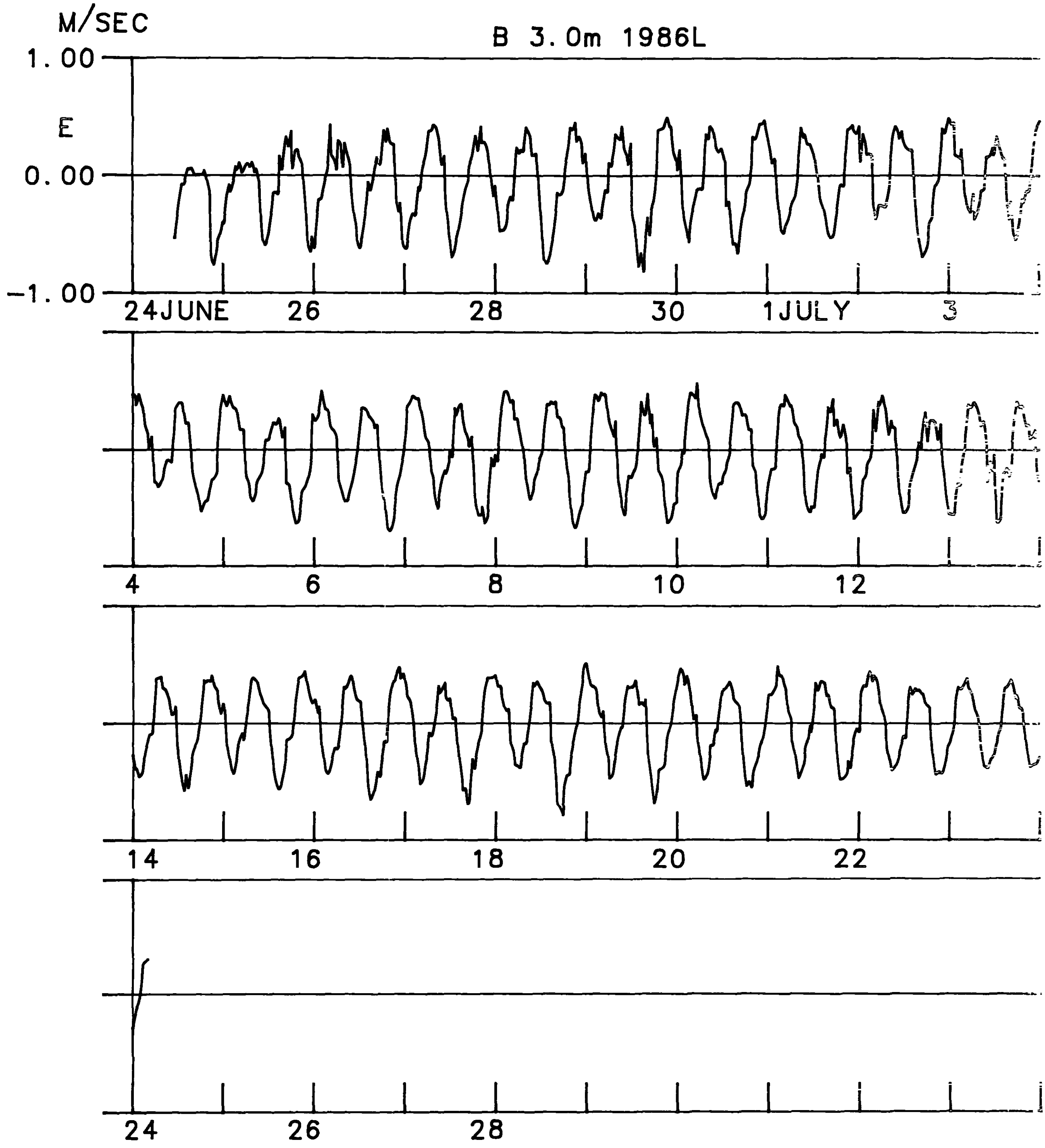
James River Bridge Station D, 2.4 m below surface



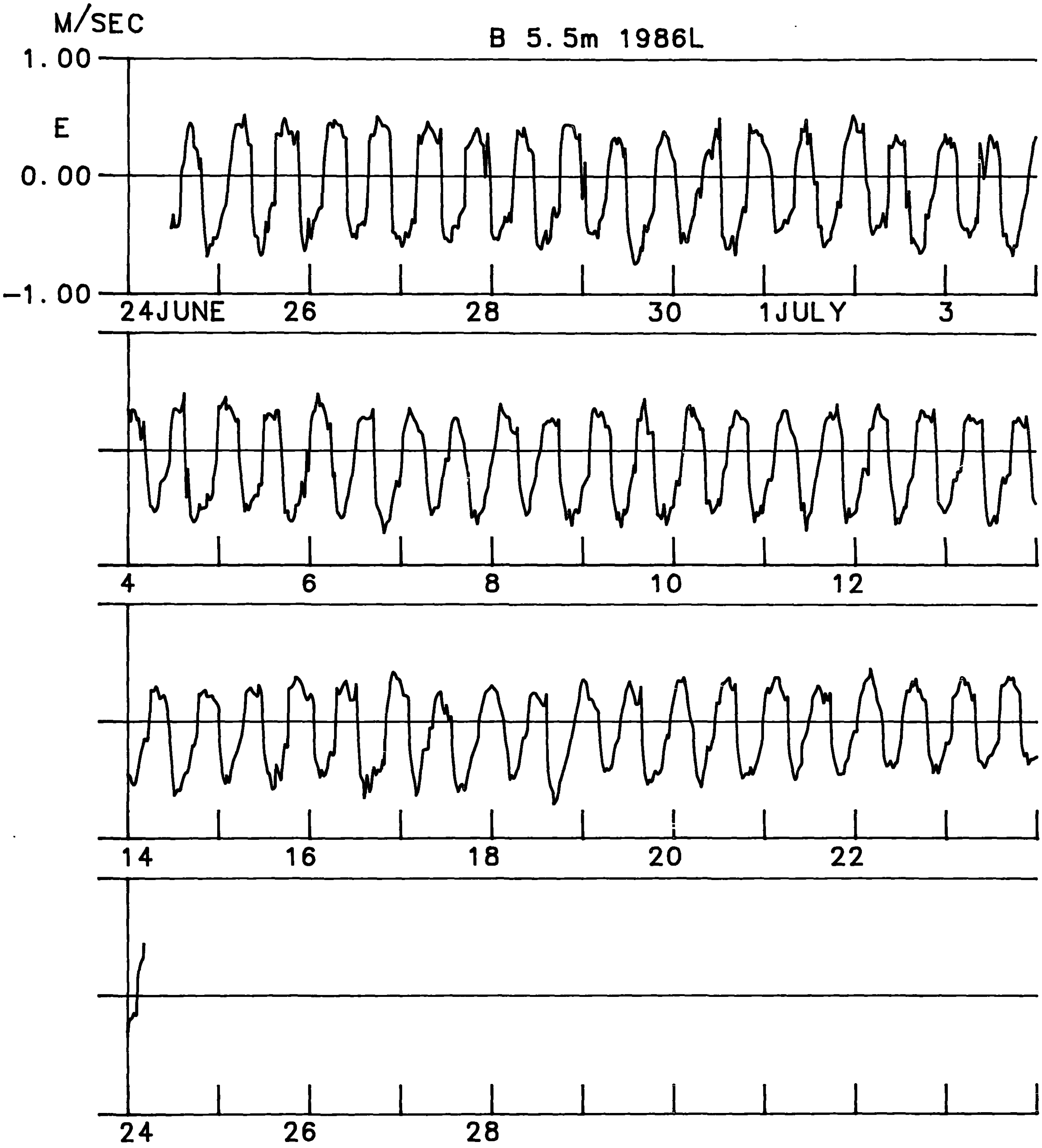
James River Bridge Station E, 0.2 m below surface



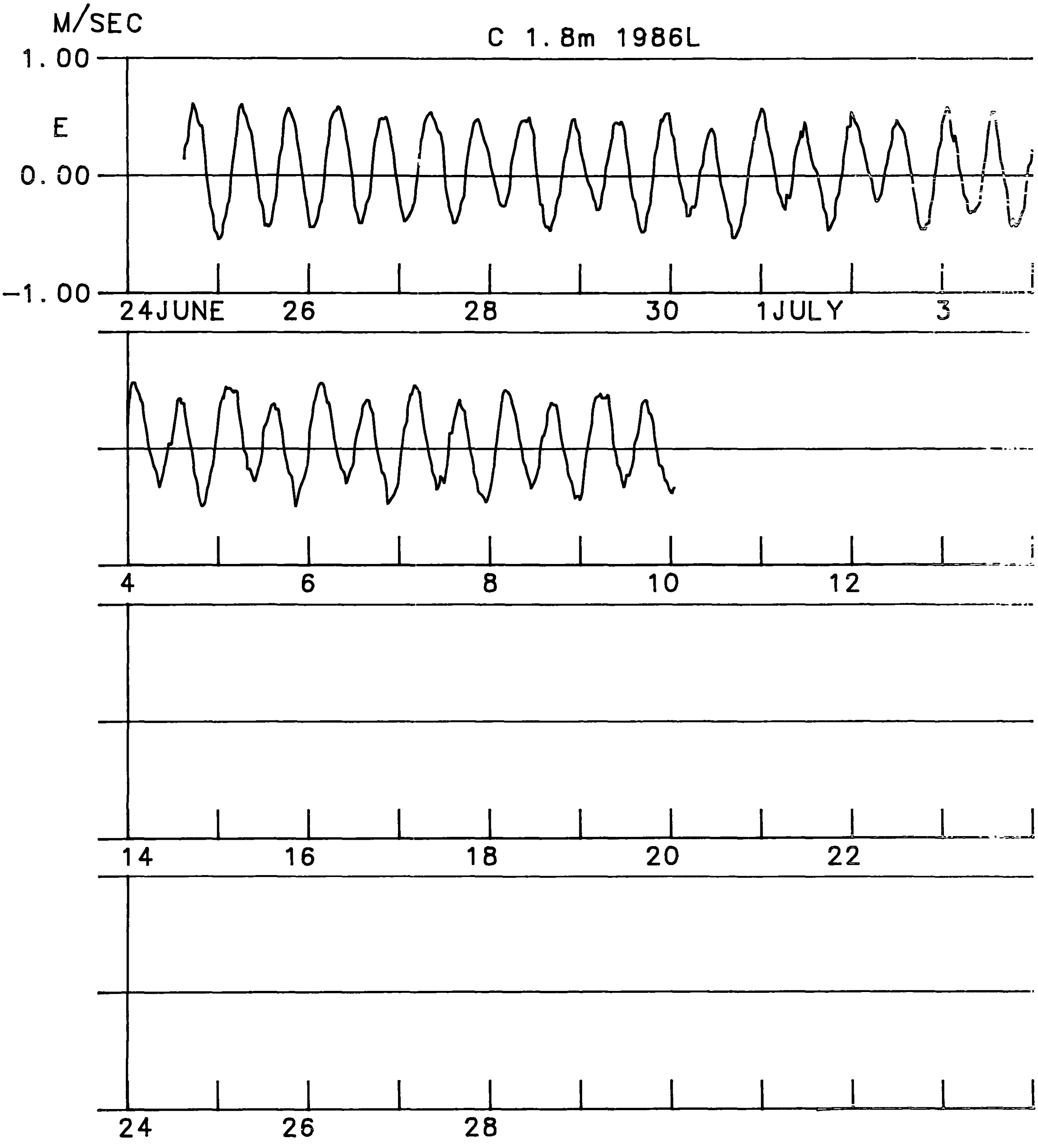
Burwell Bay Station A, 1.5 m below surface



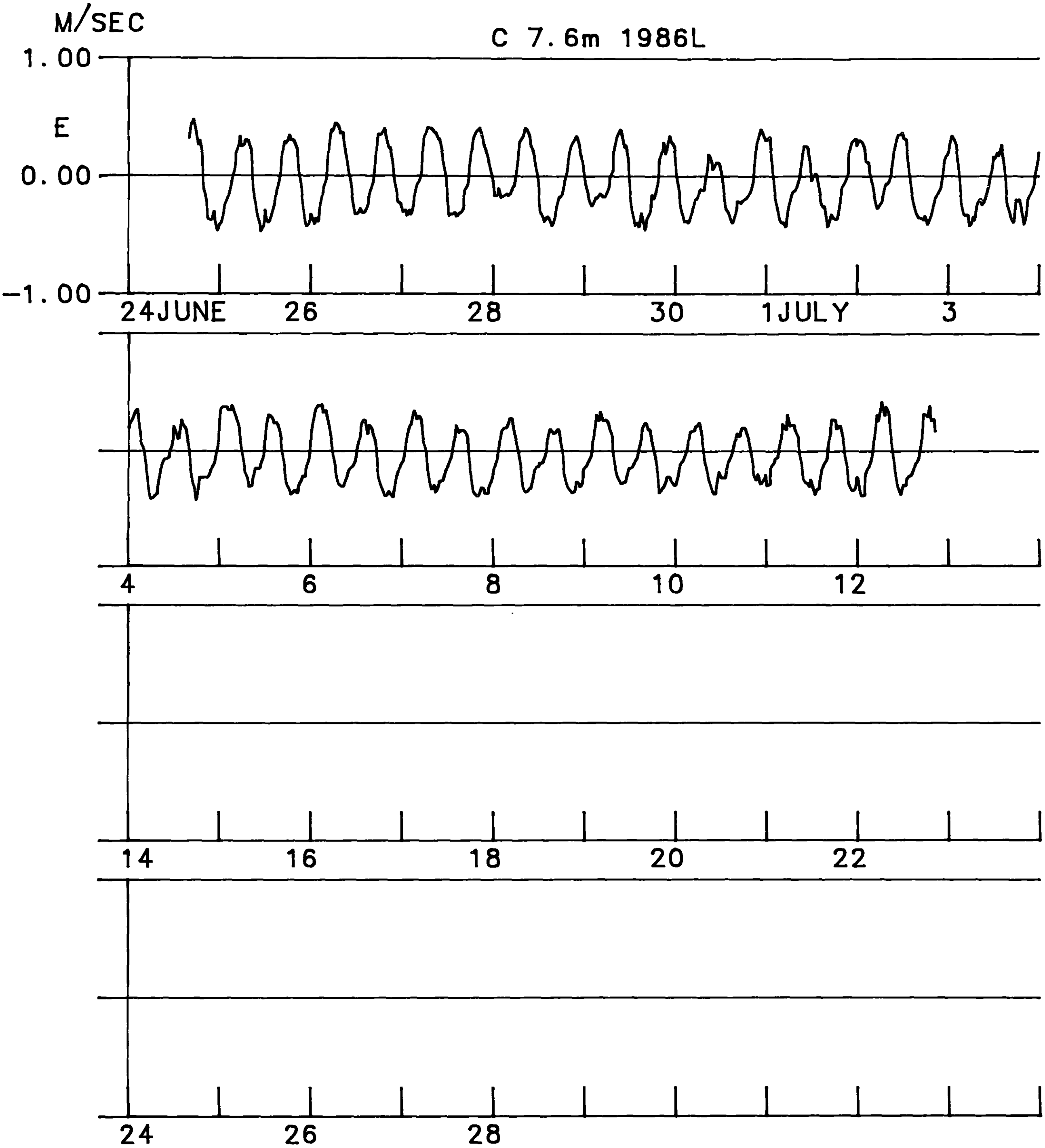
Burwell Bay Station B, 3.0 m below surface



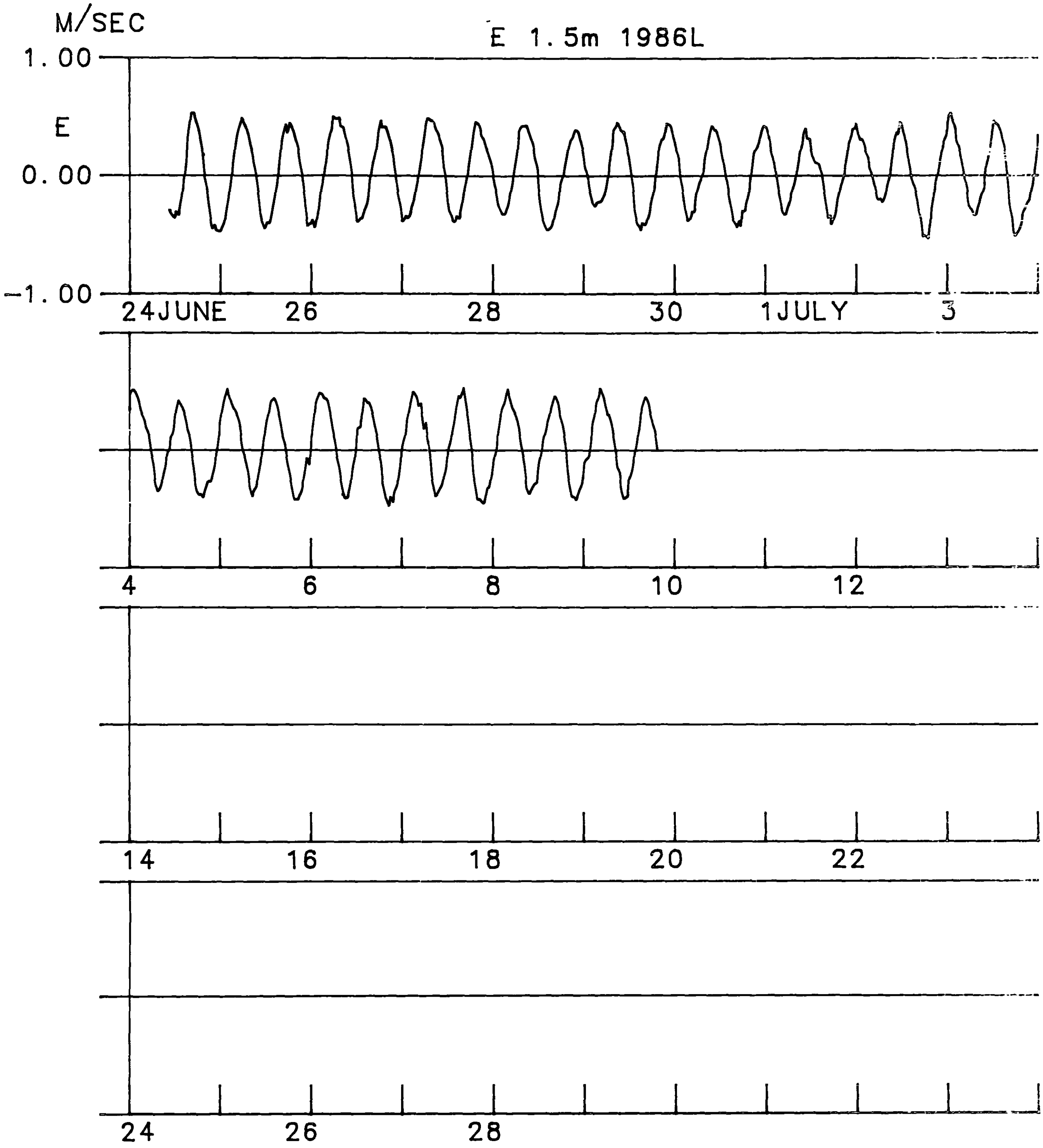
Burwell Bay Station B, 5.5 m below surface



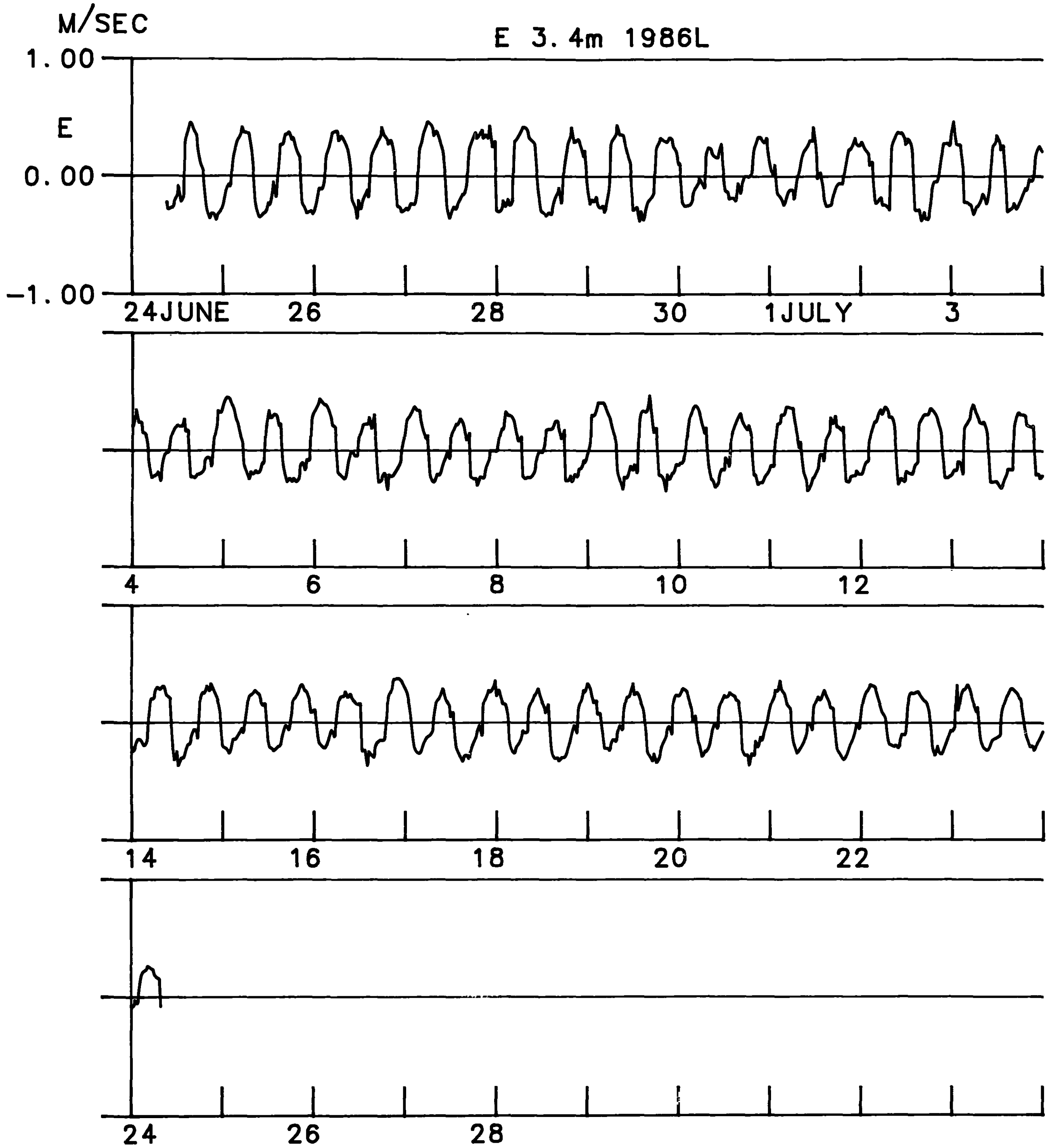
Burwell Bay Station C, 1.8 m below surface



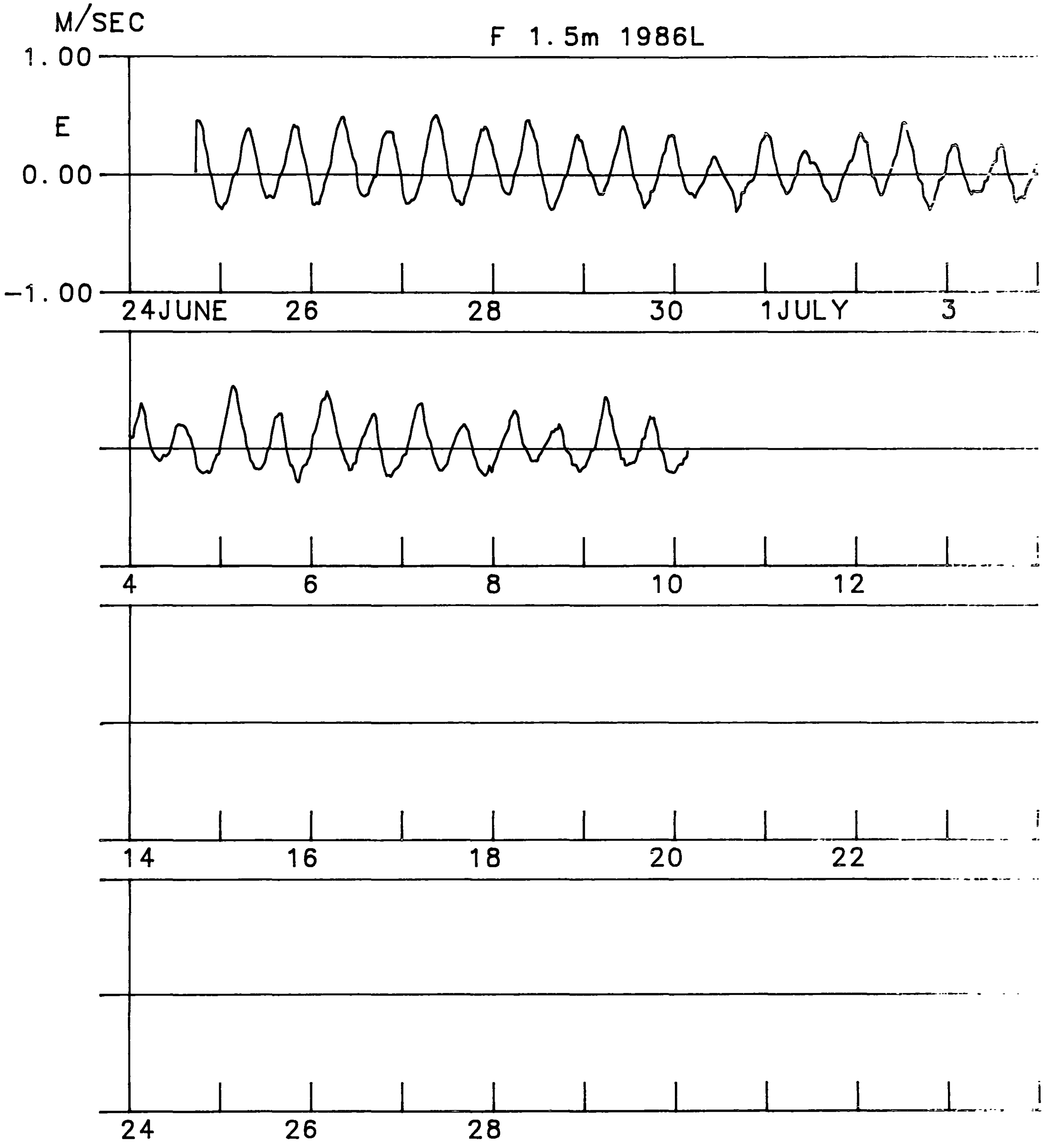
Burwell Bay Station C, 7.6 m below surface



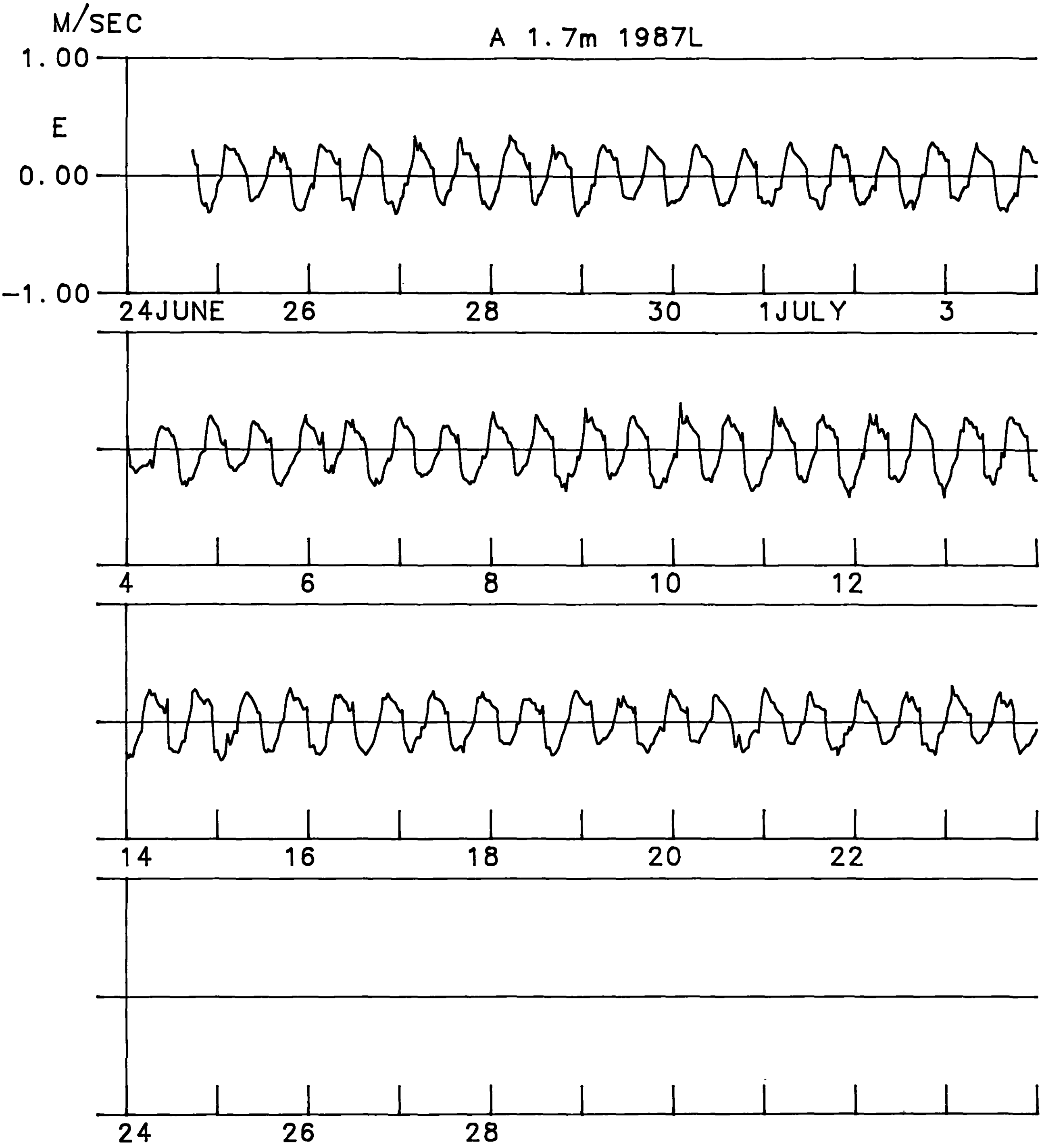
Burwell Bay Station E, 1.5 m below surface



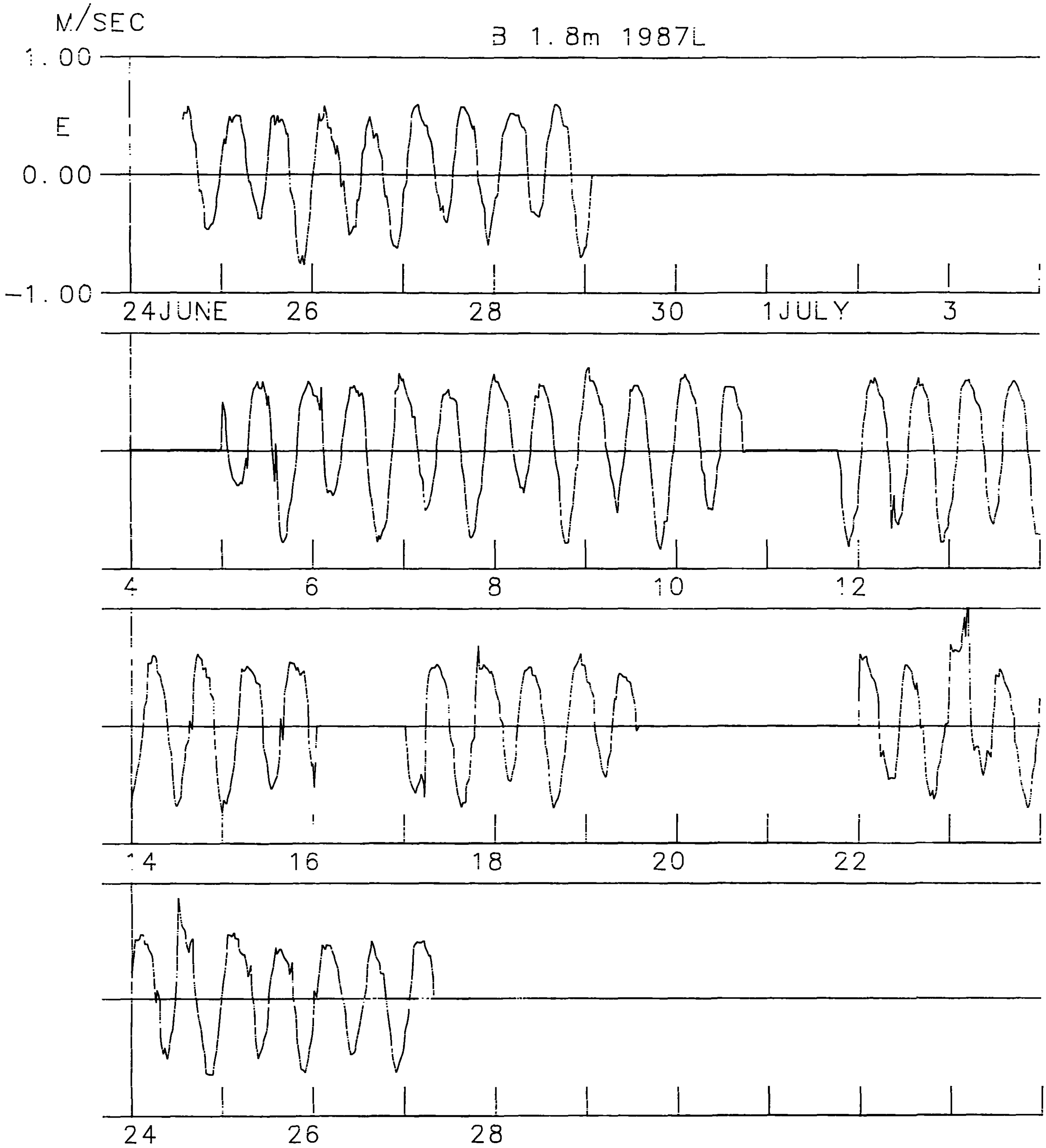
Burwell Bay Station E, 3.4 m below surface



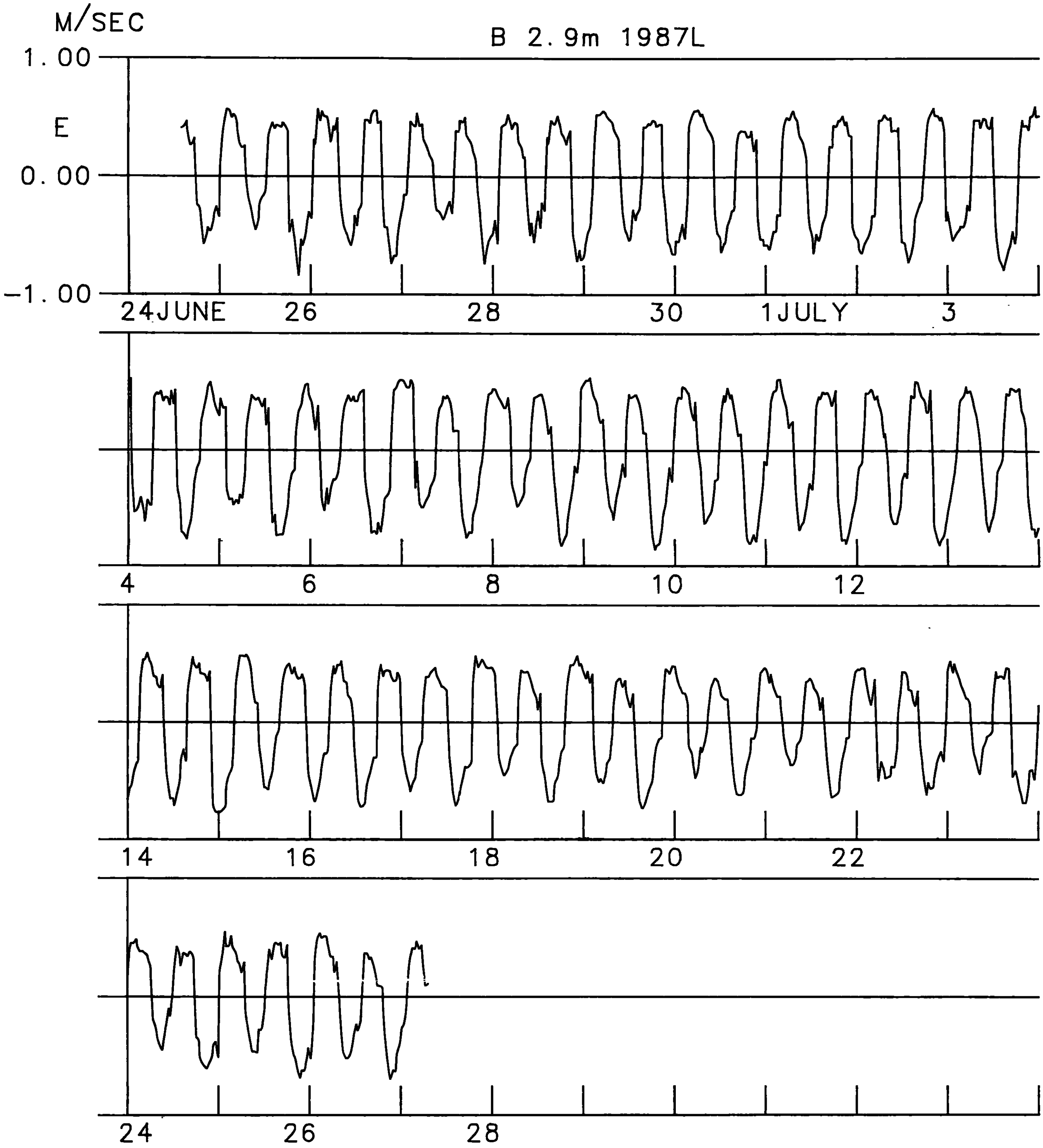
Burwell Bay Station F, 1.5 m below surface



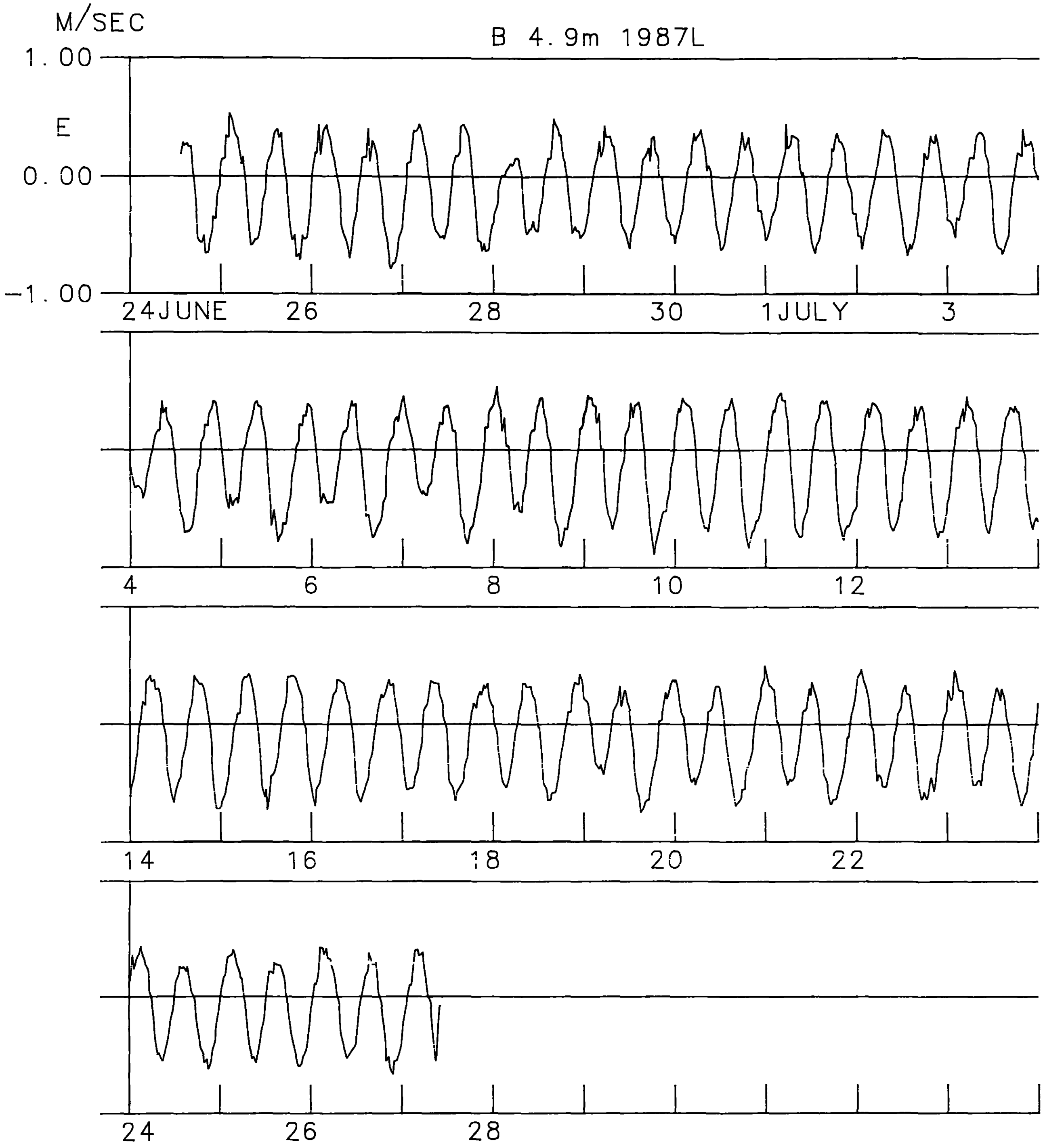
Burwell Bay Station A, 1.7 m below surface



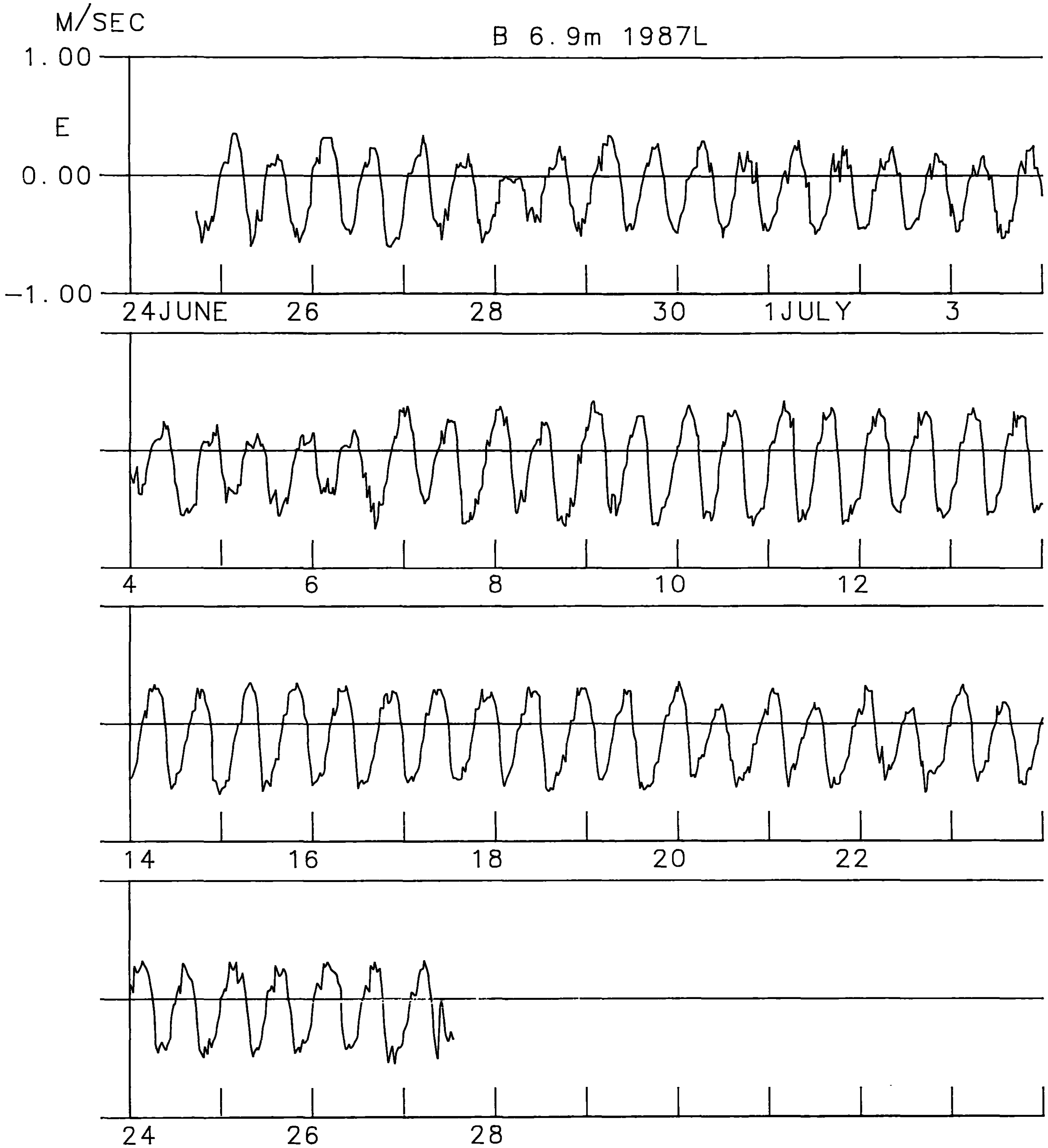
Burwell Bay Station B, 1.8 m below surface



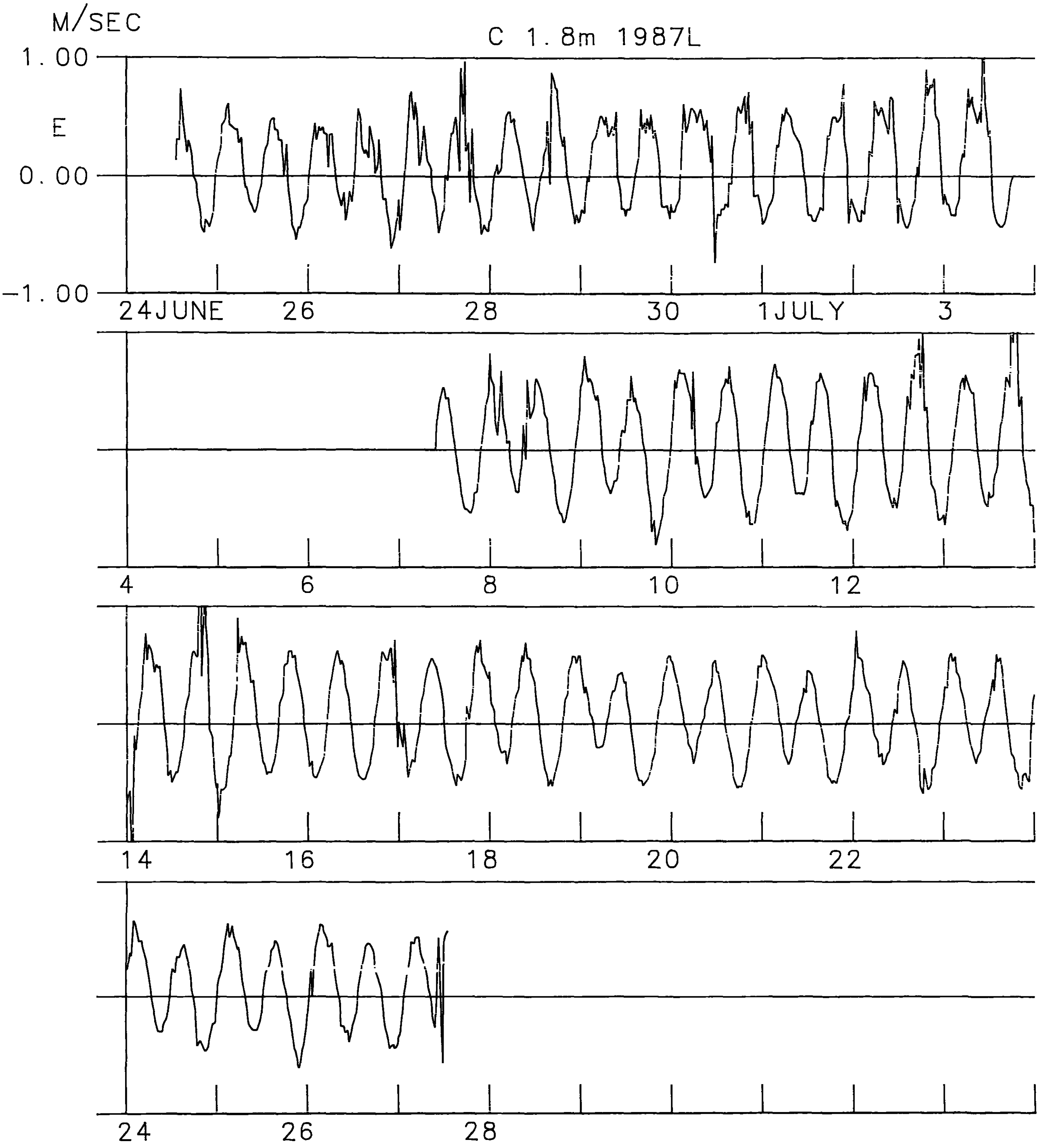
Burwell Bay Station B, 2.9 m below surface



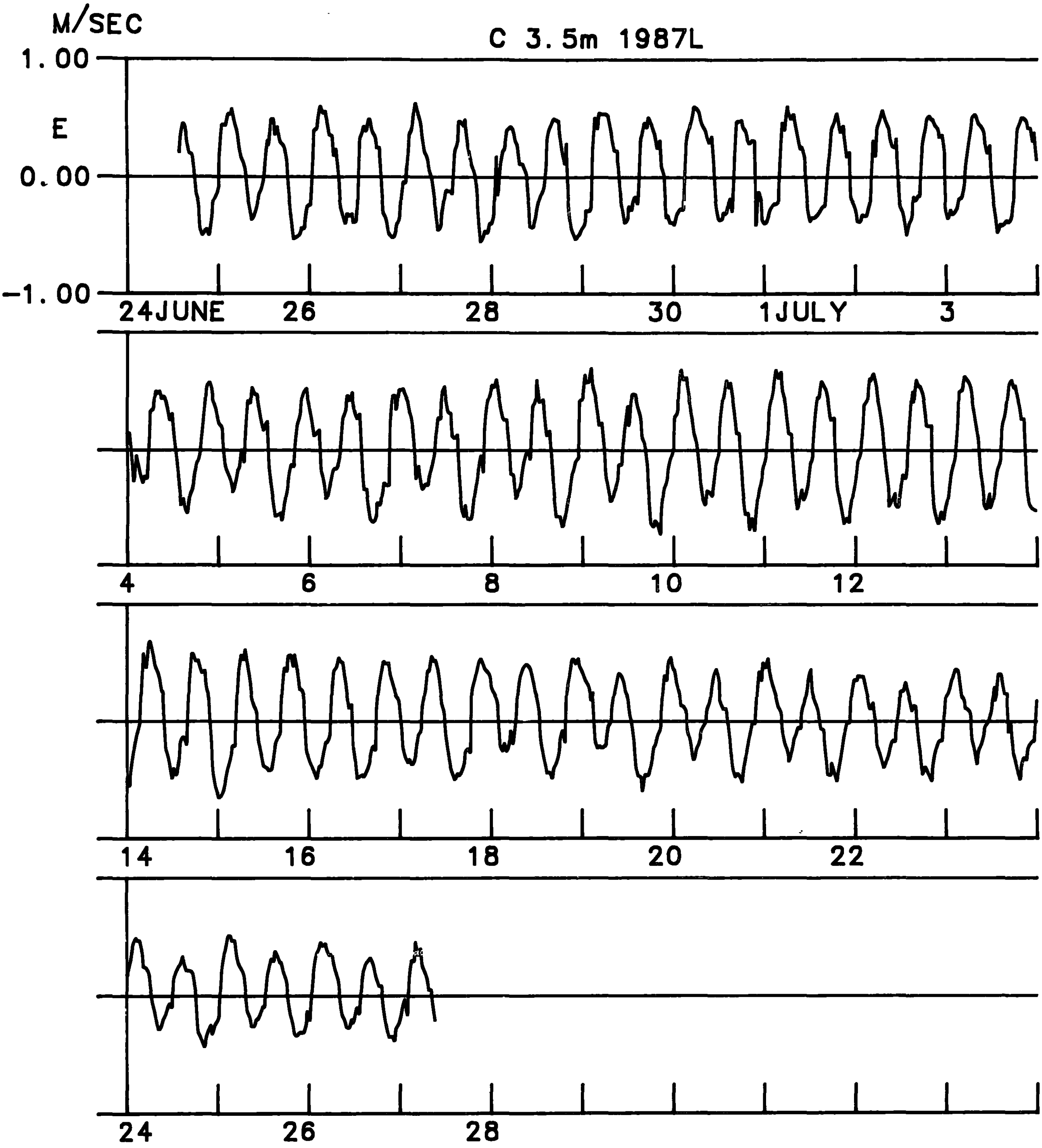
Burwell Bay Station B, 4.9 m below surface



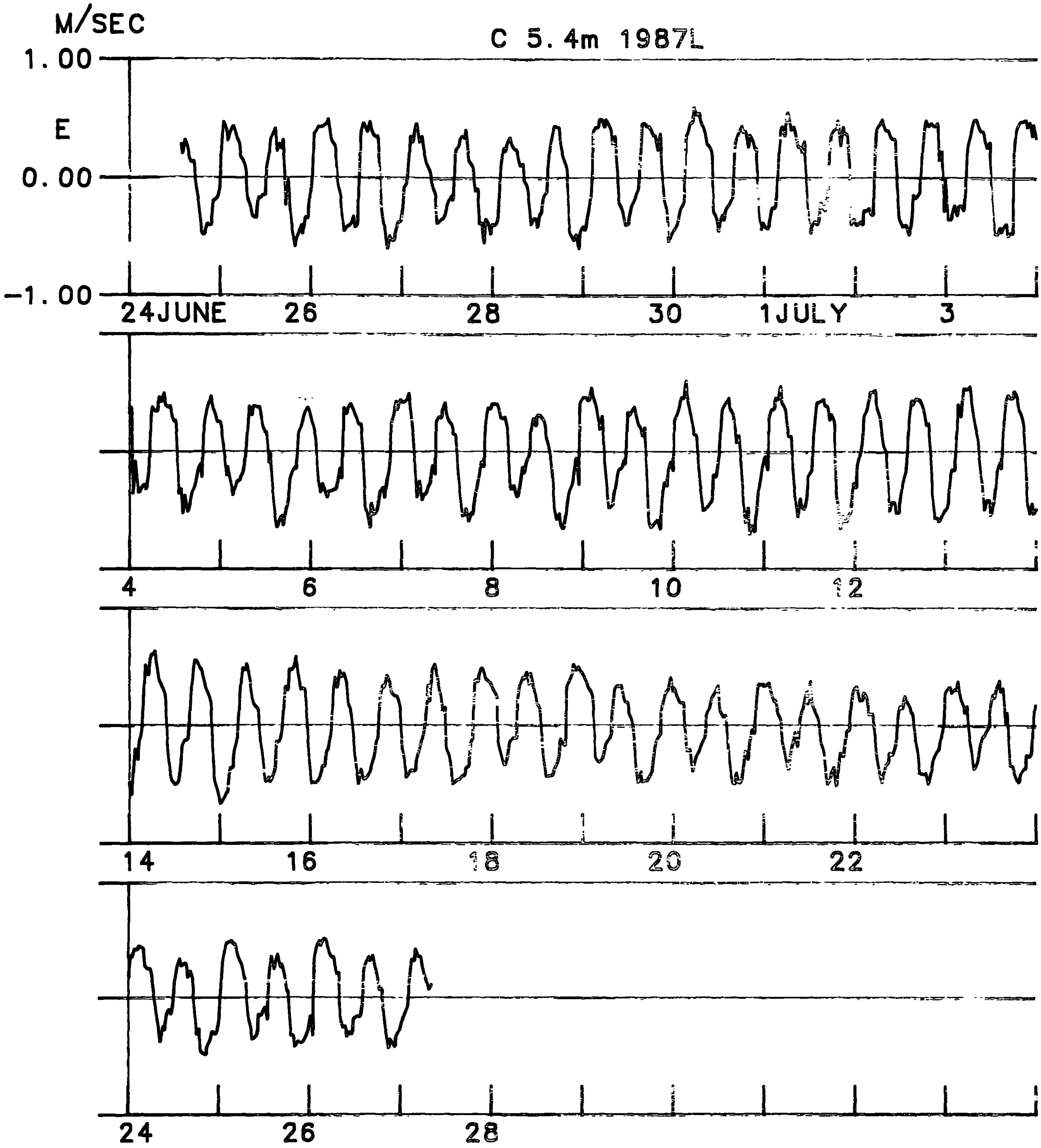
Burwell Bay Station B, 6.9 m below surface



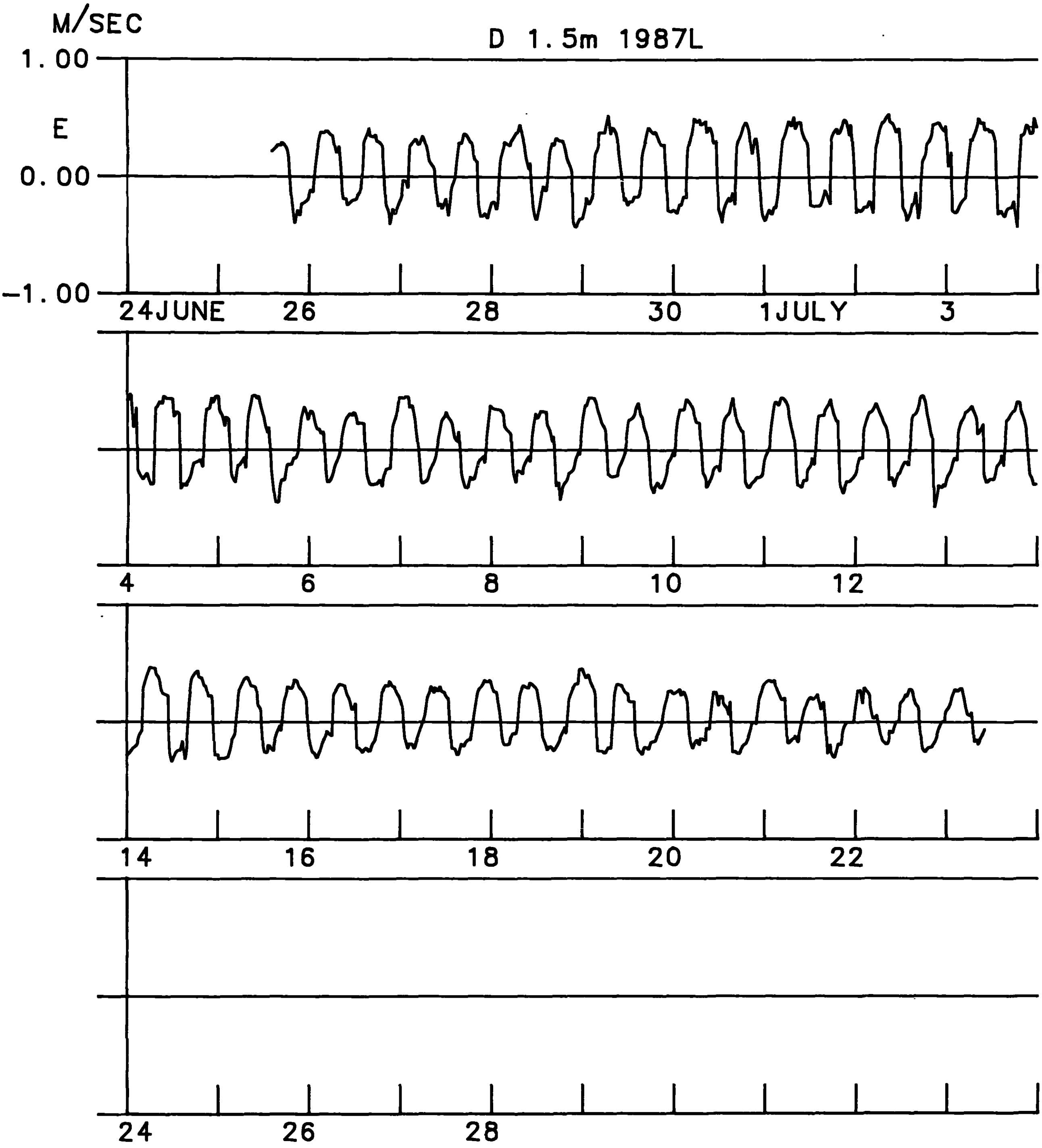
Burwell Bay Station C, 1.8 m below surface



Burwell Bay Station C, 3.5 m below surface



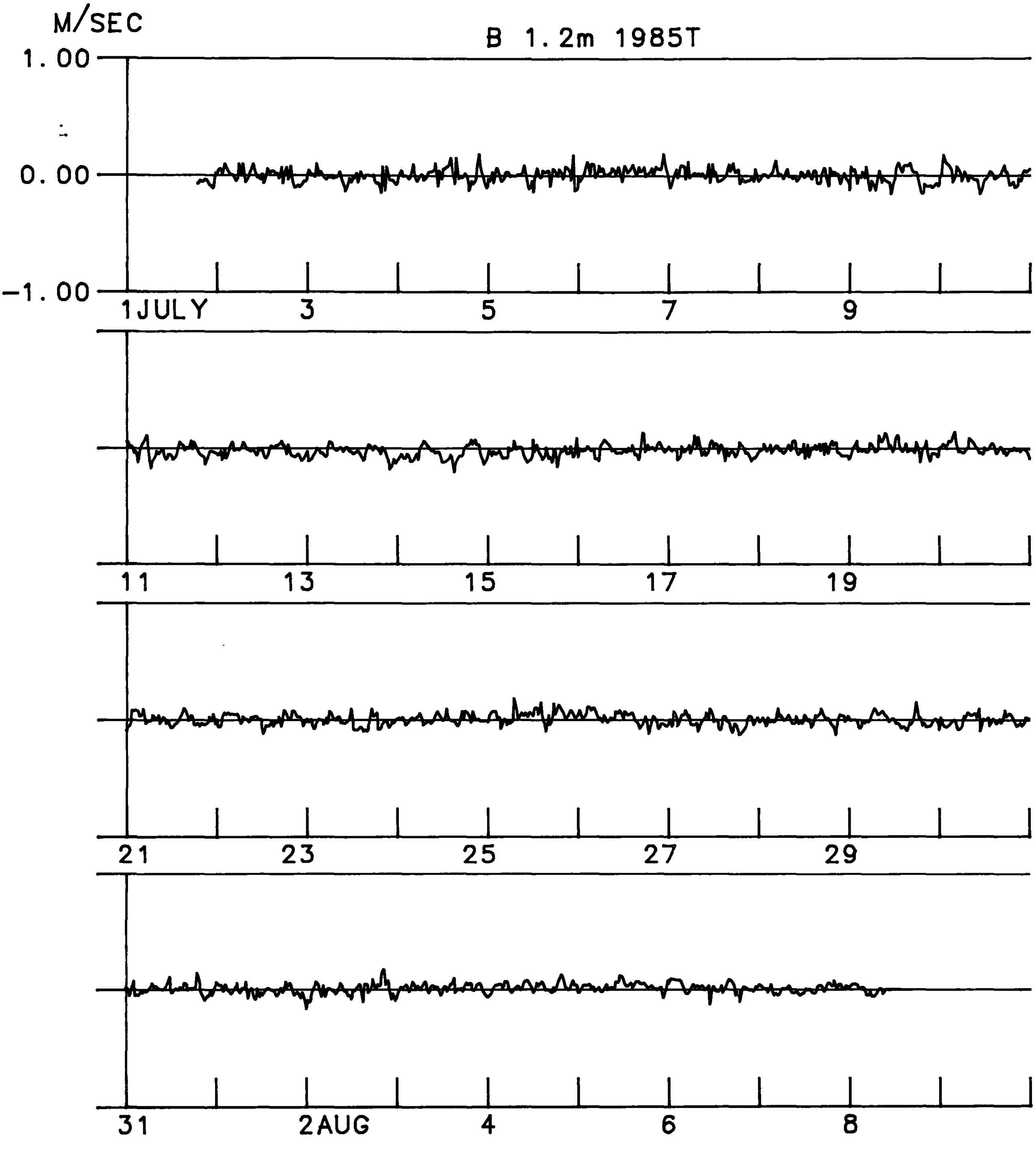
Burwell Bay Station C, 5.4 m below surface



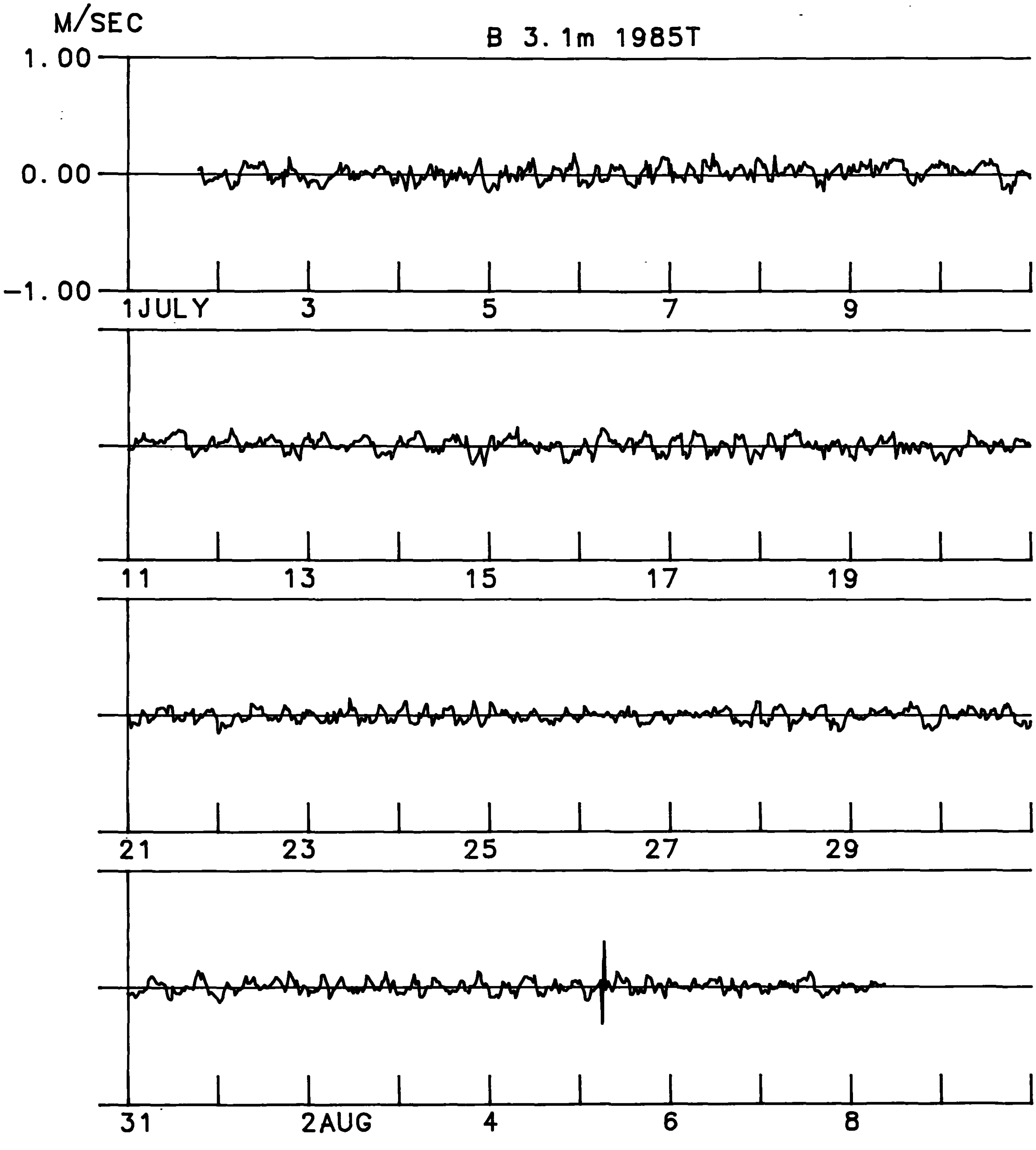
Burwell Bay Station D, 1.5 m below surface

APPENDIX D

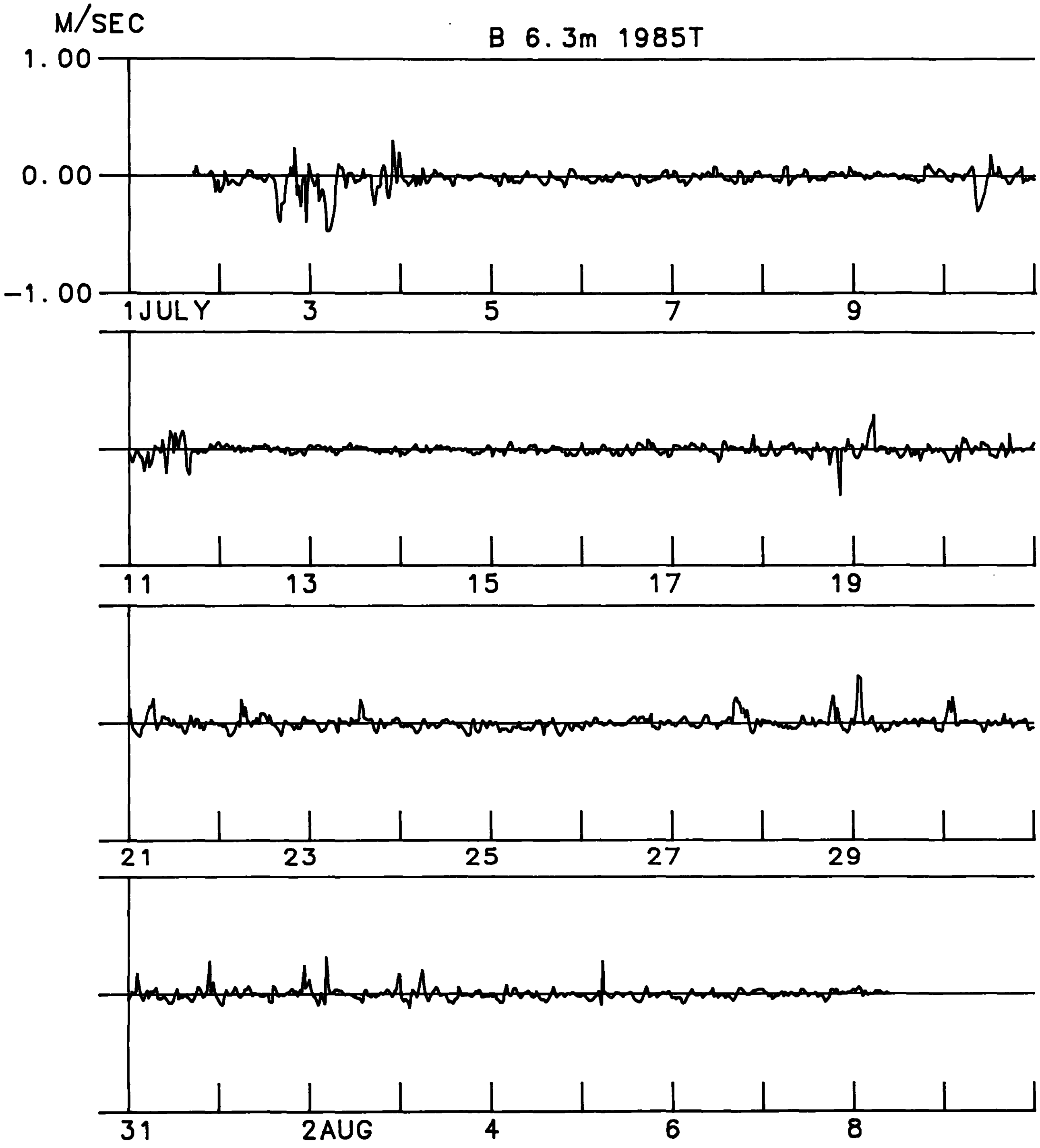
TRANSVERSE COMPONENTS OF CURRENTS



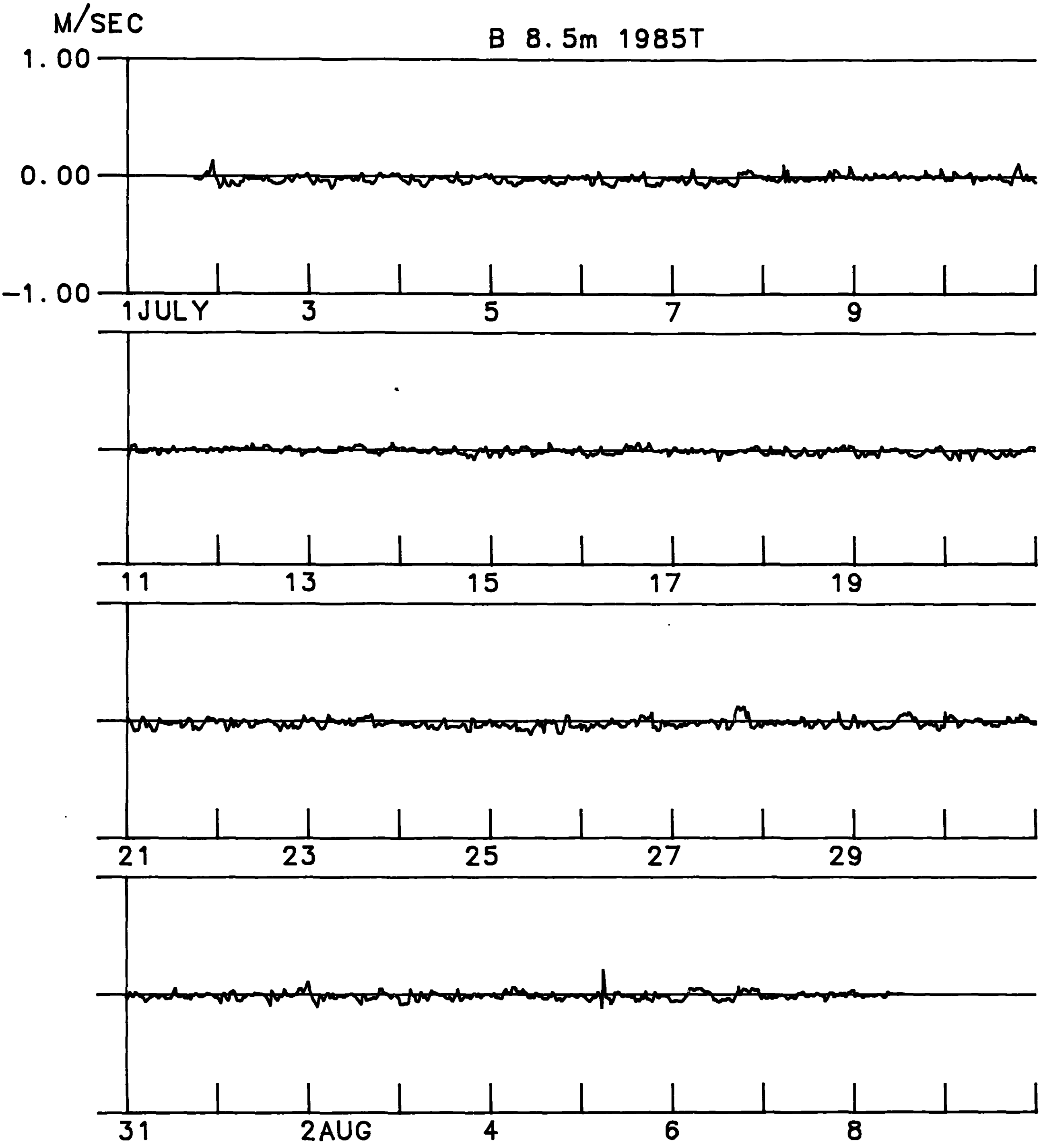
James River Bridge Station B, 1.2 m below surface



James River Bridge Station B, 3.1 m below surface



James River Bridge Station B, 6.3 m below surface

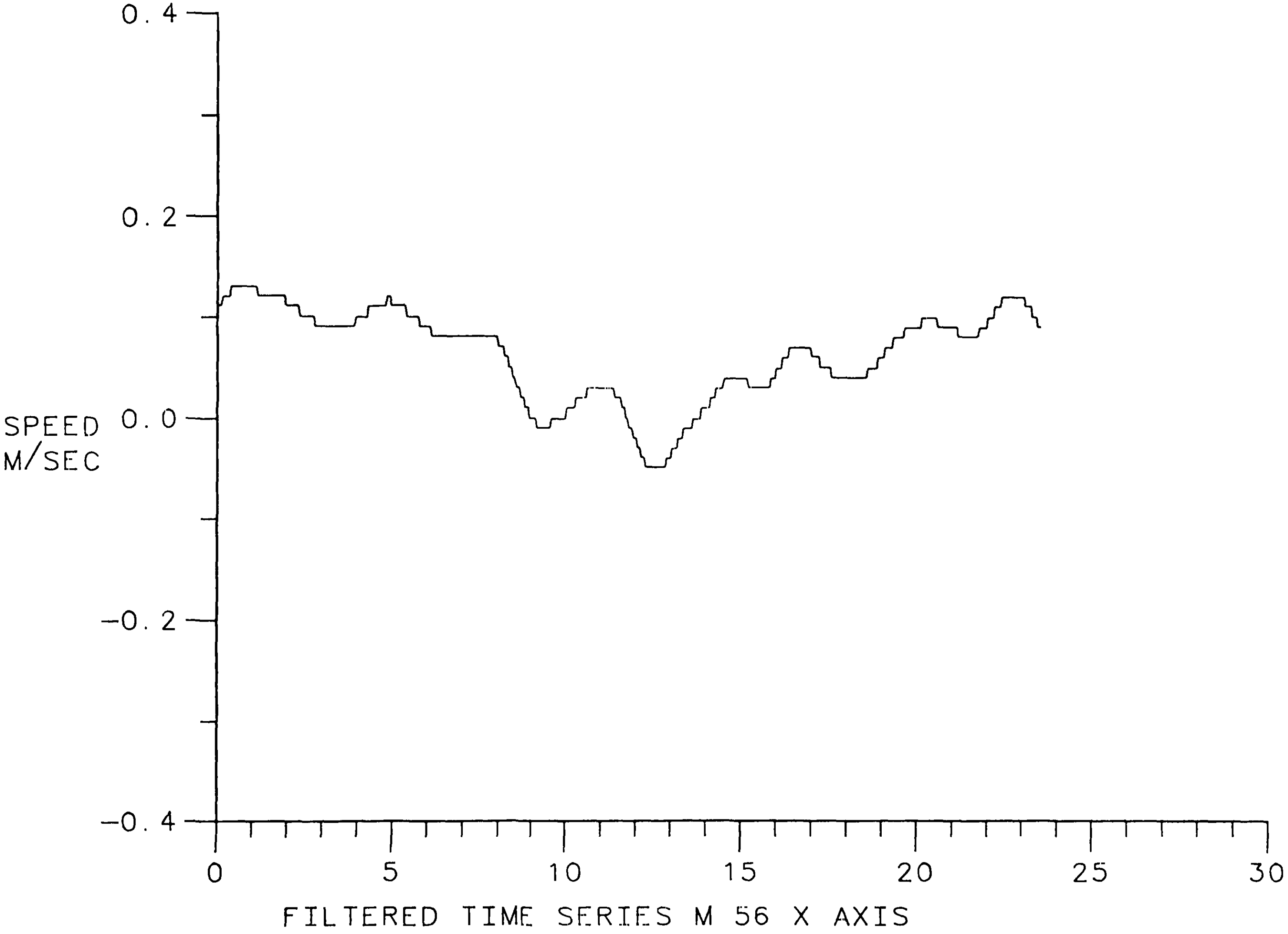


James River Bridge Station B, 8.5 m below surface

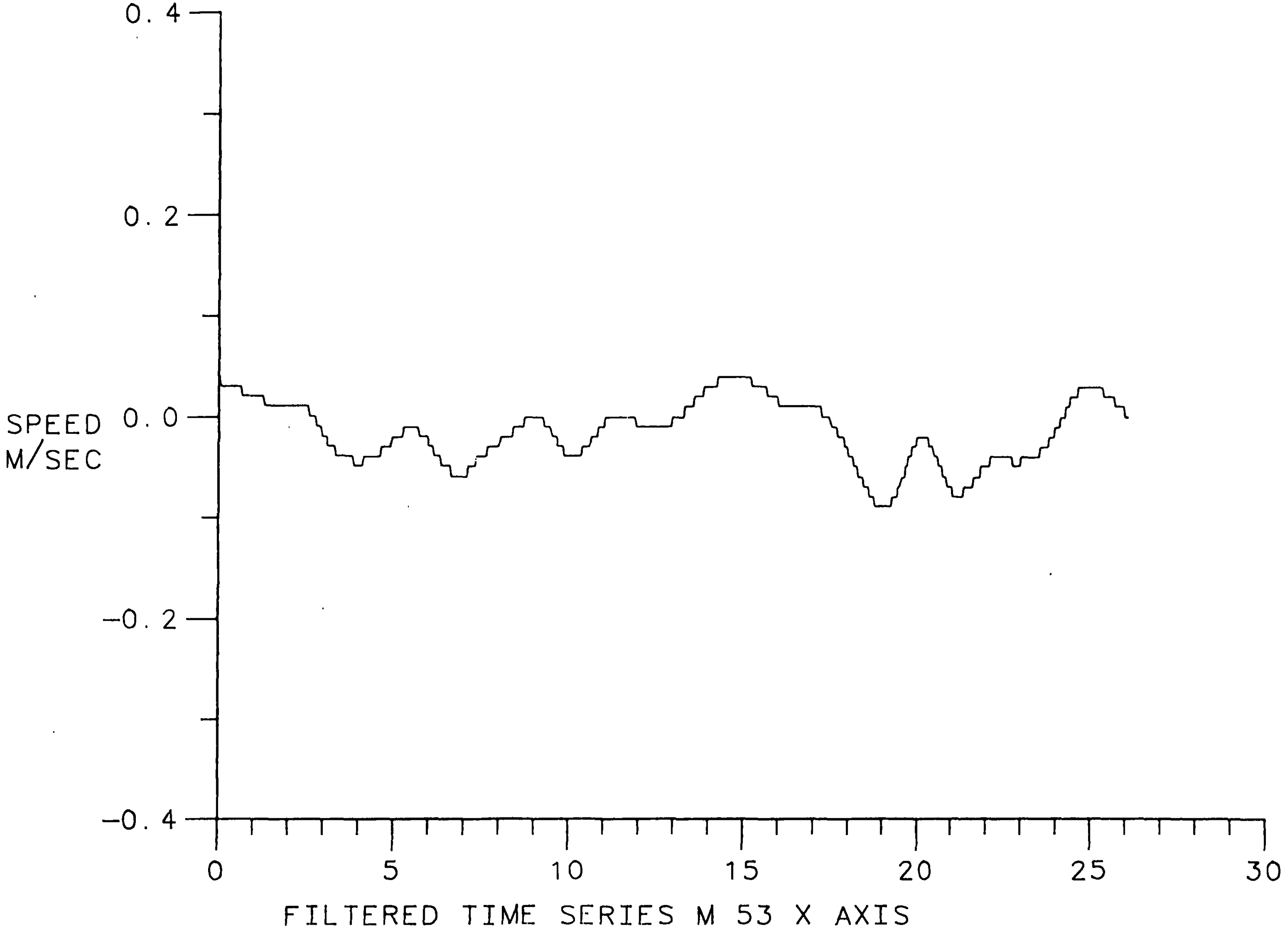
APPENDIX E

LOW PASS FILTERED LONGITUDINAL COMPONENTS OF CURRENTS

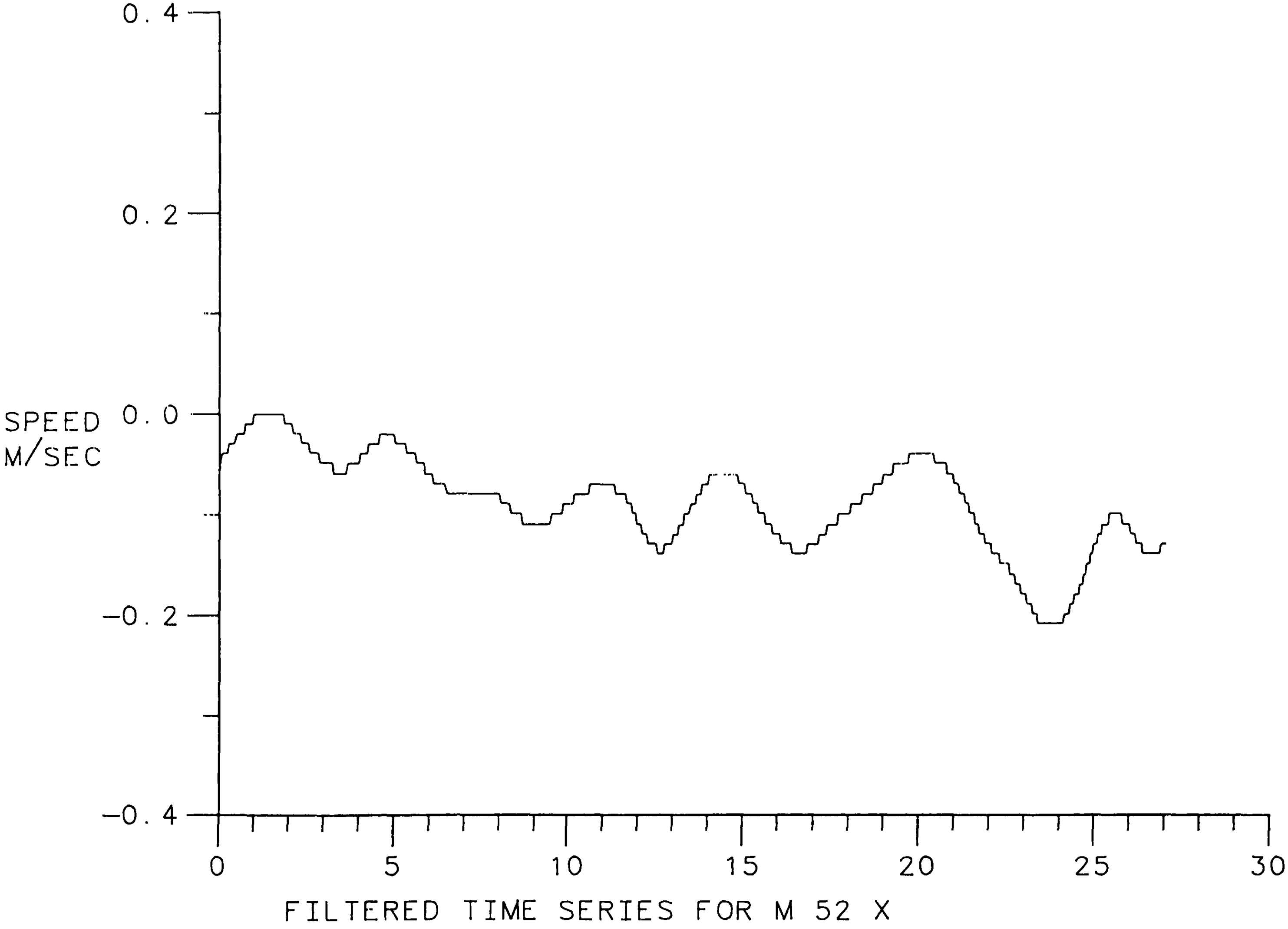
(Positive is in ebb direction)



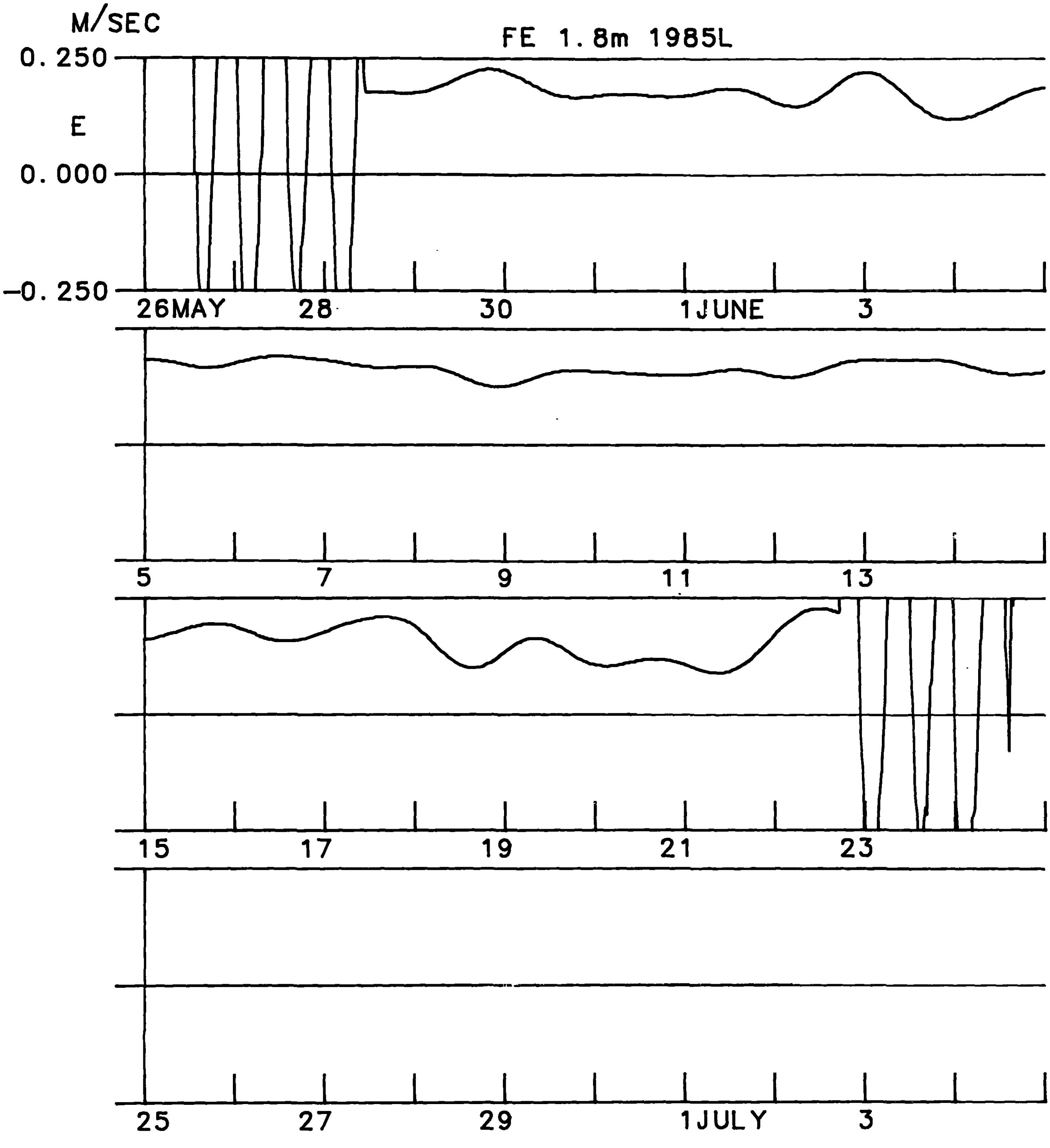
The longitudinal component of the non-tidal current at 2.4 m depth, starting 0900 hr., Oct. 21, 1984.



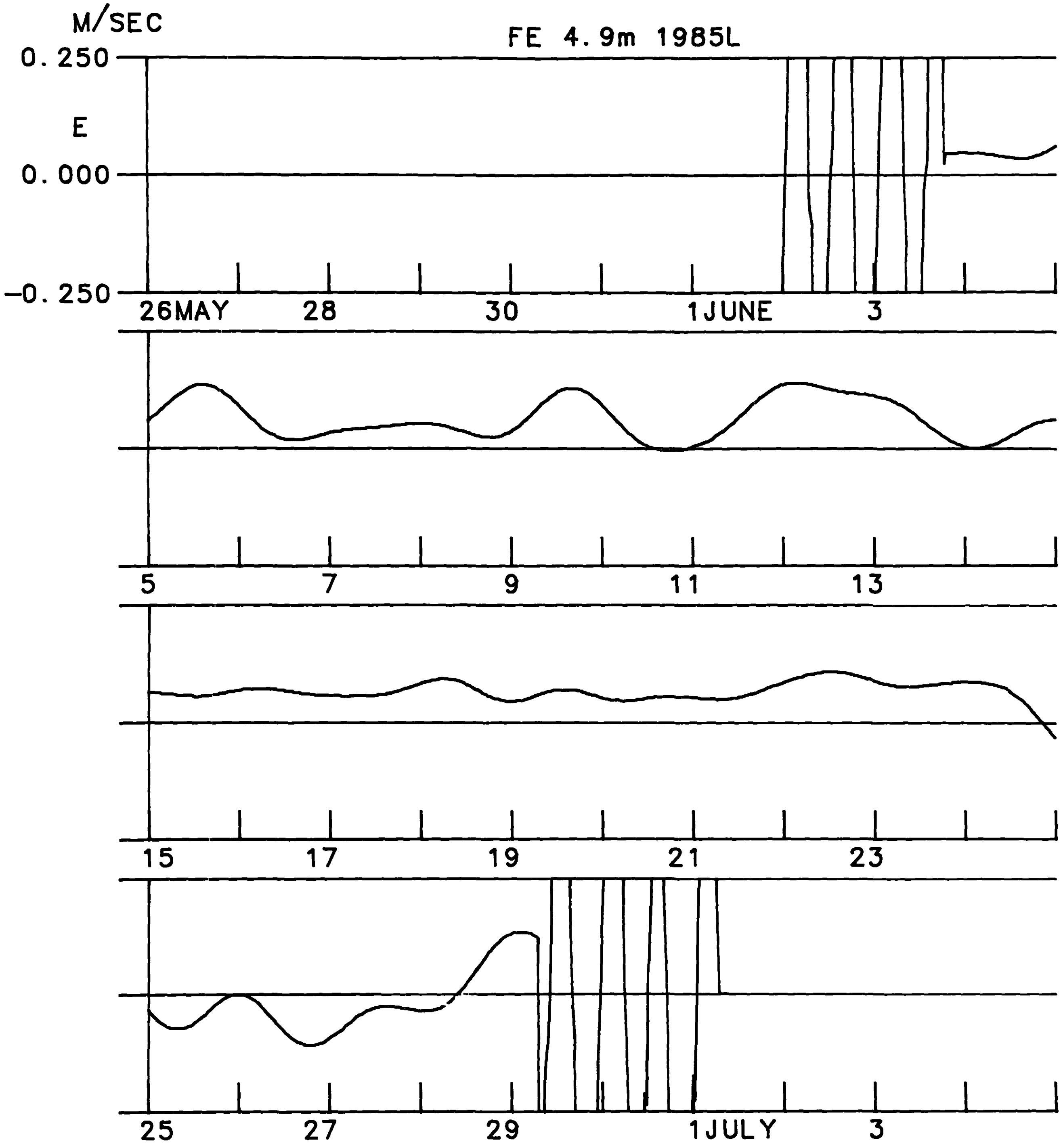
The longitudinal component of the non-tidal current at 4.9m depth, starting 2300 hr., Oct. 26, 1984.



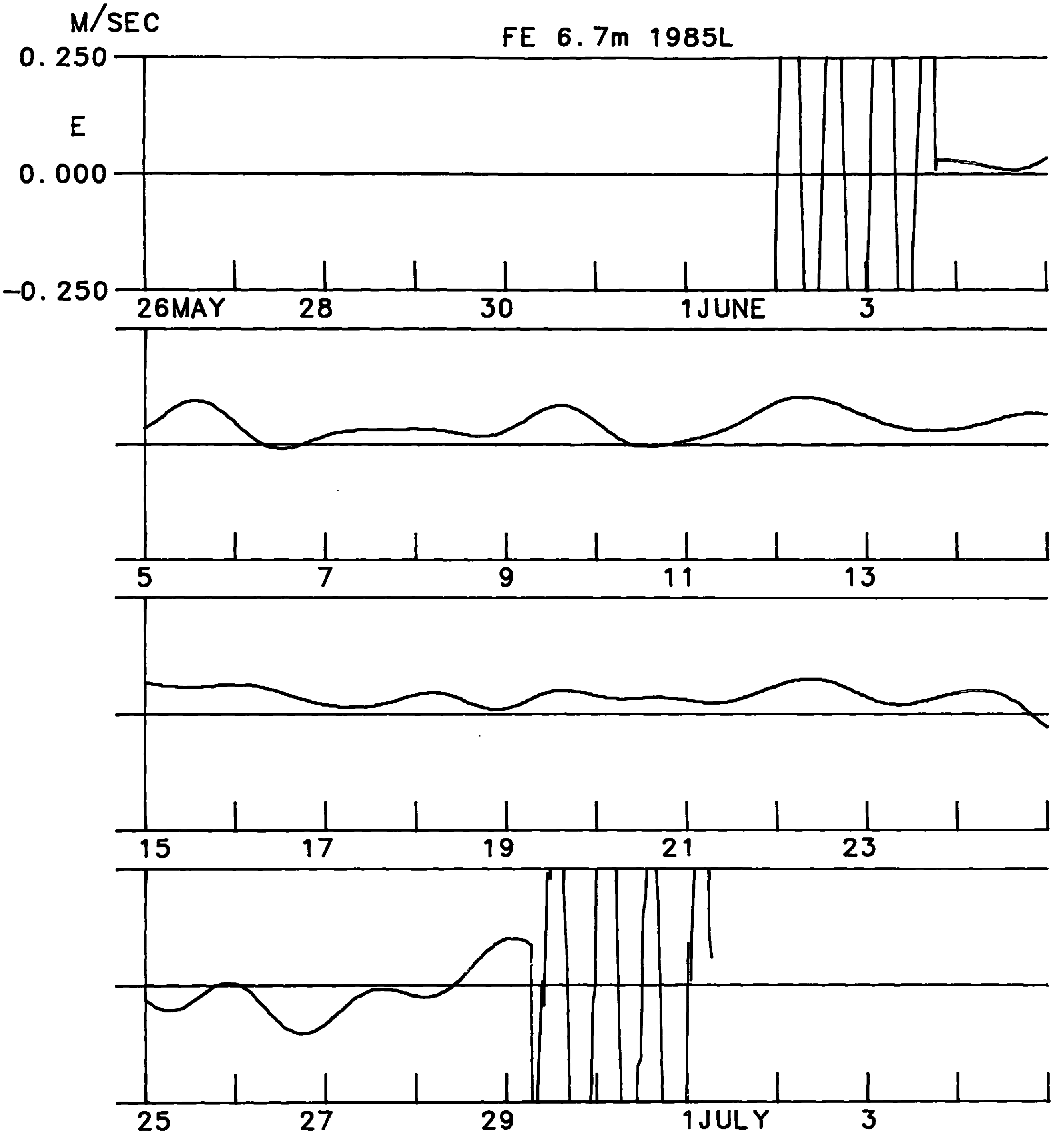
The longitudinal component of the non-tidal current at 9.1 m depth, starting 0900 hr., Oct. 21, 1984.



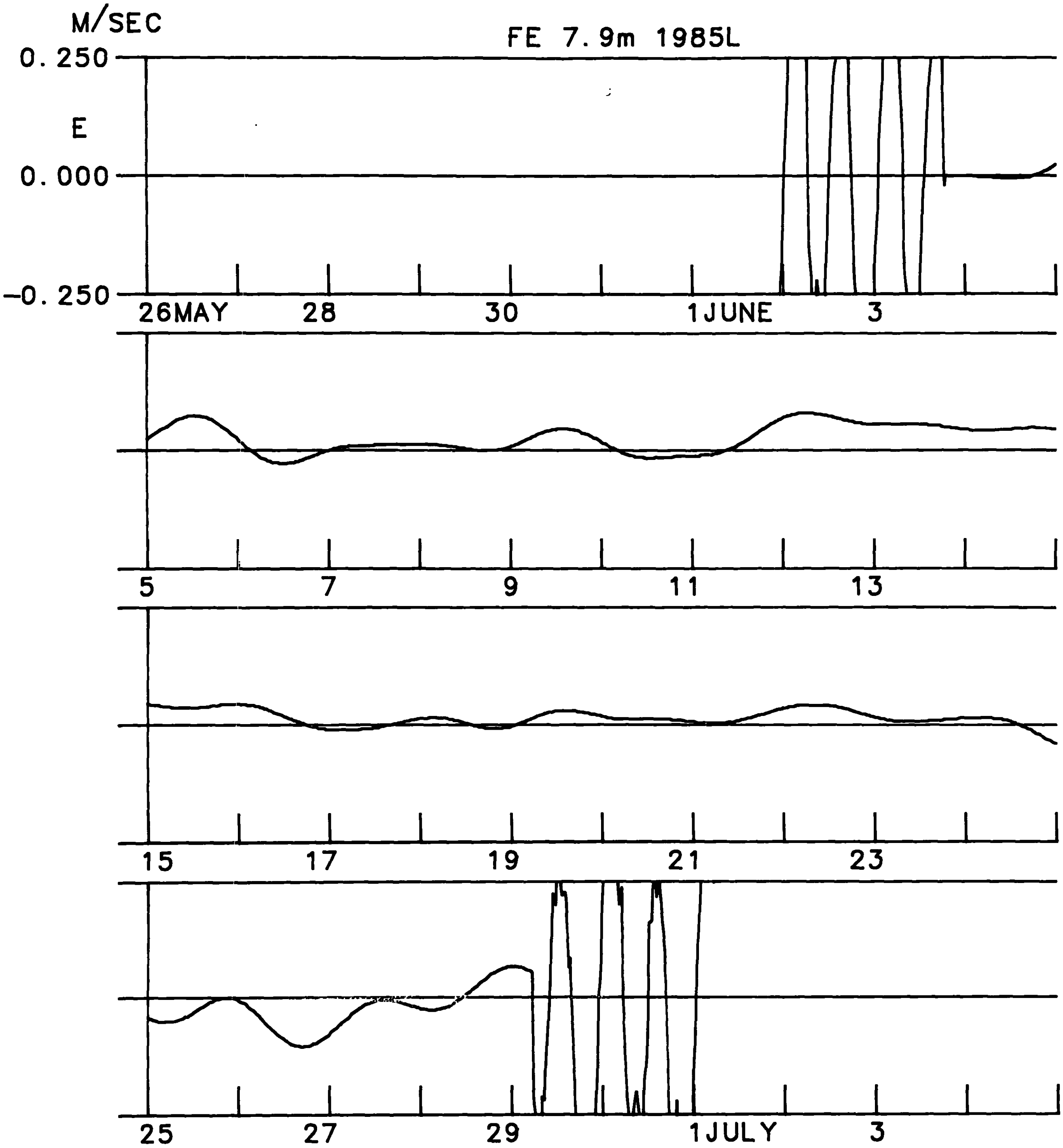
Fort Eustis Station, 1.8 m below surface



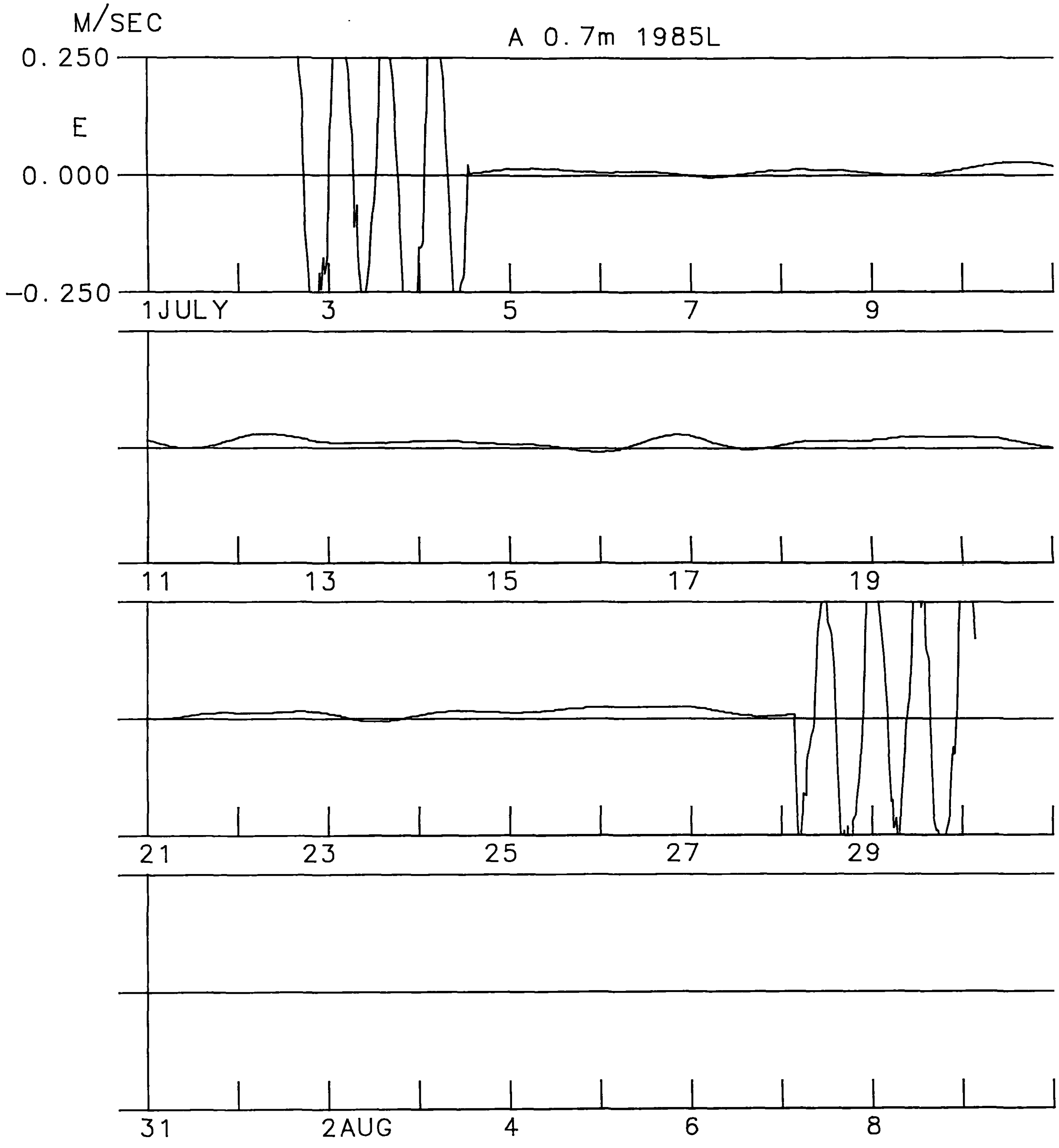
Fort Eustis Station, 4.9 m below surface



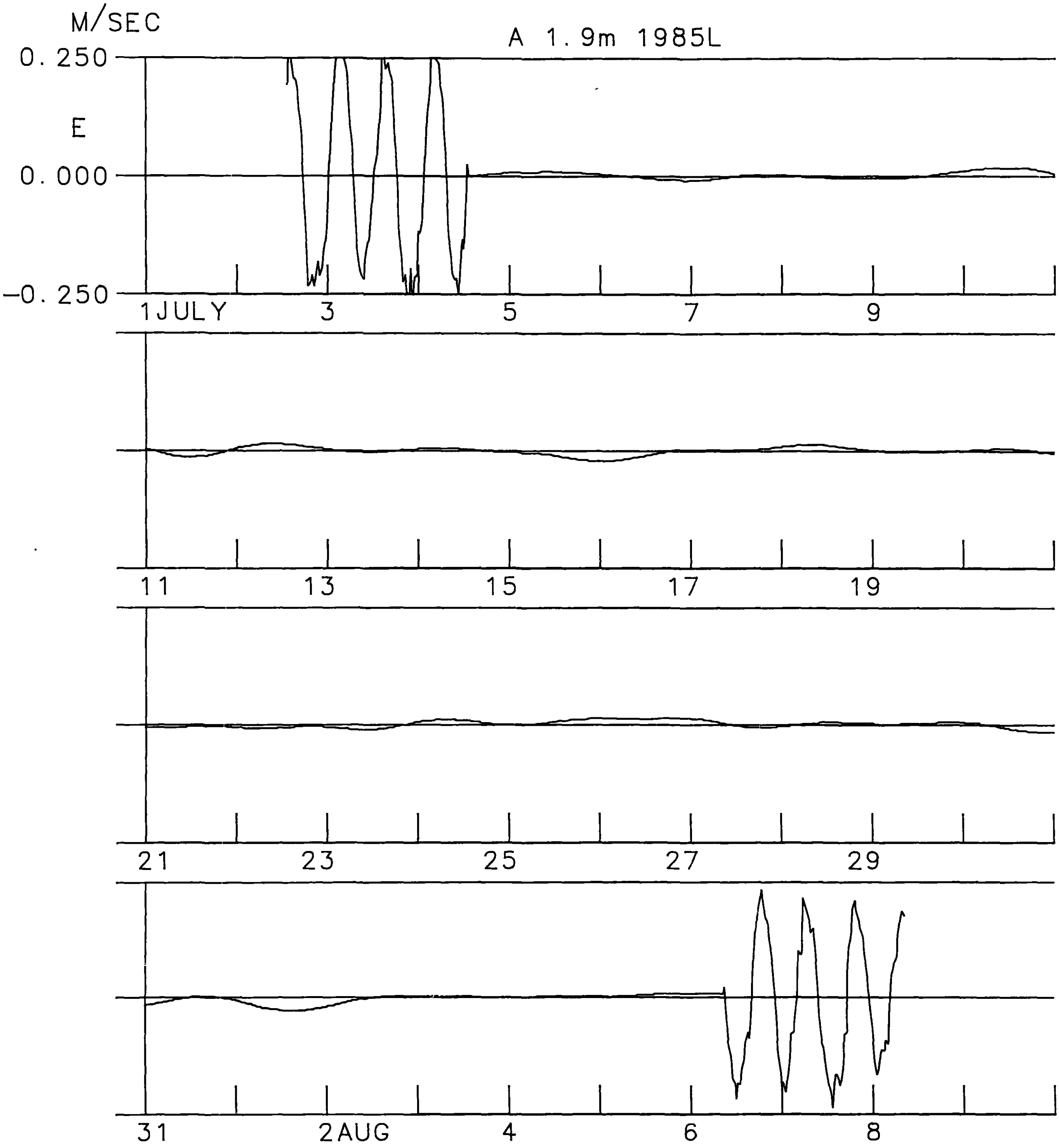
Fort Eustis Station, 6.7 m below surface



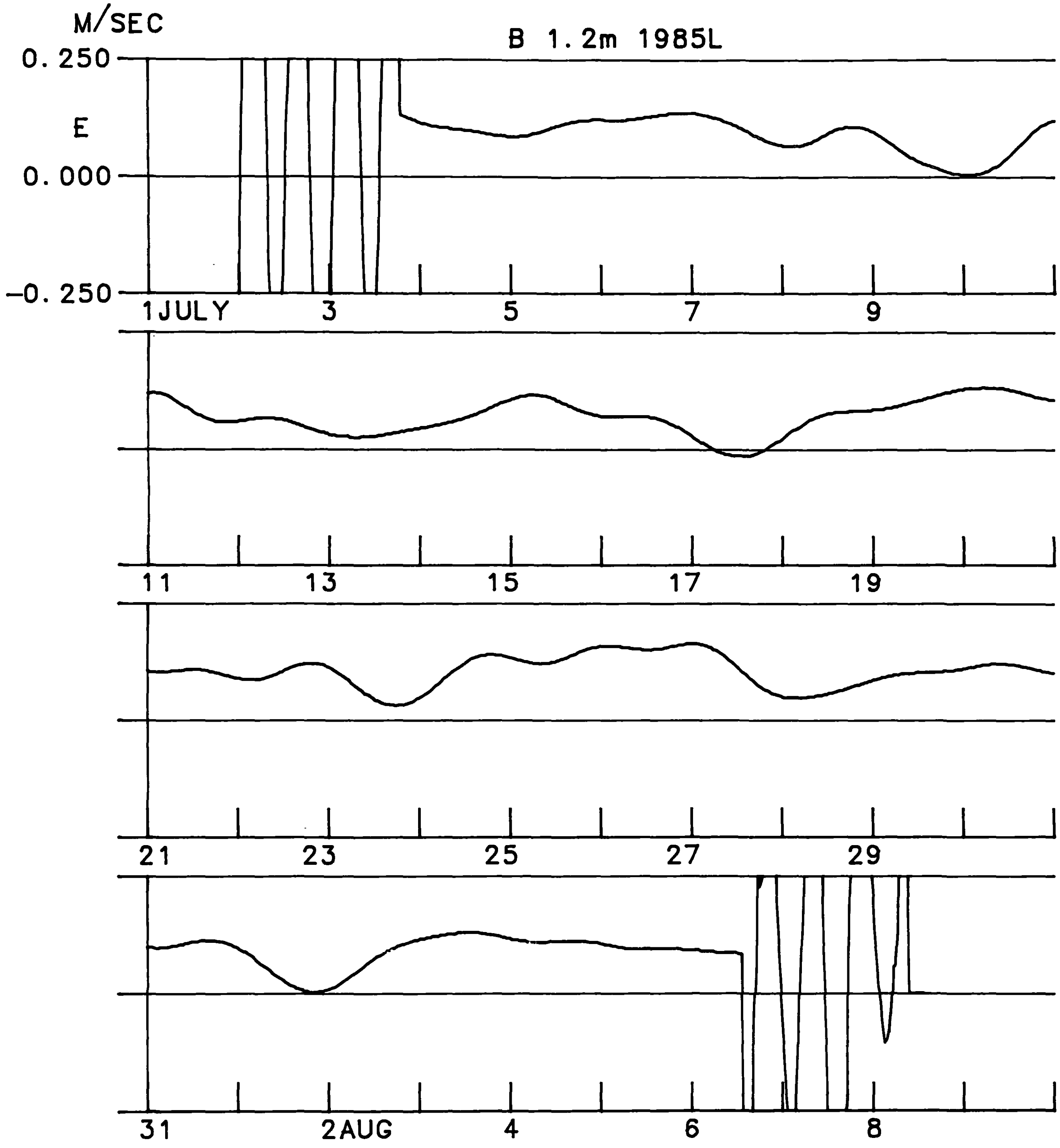
Fort Eustis Station, 7.9 m below surface



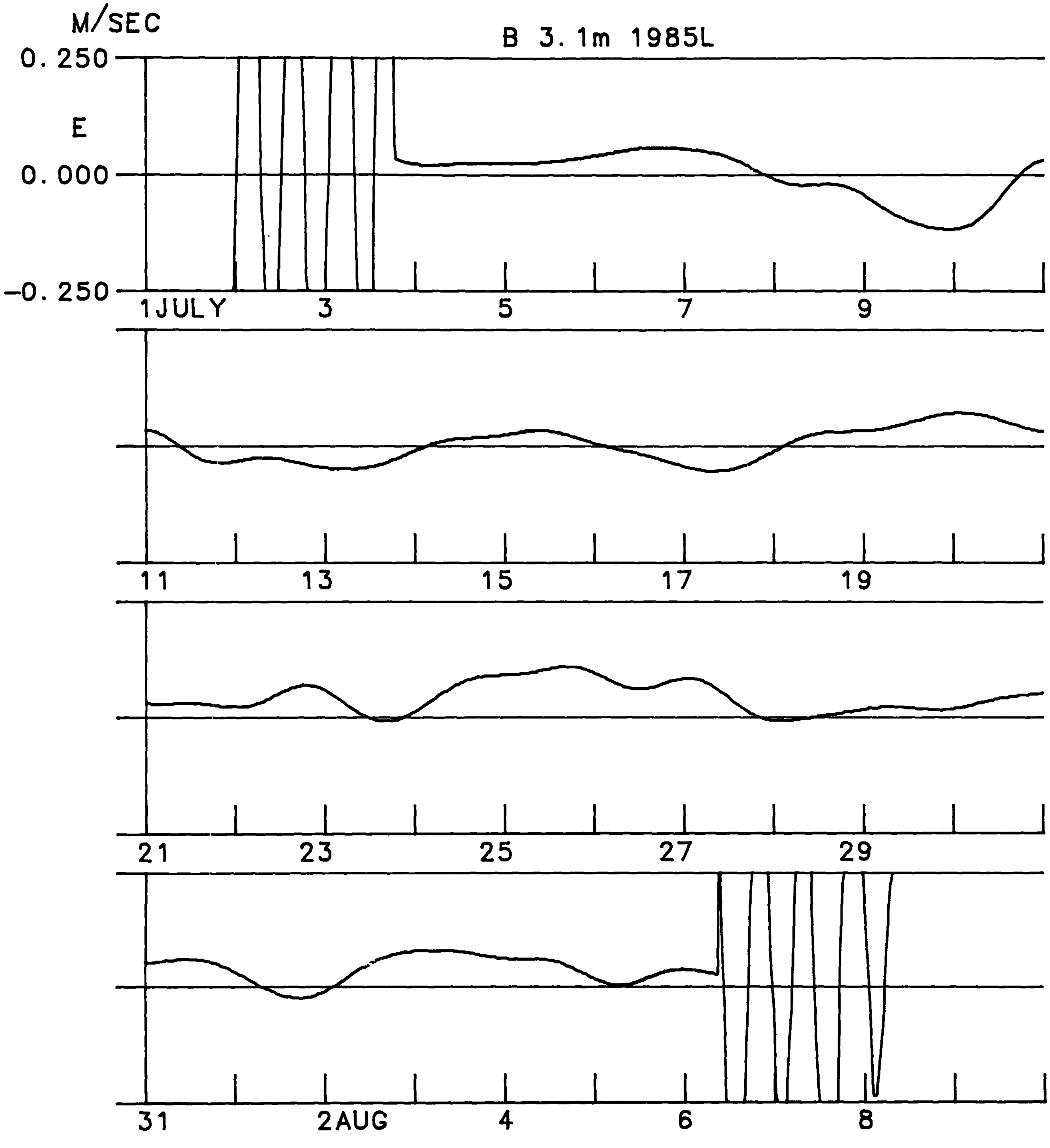
James River Bridge Station A, 0.7 m below surface



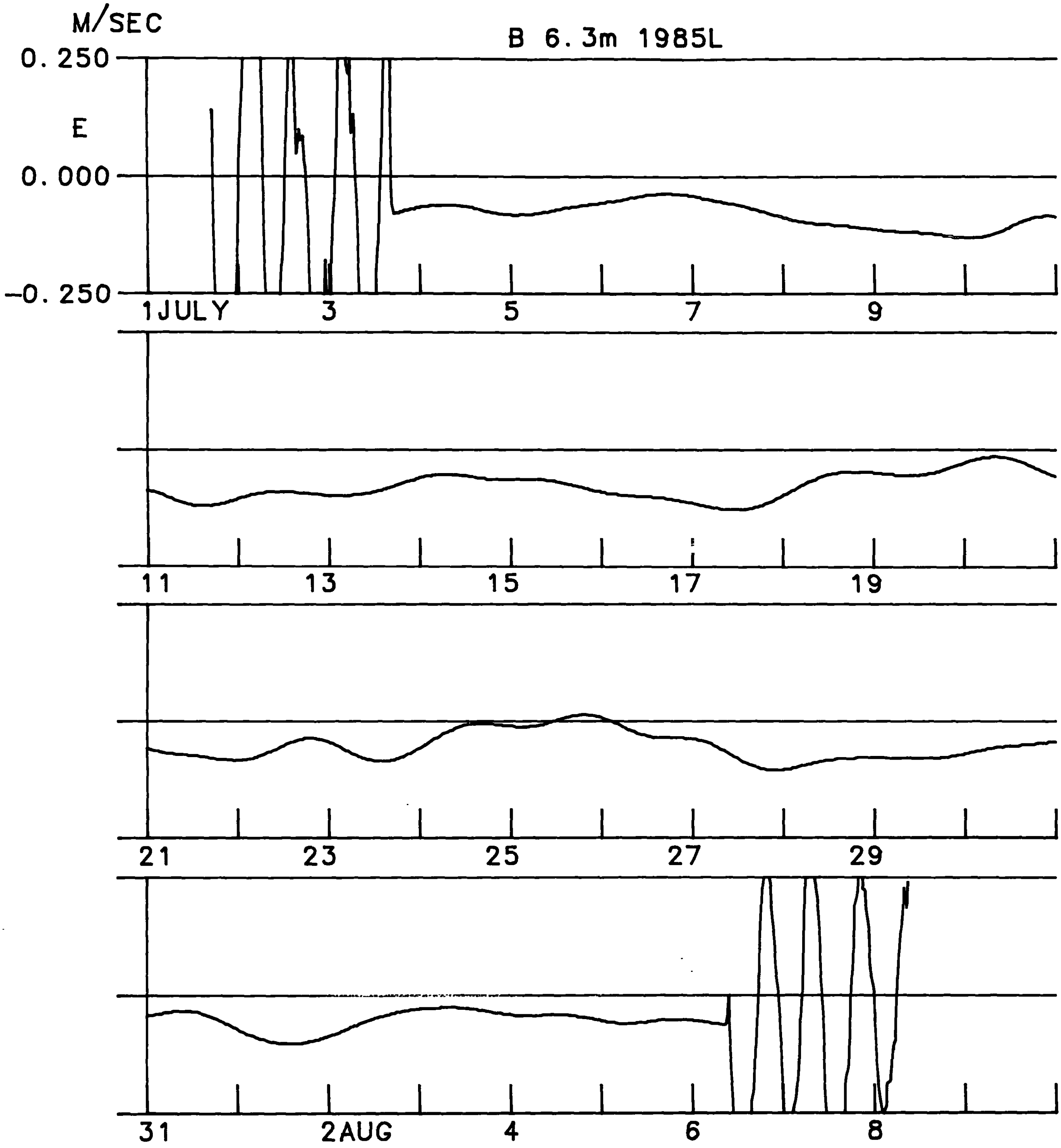
James River Bridge Station A, 1.9 m below surface



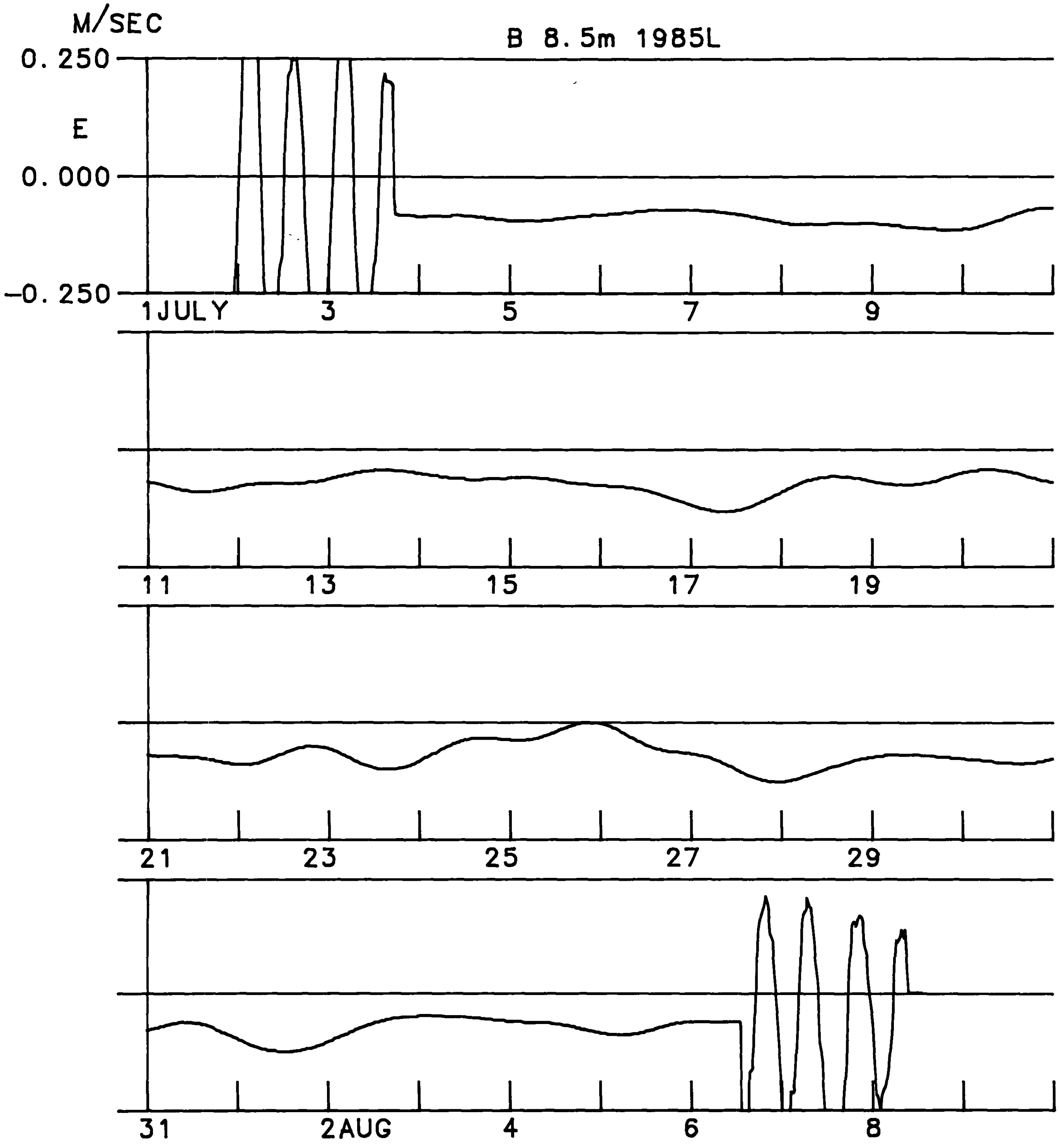
James River Bridge Station B, 1.2 m below surface



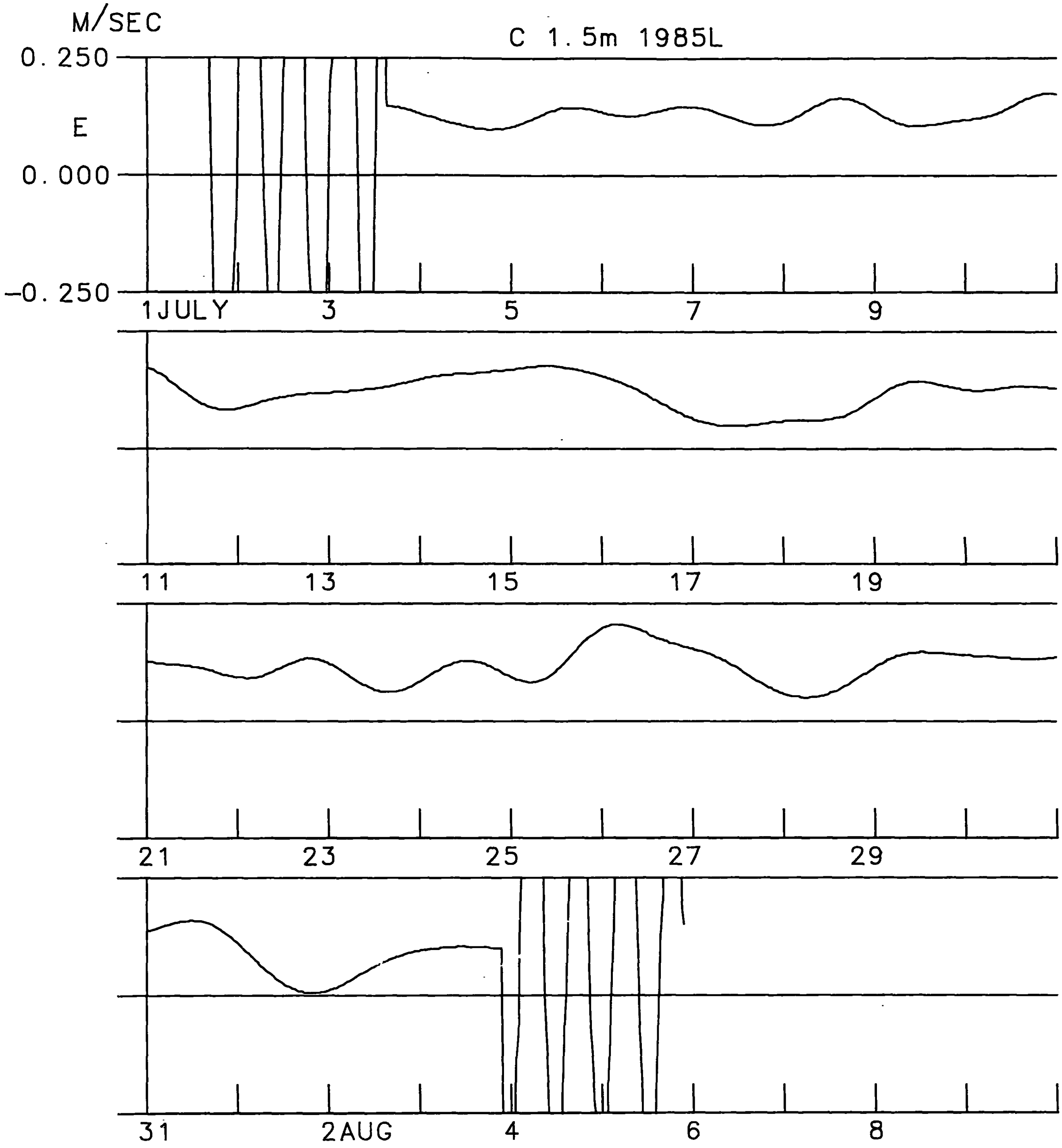
James River Bridge Station B, 3.1 m below surface



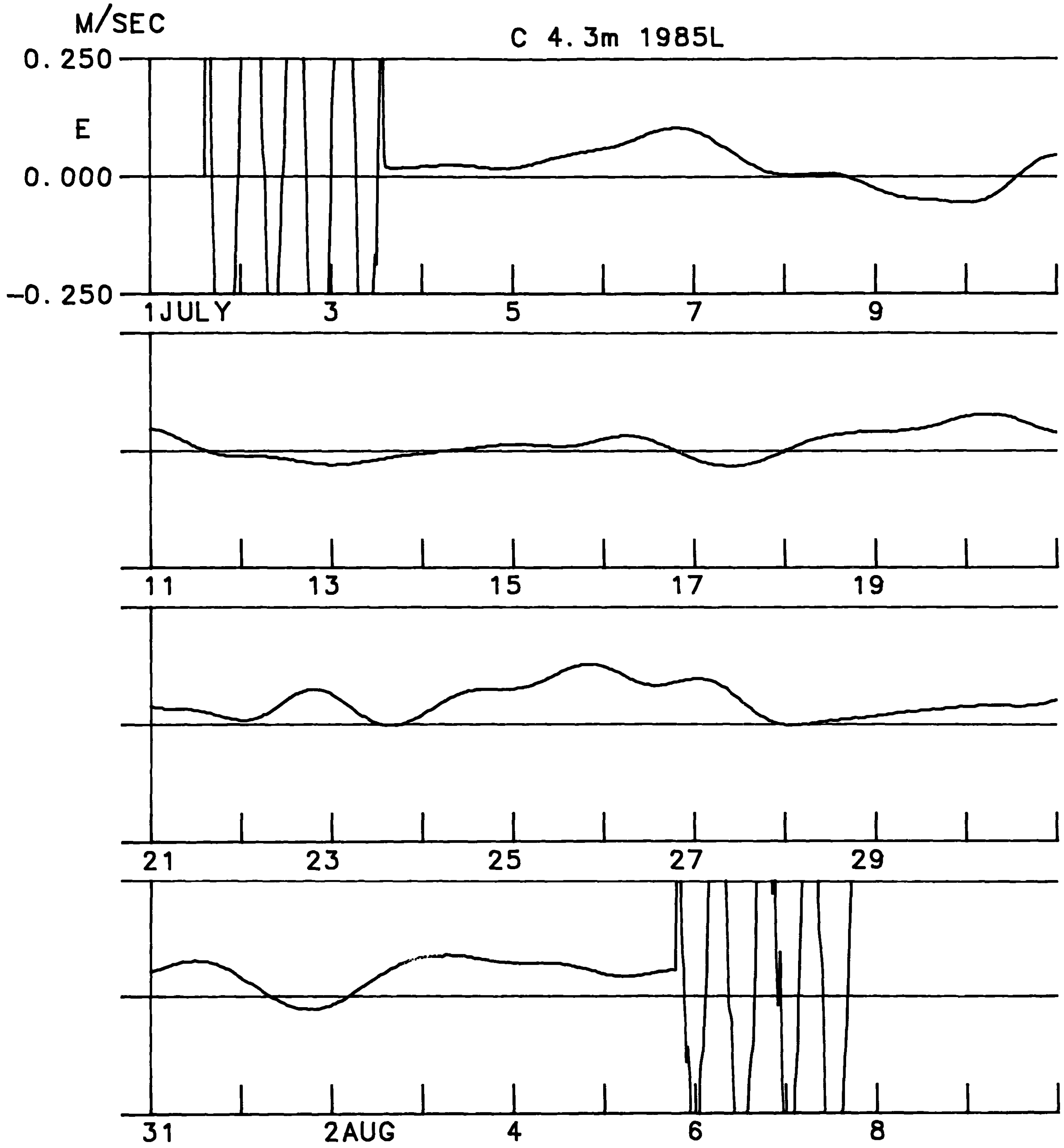
James River Bridge Station B, 6.3 m below surface



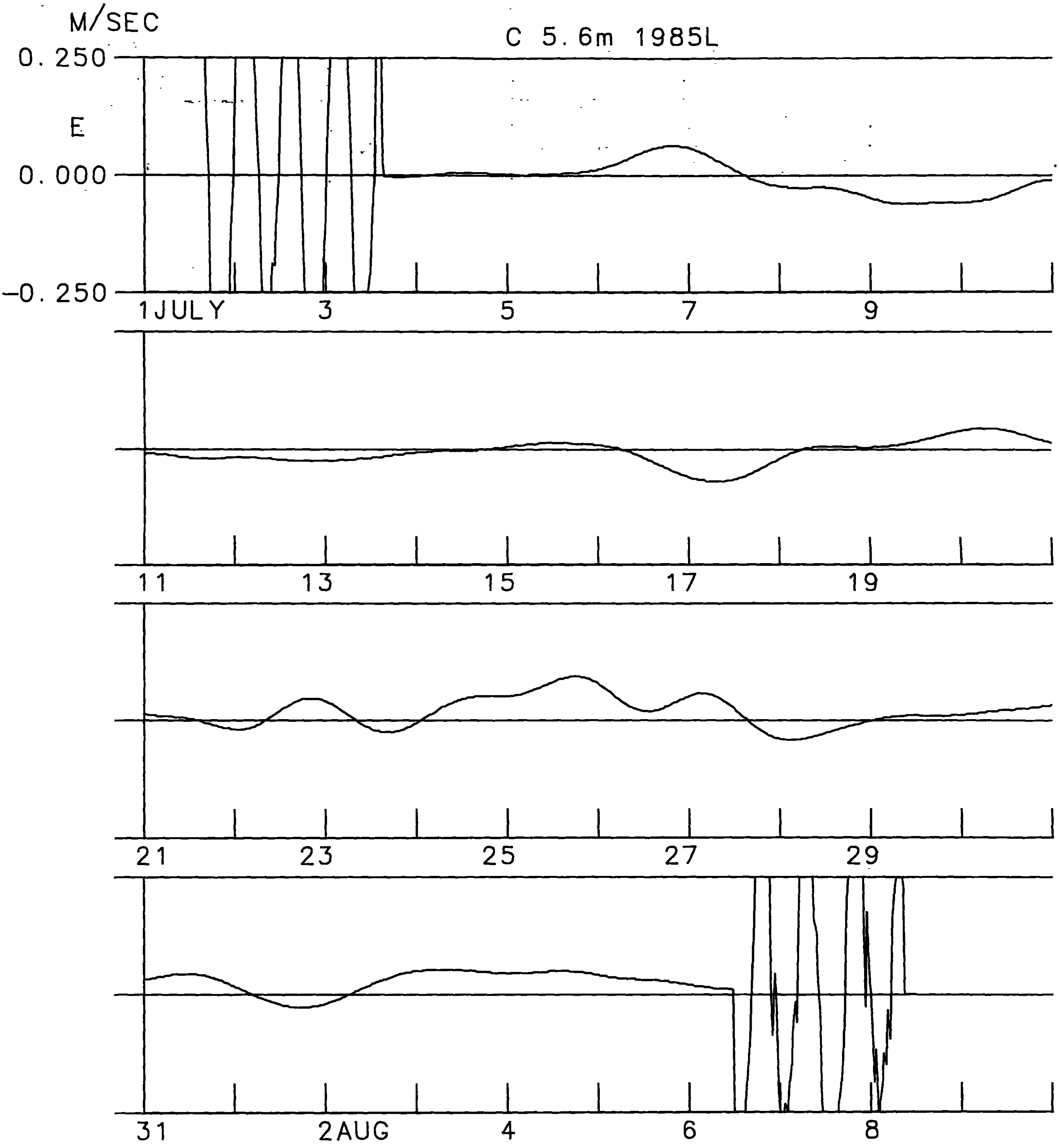
James River Bridge Station B, 8.5 m below surface



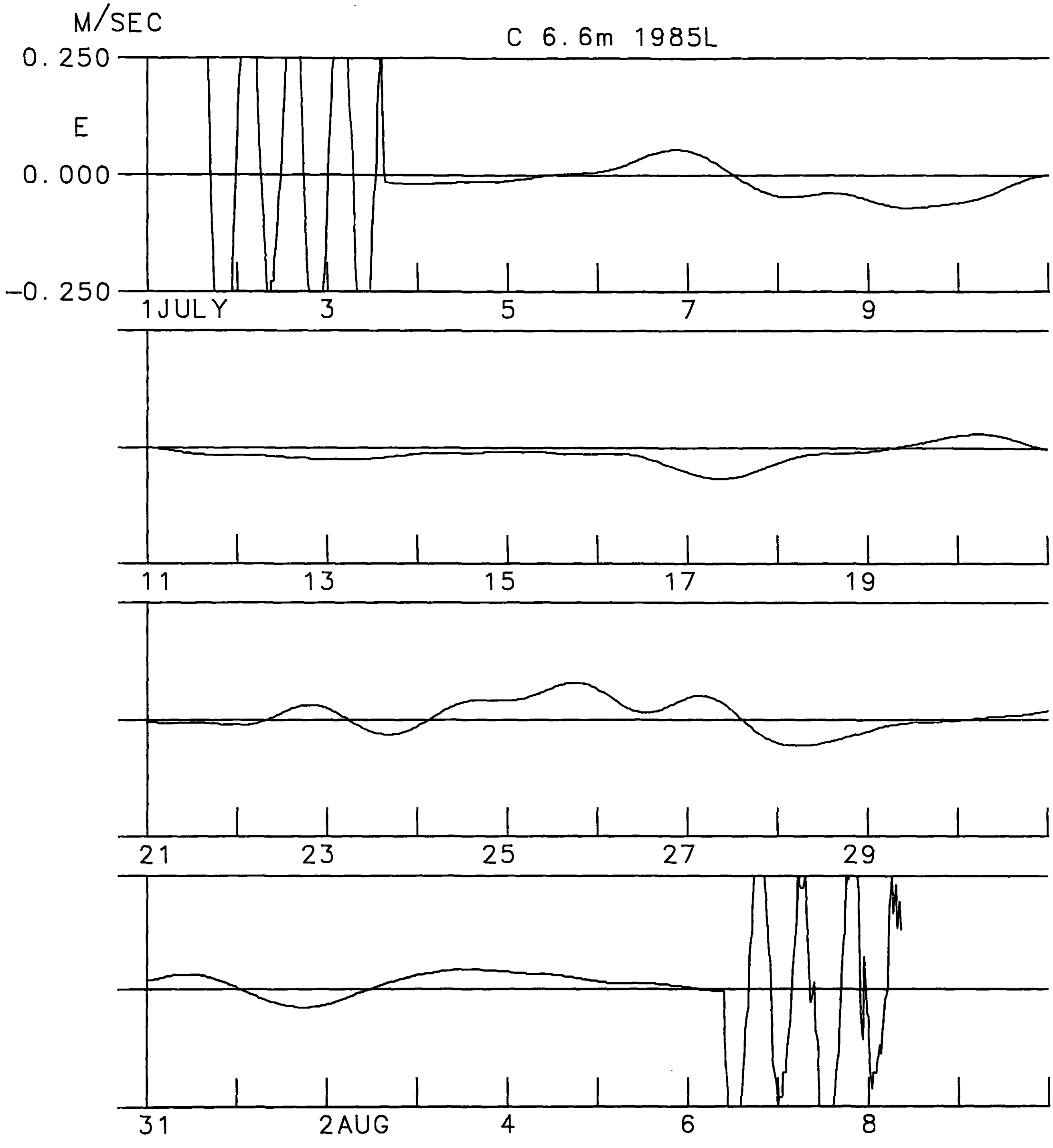
James River Bridge Station C, 1.5 m below surface



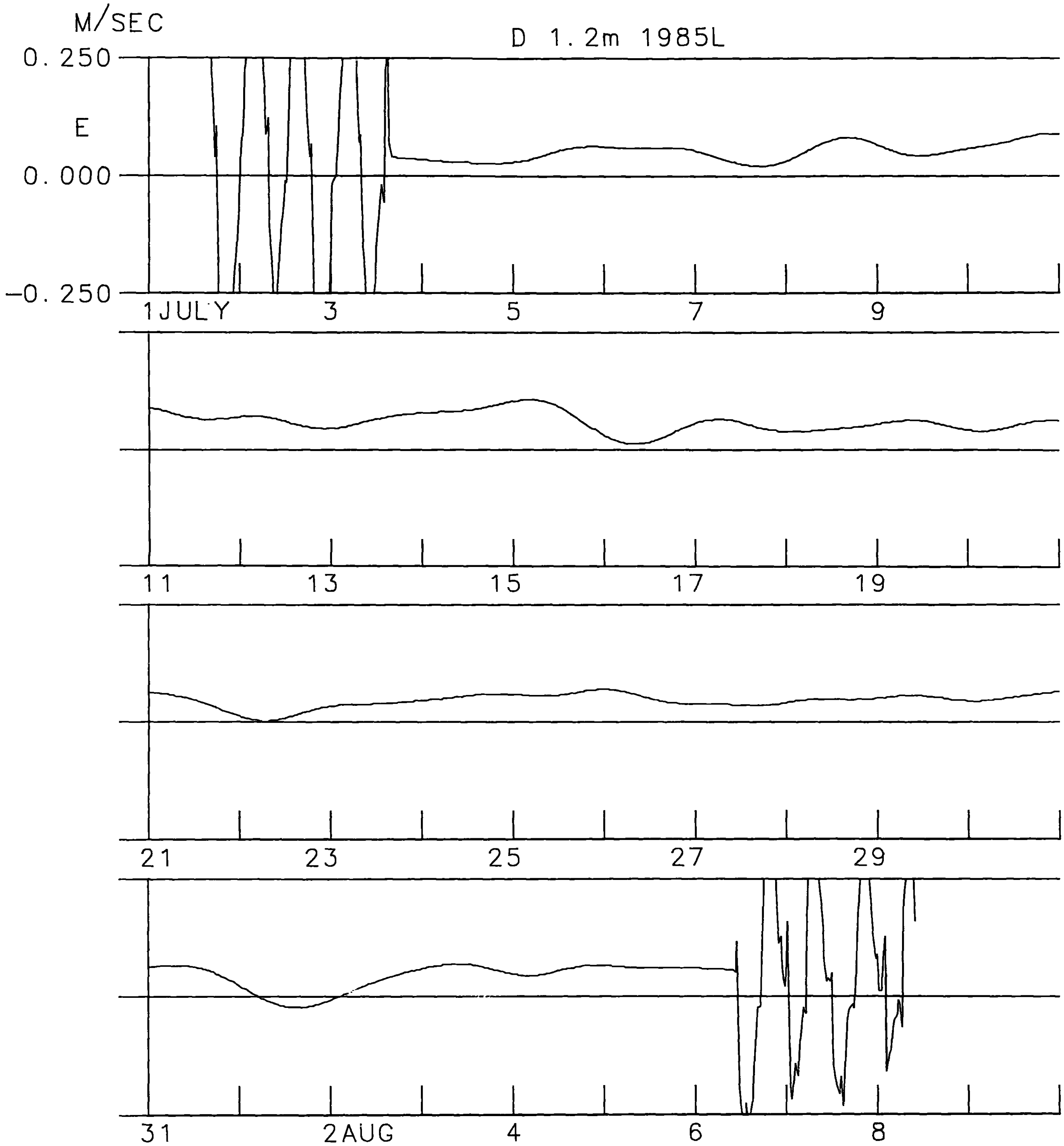
James River Bridge Station C, 4.3 m below surface



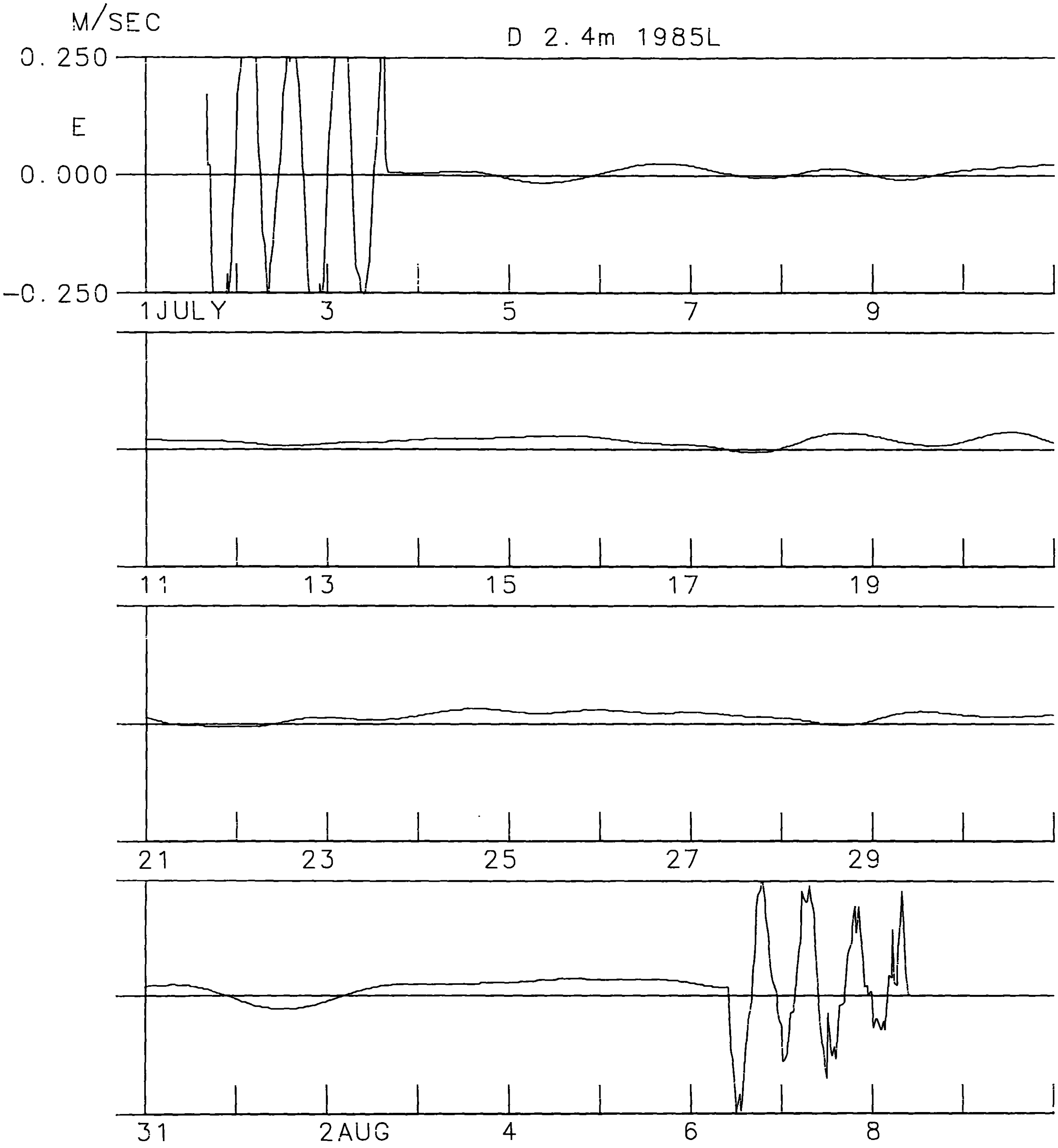
James River Bridge Station C, 5.6 m below surface



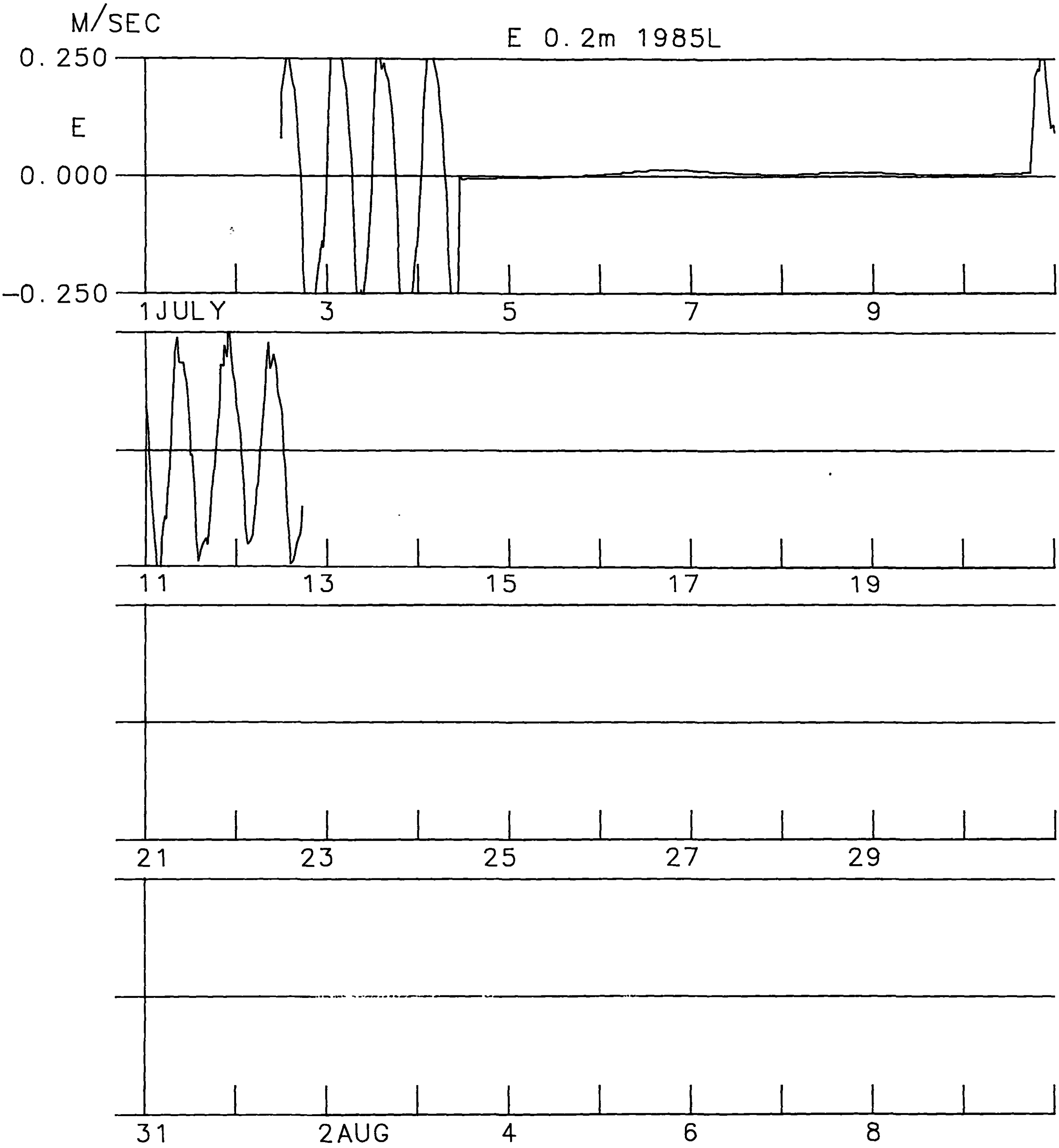
James River Bridge Station C, 6.6 m below surface



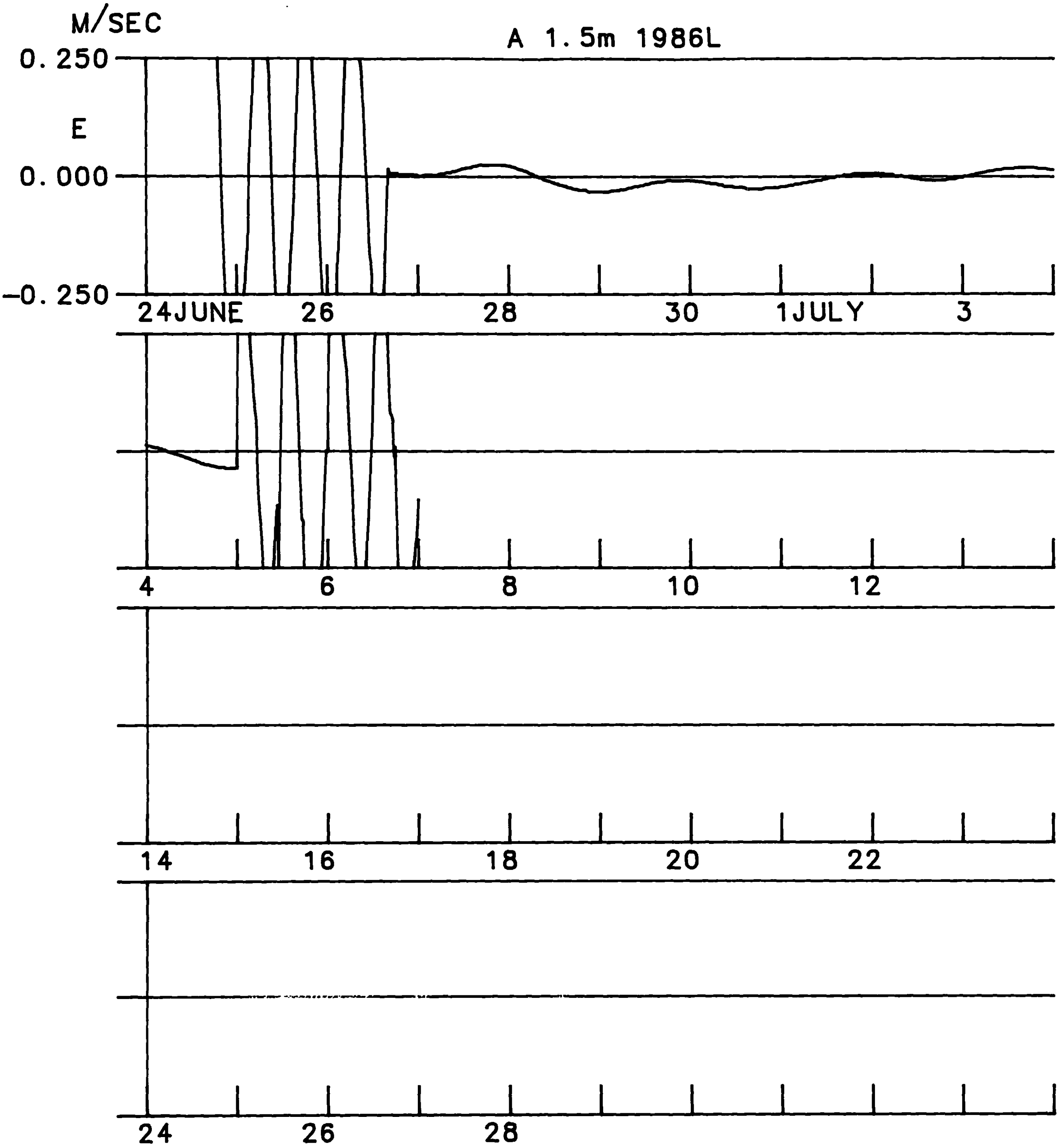
James River Bridge Station D, 1.2 m below surface



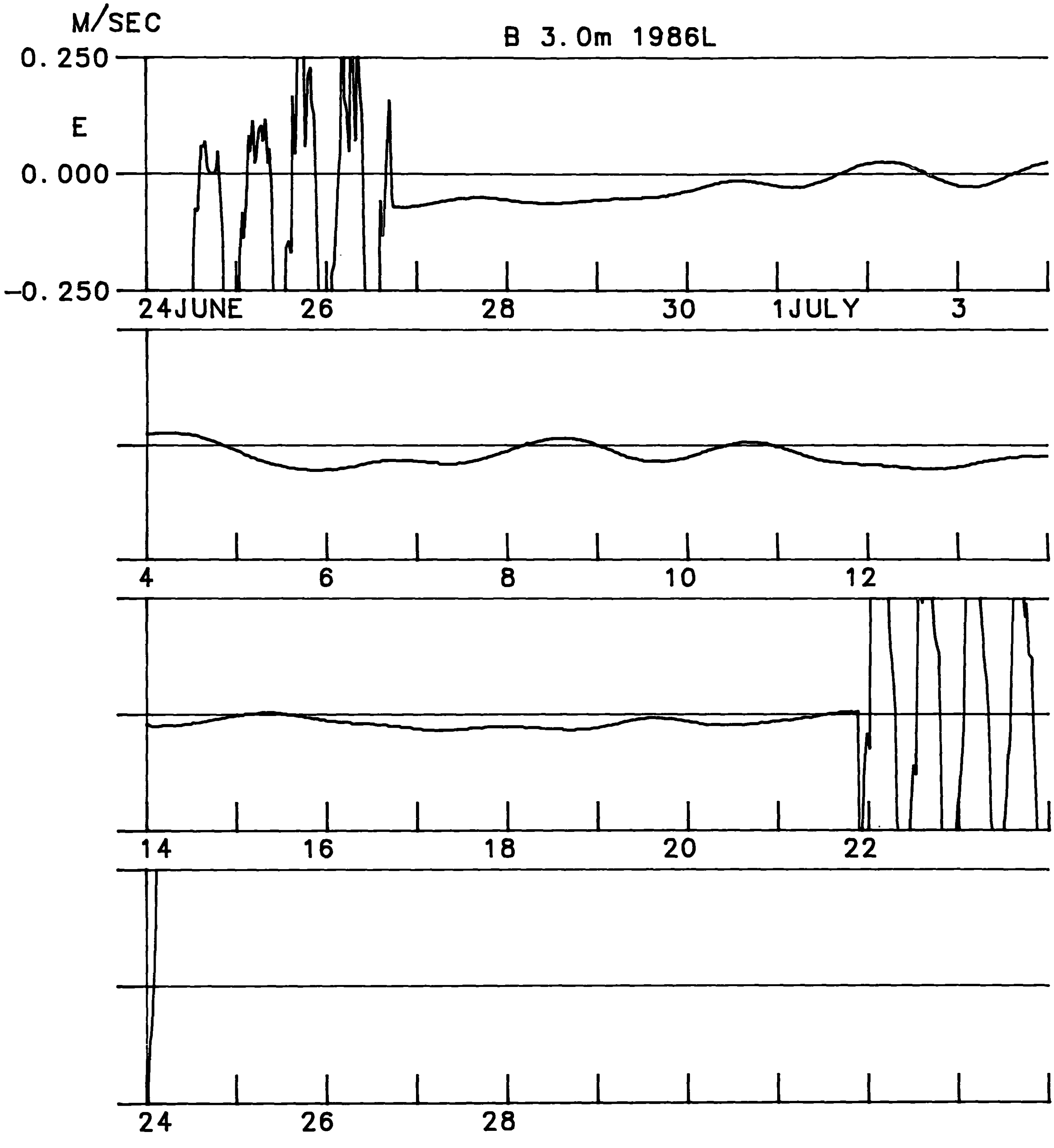
James River Bridge Station D, 2.4 m below surface



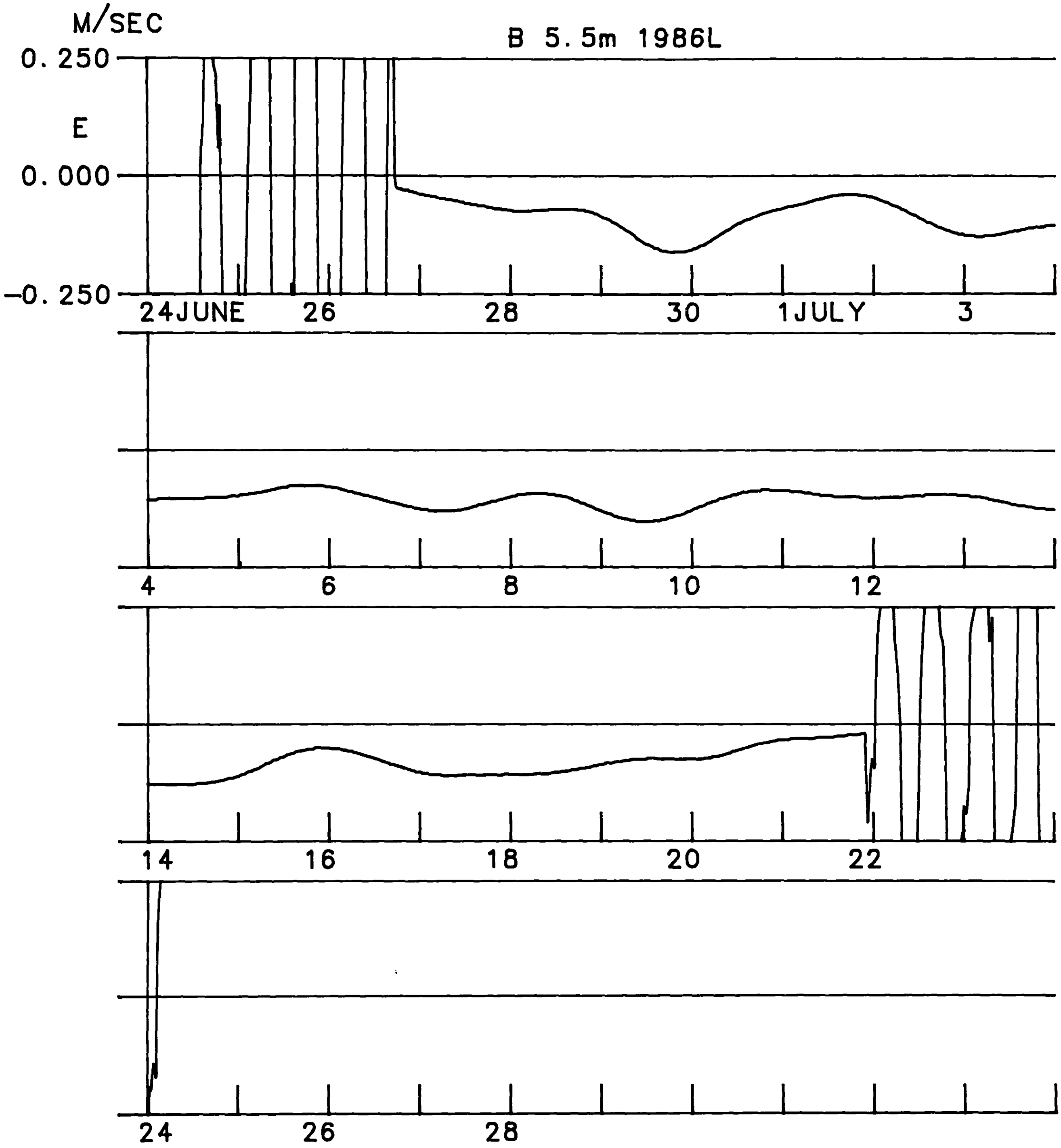
James River Bridge Station E, 0.2 m below surface



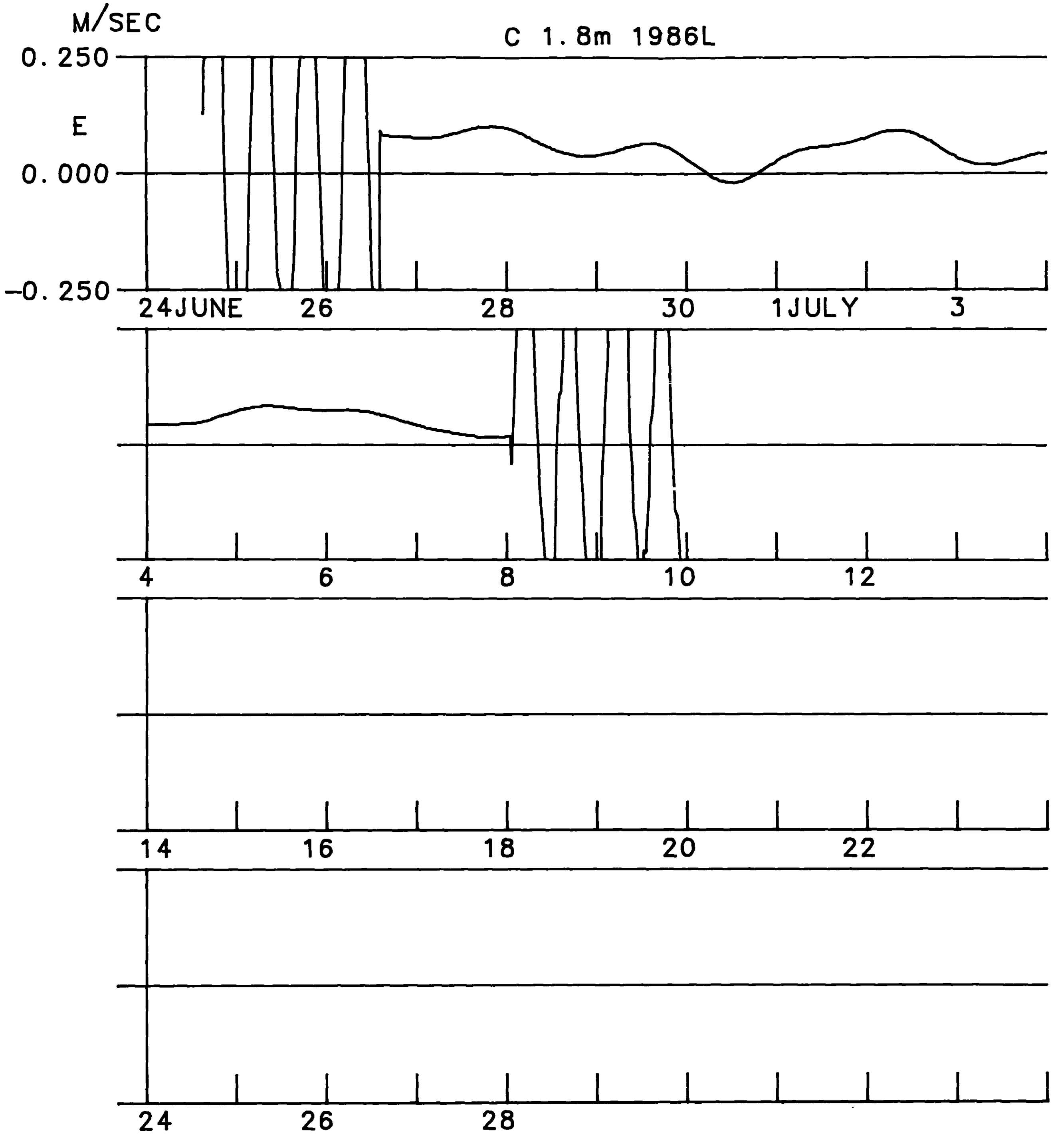
Burwell Bay Station A, 1.5 m below surface



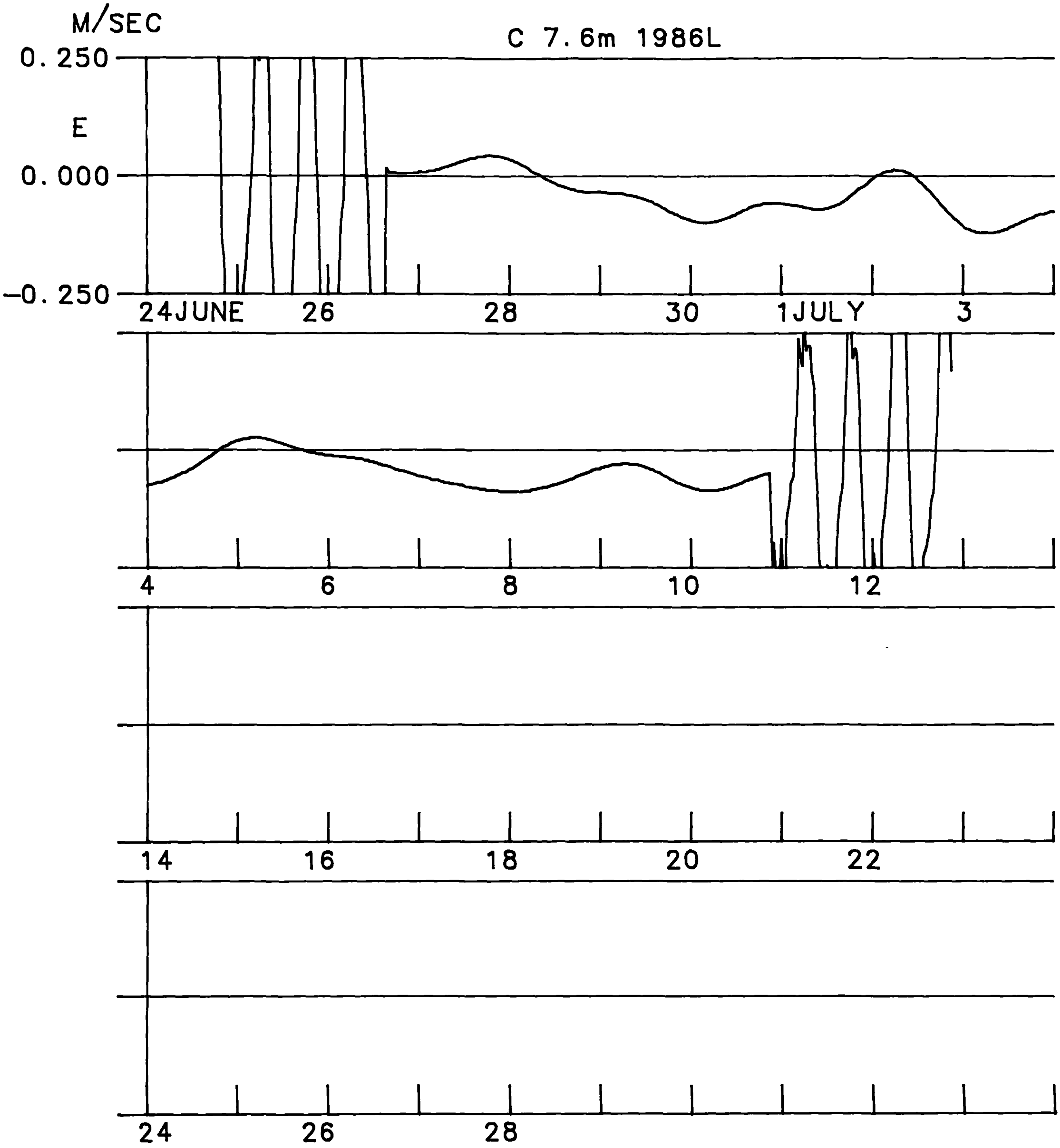
Burwell Bay Station B, 3.0 m below surface



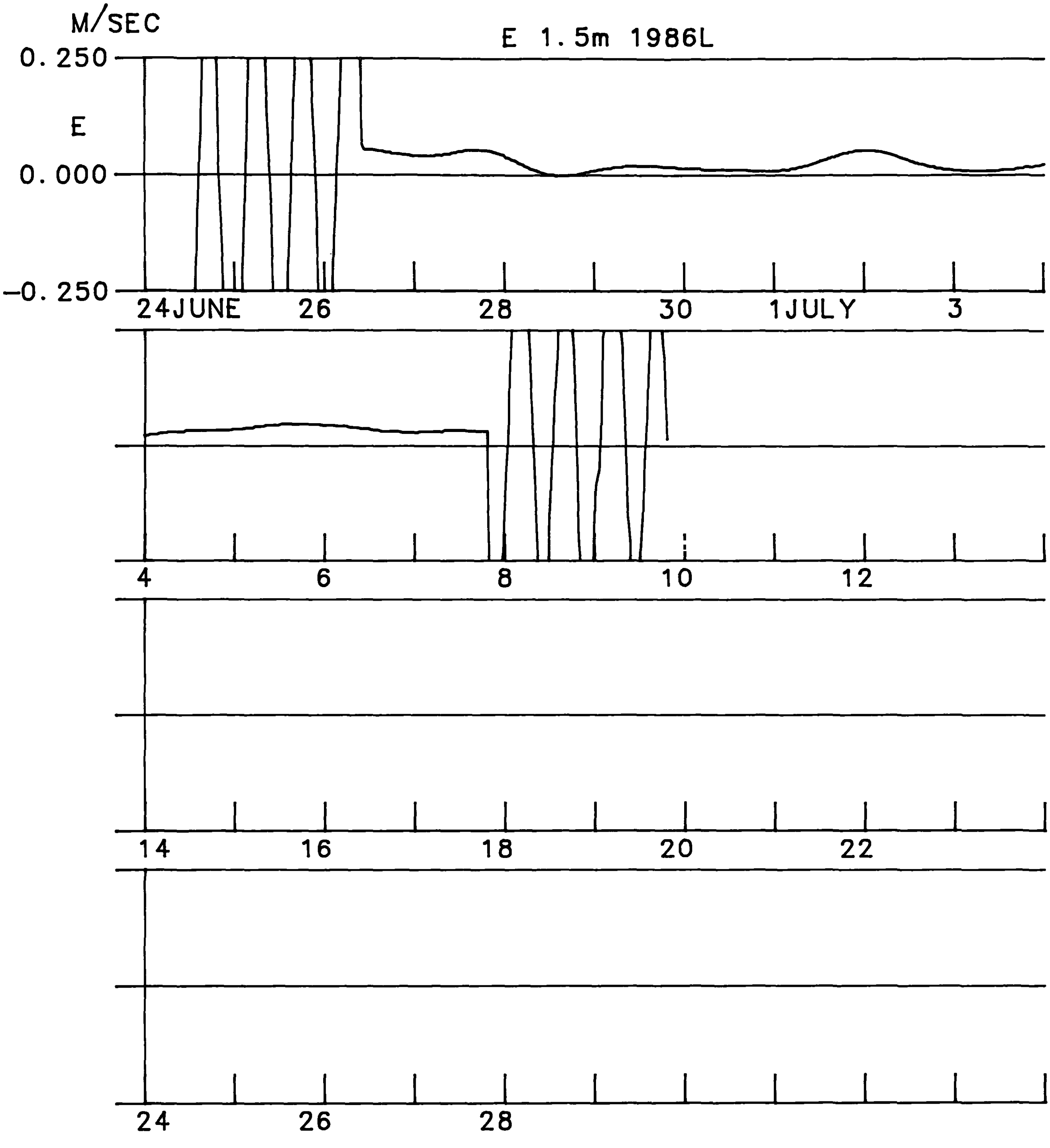
Burwell Bay Station B, 5.5 m below surface



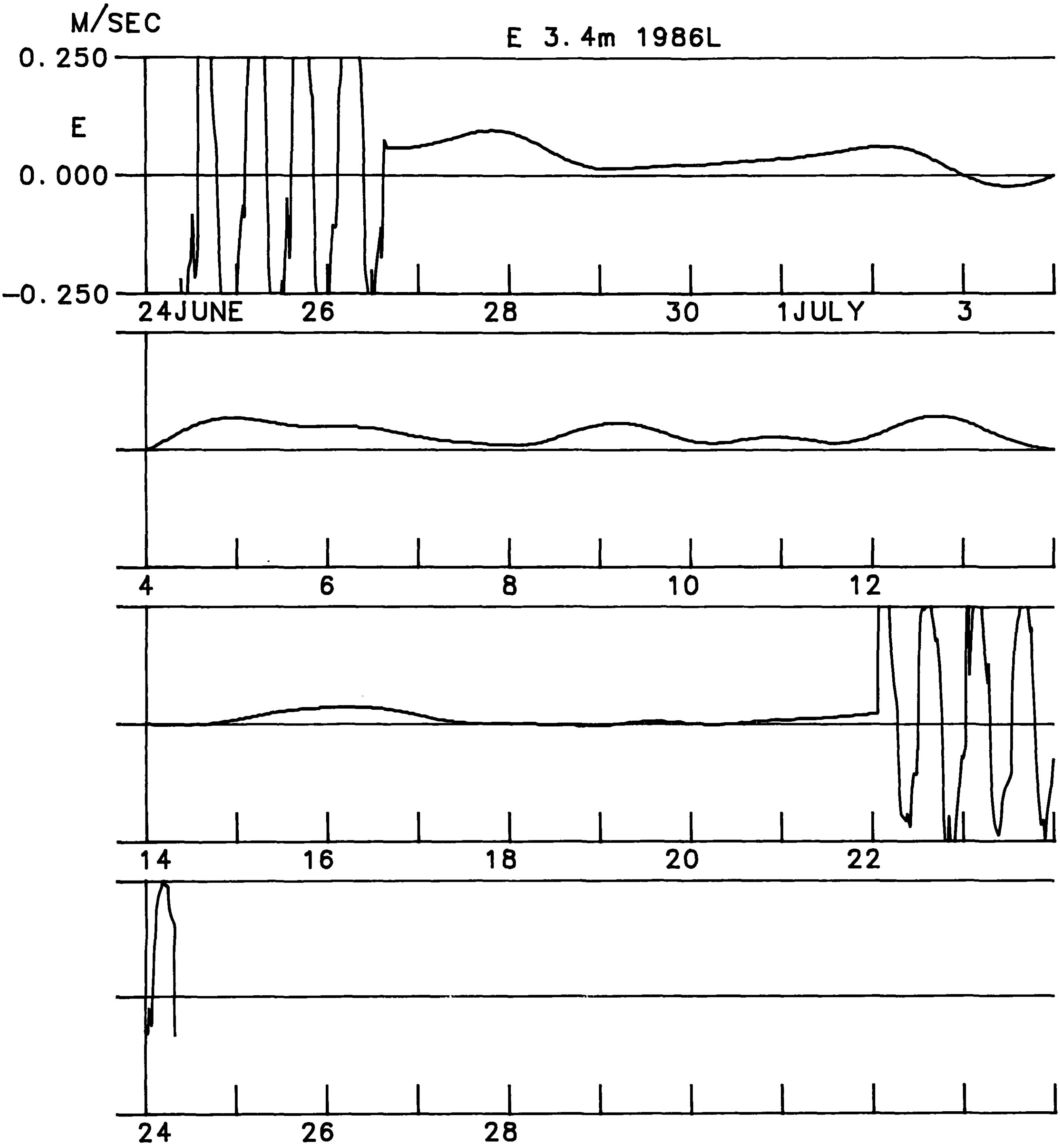
Burwell Bay Station C, 1.8 m below surface



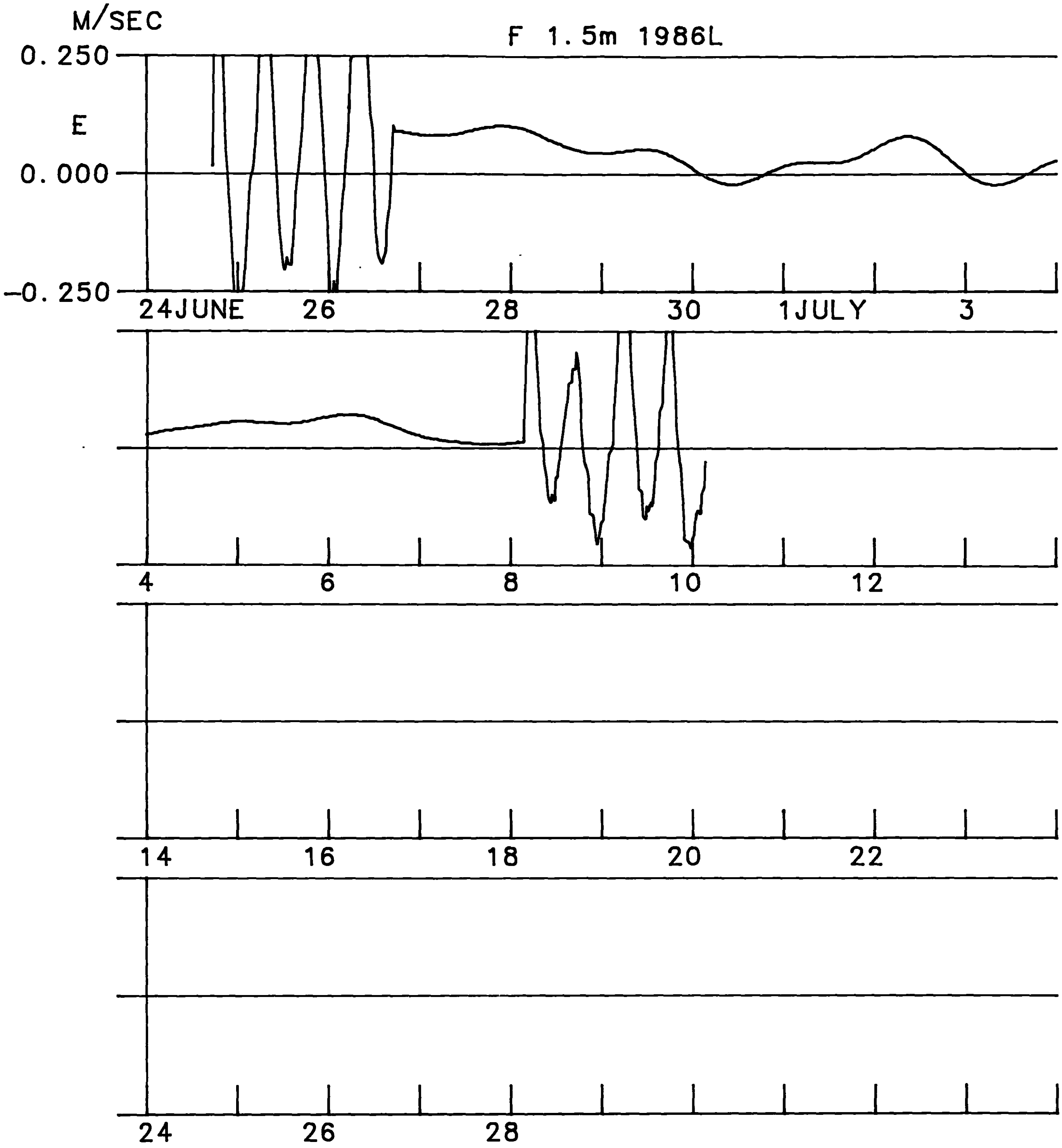
Burwell Bay Station C, 7.6 m below surface



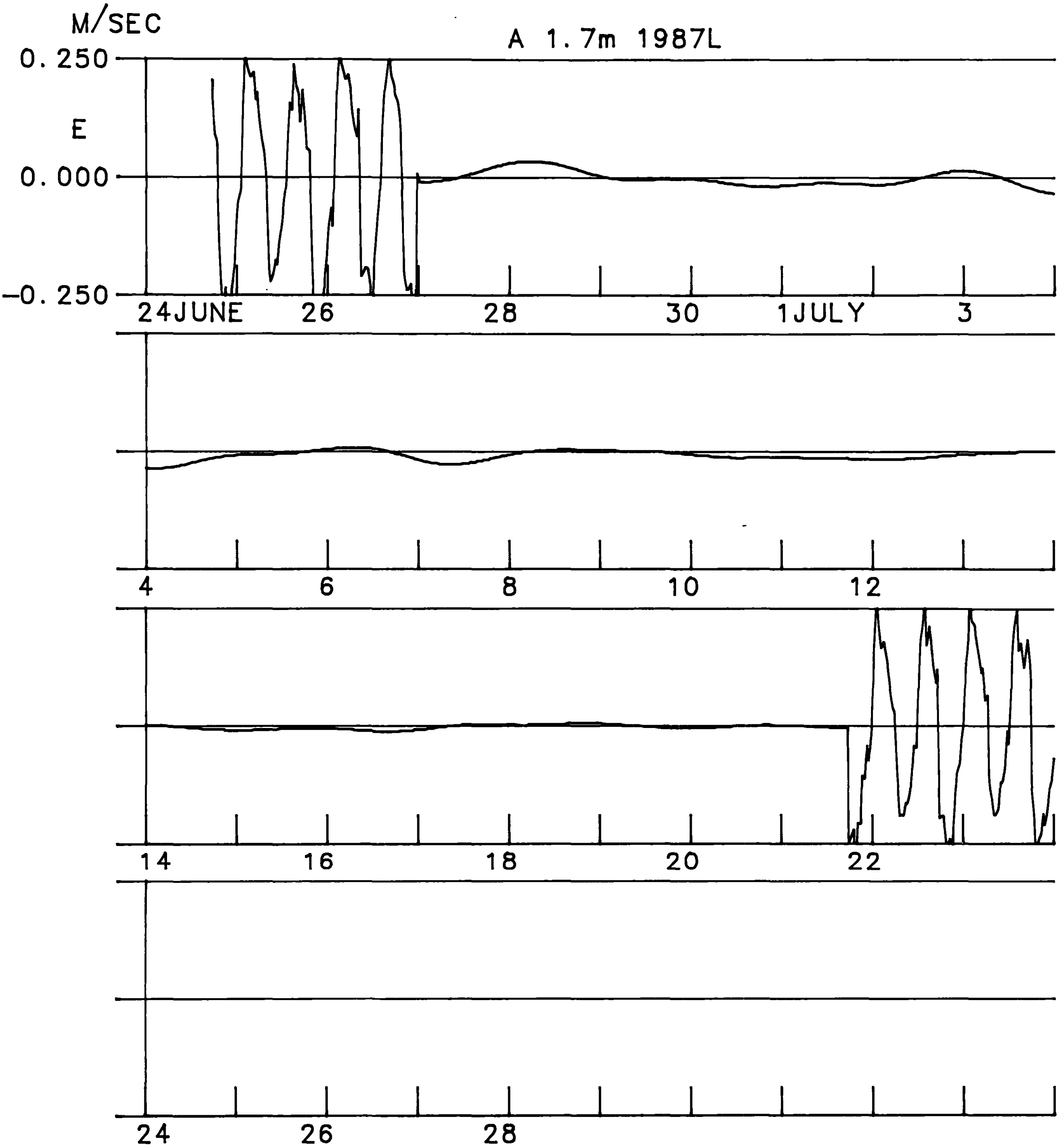
Burwell Bay Station E, 1.5 m below surface



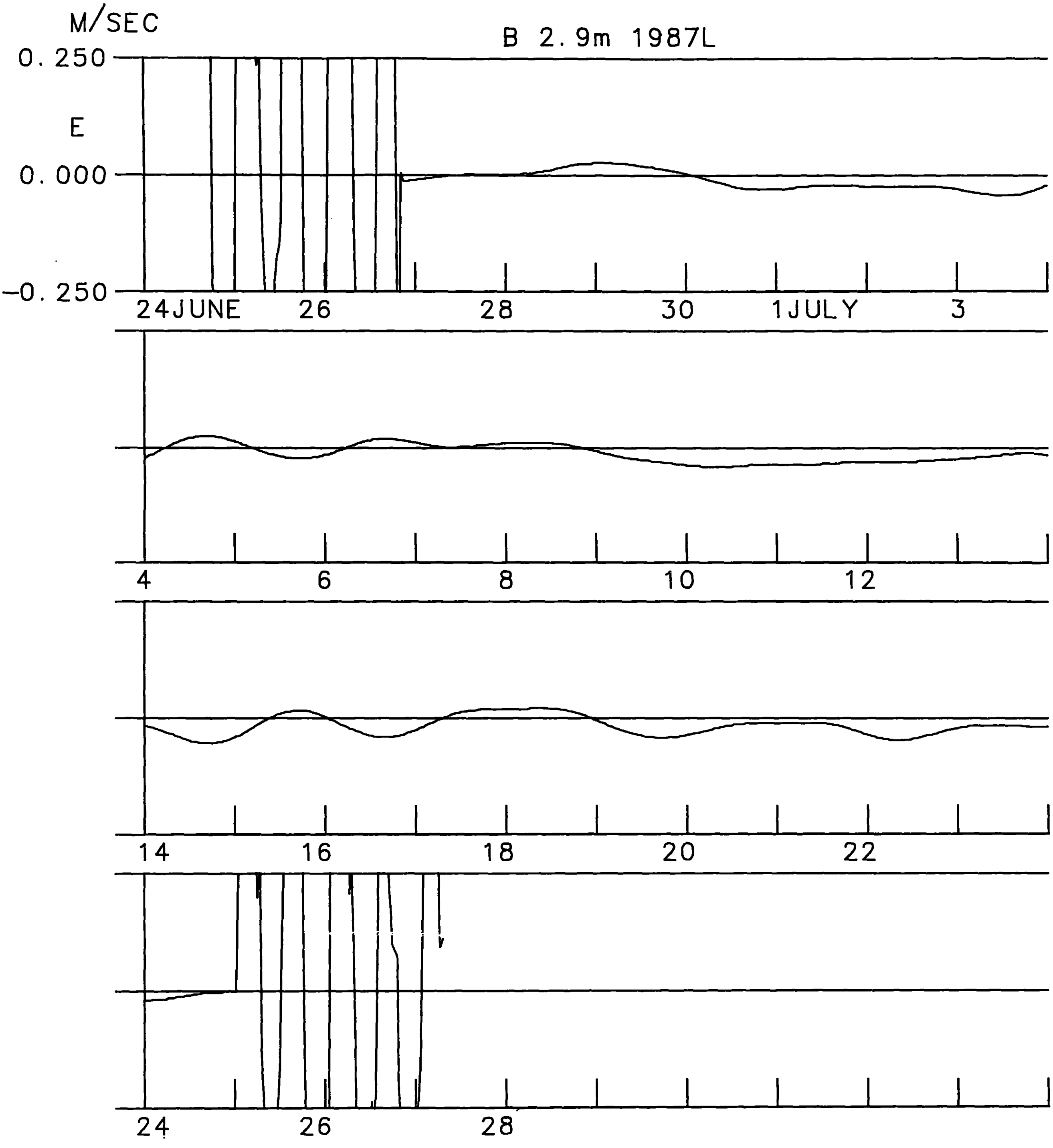
Burwell Bay Station E, 3.4 m below surface



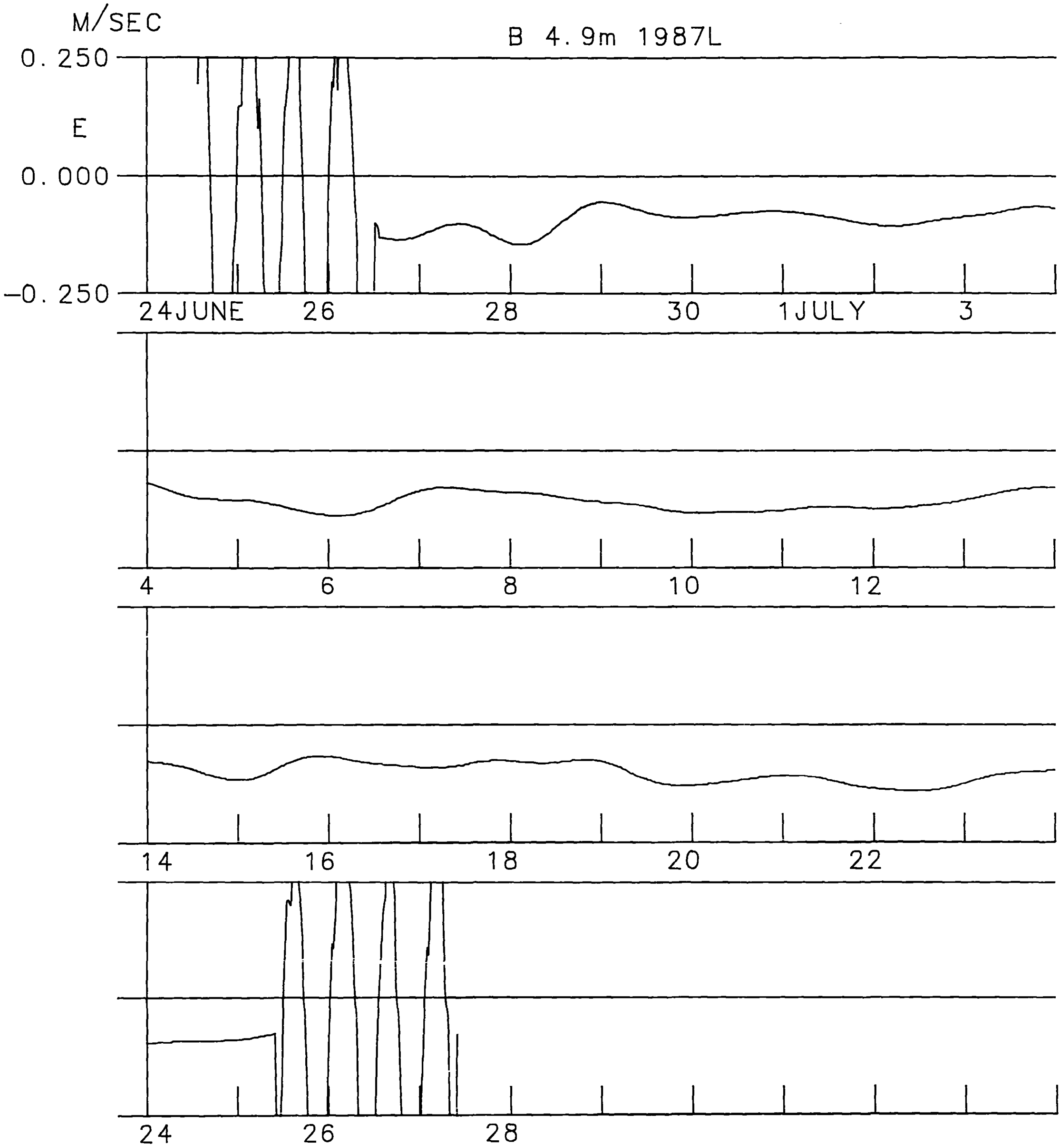
Burwell Bay Station F, 1.5 m below surface



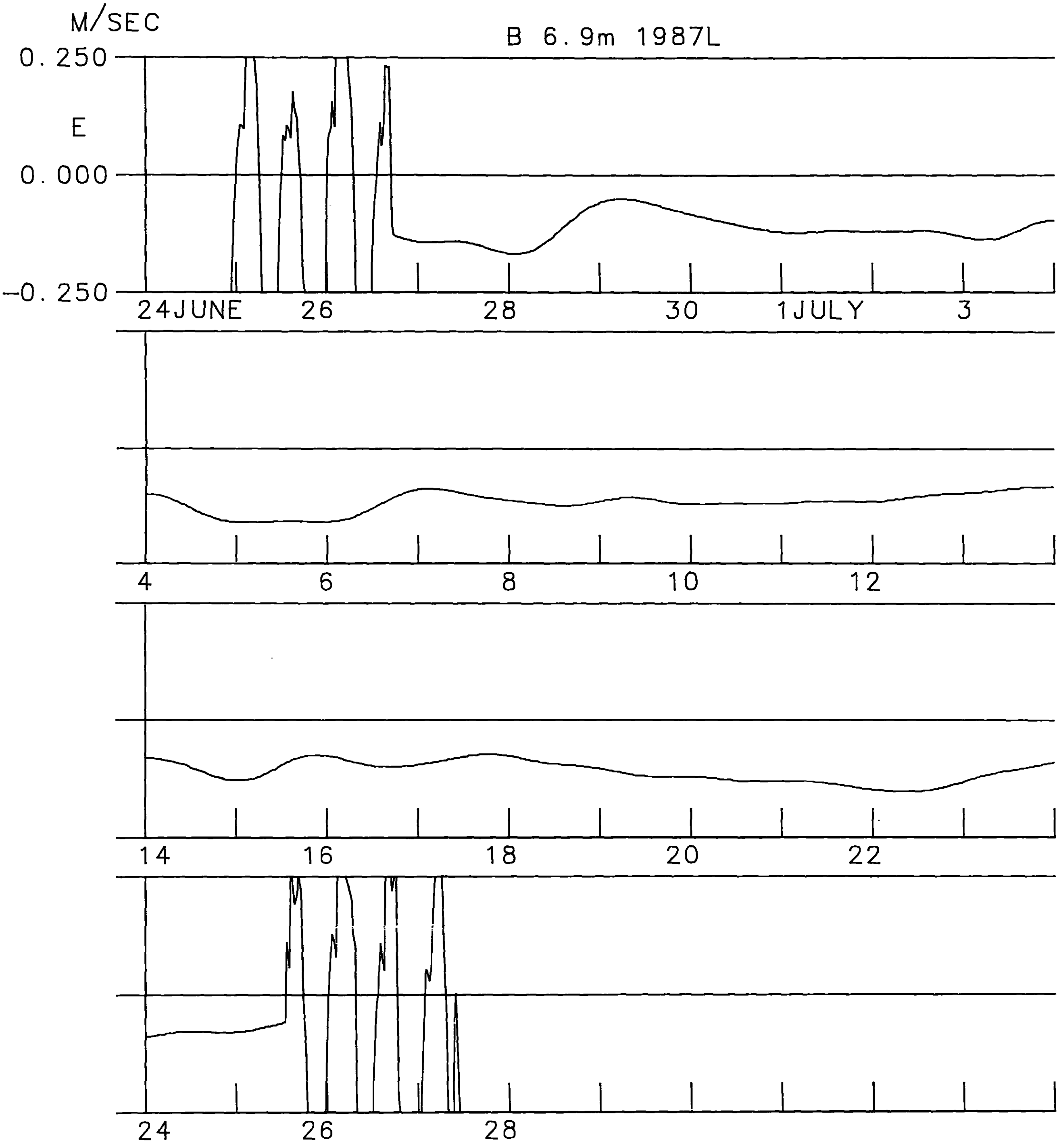
Burwell Bay Station A, 1.7 m below surface



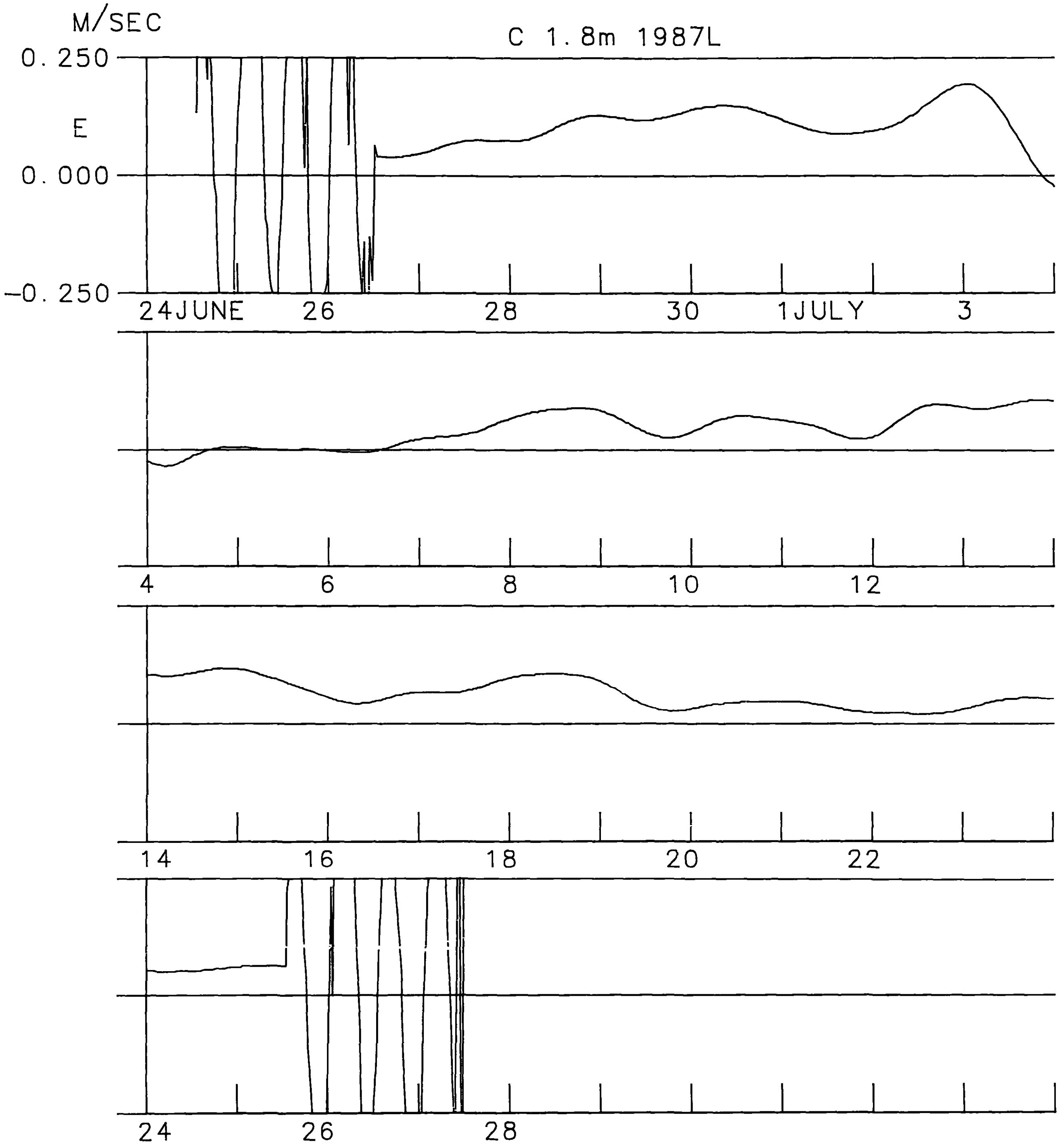
Burwell Bay Station B, 2.9 m below surface



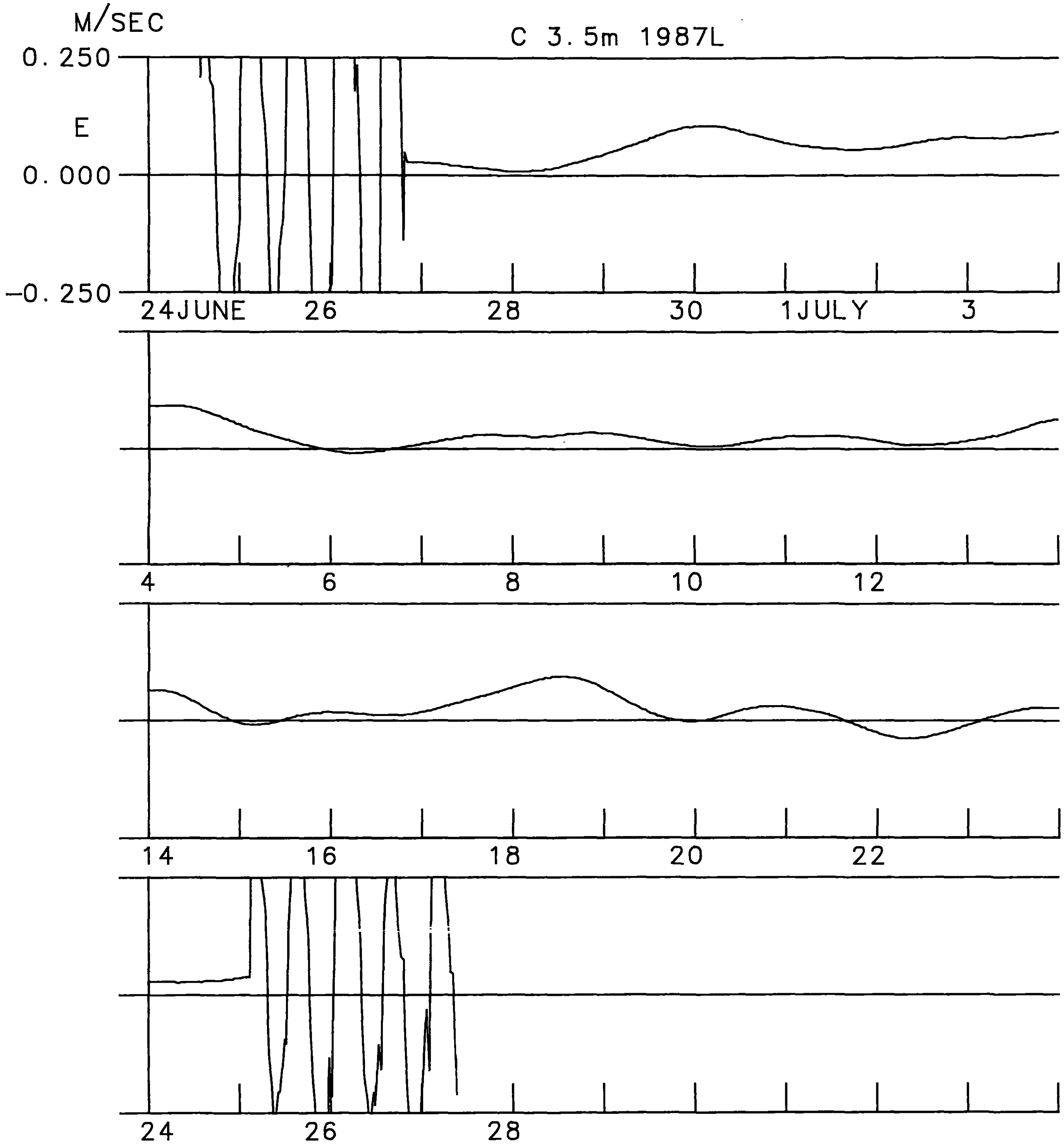
Burwell Bay Station B, 4.9 m below surface



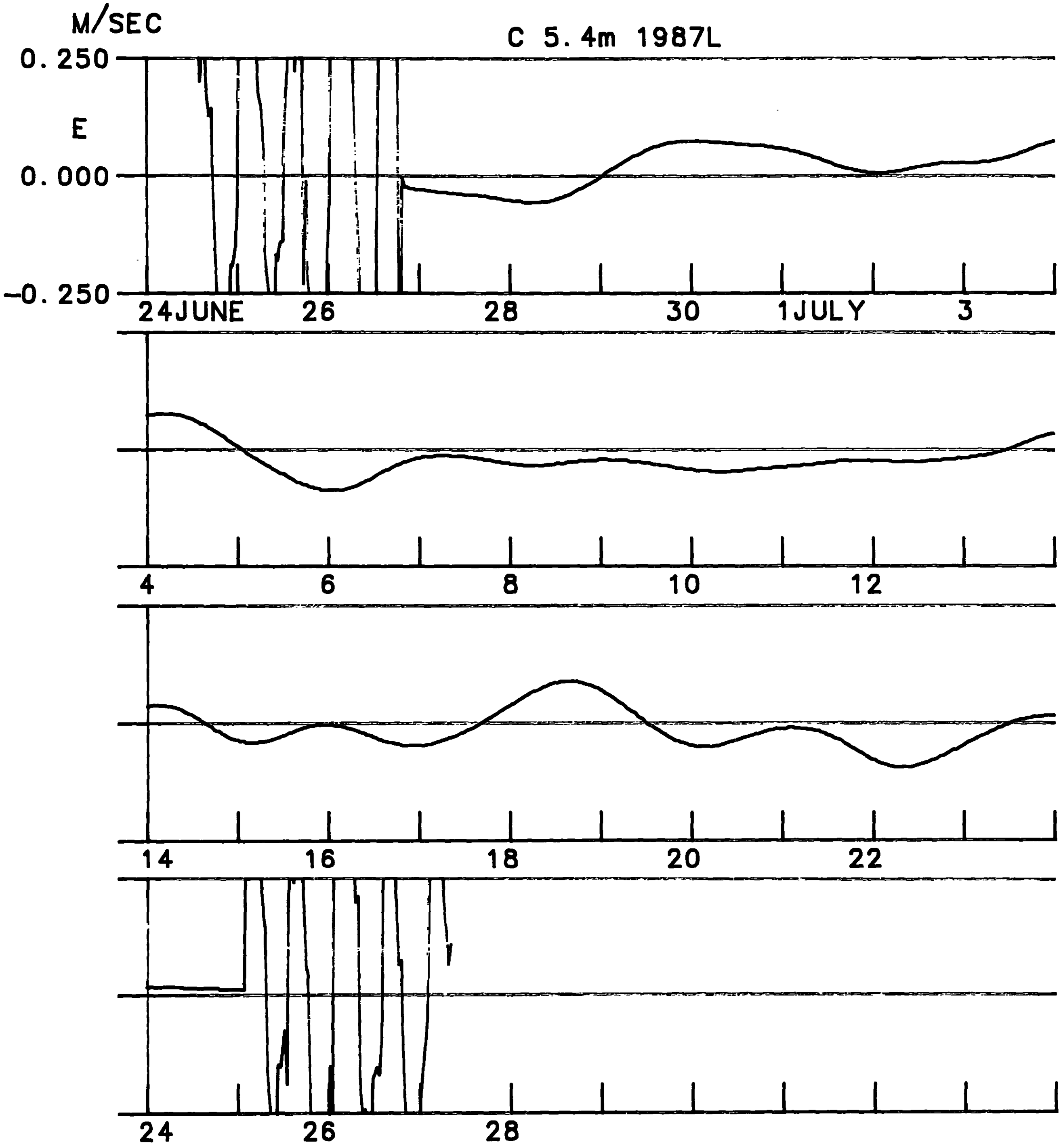
Burwell Bay Station B, 6.9 m below surface



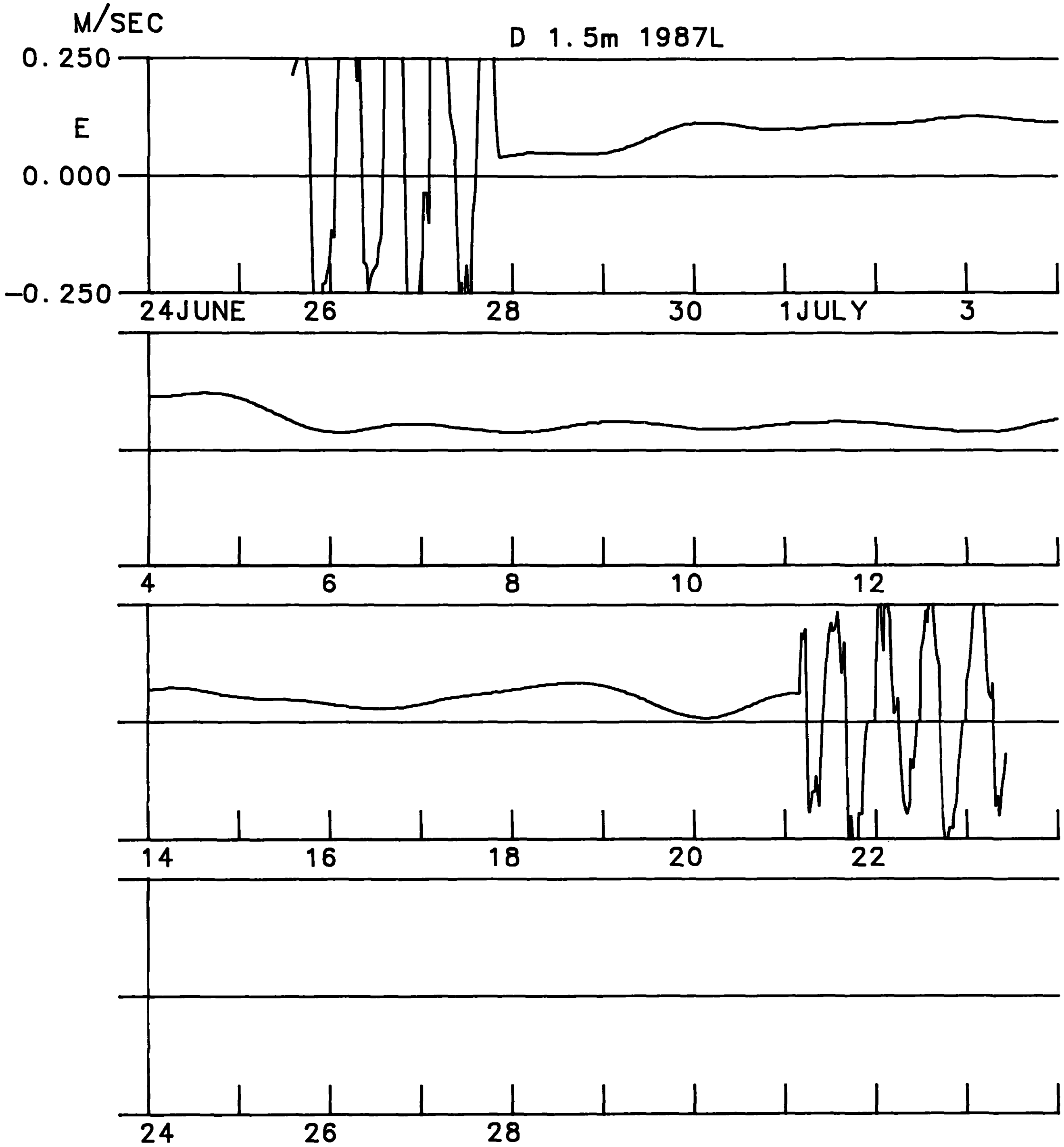
Burwell Bay Station C, 1.8 m below surface



Burwell Bay Station C, 3.5 m below surface



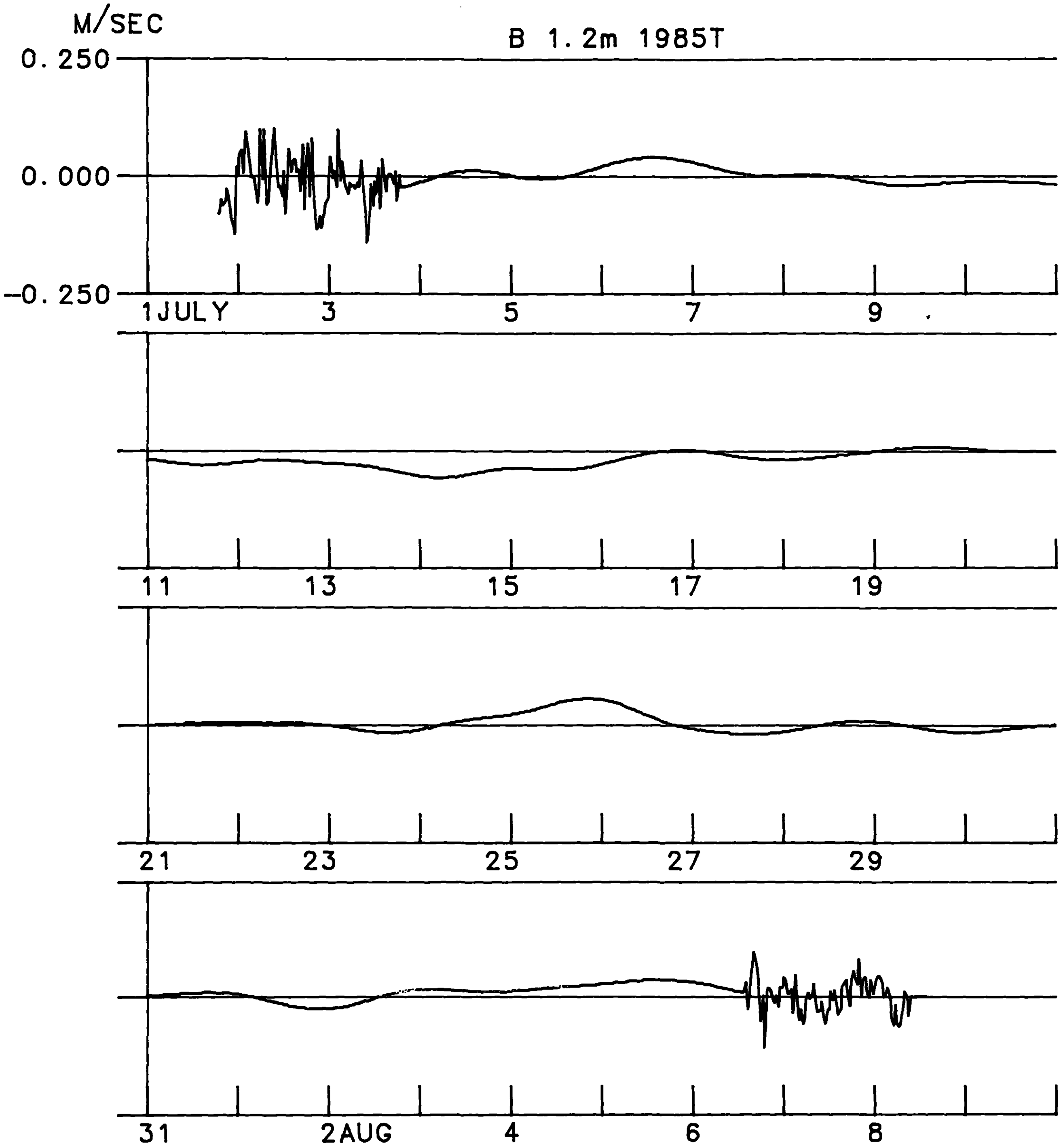
Burwell Bay Station C, 5.4 m below surface



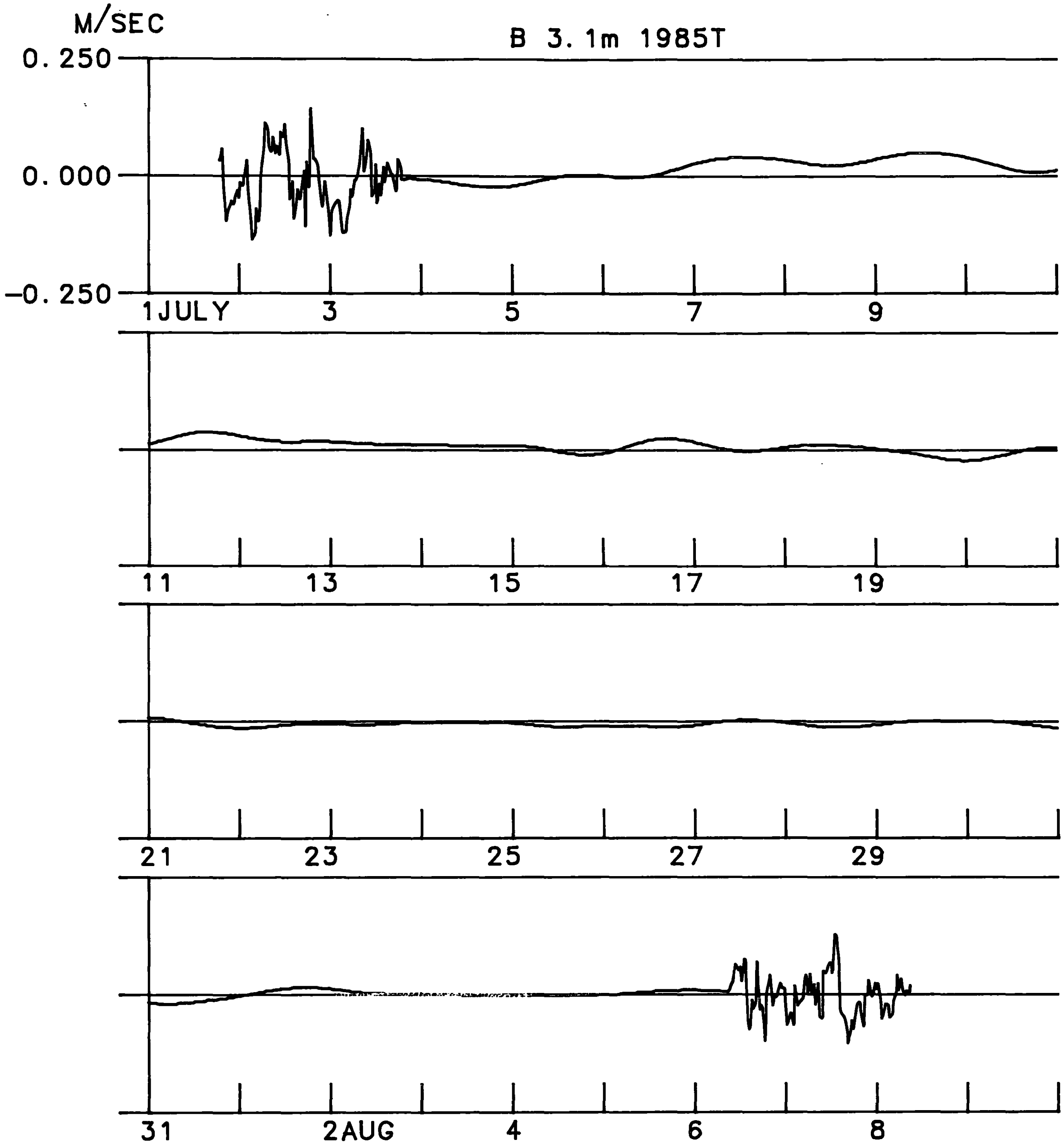
Burwell Bay Station D, 1.5 m below surface

APPENDIX F

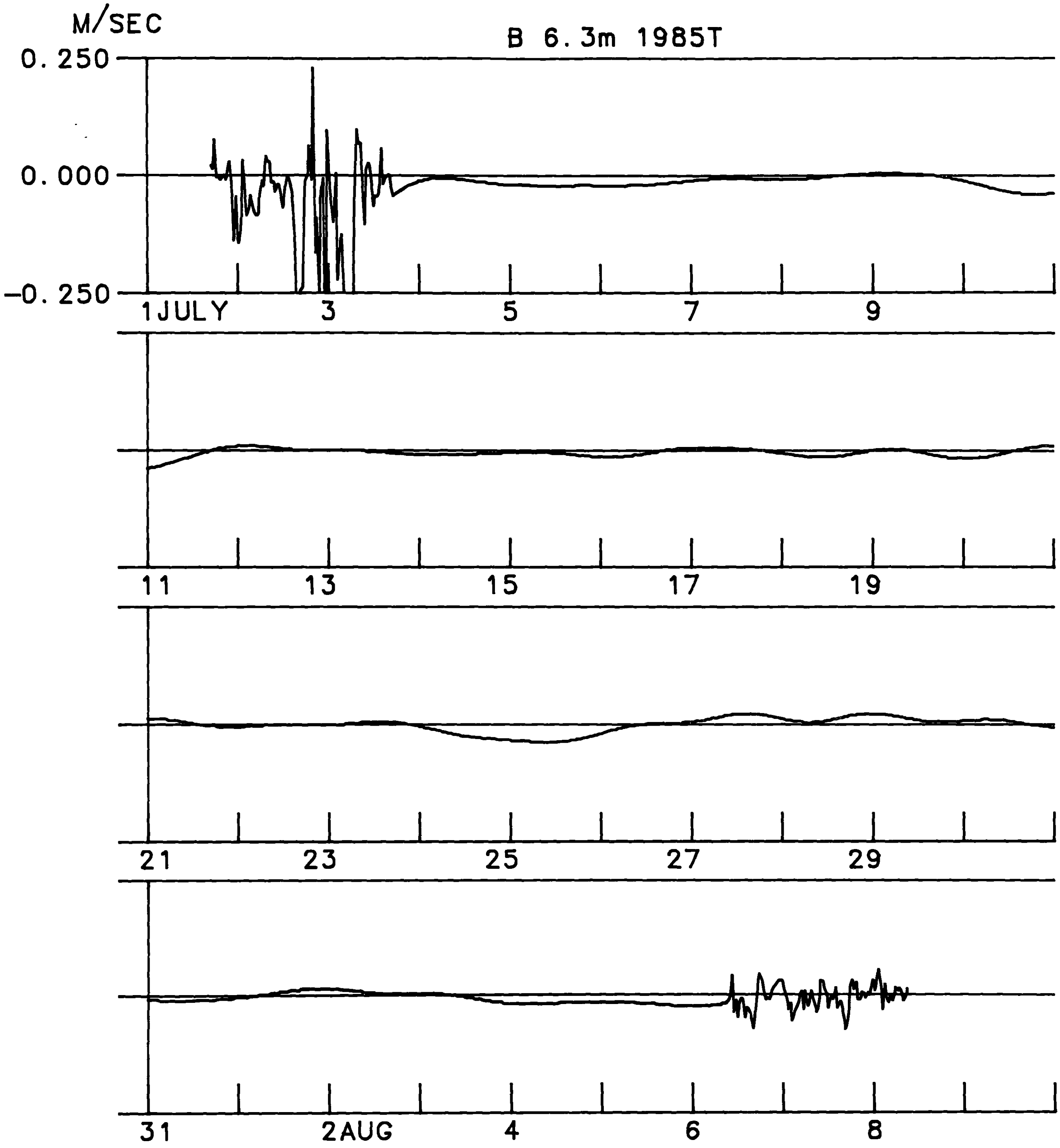
LOW PASS FILTERED TRANSVERSE COMPONENTS OF CURRENTS



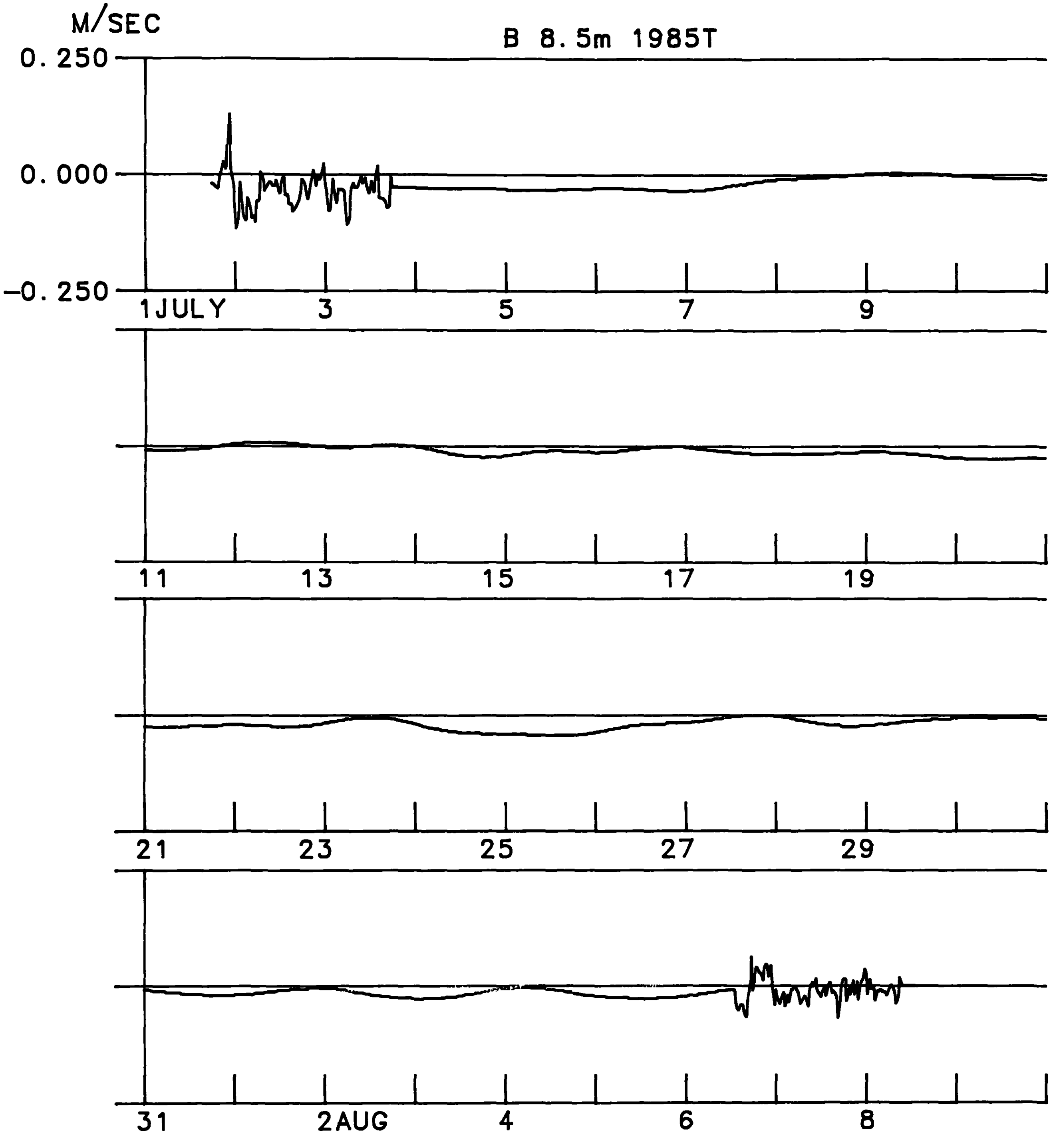
James River Bridge Station B, 1.2 m below surface



James River Bridge Station B, 3.1 m below surface



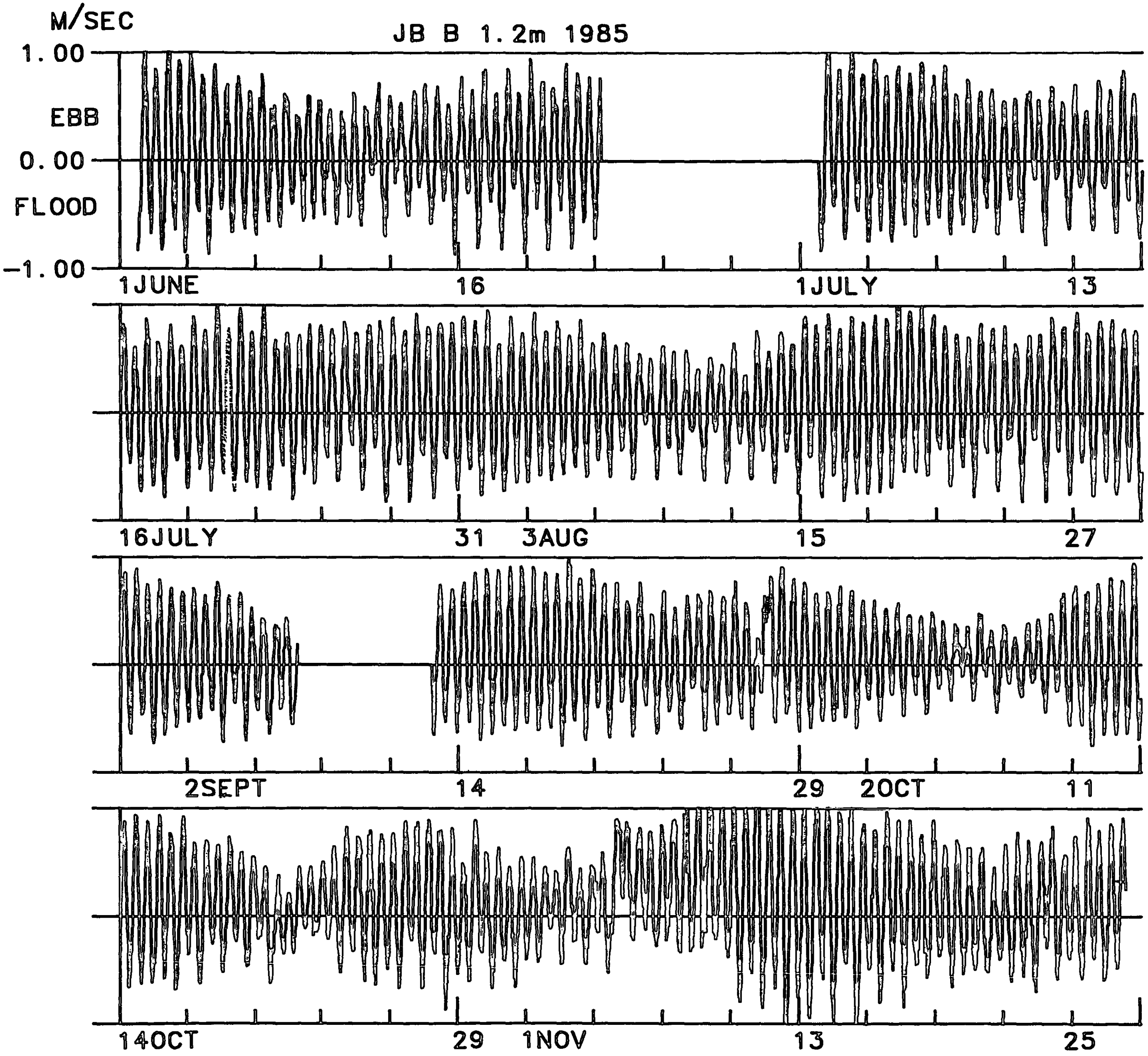
James River Bridge Station B, 6.3 m below surface



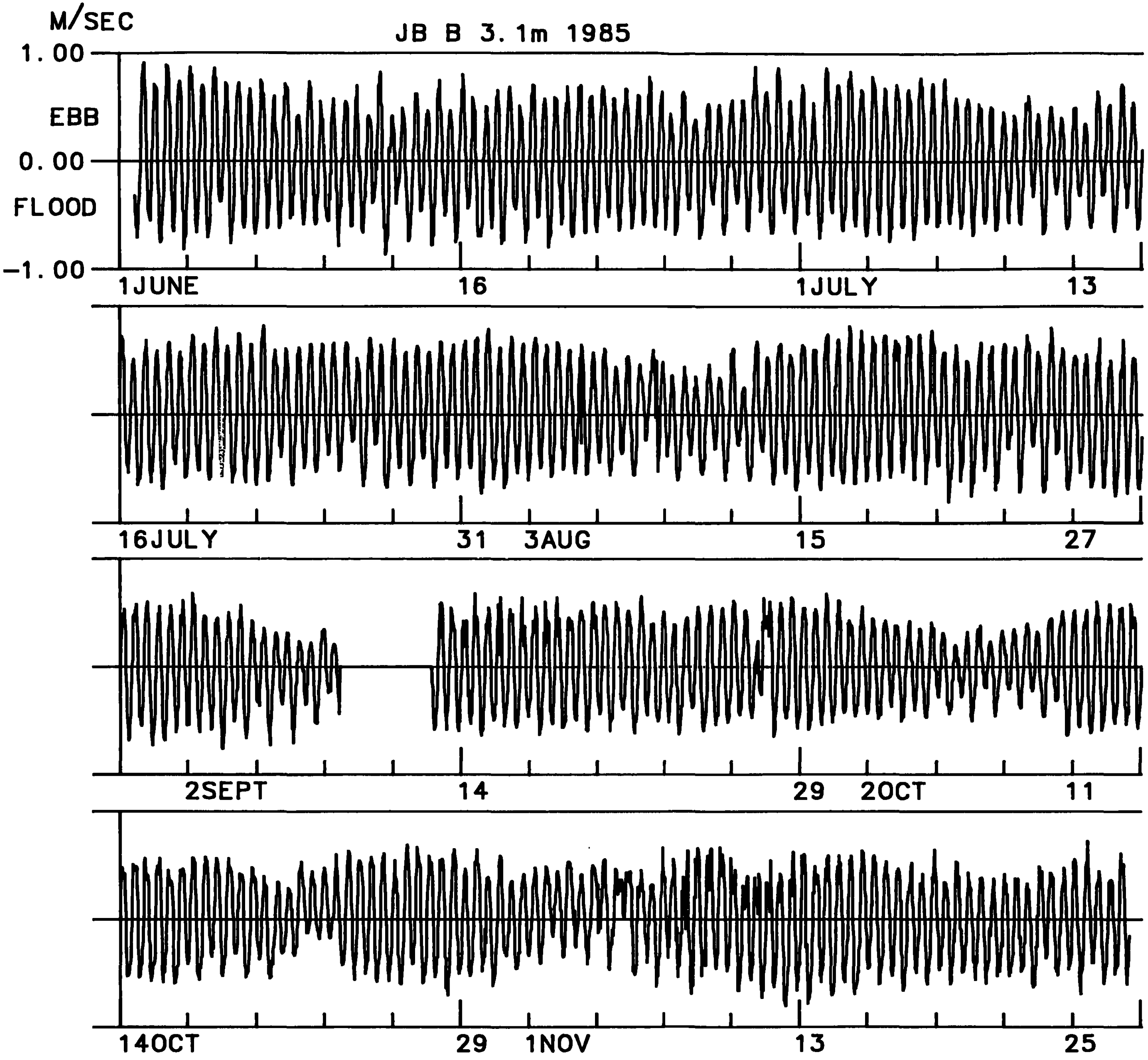
James River Bridge Station B, 8.5 m below surface

APPENDIX G

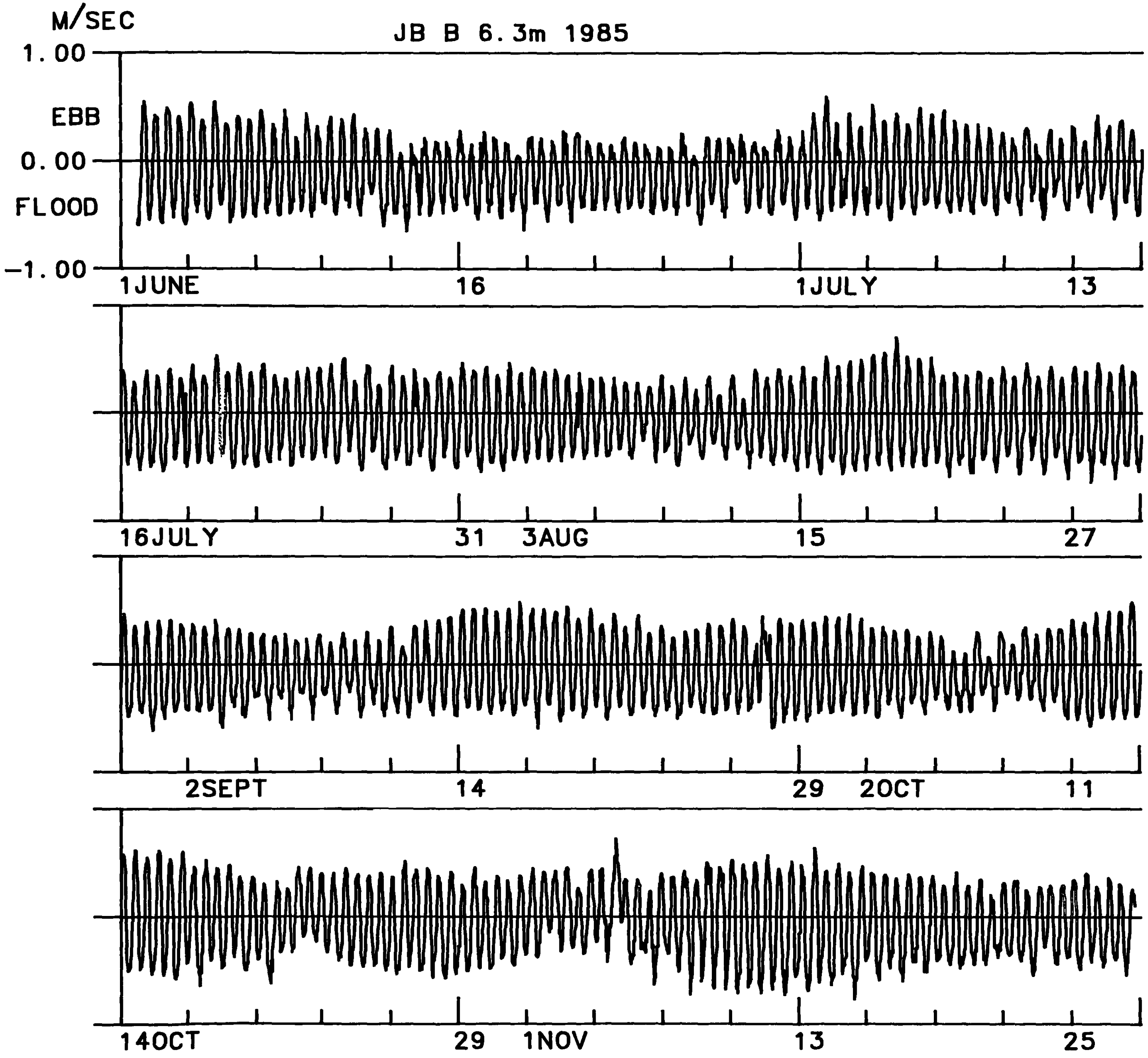
LONGITUDINAL COMPONENTS OF CURRENTS
AT STATION B
(JAMES RIVER BRIDGE TRANSECT)
JUNE THROUGH NOVEMBER 1985



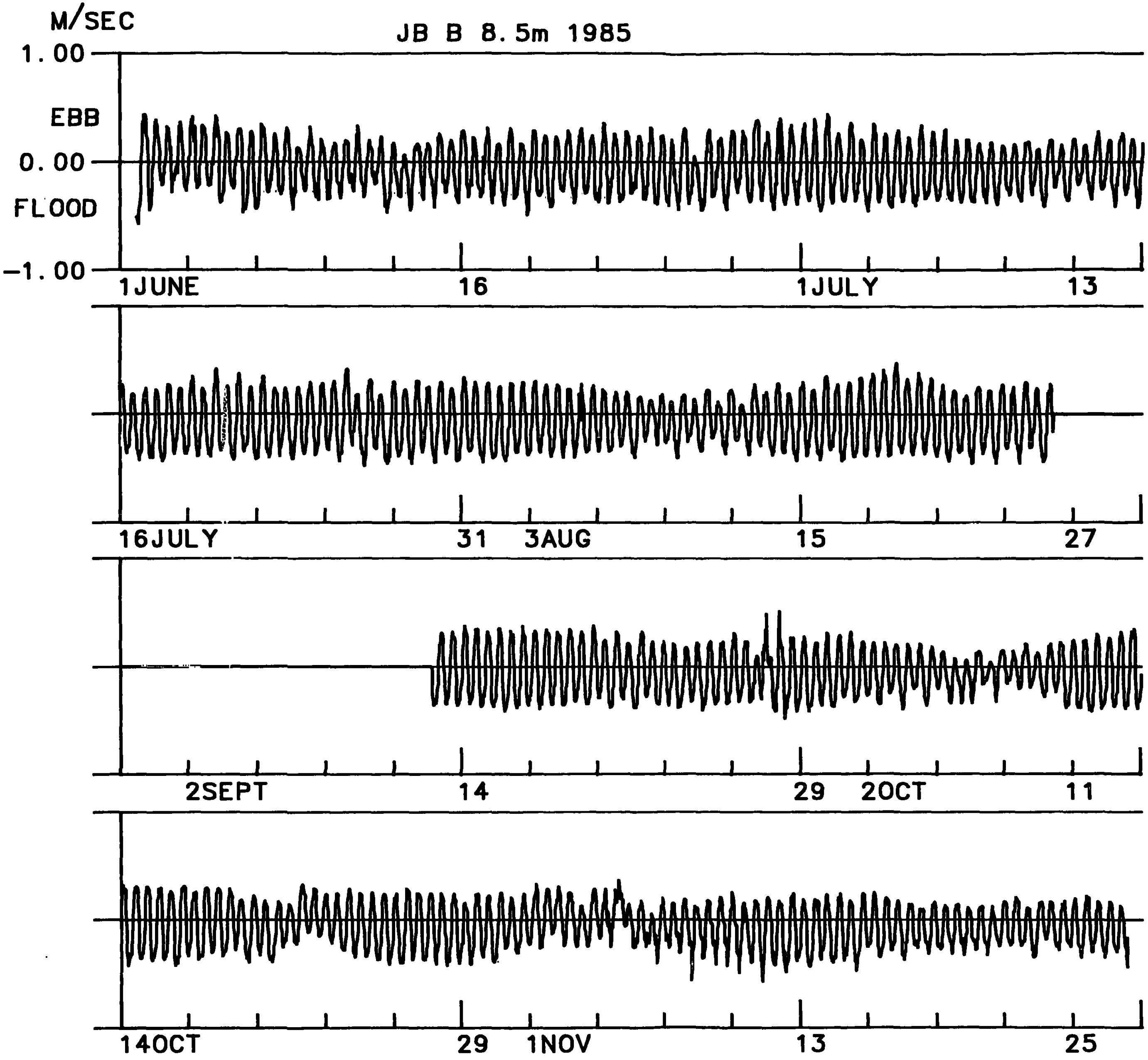
Current at 1.2 m below surface



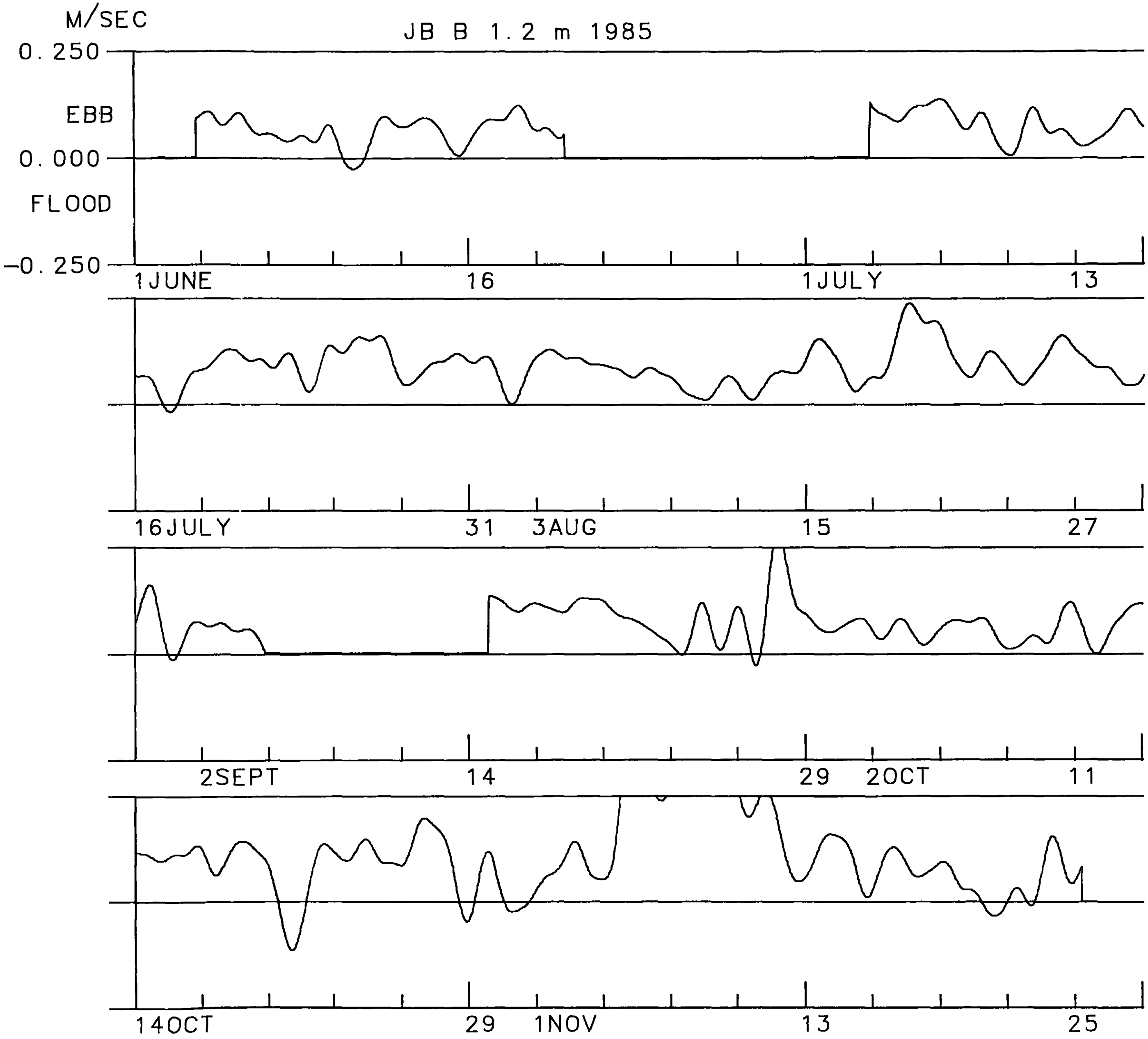
Current at 3.1 m below surface



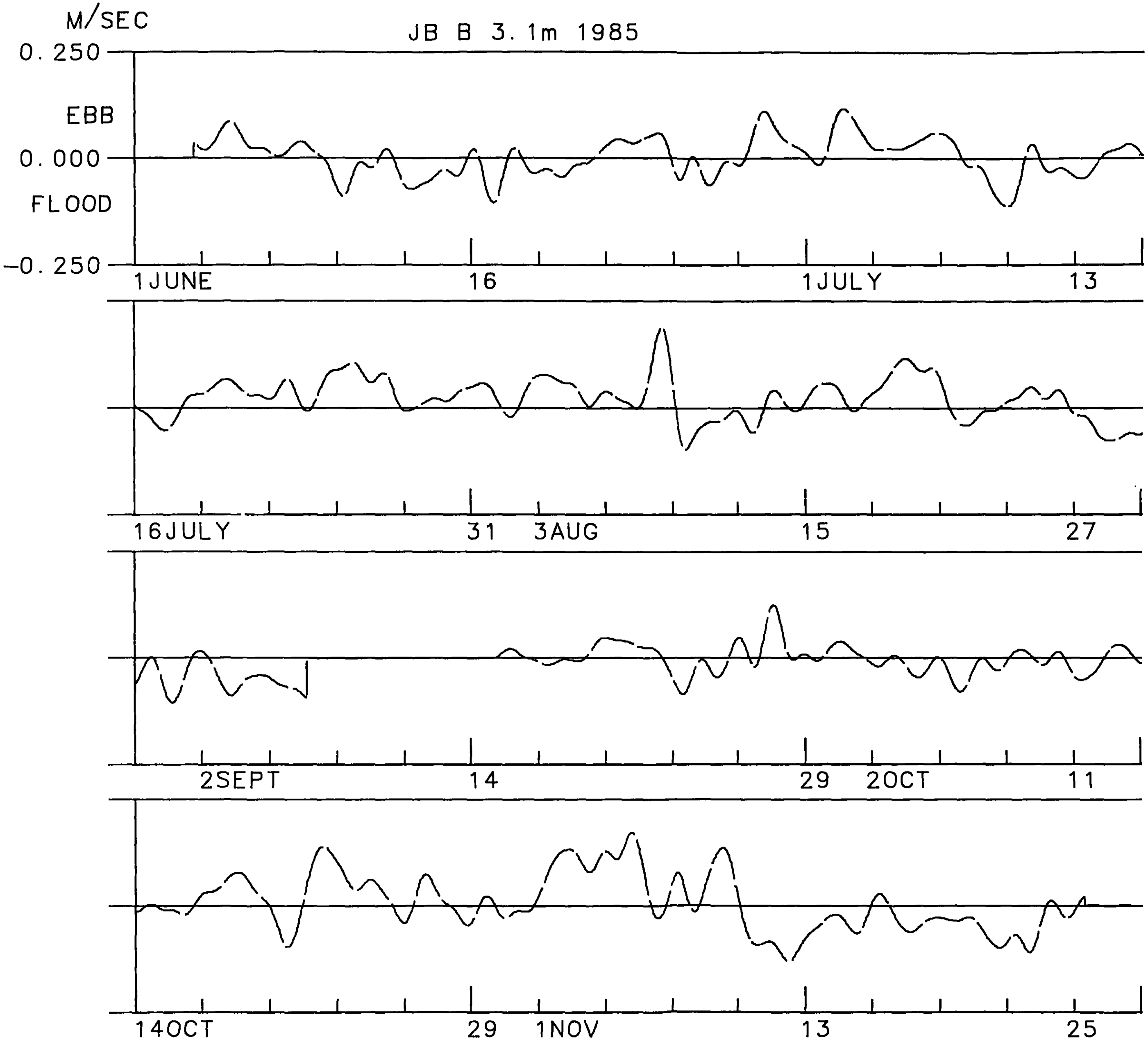
Current at 6.3 m below surface



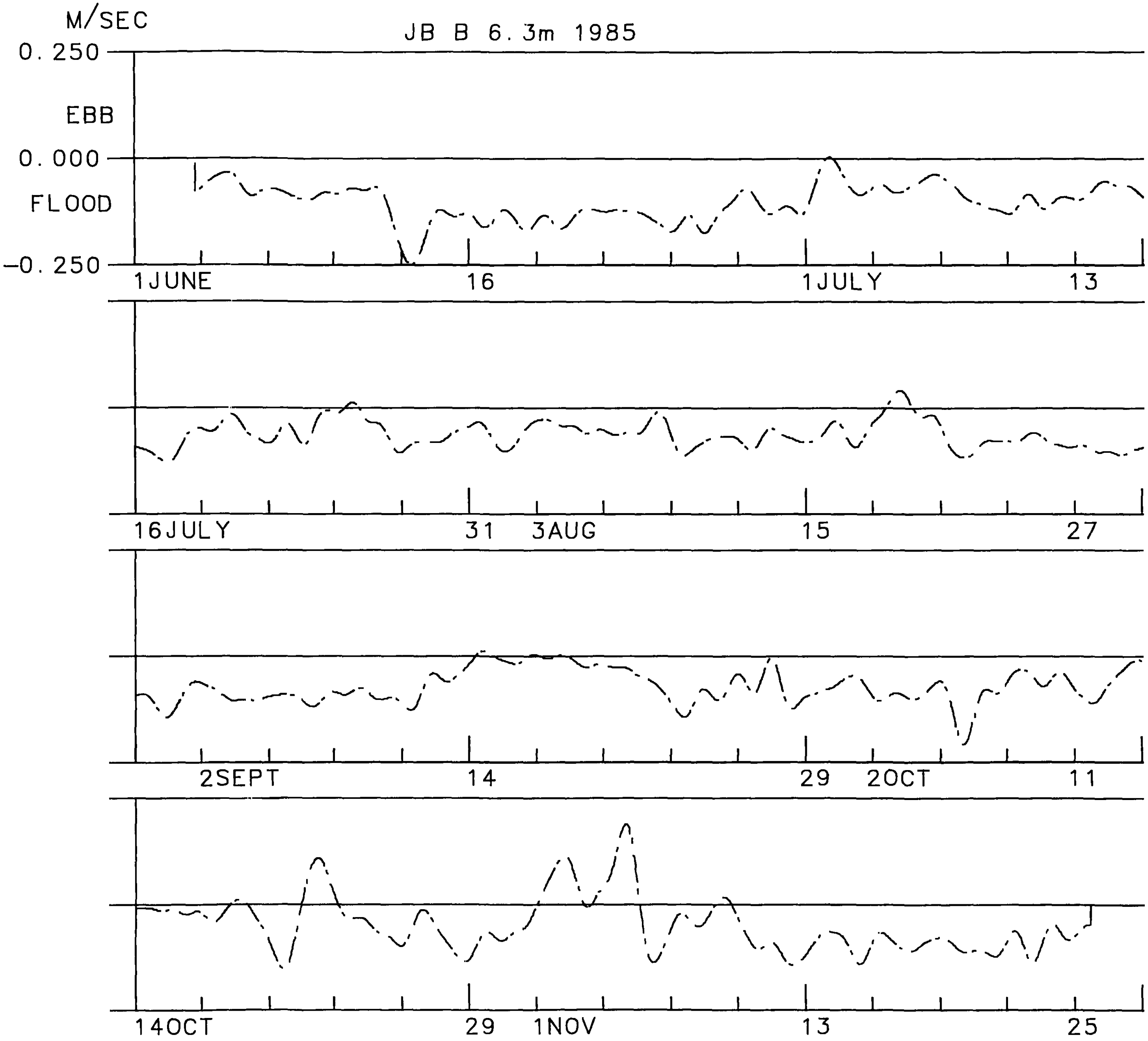
Current at 8.5 m below surface



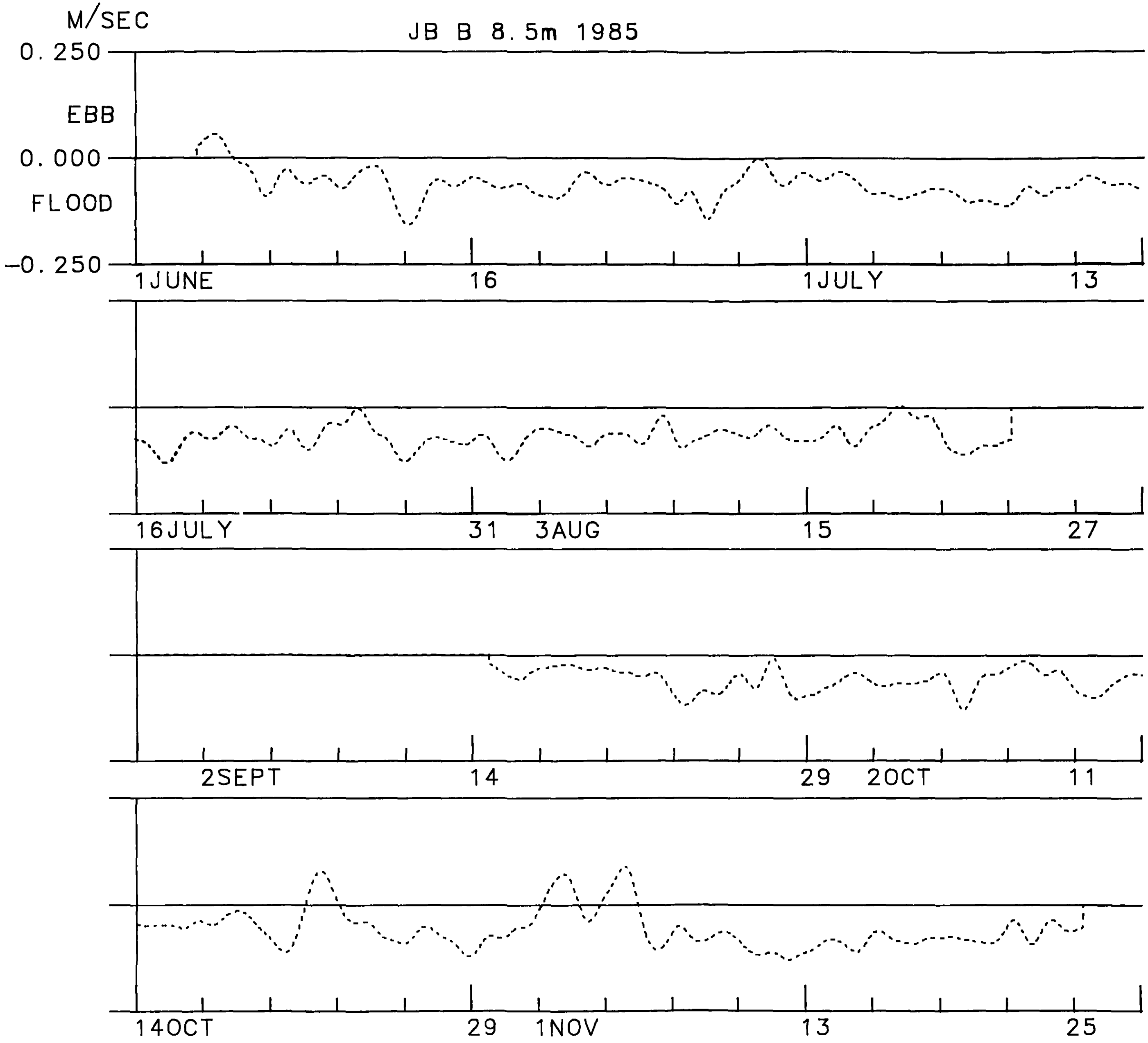
Sub-tidal current at 1.2 m below surface



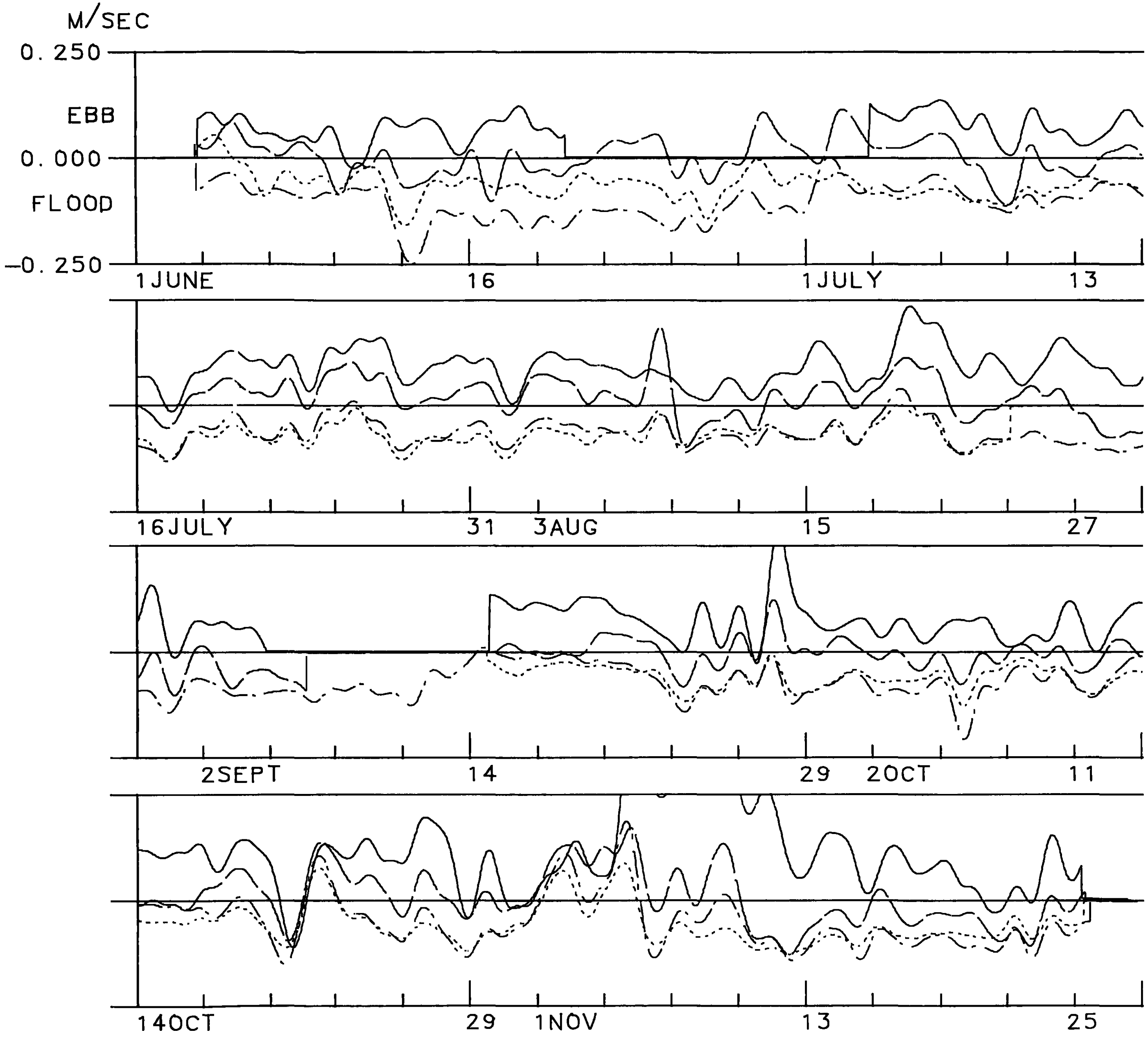
Sub-tidal current at 3.1 m below surface



Sub-tidal current at 6.3 m below surface



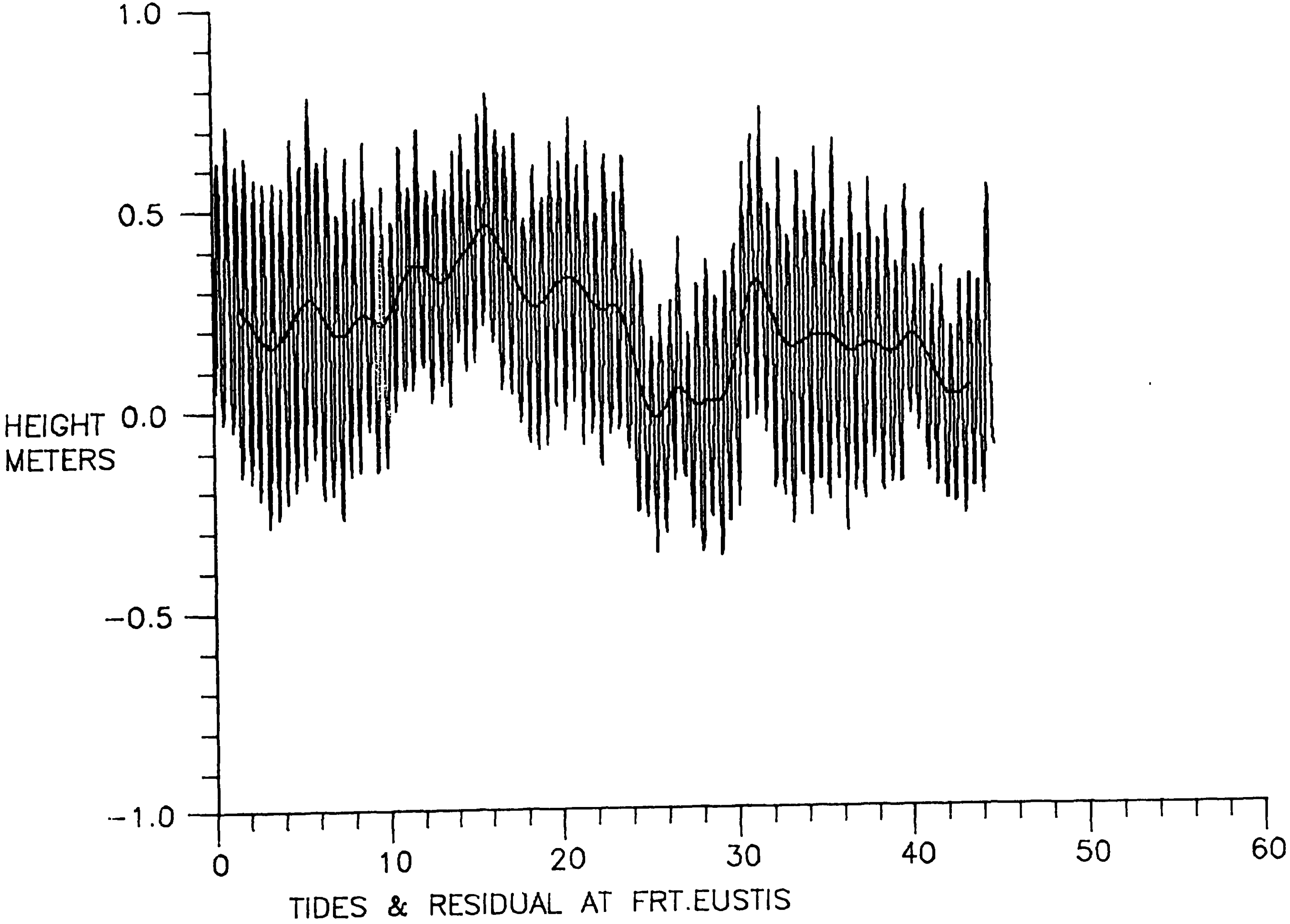
Sub-tidal current at 8.5 m below surface



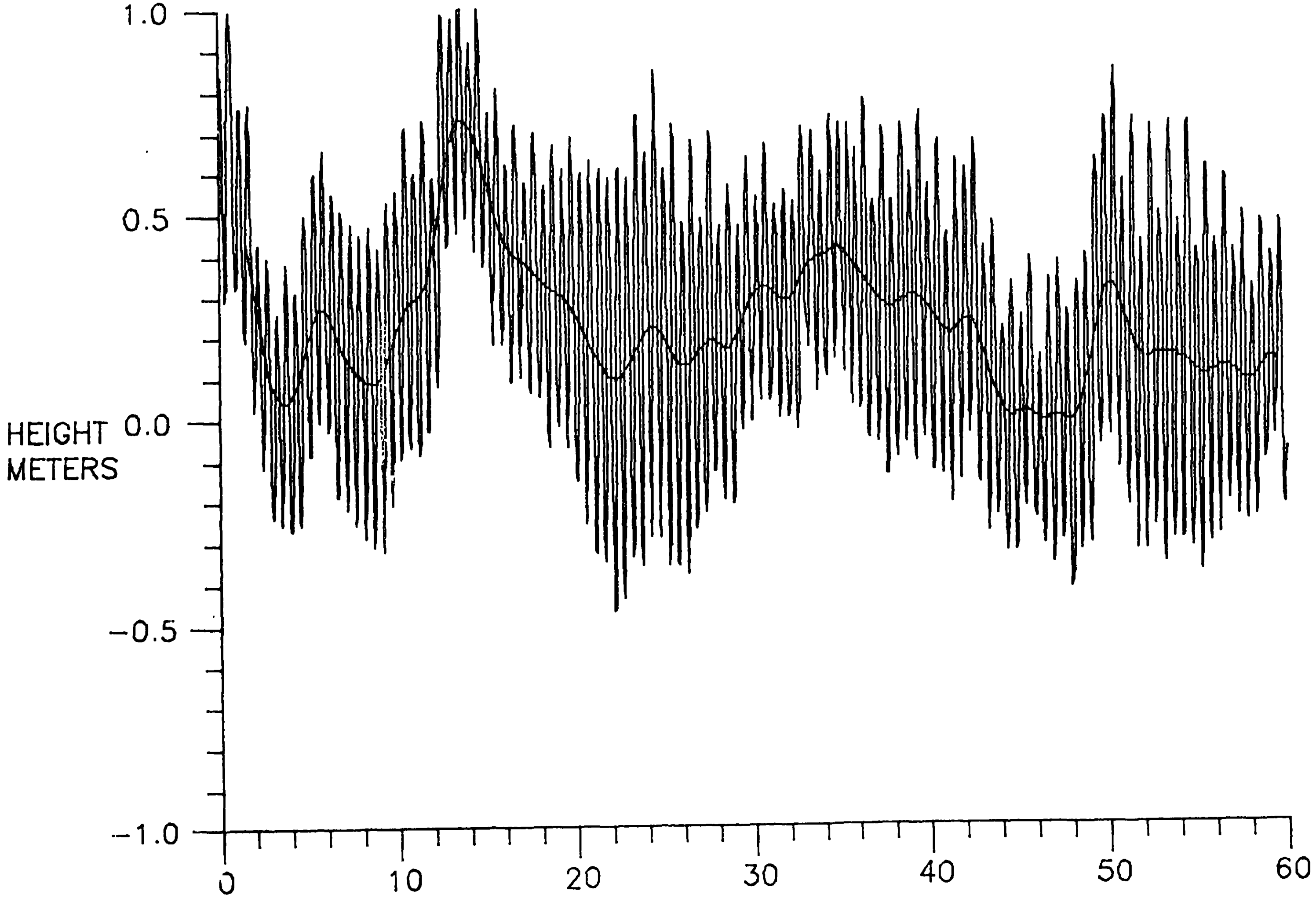
Sub-tidal currents at various depths

APPENDIX H

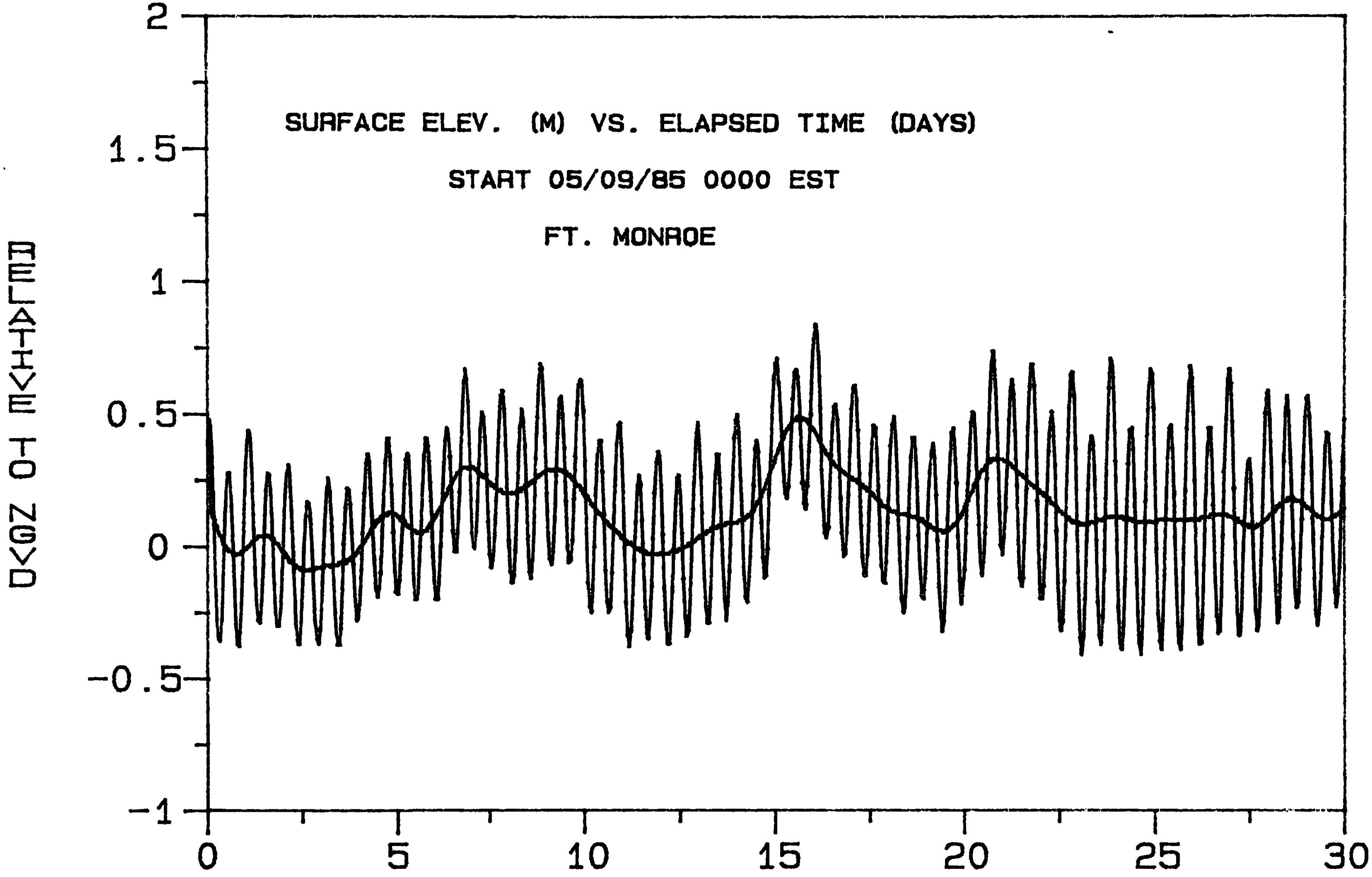
OBSERVED AND LOW PASS FILTERED SURFACE ELEVATIONS

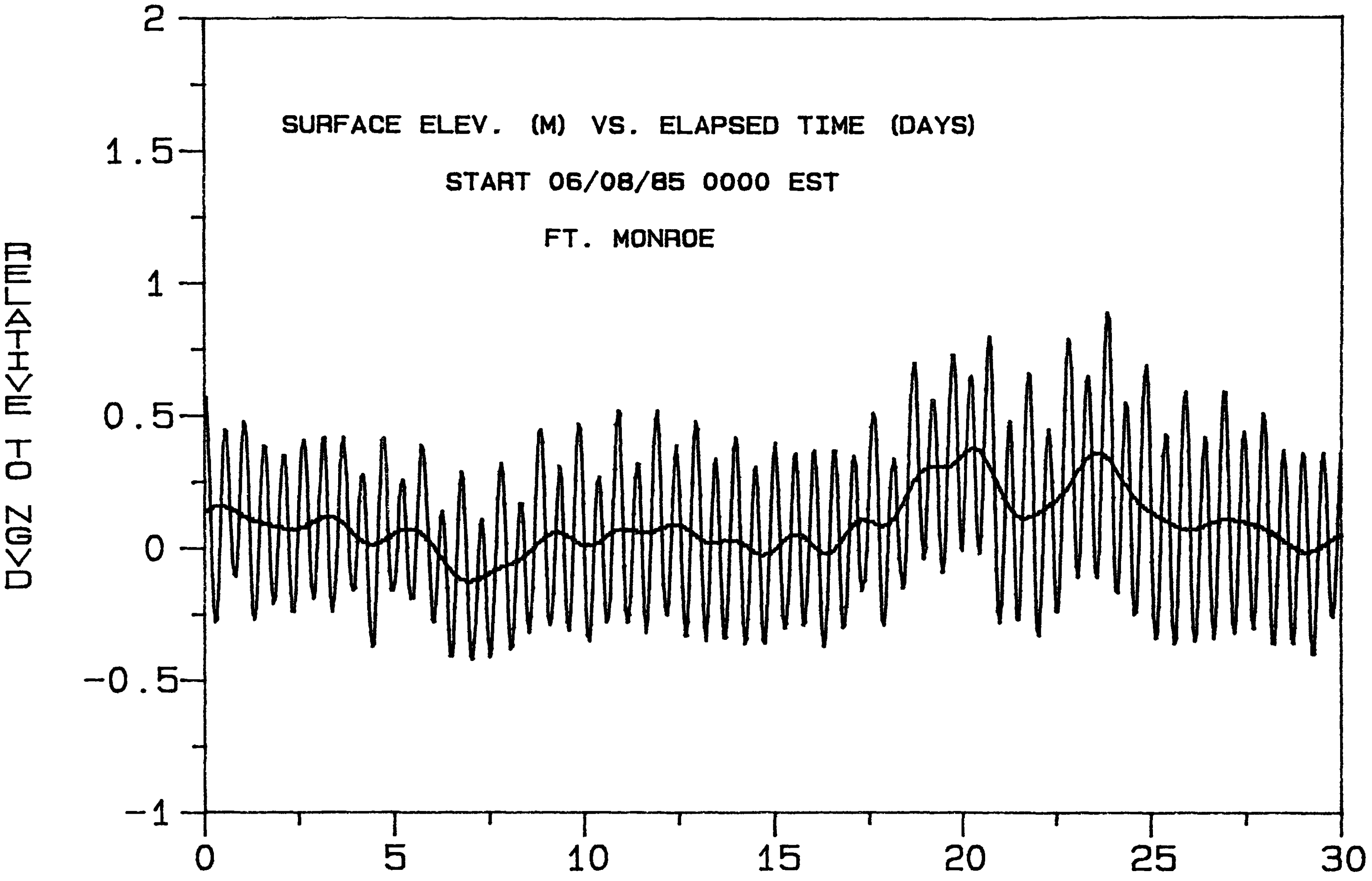


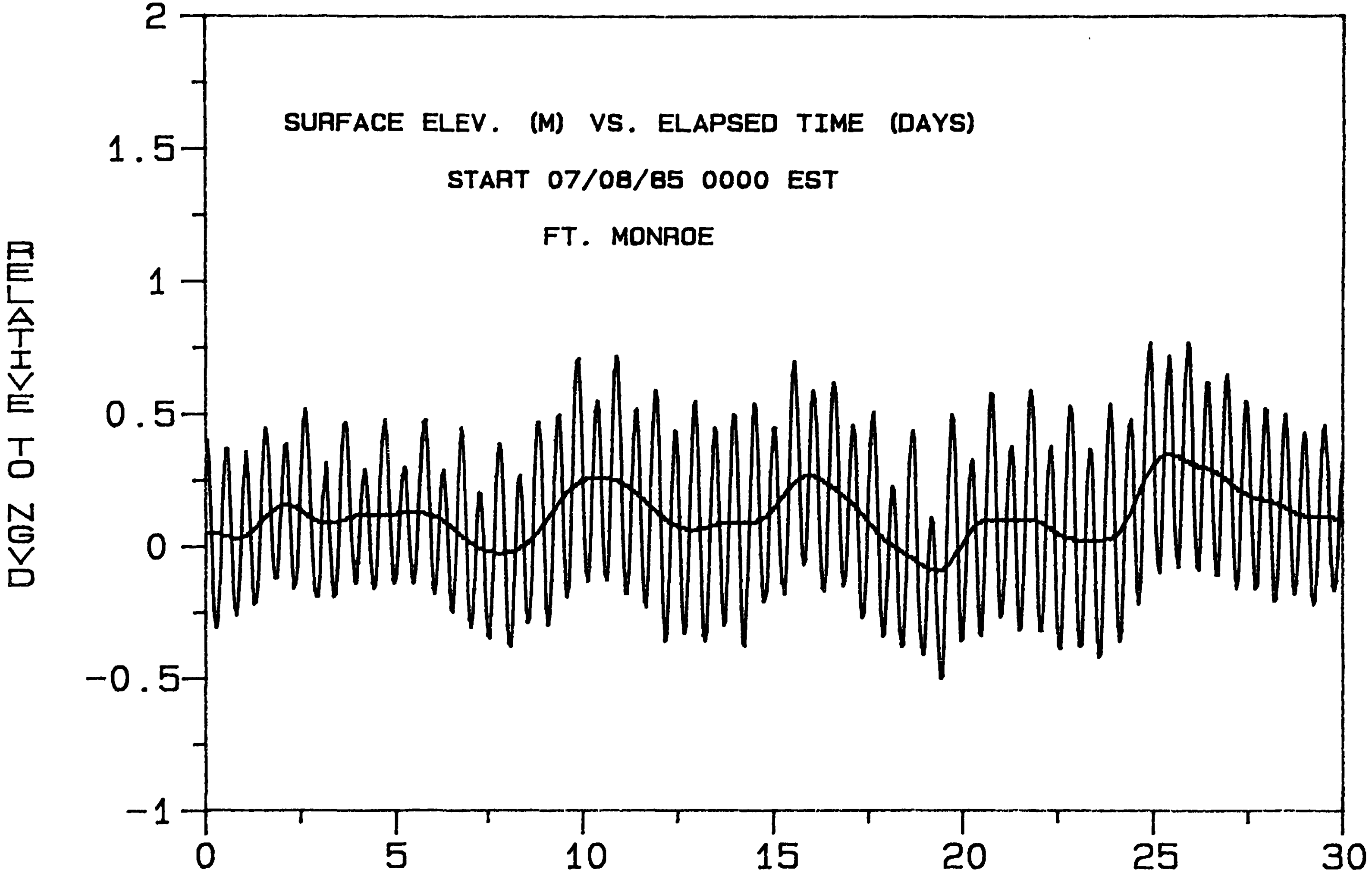
Tidal record and residual at Fort Eustis referred to NGVD.
(starting 1800 hr, Oct. 19, 1984)

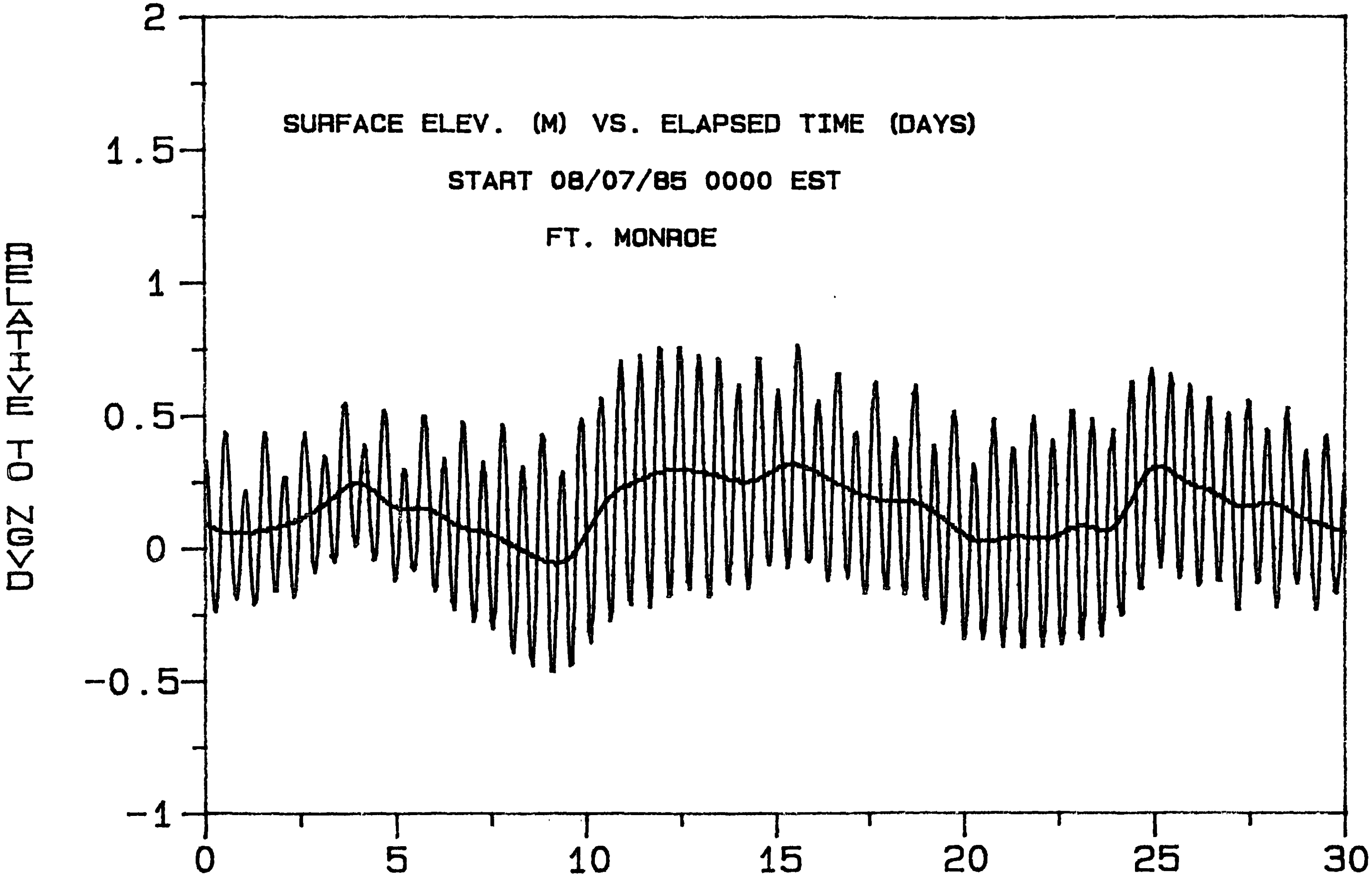


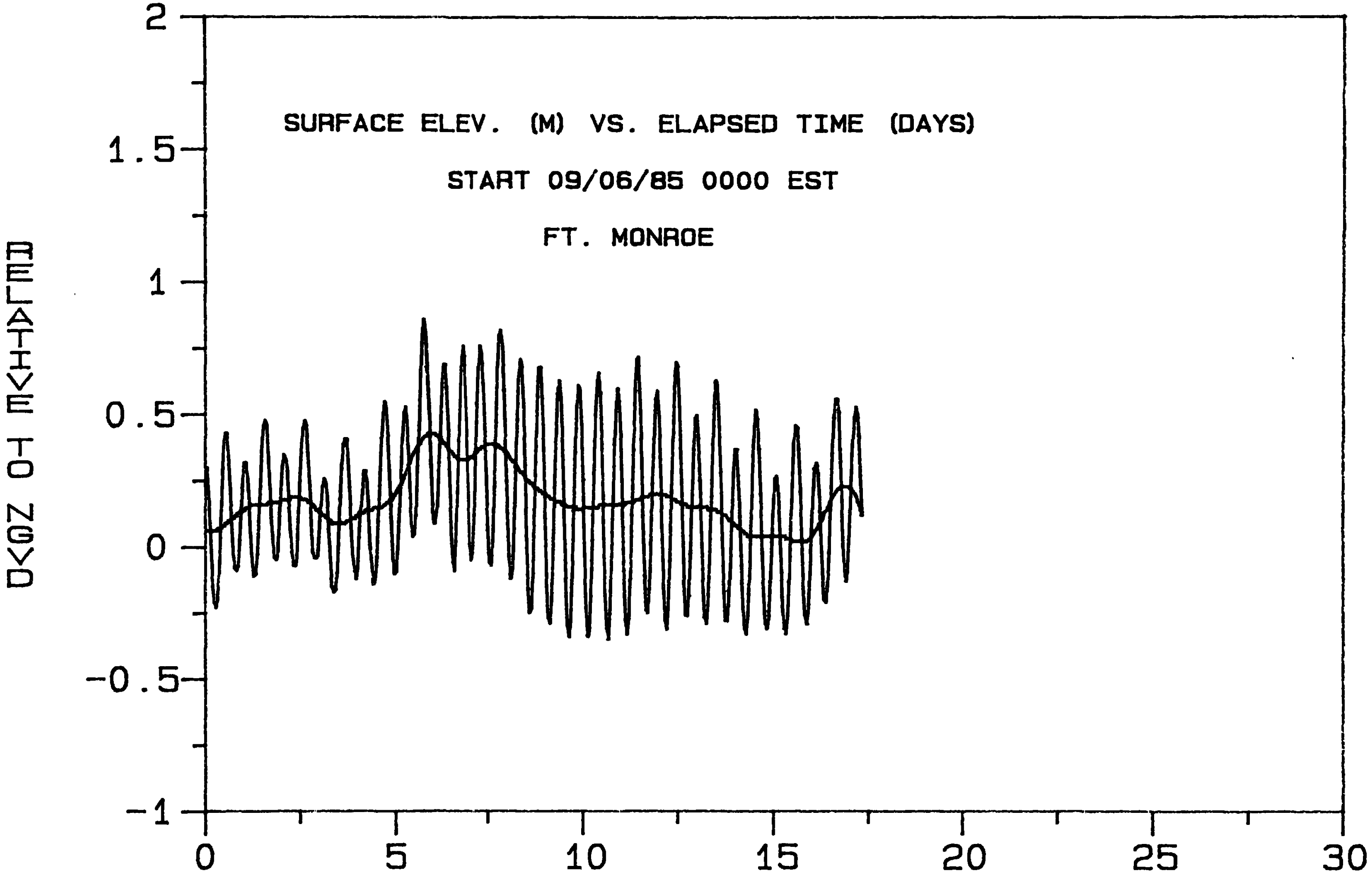
Tidal record and residual at Sewell's Point referred to NGVD. (starting 0000 hr, Oct. 1, 1984)

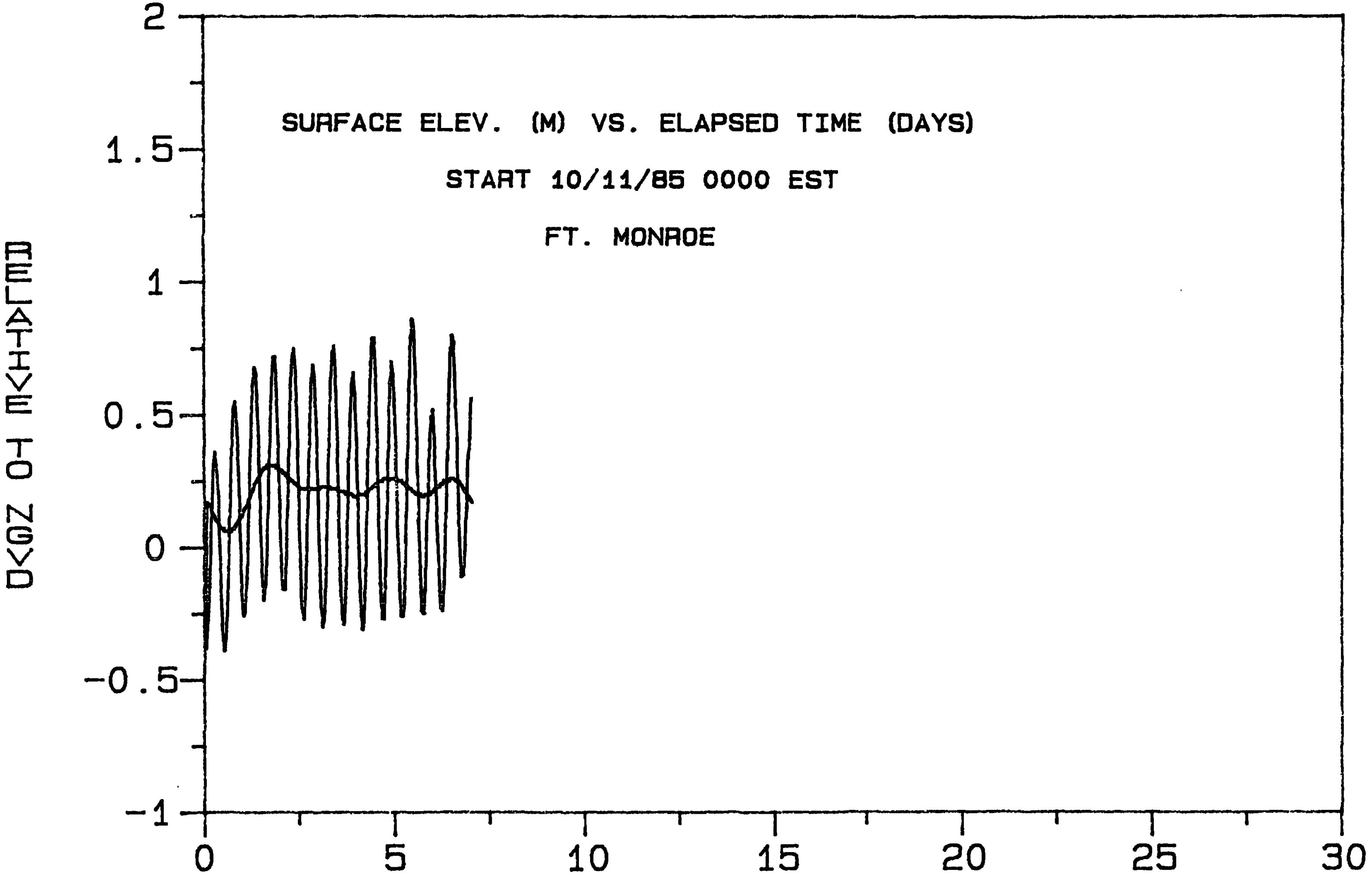

SURFACE ELEV. (M) VS. ELAPSED TIME (DAYS)
START 05/09/85 0000 EST
FT. MONROE
RELATIVE TO NGVD
2
1.5
1
0.5
0
-0.5
-1
0
5
10
15
20
25
30

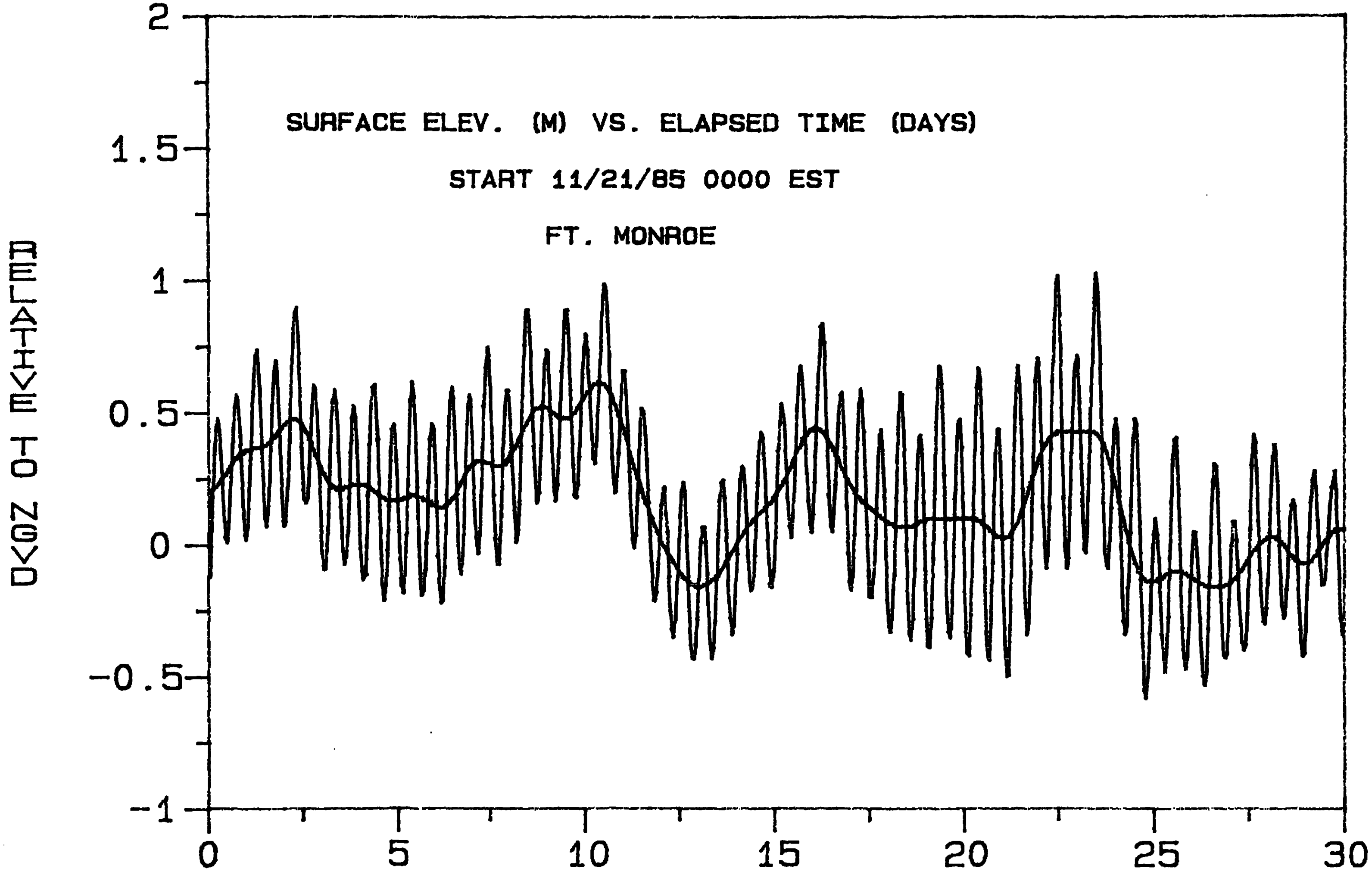

SURFACE ELEV. (M) VS. ELAPSED TIME (DAYS)
START 06/08/85 0000 EST
FT. MONROE
RELATIVE TO NGVD
2
1.5
1
0.5
0
-0.5
-1
0
5
10
15
20
25
30

SURFACE ELEV. (M) VS. ELAPSED TIME (DAYS)
START 07/08/85 0000 EST
FT. MONROE
RELATIVE TO NGVD
2
1.5
1
0.5
0
-0.5
-1
0
5
10
15
20
25
30

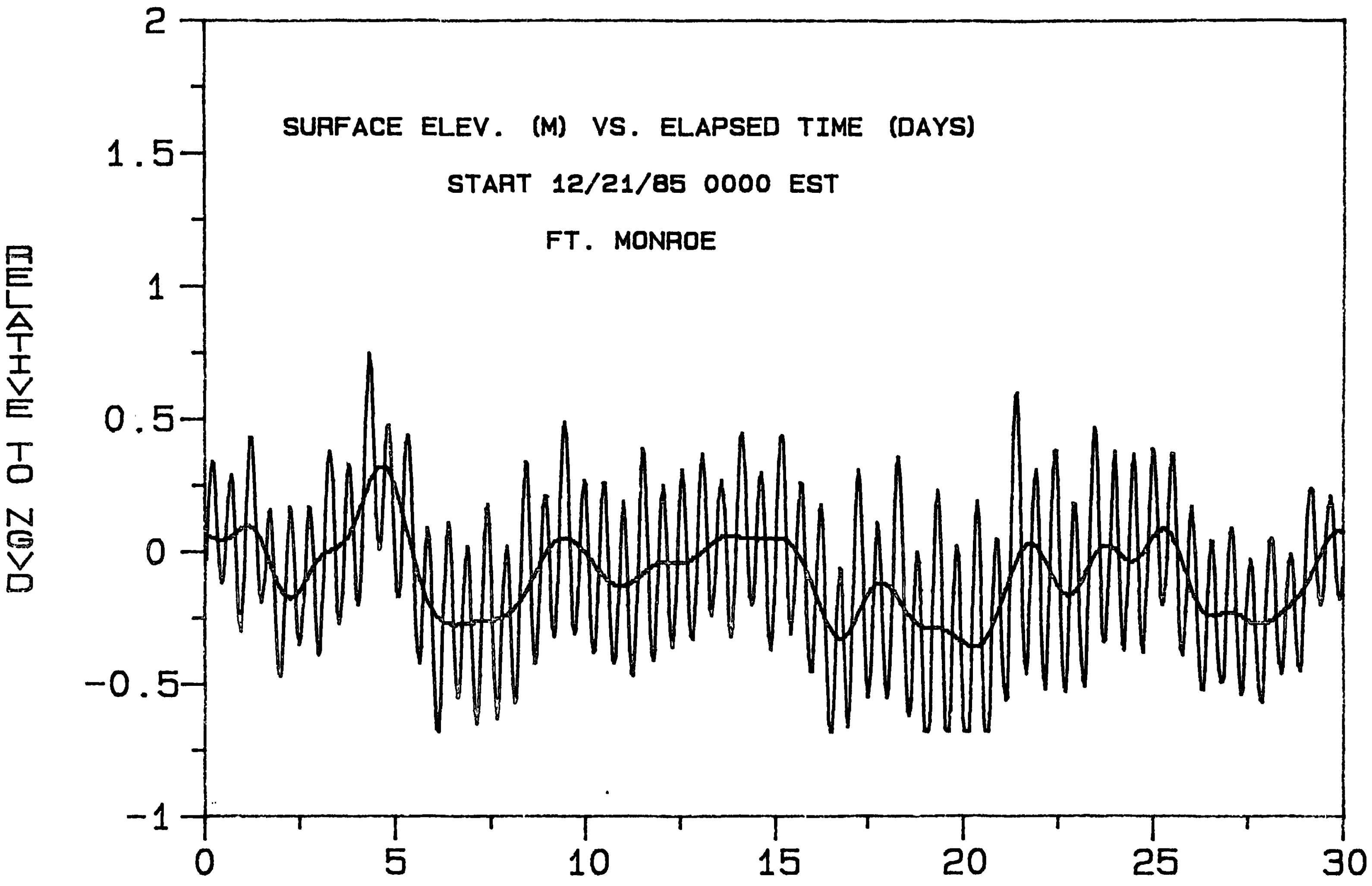

SURFACE ELEV. (M) VS. ELAPSED TIME (DAYS)
START 08/07/85 0000 EST
FT. MONROE
RELATIVE TO NGVD
2
1.5
1
0.5
0
-0.5
-1
0
5
10
15
20
25
30

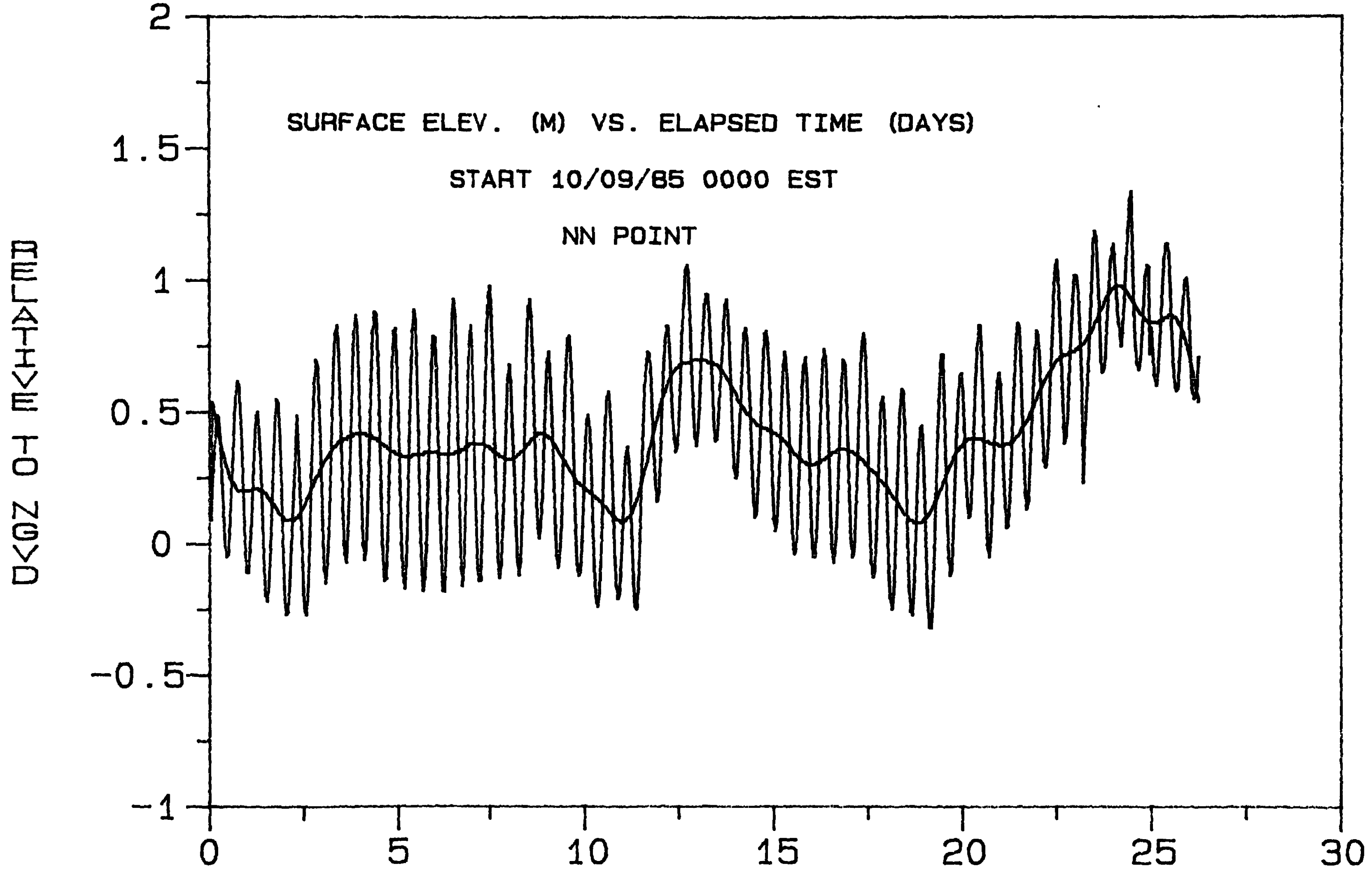

SURFACE ELEV. (M) VS. ELAPSED TIME (DAYS)
START 09/06/85 0000 EST
FT. MONROE
RELATIVE TO NGVD
2
1.5
1
0.5
0
-0.5
-1
0
5
10
15
20
25
30

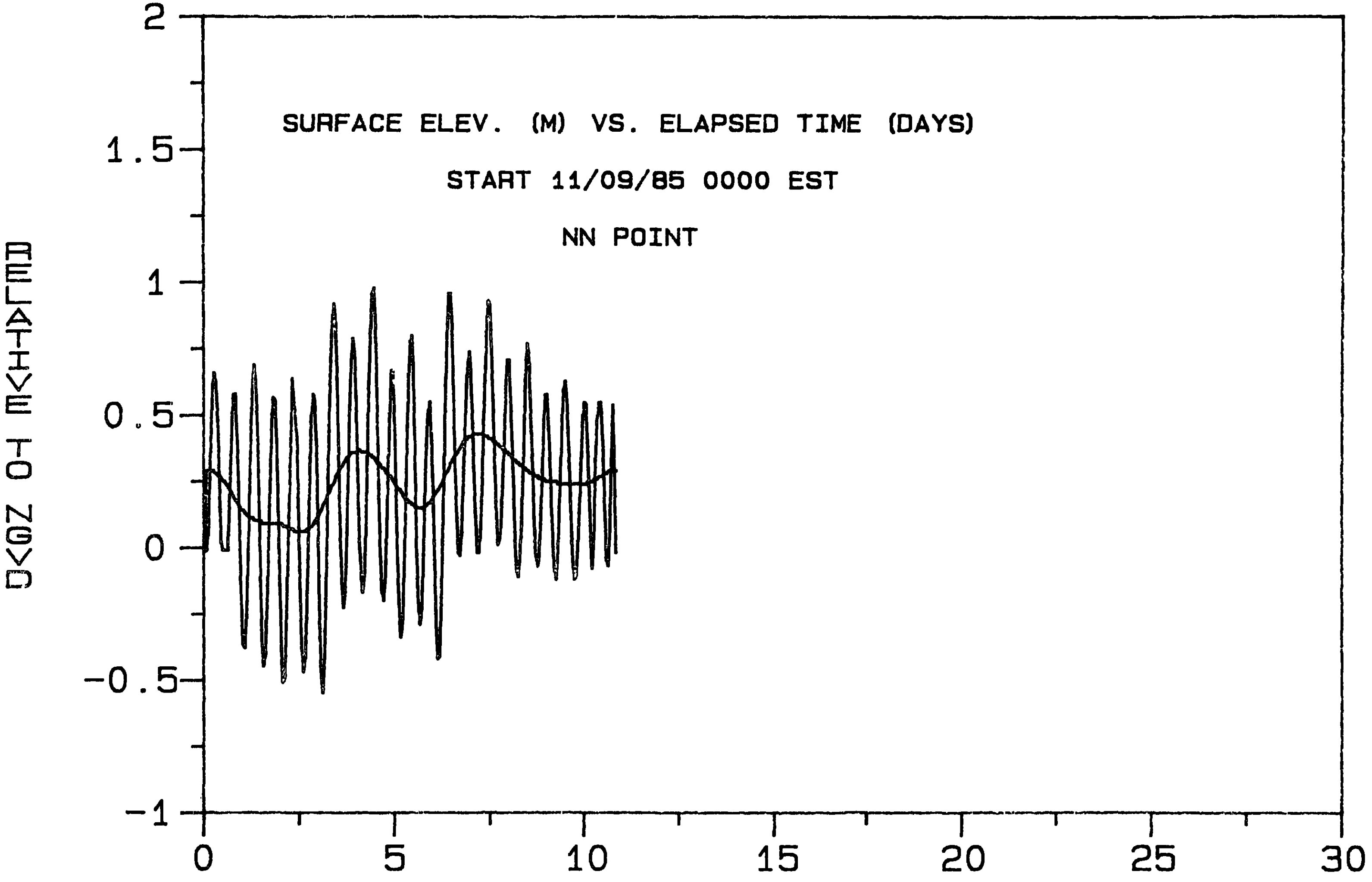

SURFACE ELEV. (M) VS. ELAPSED TIME (DAYS)
START 10/11/85 0000 EST
FT. MONROE
RELATIVE TO NGVD
2
1.5
1
0.5
0
-0.5
-1
0
5
10
15
20
25
30

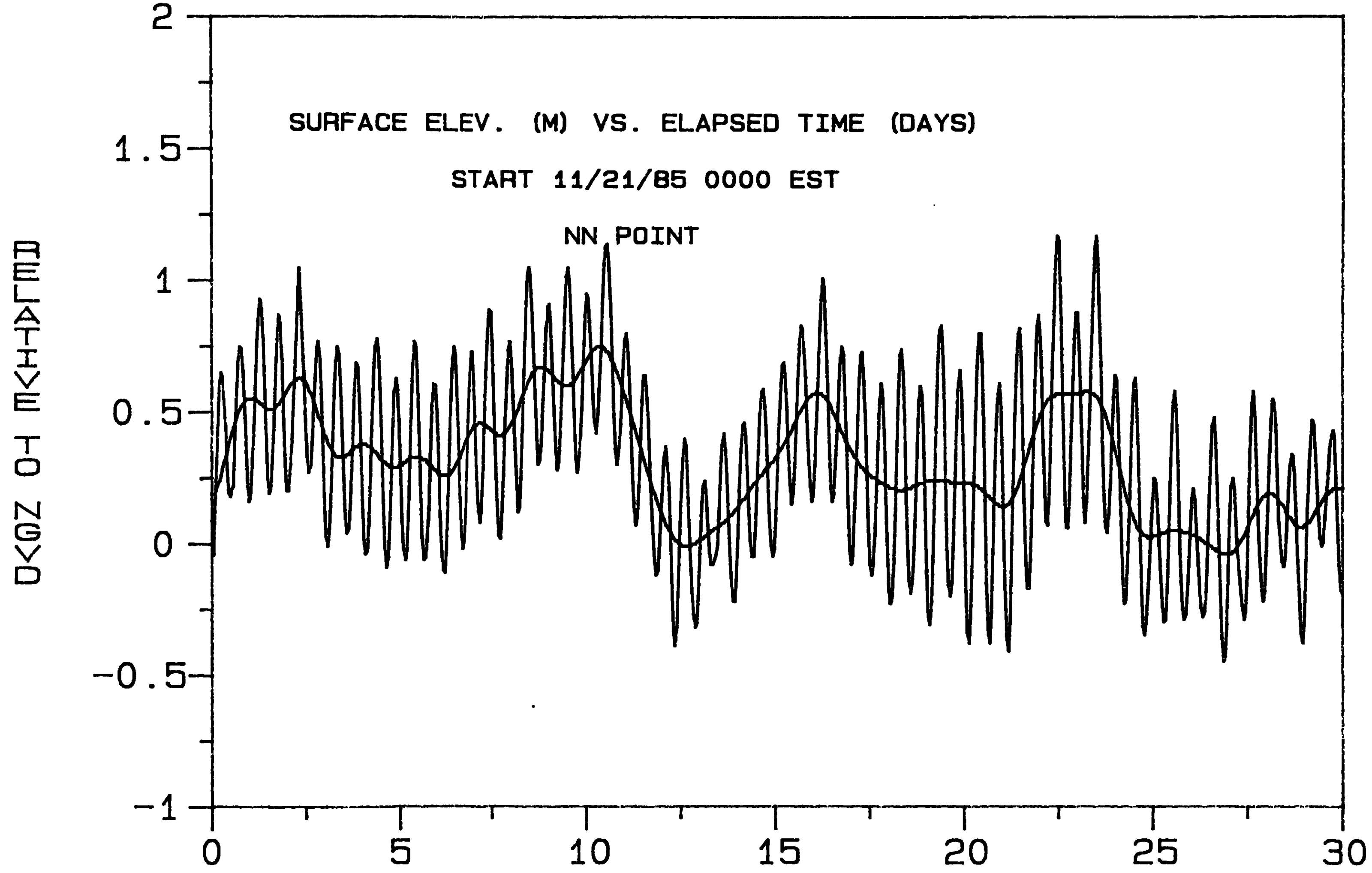


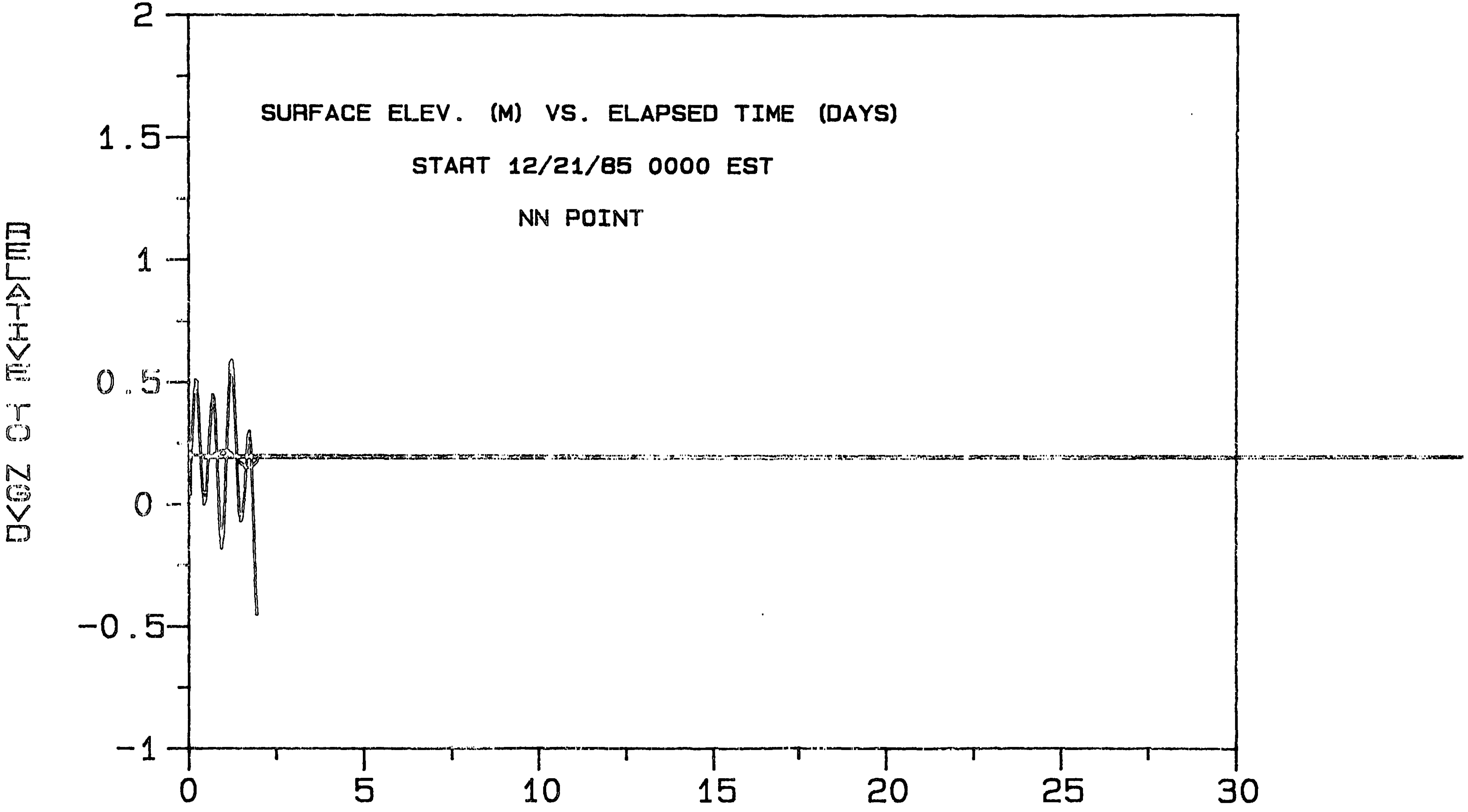
SURFACE ELEV. (M) VS. ELAPSED TIME (DAYS)
START 11/21/85 0000 EST
FT. MONROE
RELATIVE TO NGVD
2
1.5
1
0.5
0
-0.5
-1
0
5
10
15
20
25
30

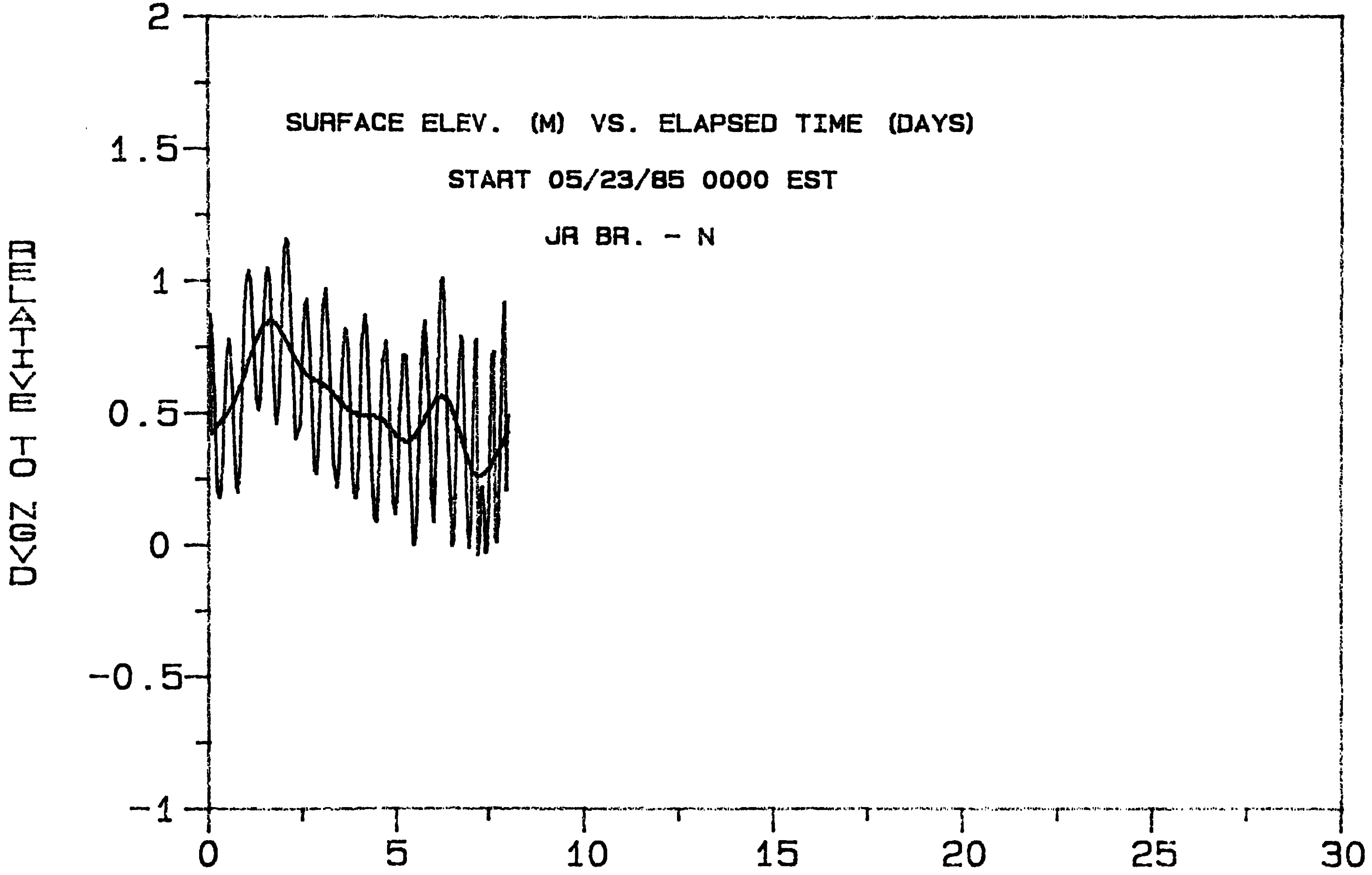

SURFACE ELEV. (M) VS. ELAPSED TIME (DAYS)
START 12/21/85 0000 EST
FT. MONROE
RELATIVE TO NGVD
2
1.5
1
0.5
0
-0.5
-1
0
5
10
15
20
25
30

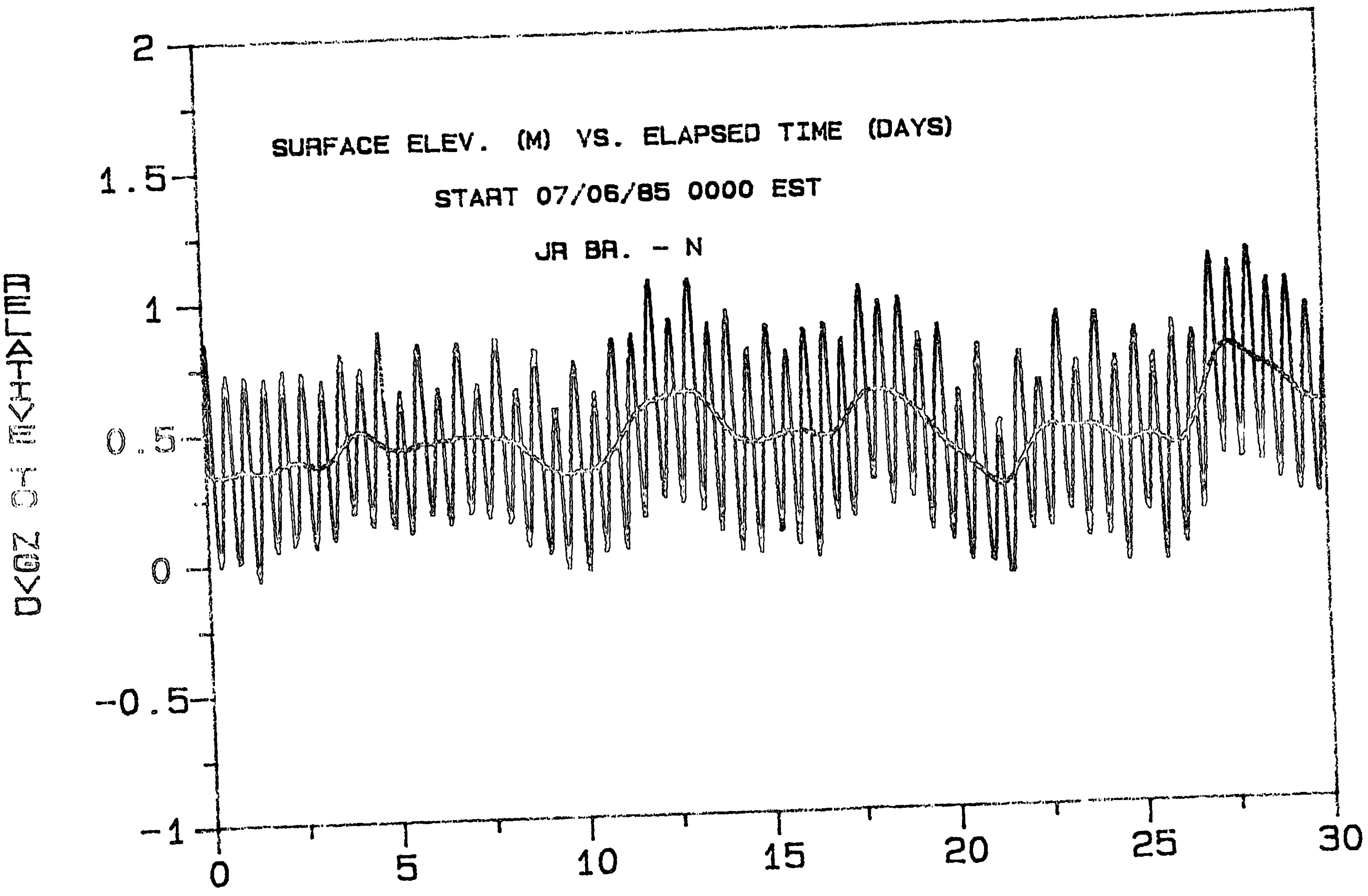

SURFACE ELEV. (M) VS. ELAPSED TIME (DAYS)
START 10/09/85 0000 EST
NN POINT
RELATIVE TO NGVD
2
1.5
1
0.5
0
−0.5
−1
0
5
10
15
20
25
30

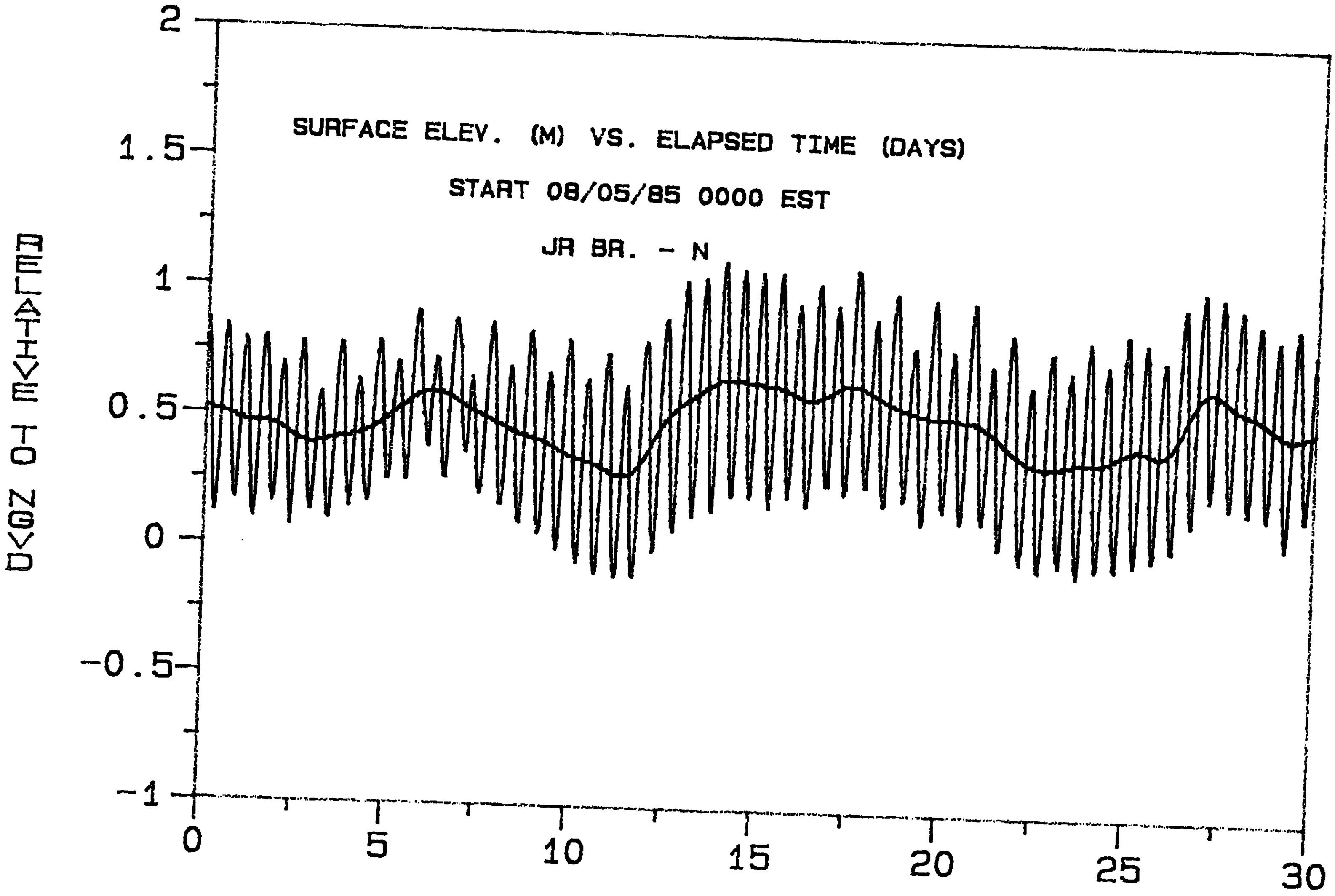

SURFACE ELEV. (M) VS. ELAPSED TIME (DAYS)
START 11/09/85 0000 EST
NN POINT
RELATIVE TO NGVD
2
1.5
1
0.5
0
-0.5
-1
0
5
10
15
20
25
30

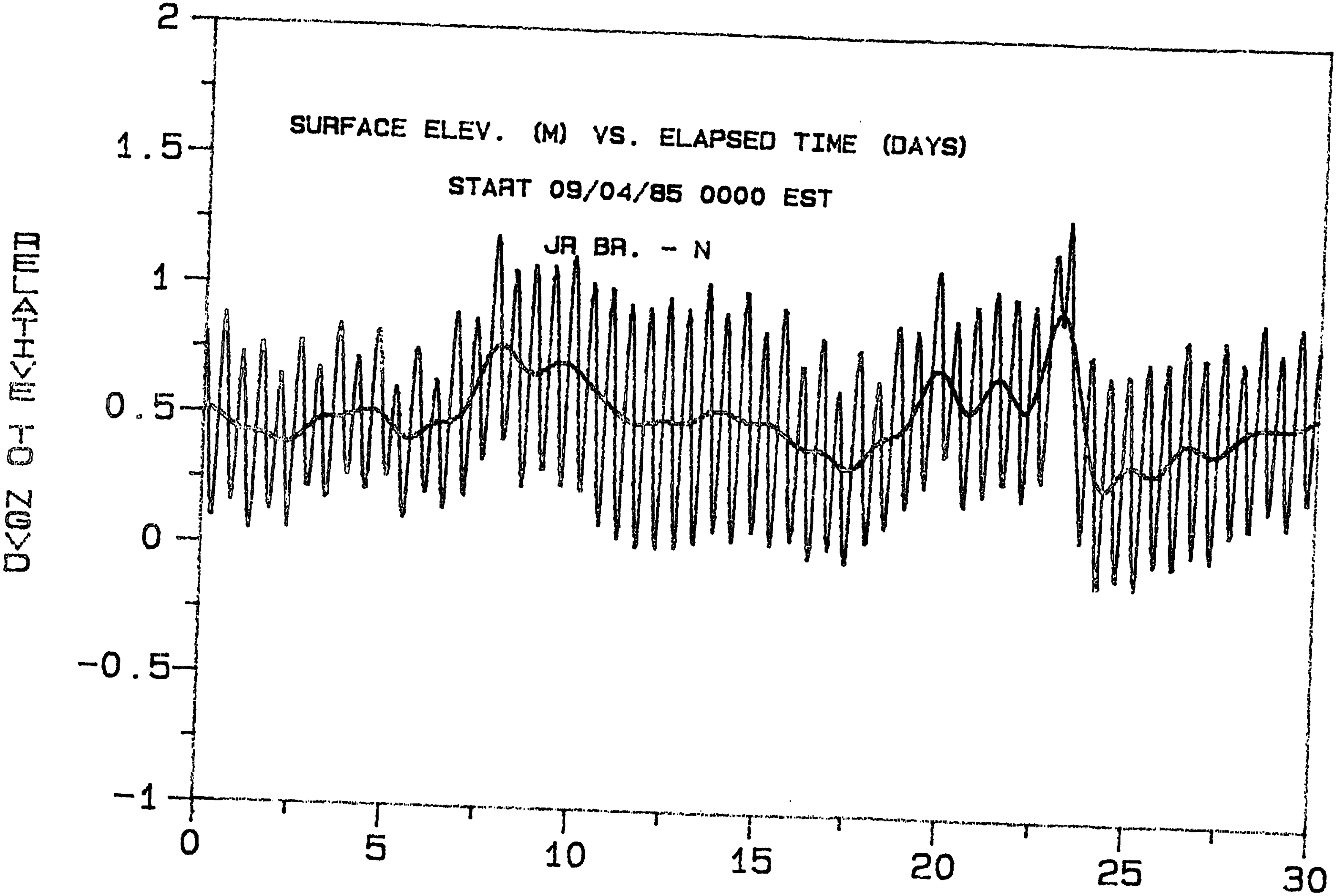

SURFACE ELEV. (M) VS. ELAPSED TIME (DAYS)
START 11/21/85 0000 EST
NN POINT
RELATIVE TO NGVD
2
1.5
1
0.5
0
-0.5
-1
0
5
10
15
20
25
30


SURFACE ELEV. (M) VS. ELAPSED TIME (DAYS)
START 12/21/85 0000 EST
NN POINT
RELATIVE TO NGVD
2
1.5
1
0.5
0
-0.5
-1
0
5
10
15
20
25
30


SURFACE ELEV. (M) VS. ELAPSED TIME (DAYS)
START 05/23/85 0000 EST
JR BR. - N
RELATIVE TO NGVD
2
1.5
1
0.5
0
-0.5
-1
0
5
10
15
20
25
30


SURFACE ELEV. (M) VS. ELAPSED TIME (DAYS)
START 07/06/85 0000 EST
JR BR. - N
RELATIVE TO NGVD
2
1.5
1
0.5
0
-0.5
-1
0
5
10
15
20
25
30


SURFACE ELEV. (M) VS. ELAPSED TIME (DAYS)
START 08/05/85 0000 EST
JR BR. - N
RELATIVE TO NGVD
2
1.5
1
0.5
0
-0.5
-1
0
5
10
15
20
25
30


SURFACE ELEV. (M) VS. ELAPSED TIME (DAYS)
START 09/04/85 0000 EST
JR BR. - N
RELATIVE TO NGVD
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1
0.5
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-0.5
-1
0
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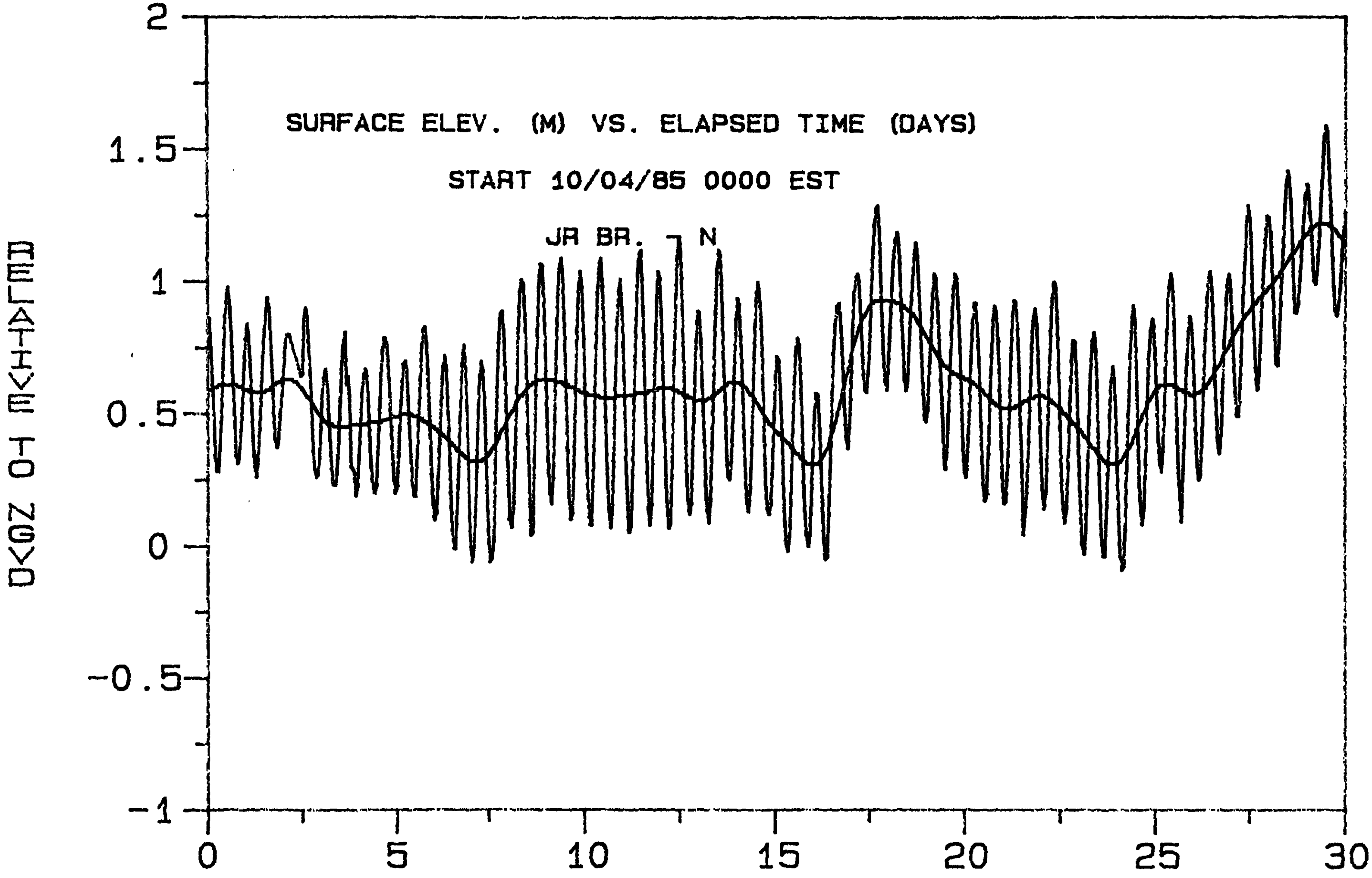
15
20
25
30

SURFACE ELEV. (M) VS. ELAPSED TIME (DAYS)
START 10/04/85 0000 EST
JR BR. - N
RELATIVE TO NGVD
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-0.5
-1
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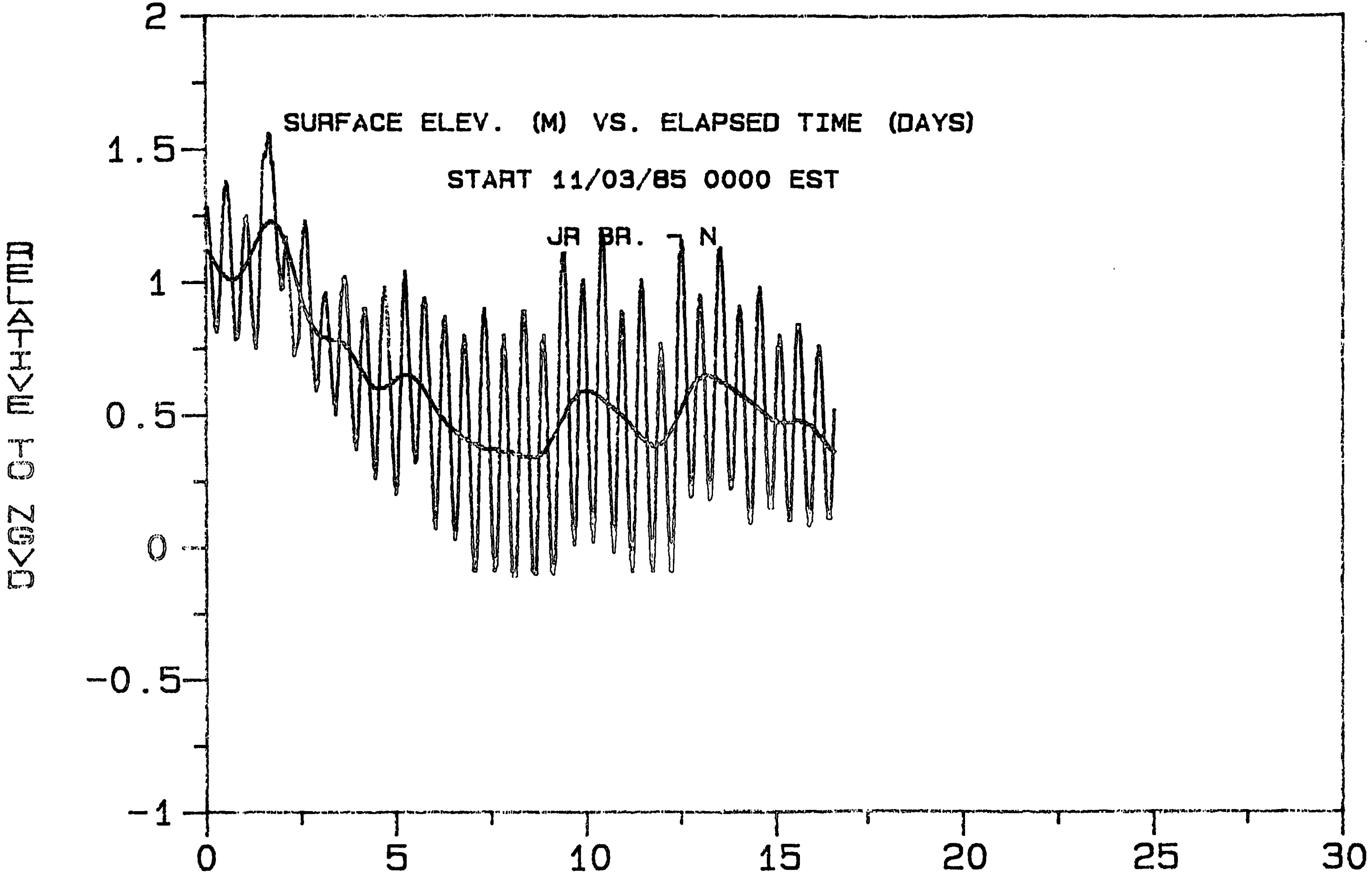
SURFACE ELEV. (M) VS. ELAPSED TIME (DAYS)
START 11/03/85 0000 EST
JR BR. - N
RELATIVE TO NGVD
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-0.5
-1
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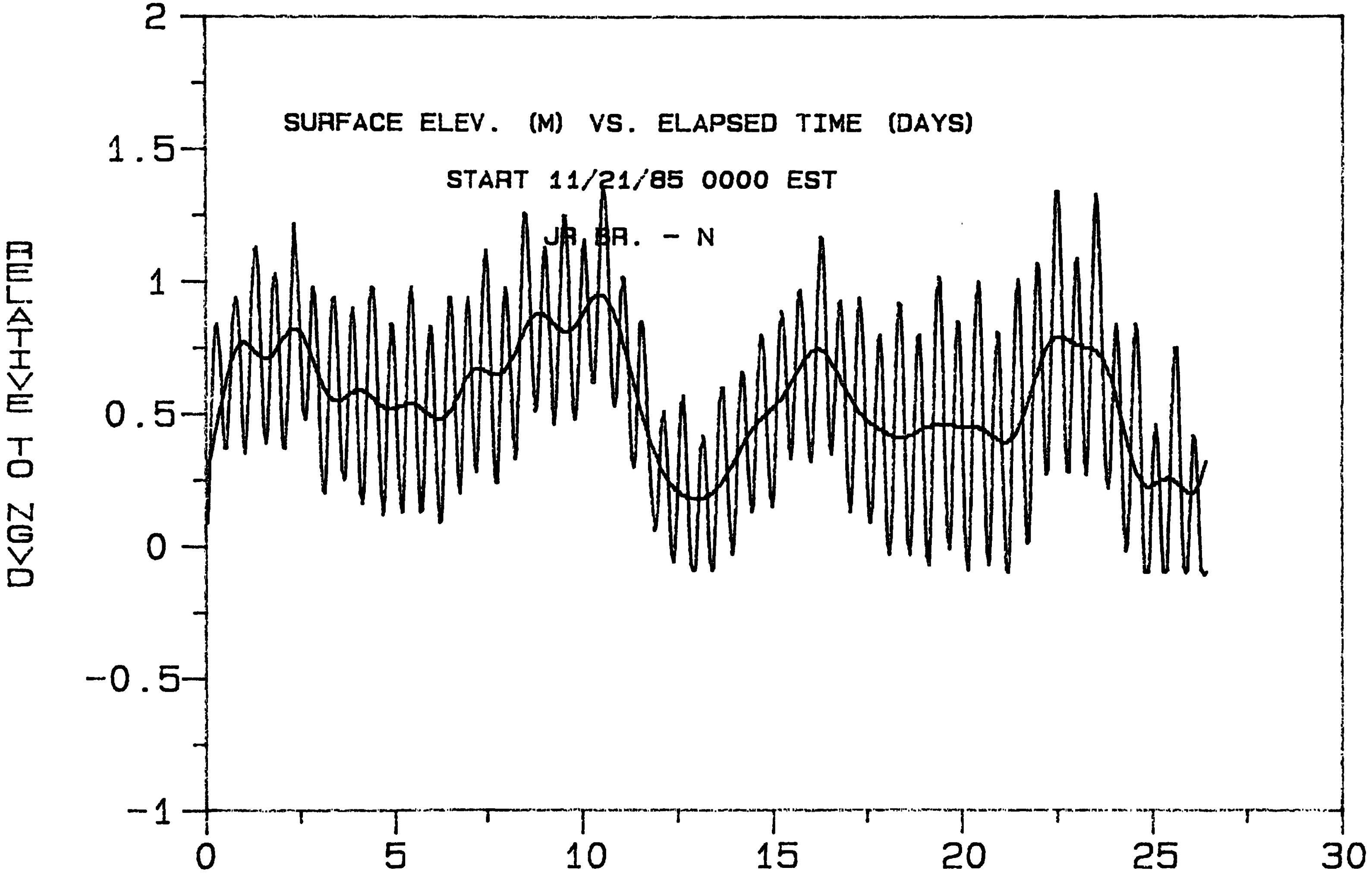
SURFACE ELEV. (M) VS. ELAPSED TIME (DAYS)
START 11/21/85 0000 EST
JR BR. - N
RELATIVE TO NGVD
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-0.5
-1
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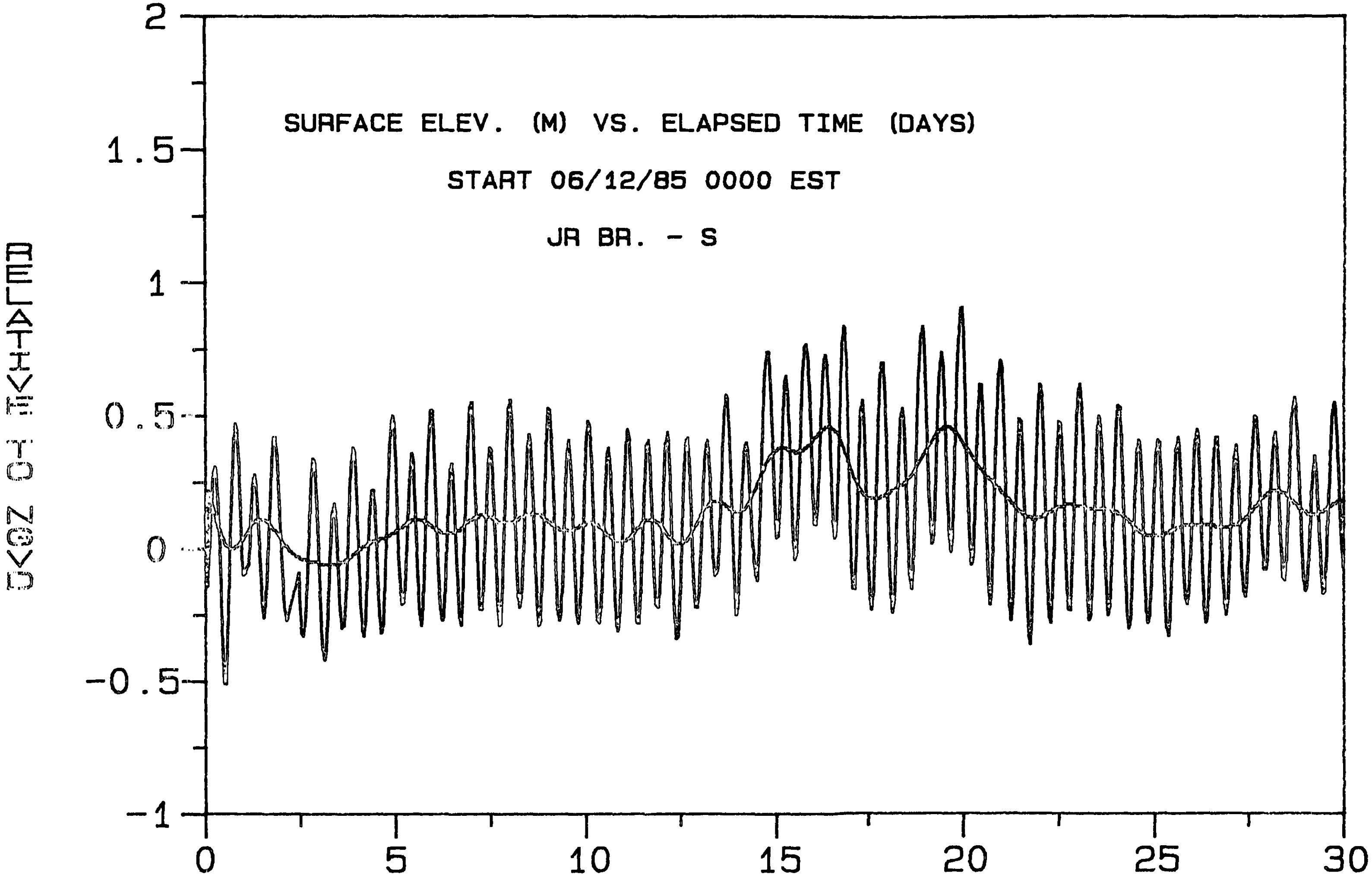
SURFACE ELEV. (M) VS. ELAPSED TIME (DAYS)
START 06/12/85 0000 EST
JR BR. - S
RELATIVE TO NGVD
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-0.5
-1
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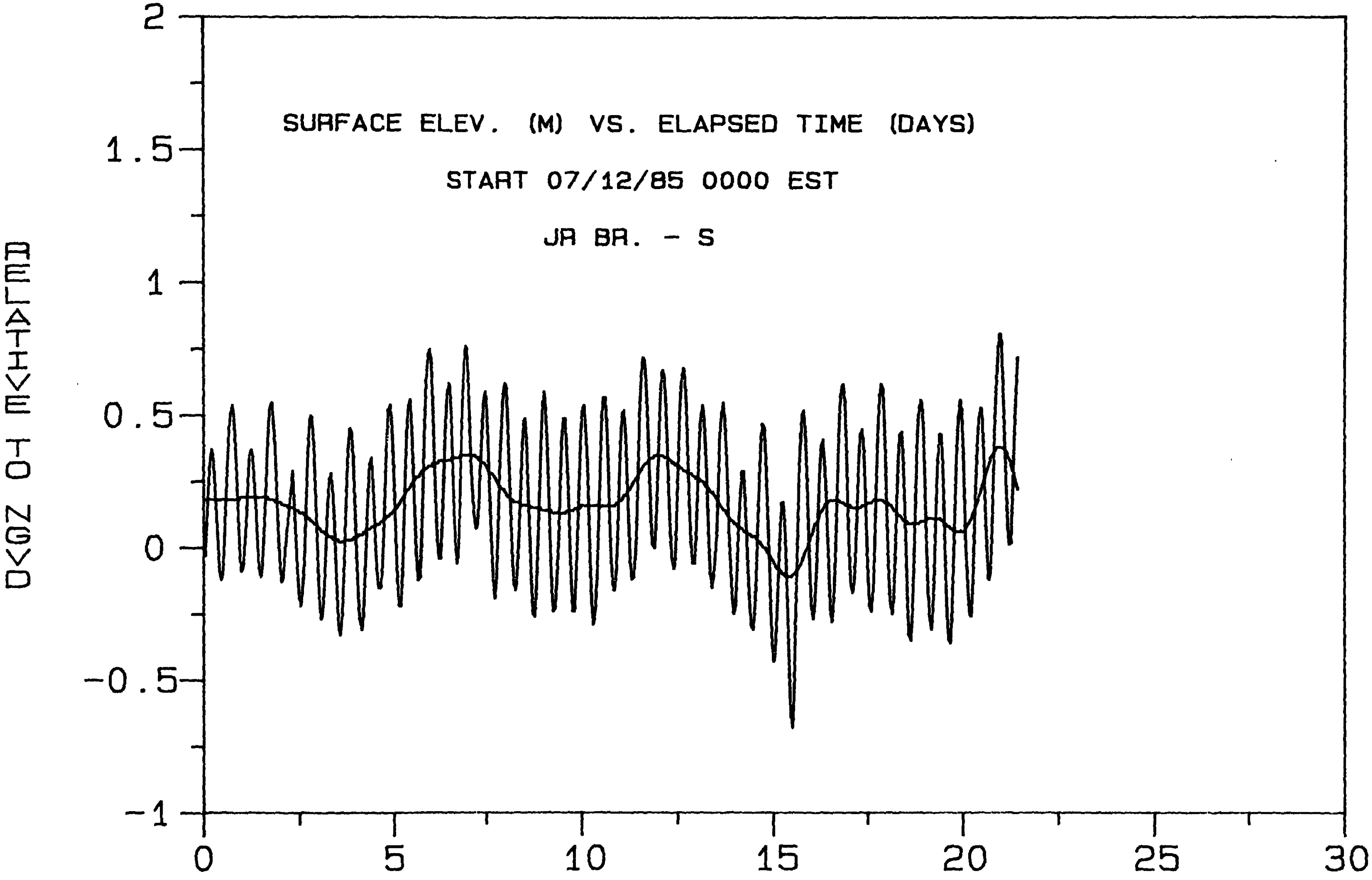
SURFACE ELEV. (M) VS. ELAPSED TIME (DAYS)
START 07/12/85 0000 EST
JR BR. - S
RELATIVE TO NGVD
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-0.5
-1
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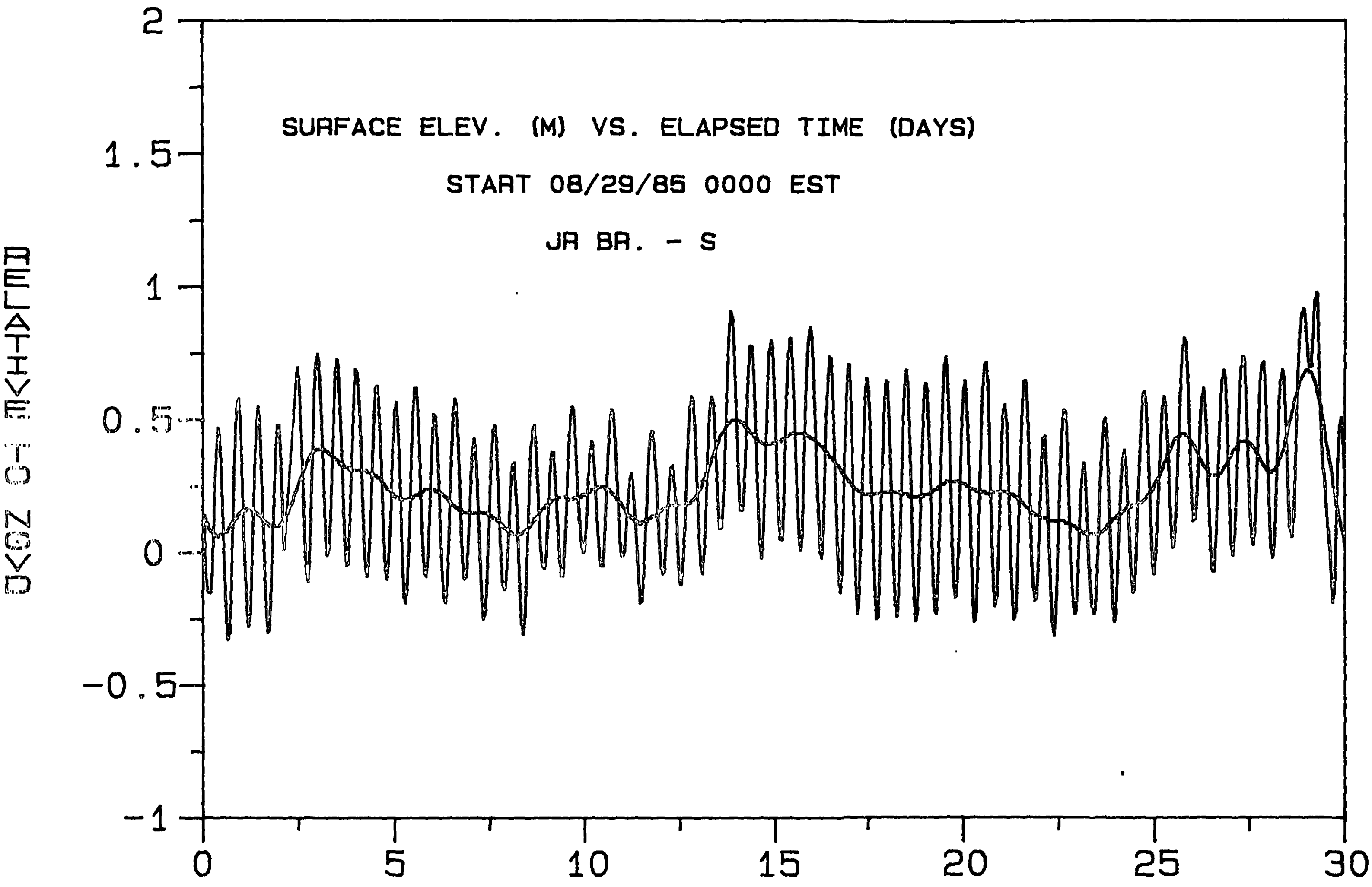
SURFACE ELEV. (M) VS. ELAPSED TIME (DAYS)
START 08/29/85 0000 EST
JR BR. - S
RELATIVE TO NGVD
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-0.5
-1
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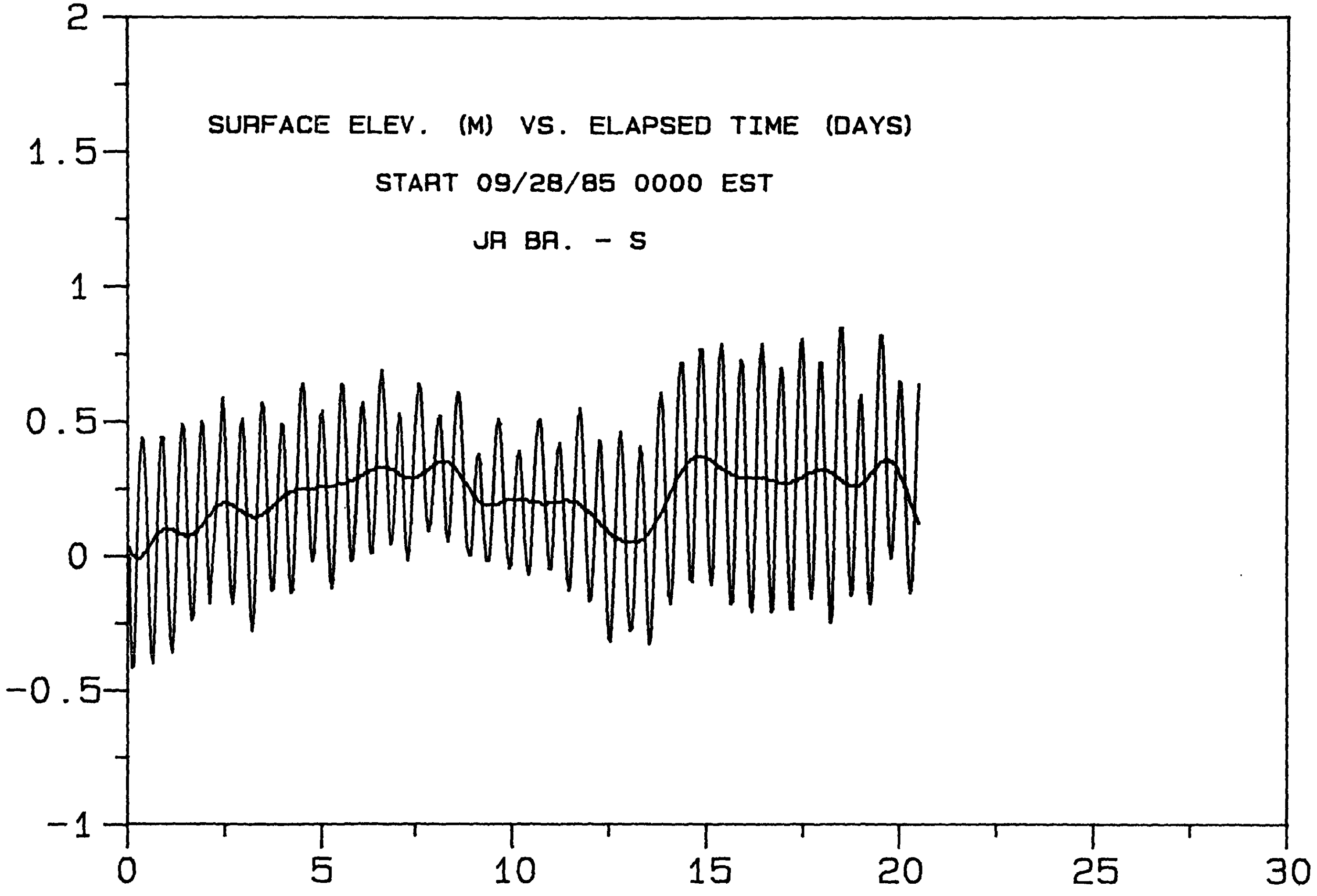
SURFACE ELEV. (M) VS. ELAPSED TIME (DAYS)
START 09/28/85 0000 EST
JR BR. - S
RELATIVE TO NGVD
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-1
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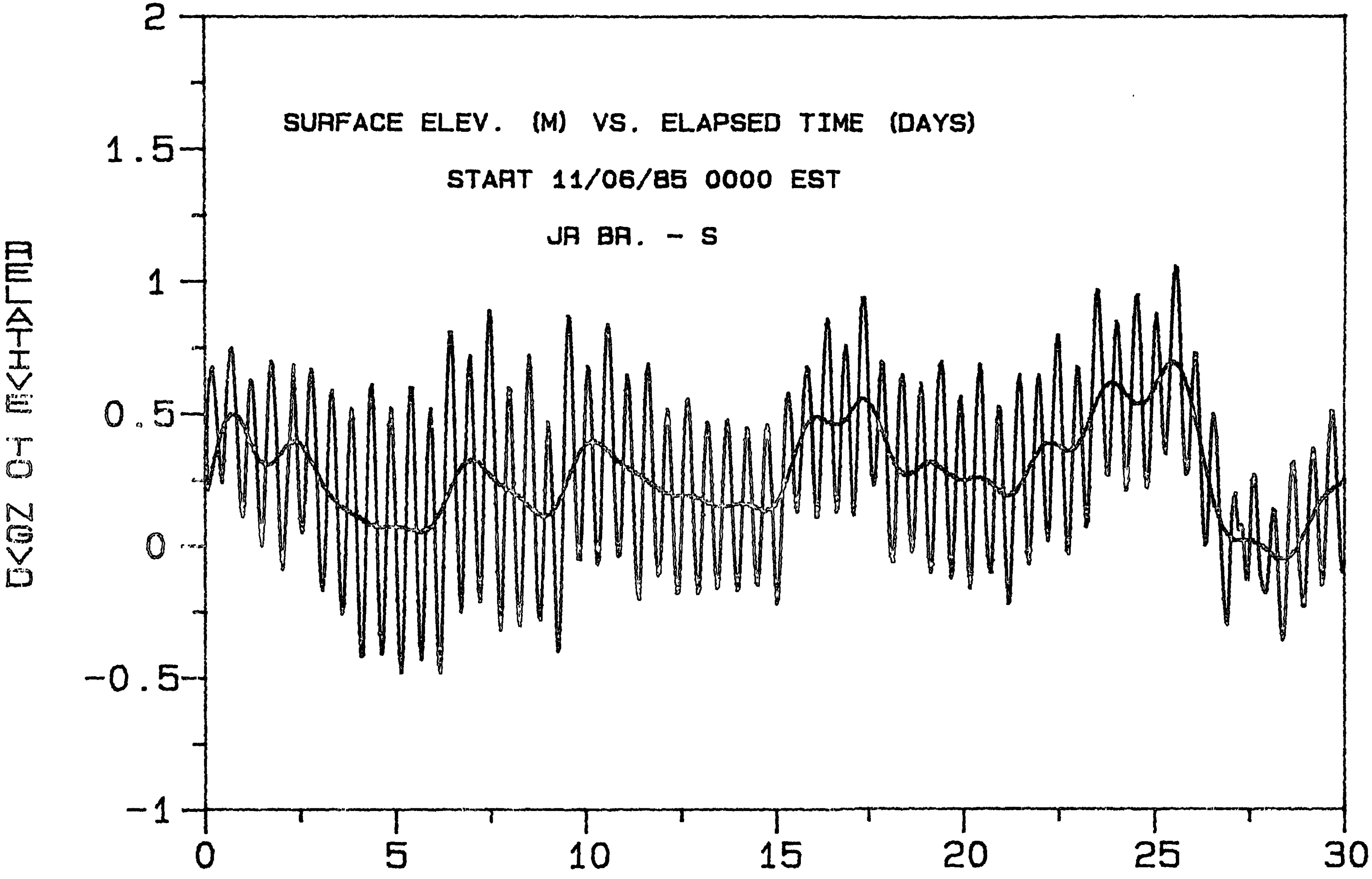
SURFACE ELEV. (M) VS. ELAPSED TIME (DAYS)
START 11/06/85 0000 EST
JR BR. - S
RELATIVE TO NGVD
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-0.5
-1
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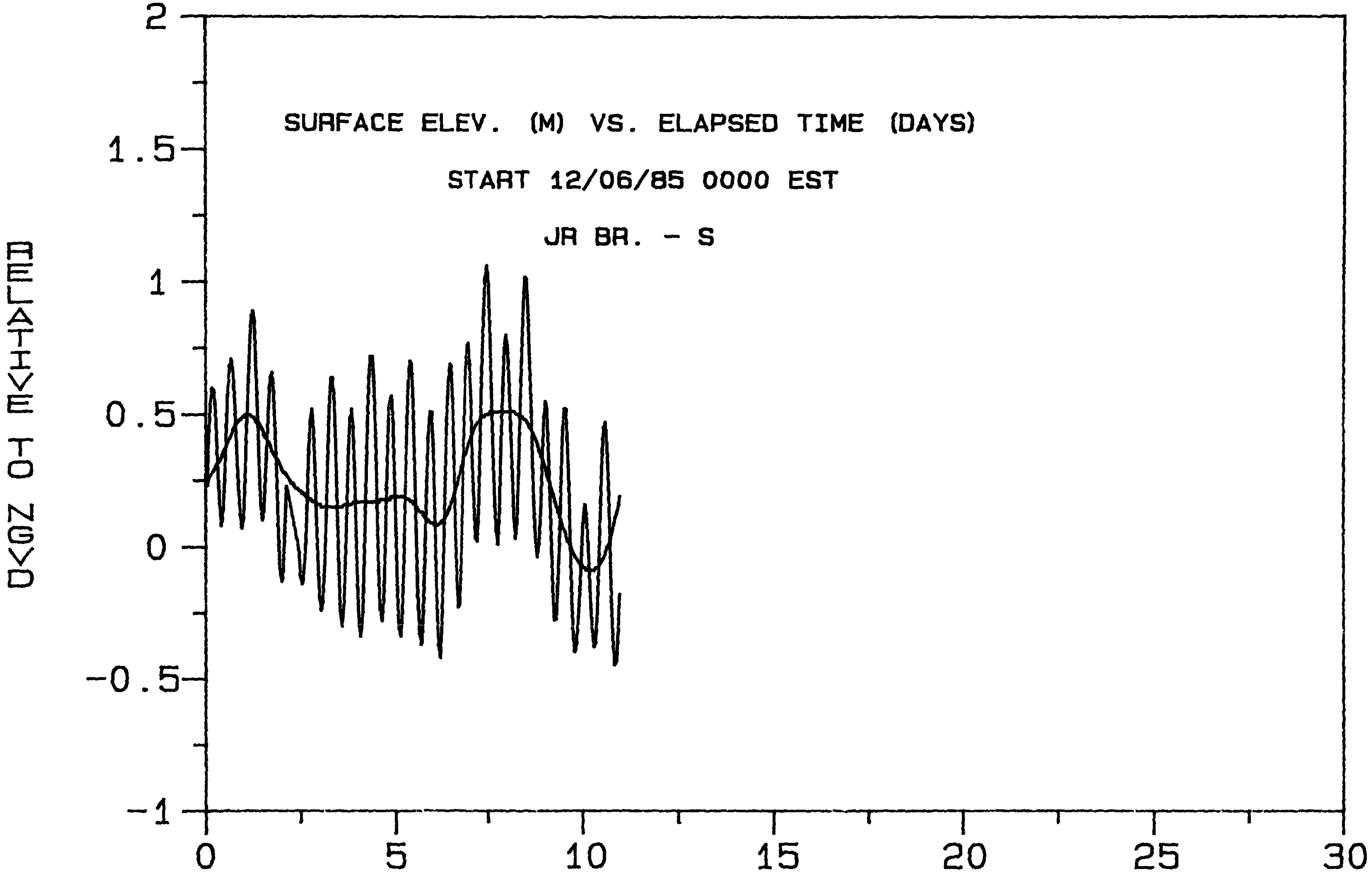
SURFACE ELEV. (M) VS. ELAPSED TIME (DAYS)
START 12/06/85 0000 EST
JR BR. - S
RELATIVE TO NGVD
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-0.5
-1
0
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15
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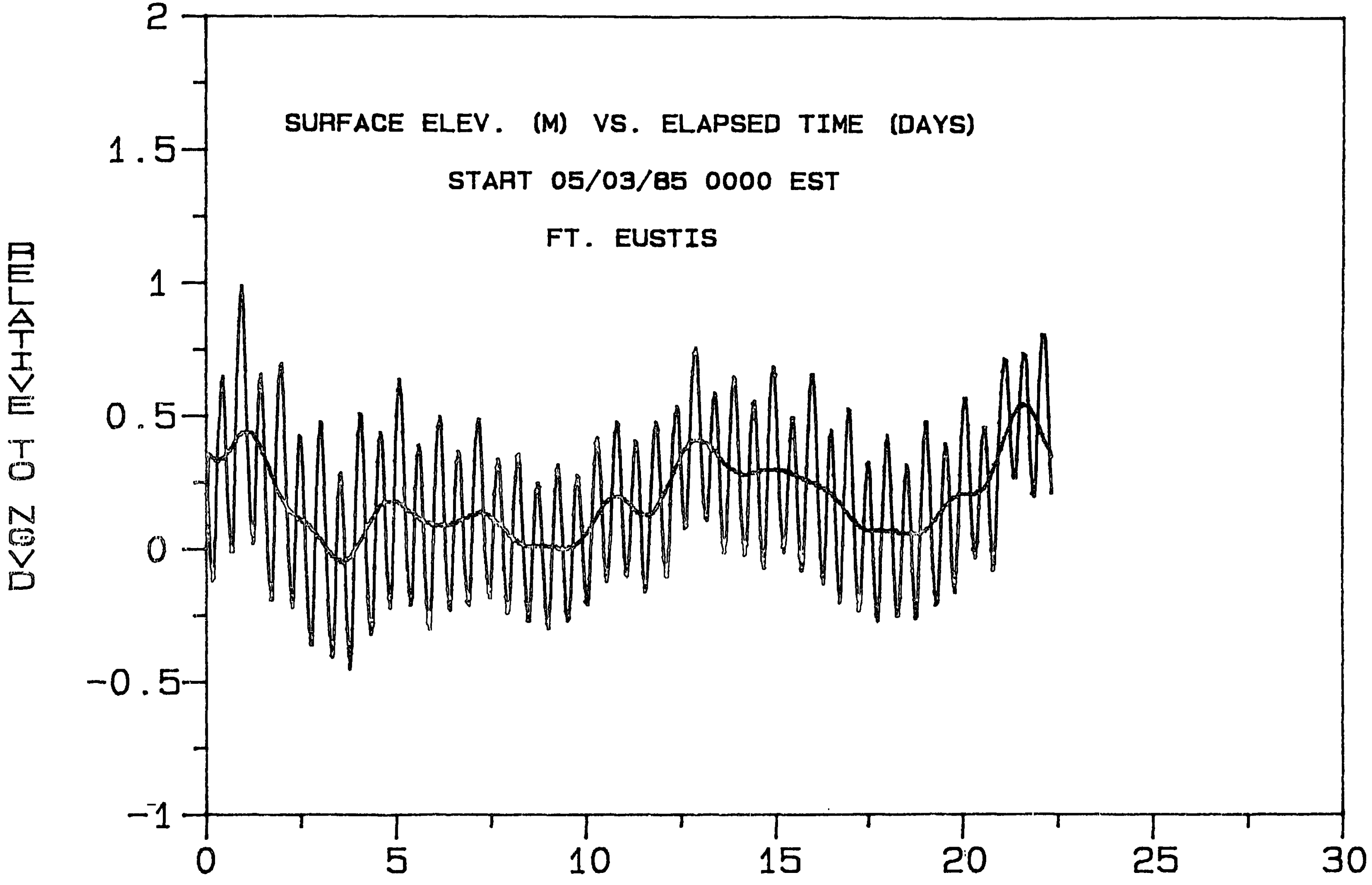
SURFACE ELEV. (M) VS. ELAPSED TIME (DAYS)
START 05/03/85 0000 EST
FT. EUSTIS
RELATIVE TO NGVD
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0
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-1
0
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15
20
25
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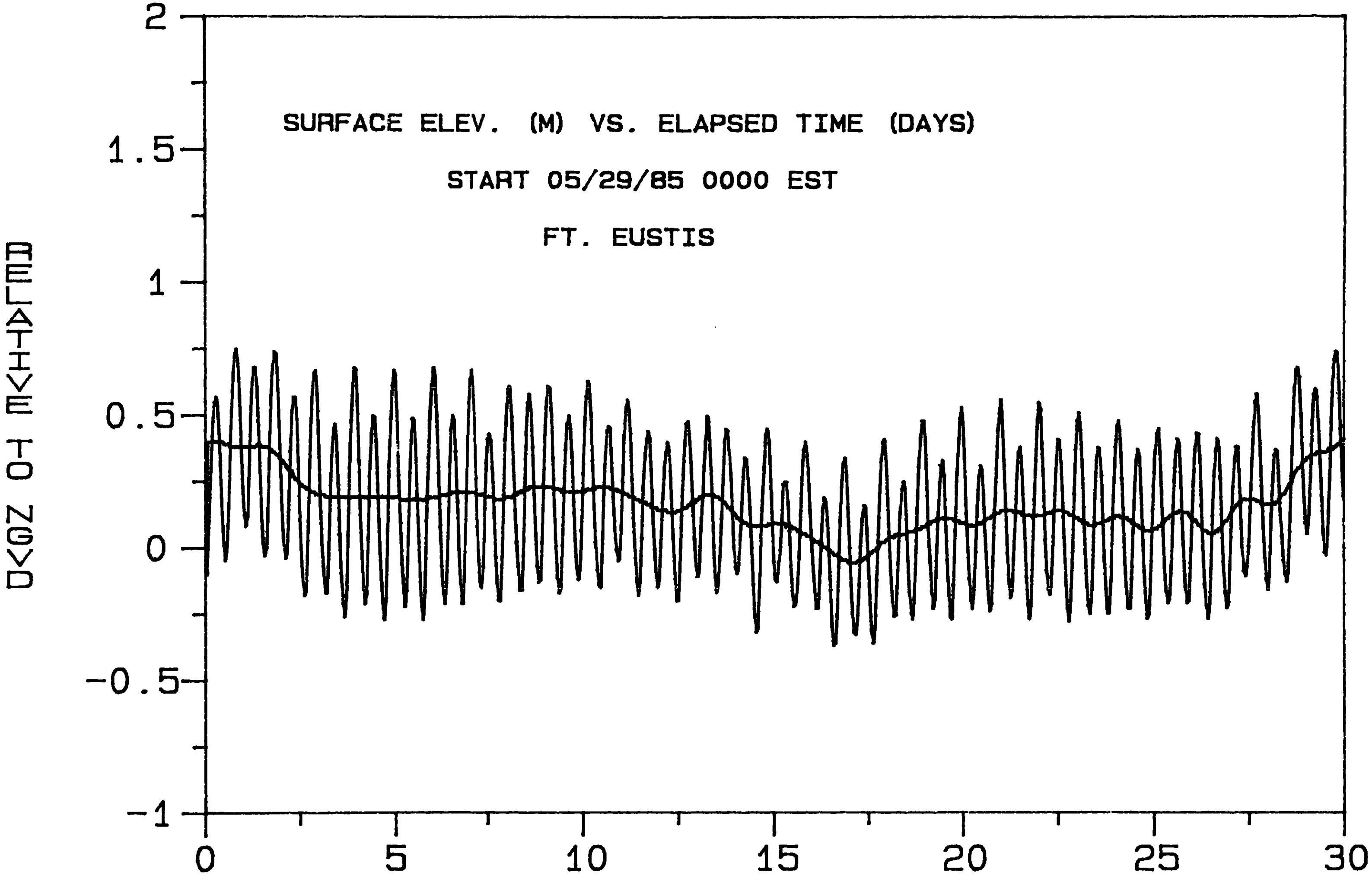
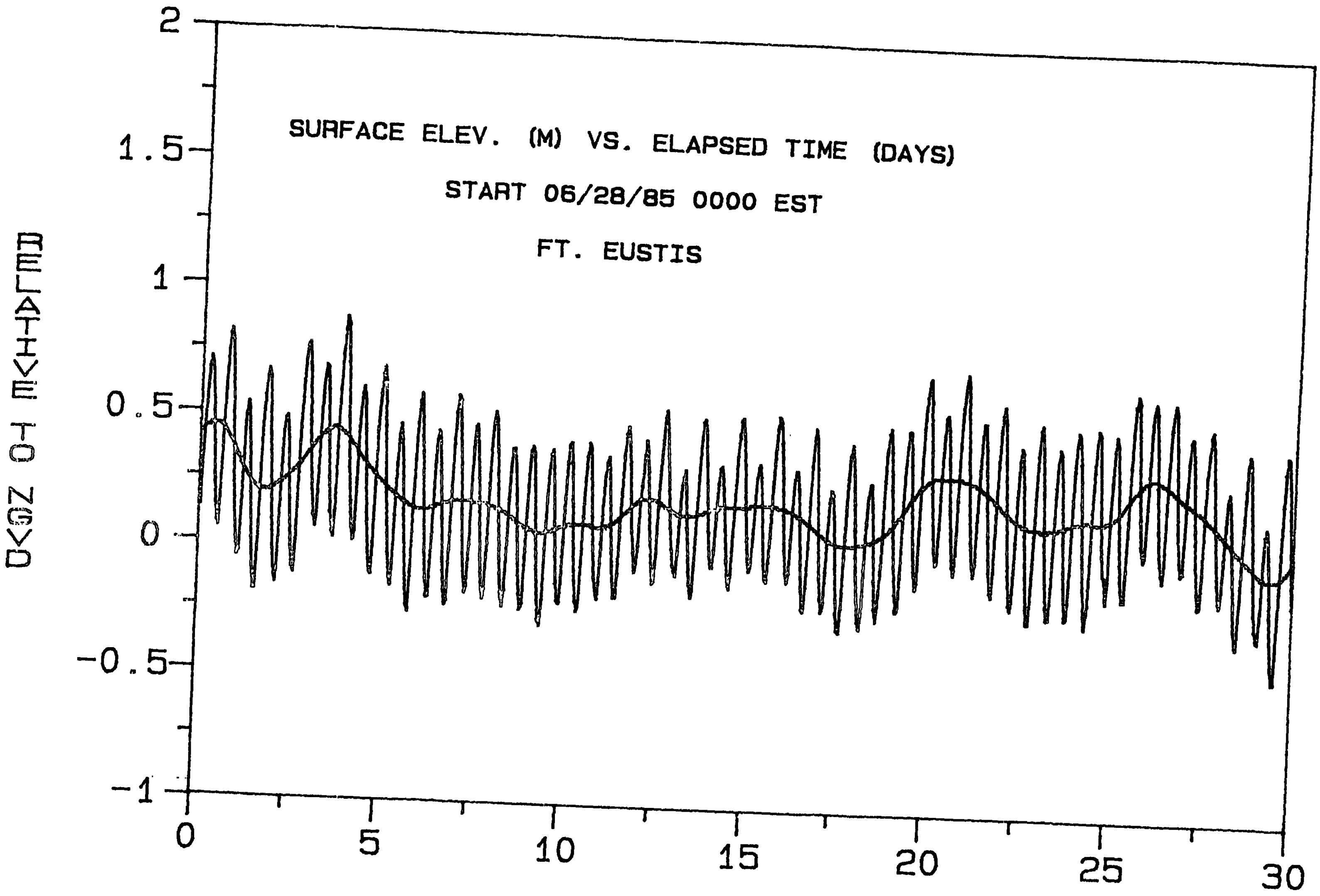


SURFACE ELEV. (M) VS. ELAPSED TIME (DAYS)

START 05/29/85 0000 EST

FT. EUSTIS


SURFACE ELEV. (M) VS. ELAPSED TIME (DAYS)
START 06/28/85 0000 EST
FT. EUSTIS
RELATIVE TO NGVD
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1.5
1
0.5
0
−0.5
−1
0
5
10
15
20
25
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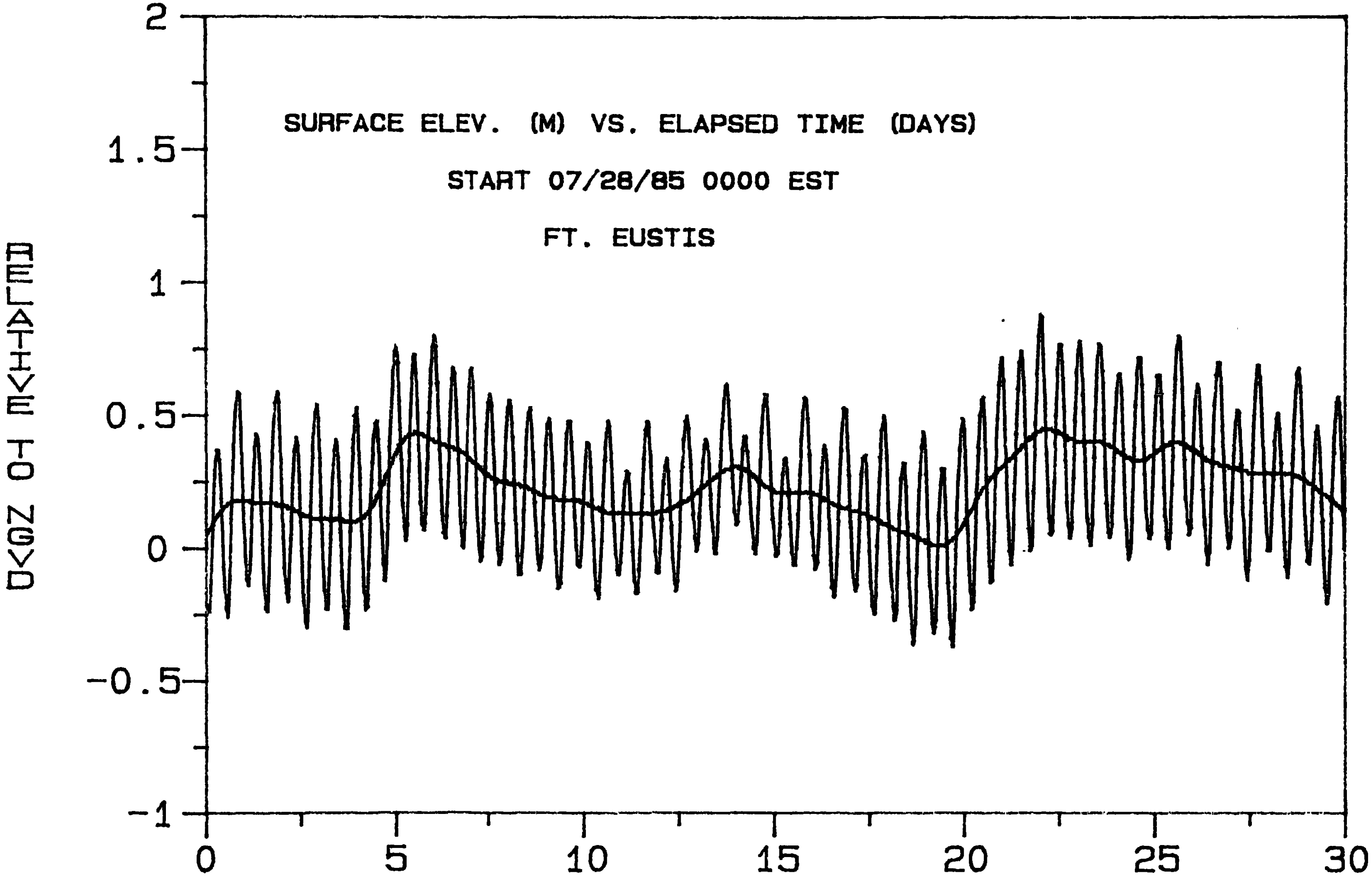
SURFACE ELEV. (M) VS. ELAPSED TIME (DAYS)
START 07/28/85 0000 EST
FT. EUSTIS
RELATIVE TO NGVD
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1
0.5
0
-0.5
-1
0
5
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15
20
25
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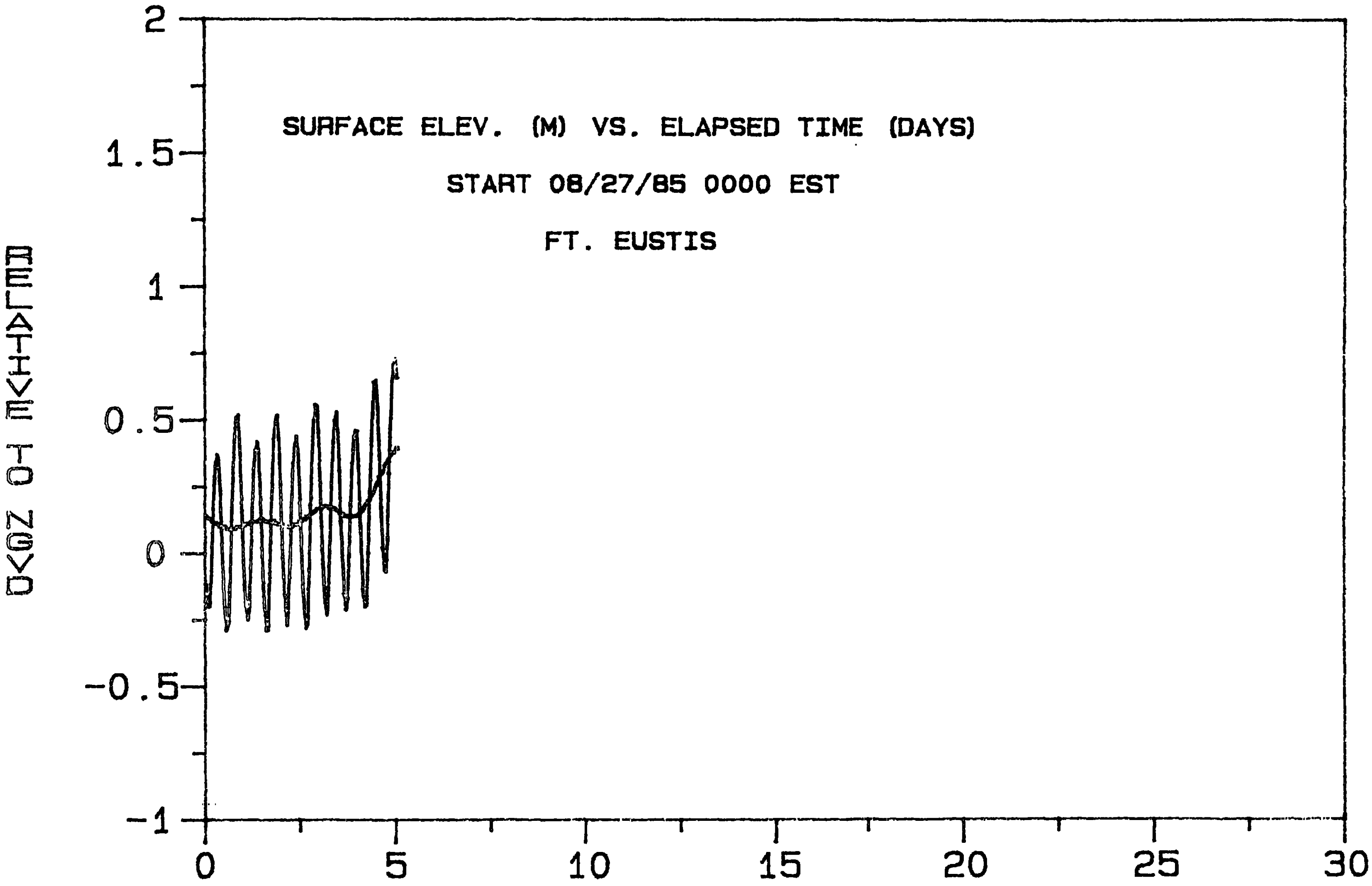
SURFACE ELEV. (M) VS. ELAPSED TIME (DAYS)
START 08/27/85 0000 EST
FT. EUSTIS
RELATIVE TO NGVD
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1
0.5
0
-0.5
-1
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15
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25
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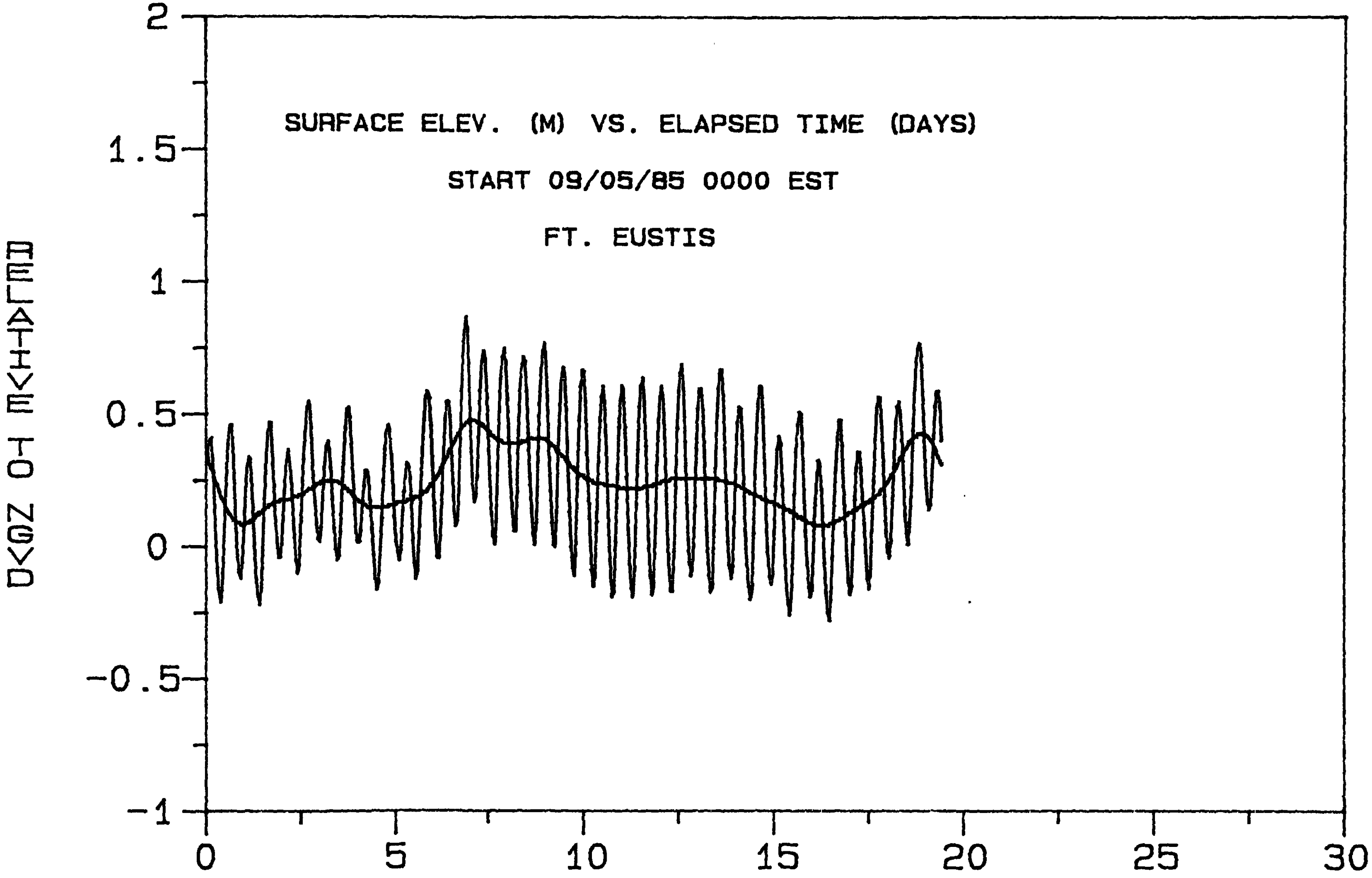
SURFACE ELEV. (M) VS. ELAPSED TIME (DAYS)
START 09/05/85 0000 EST
FT. EUSTIS
RELATIVE TO NGVD
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-0.5
-1
0
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15
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25
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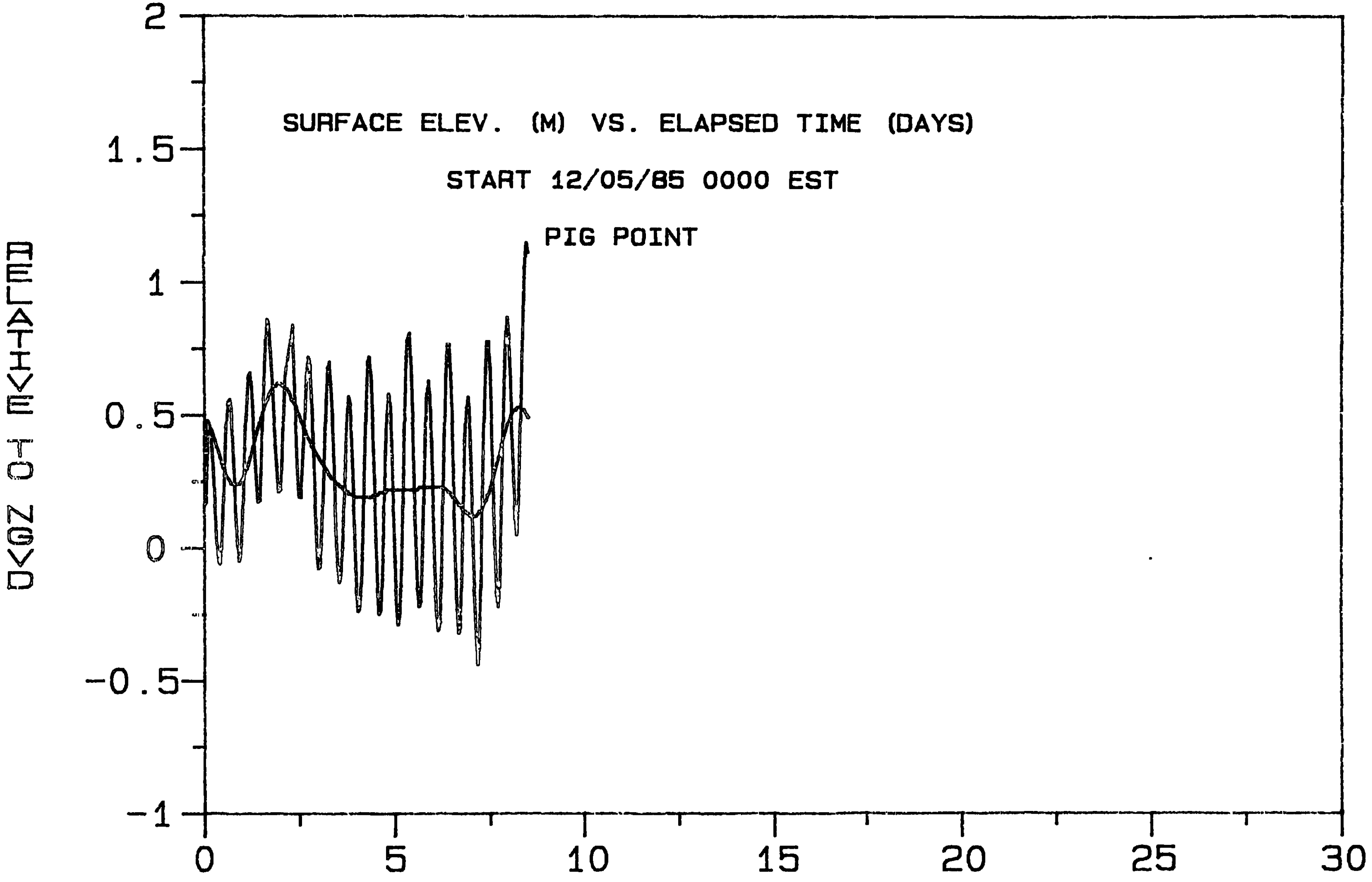
SURFACE ELEV. (M) VS. ELAPSED TIME (DAYS)
START 12/05/85 0000 EST
PIG POINT
RELATIVE TO NGVD
2
1.5
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0.5
0
-0.5
-1
0
5
10
15
20
25
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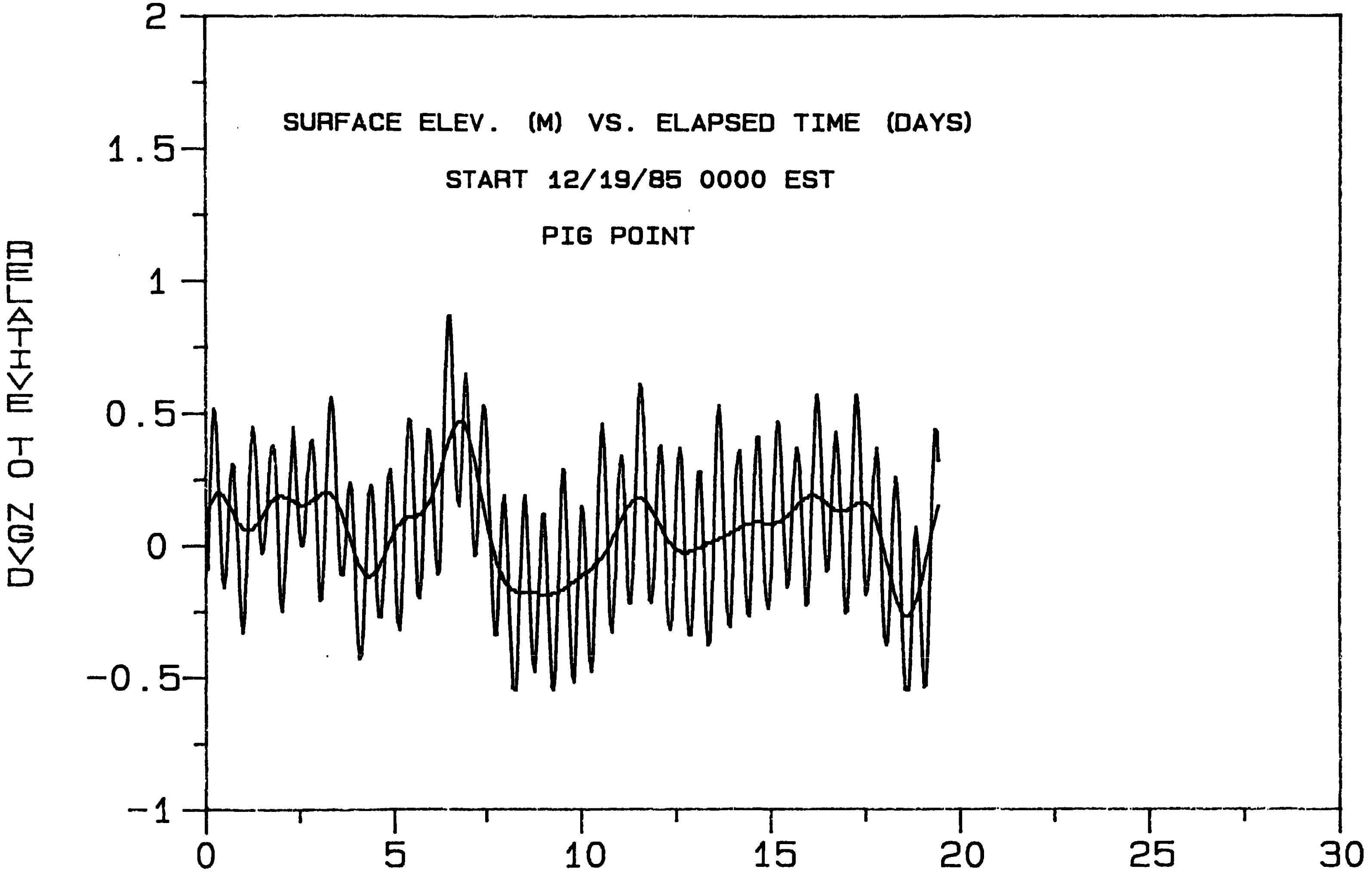
SURFACE ELEV. (M) VS. ELAPSED TIME (DAYS)
START 12/19/85 0000 EST
PIG POINT
RELATIVE TO NGVD
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-0.5
-1
0
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25
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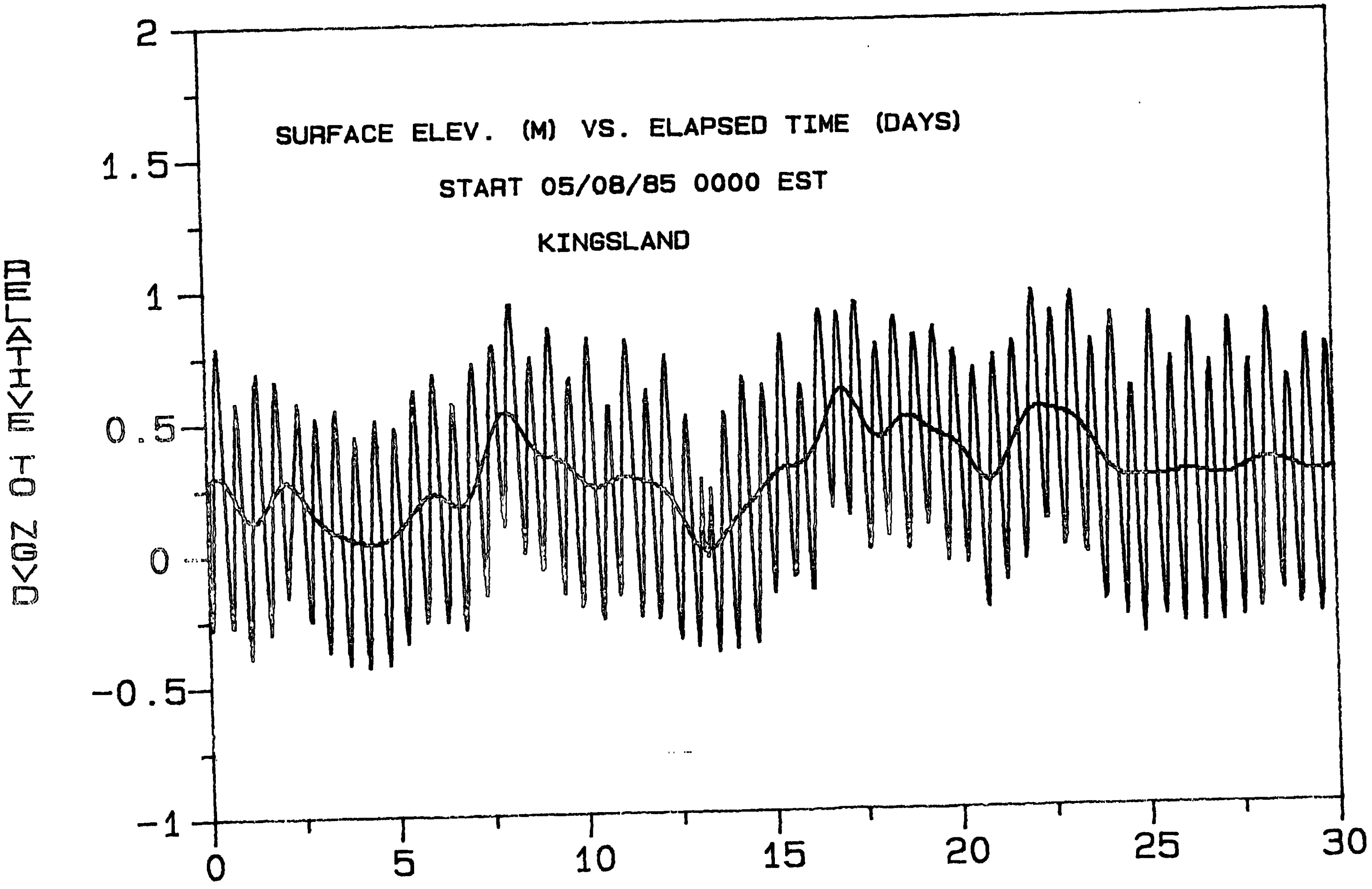
SURFACE ELEV. (M) VS. ELAPSED TIME (DAYS)
START 05/08/85 0000 EST
KINGSLAND
RELATIVE TO NGVD
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0.5
0
-0.5
-1
0
5
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15
20
25
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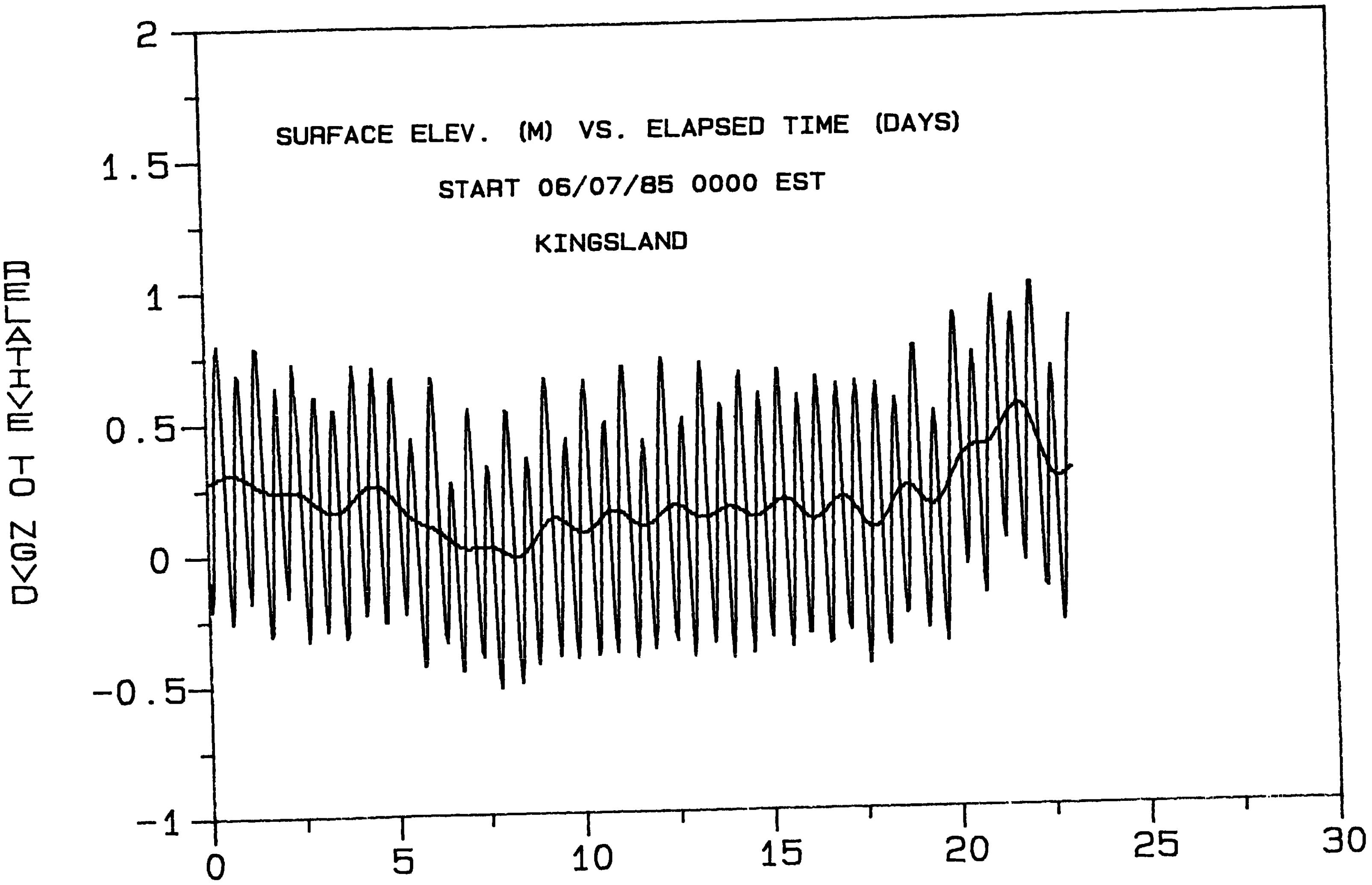
SURFACE ELEV. (M) VS. ELAPSED TIME (DAYS)
START 06/07/85 0000 EST
KINGSLAND
RELATIVE TO NGVD
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1
0.5
0
-0.5
-1
0
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15
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25
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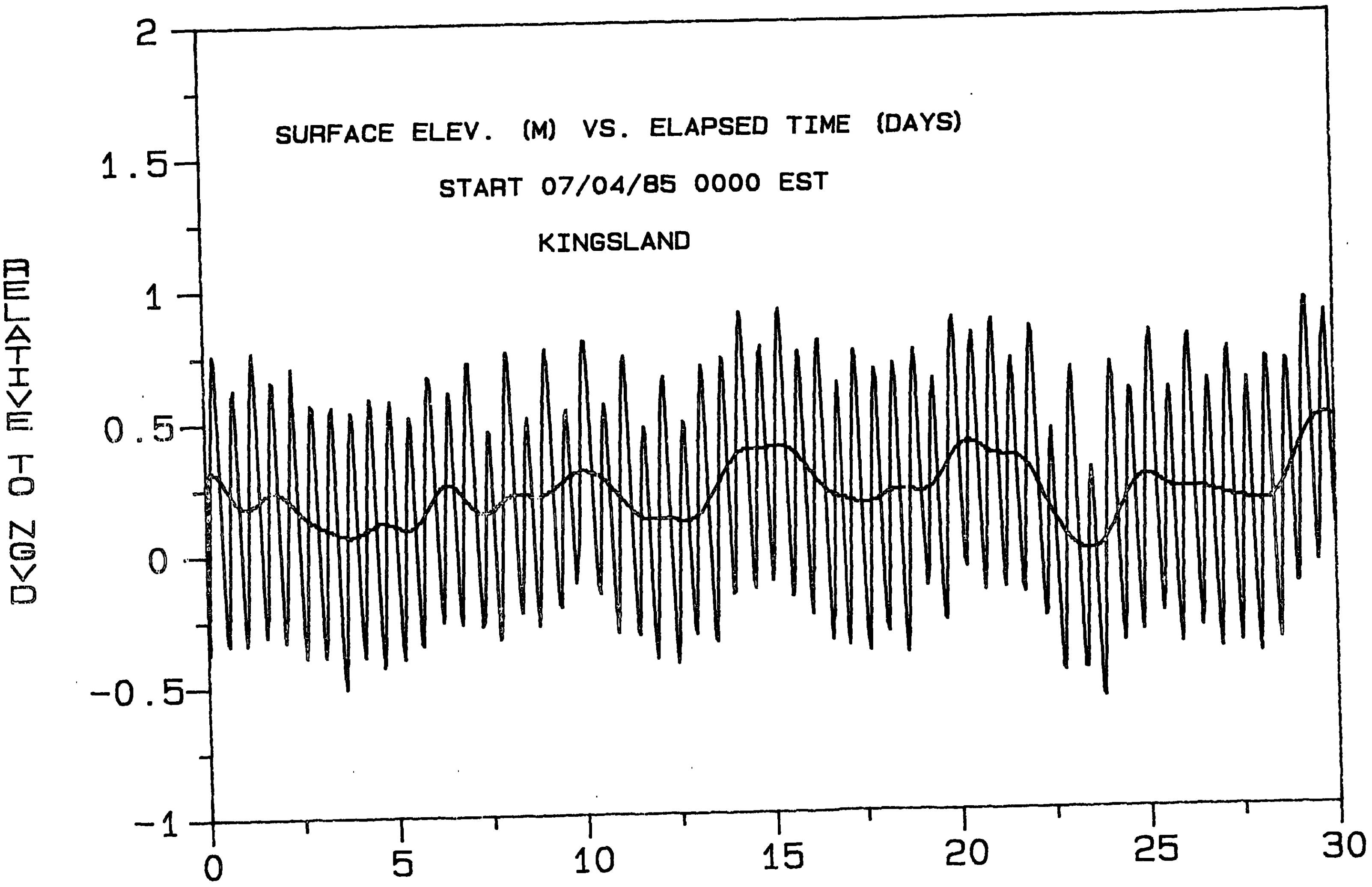
SURFACE ELEV. (M) VS. ELAPSED TIME (DAYS)
START 07/04/85 0000 EST
KINGSLAND
RELATIVE TO NGVD
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0.5
0
-0.5
-1
0
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15
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25
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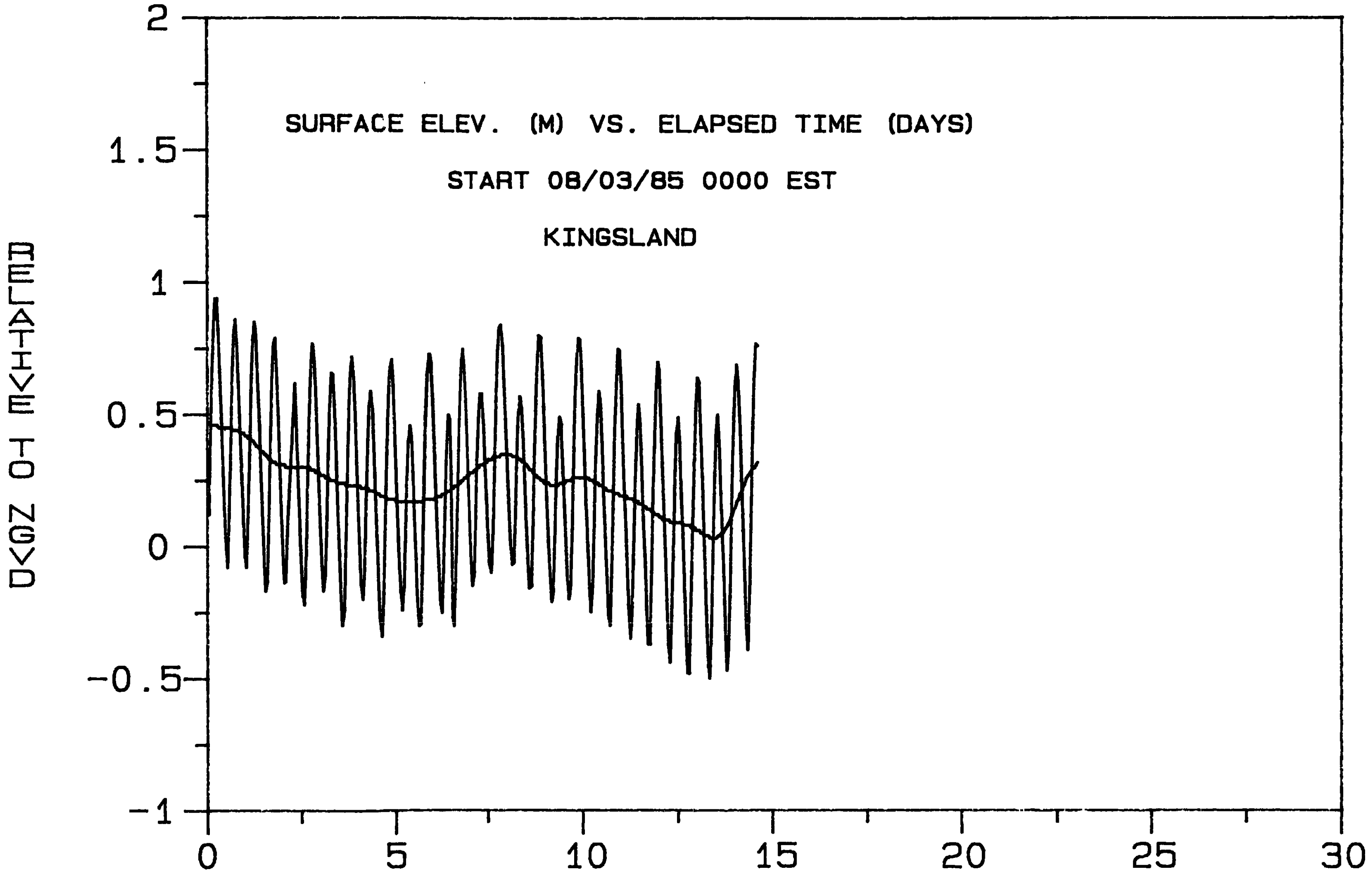
SURFACE ELEV. (M) VS. ELAPSED TIME (DAYS)
START 08/03/85 0000 EST
KINGSLAND
RELATIVE TO NGVD
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0.5
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-0.5
-1
0
5
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15
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25
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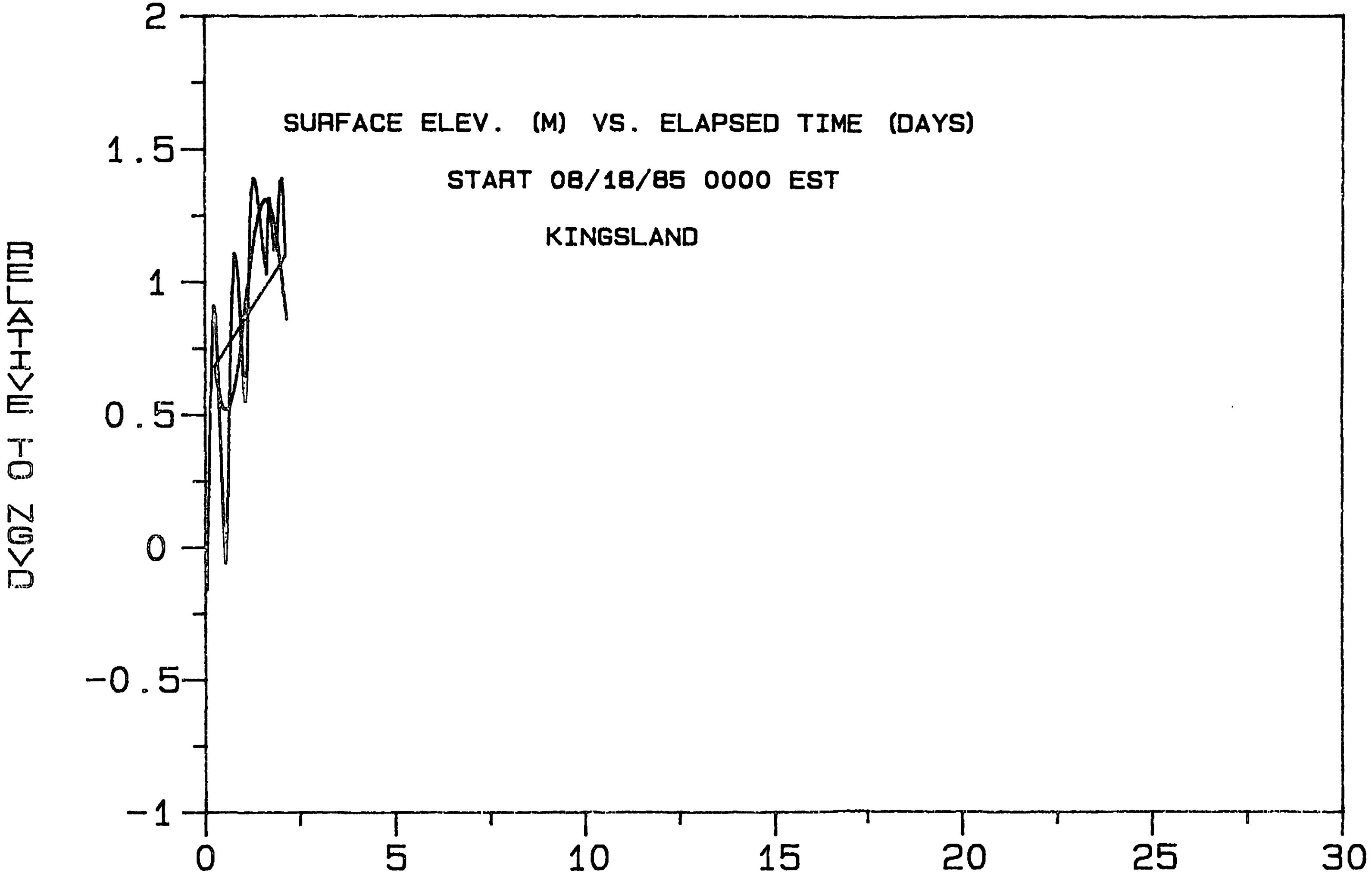
SURFACE ELEV. (M) VS. ELAPSED TIME (DAYS)
START 08/18/85 0000 EST
KINGSLAND
RELATIVE TO NGVD
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0.5
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-0.5
-1
0
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15
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25
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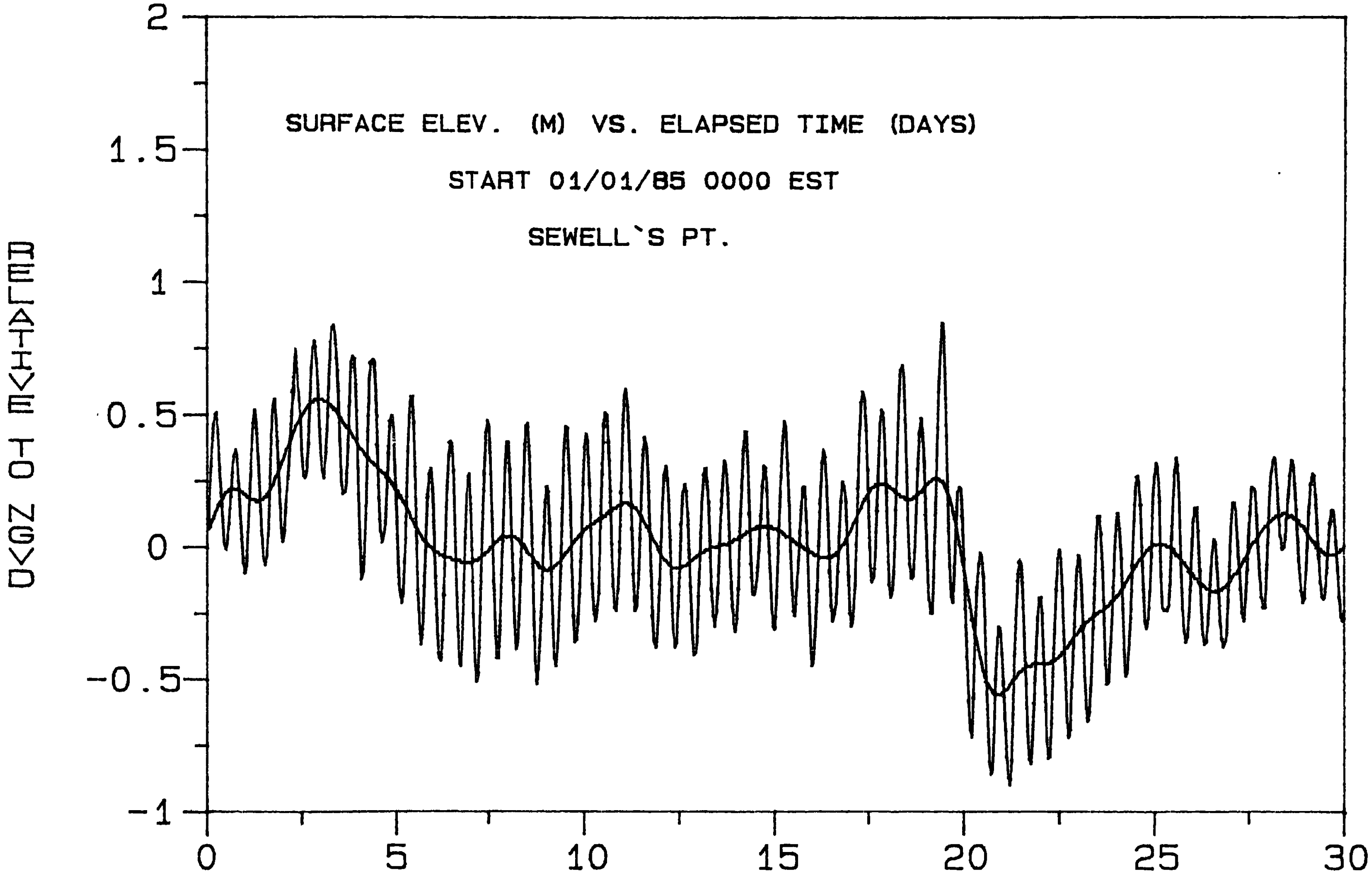
SURFACE ELEV. (M) VS. ELAPSED TIME (DAYS)
START 01/01/85 0000 EST
SEWELL`S PT.
RELATIVE TO NGVD
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1.5
1
0.5
0
-0.5
-1
0
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15
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25
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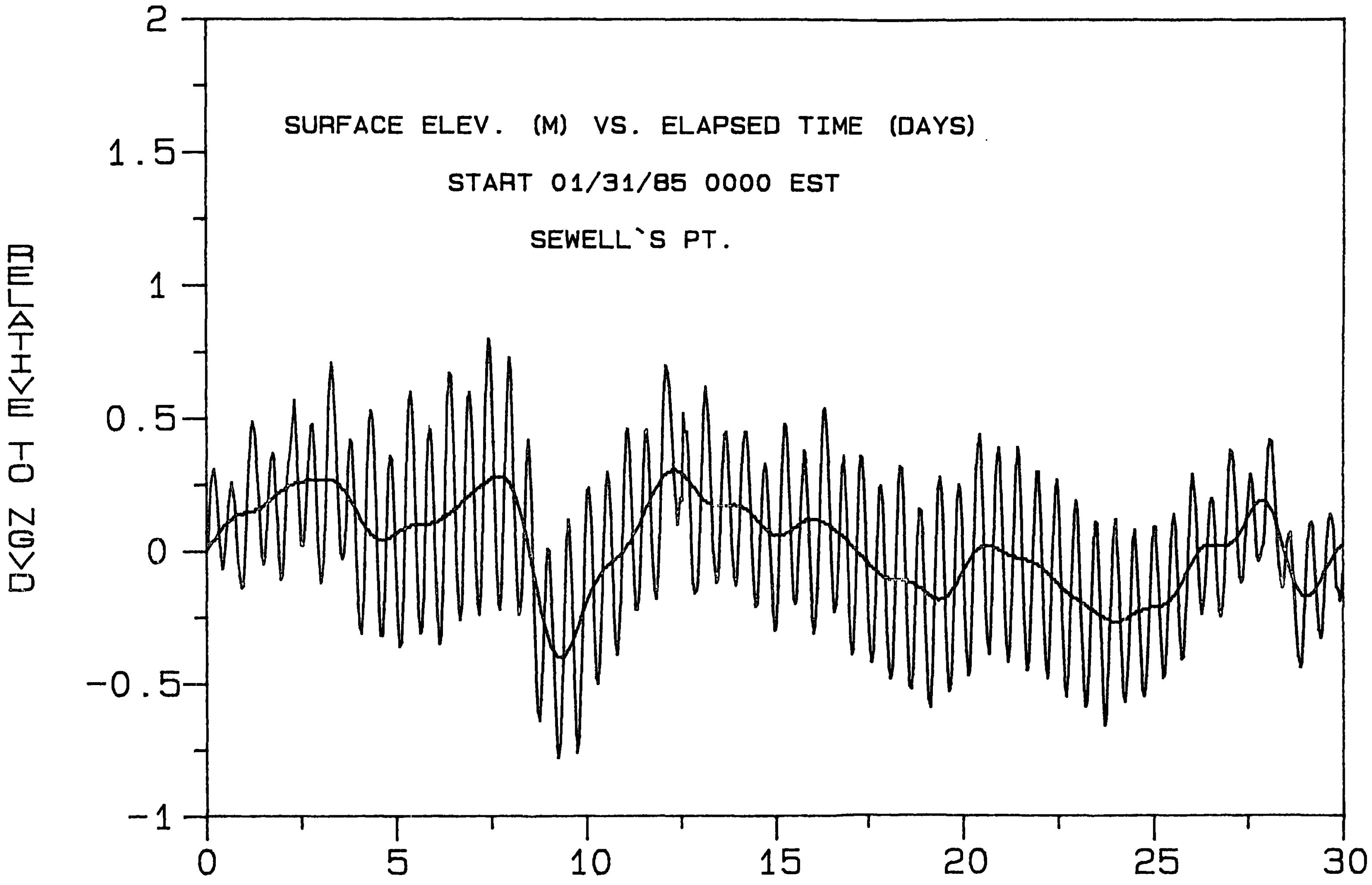
SURFACE ELEV. (M) VS. ELAPSED TIME (DAYS)
START 01/31/85 0000 EST
SEWELL`S PT.
RELATIVE TO NGVD
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0.5
0
-0.5
-1
0
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25
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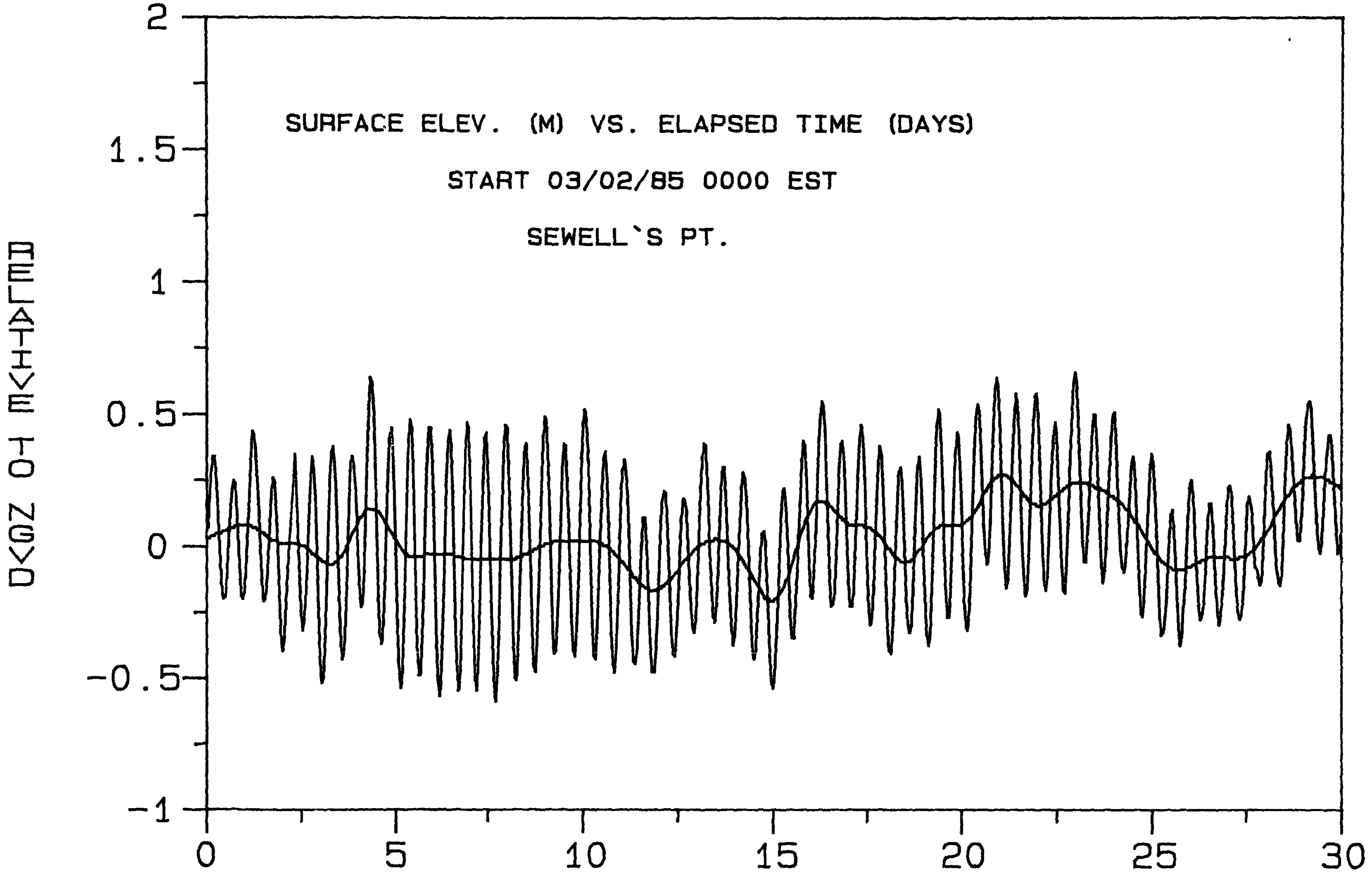
SURFACE ELEV. (M) VS. ELAPSED TIME (DAYS)
START 03/02/85 0000 EST
SEWELL`S PT.
RELATIVE TO NGVD
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-0.5
-1
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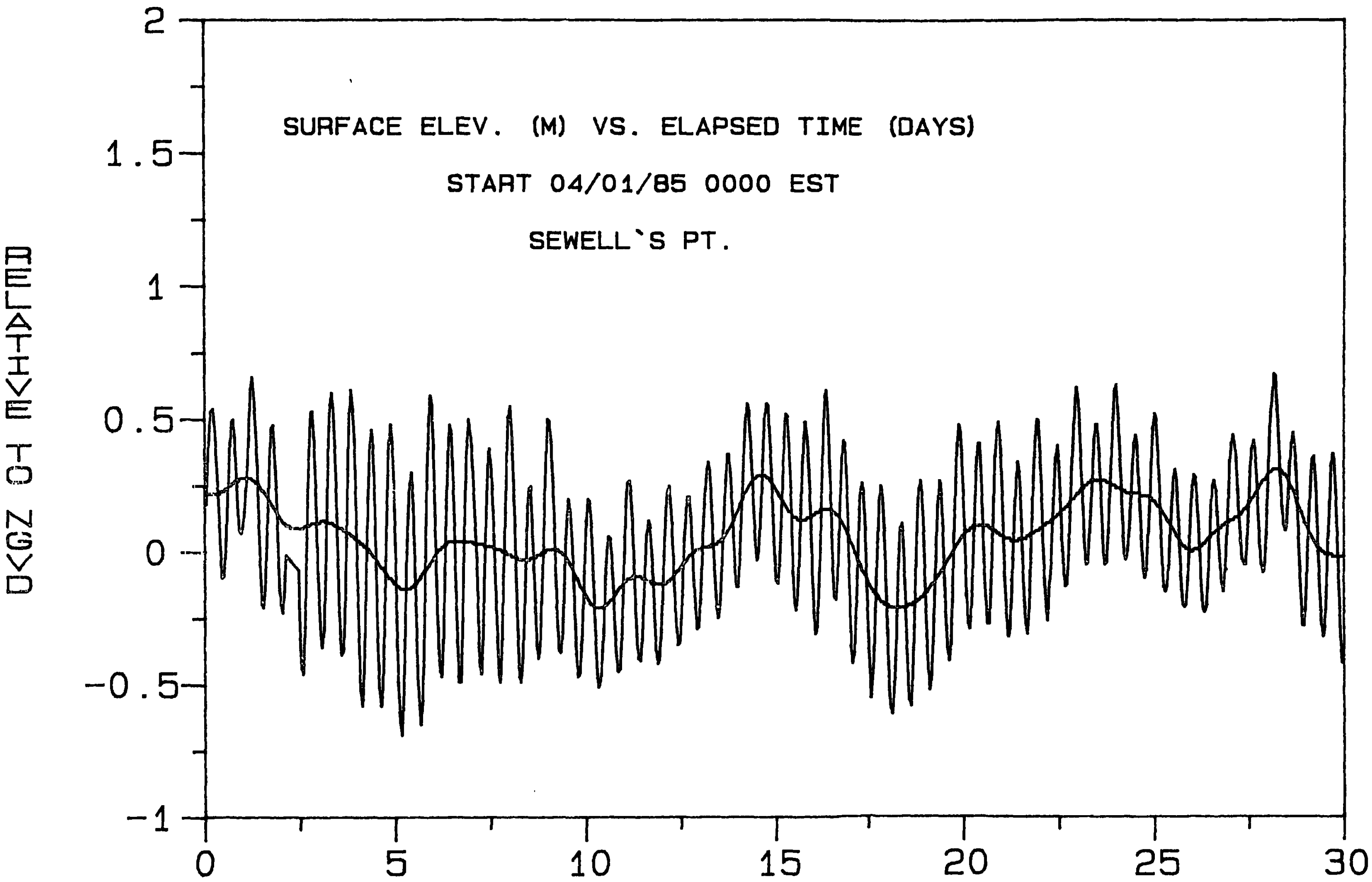
SURFACE ELEV. (M) VS. ELAPSED TIME (DAYS)
START 04/01/85 0000 EST
SEWELL'S PT.
RELATIVE TO NGVD
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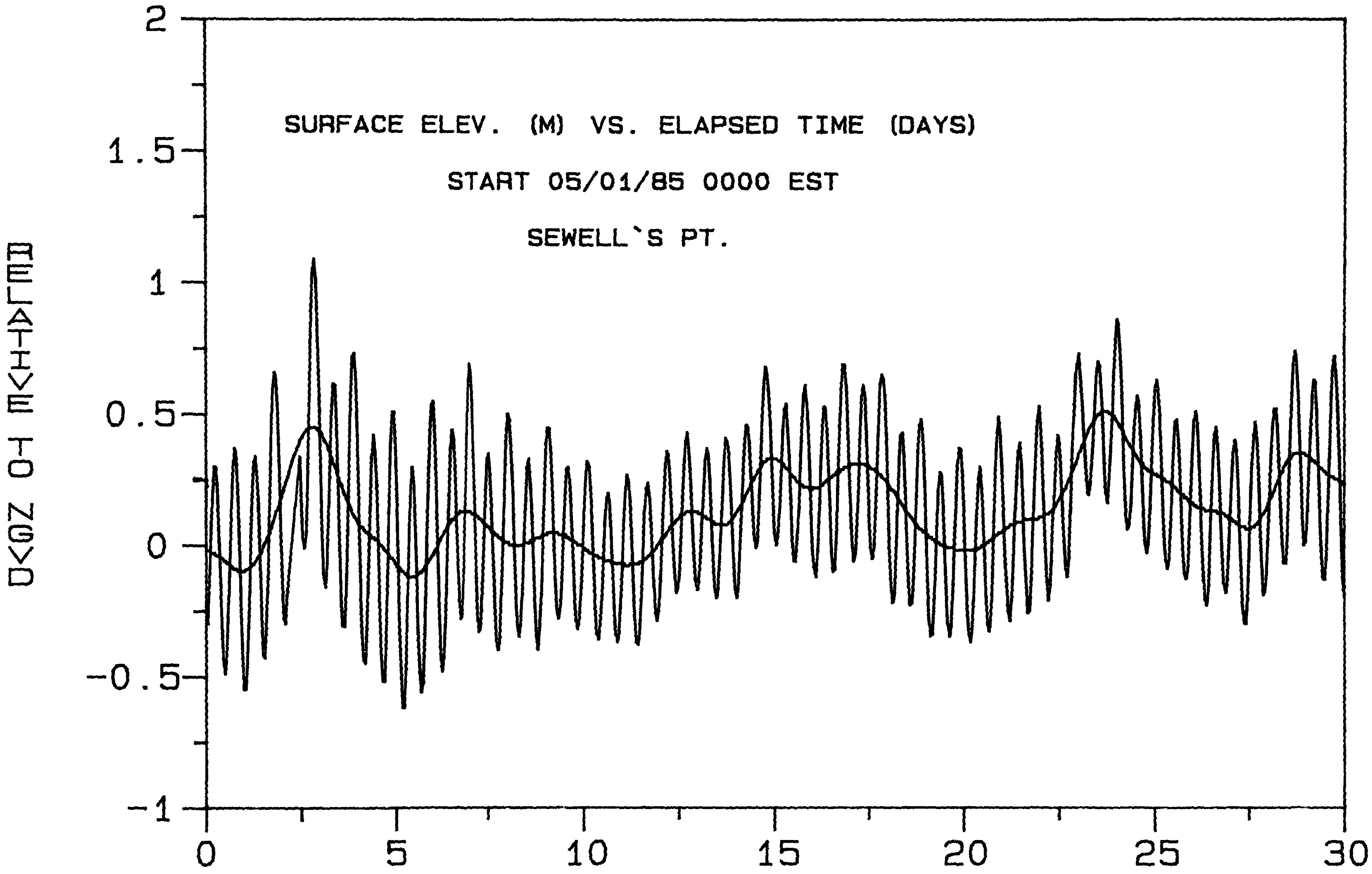
SURFACE ELEV. (M) VS. ELAPSED TIME (DAYS)
START 05/01/85 0000 EST
SEWELL`S PT.
RELATIVE TO NGVD
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0.5
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-0.5
-1
0
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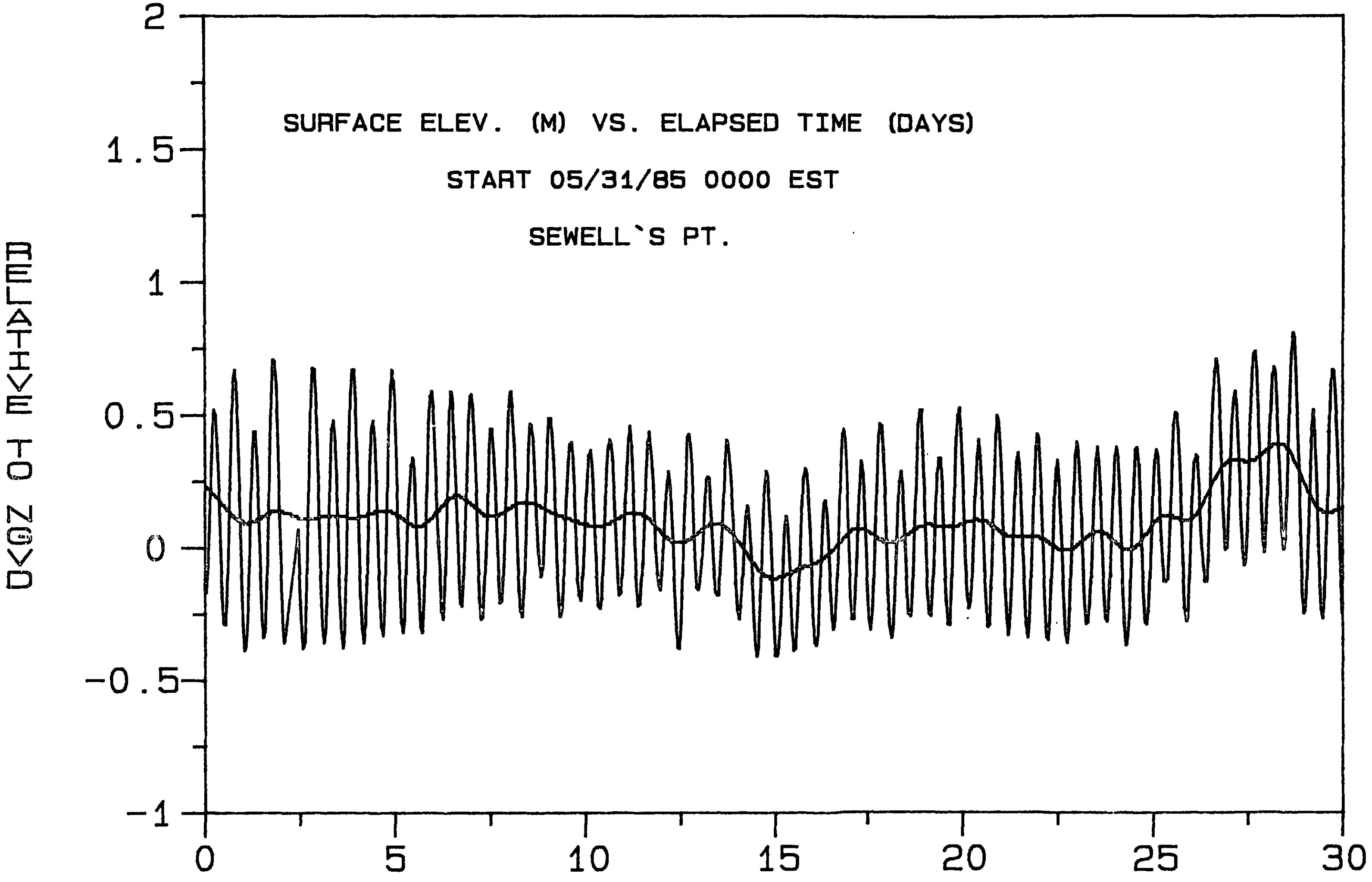
SURFACE ELEV. (M) VS. ELAPSED TIME (DAYS)
START 05/31/85 0000 EST
SEWELL`S PT.
RELATIVE TO NGVD
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0.5
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-0.5
-1
0
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15
20
25
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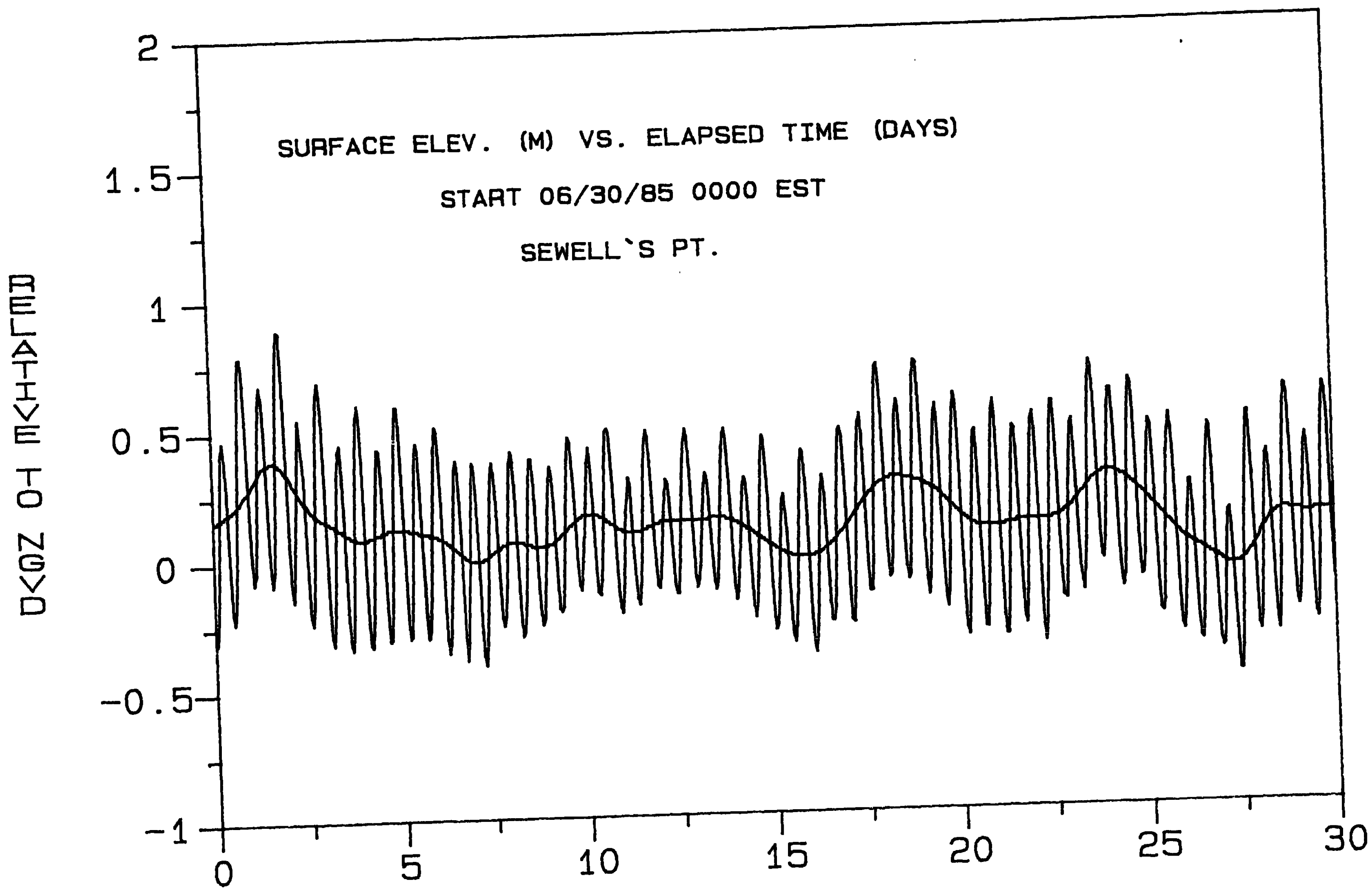
SURFACE ELEV. (M) VS. ELAPSED TIME (DAYS)
START 06/30/85 0000 EST
SEWELL`S PT.
RELATIVE TO NGVD
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−0.5
−1
0
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20
25
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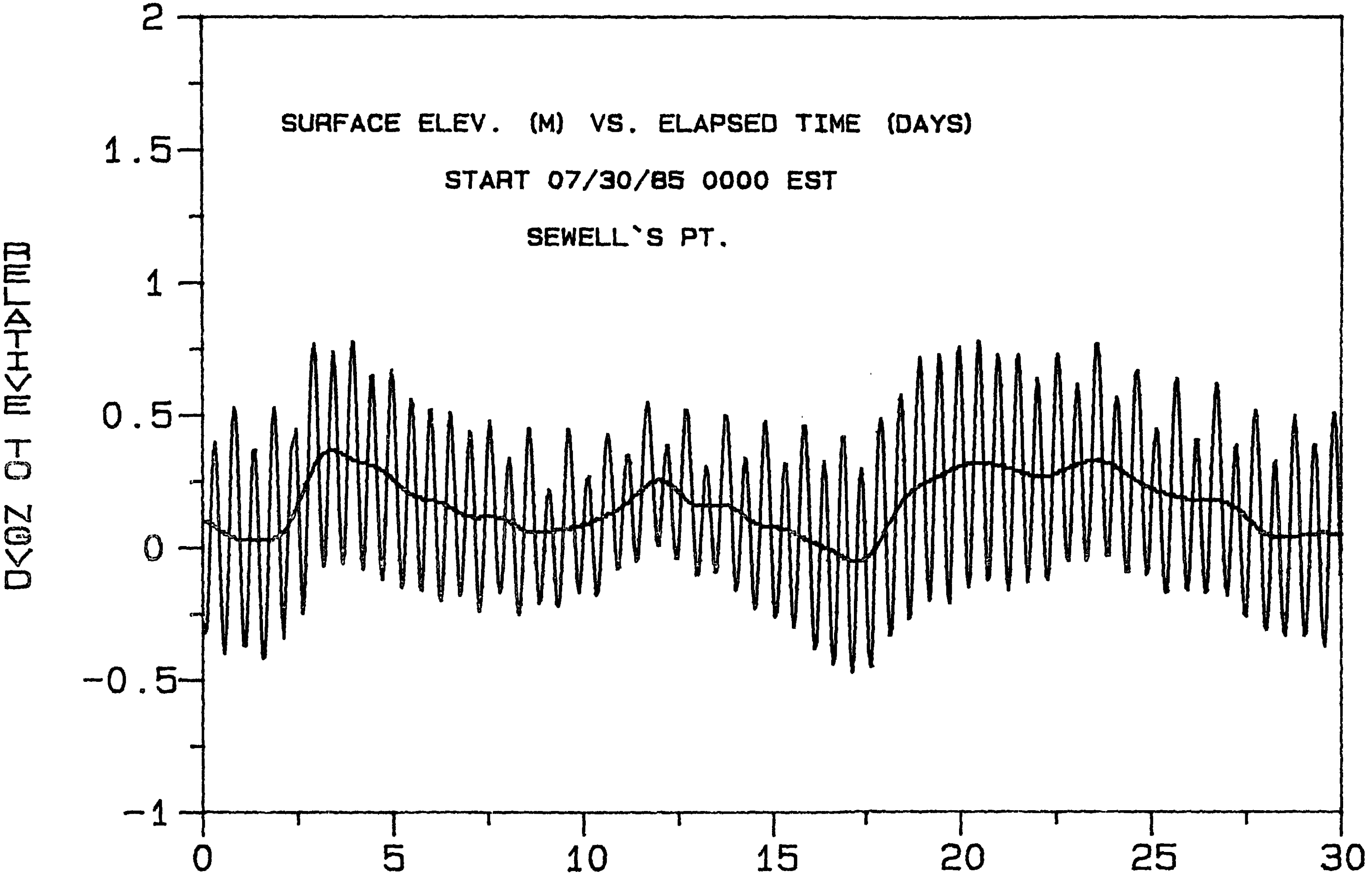
SURFACE ELEV. (M) VS. ELAPSED TIME (DAYS)
START 07/30/85 0000 EST
SEWELL`S PT.
RELATIVE TO NGVD
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0.5
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-0.5
-1
0
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15
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25
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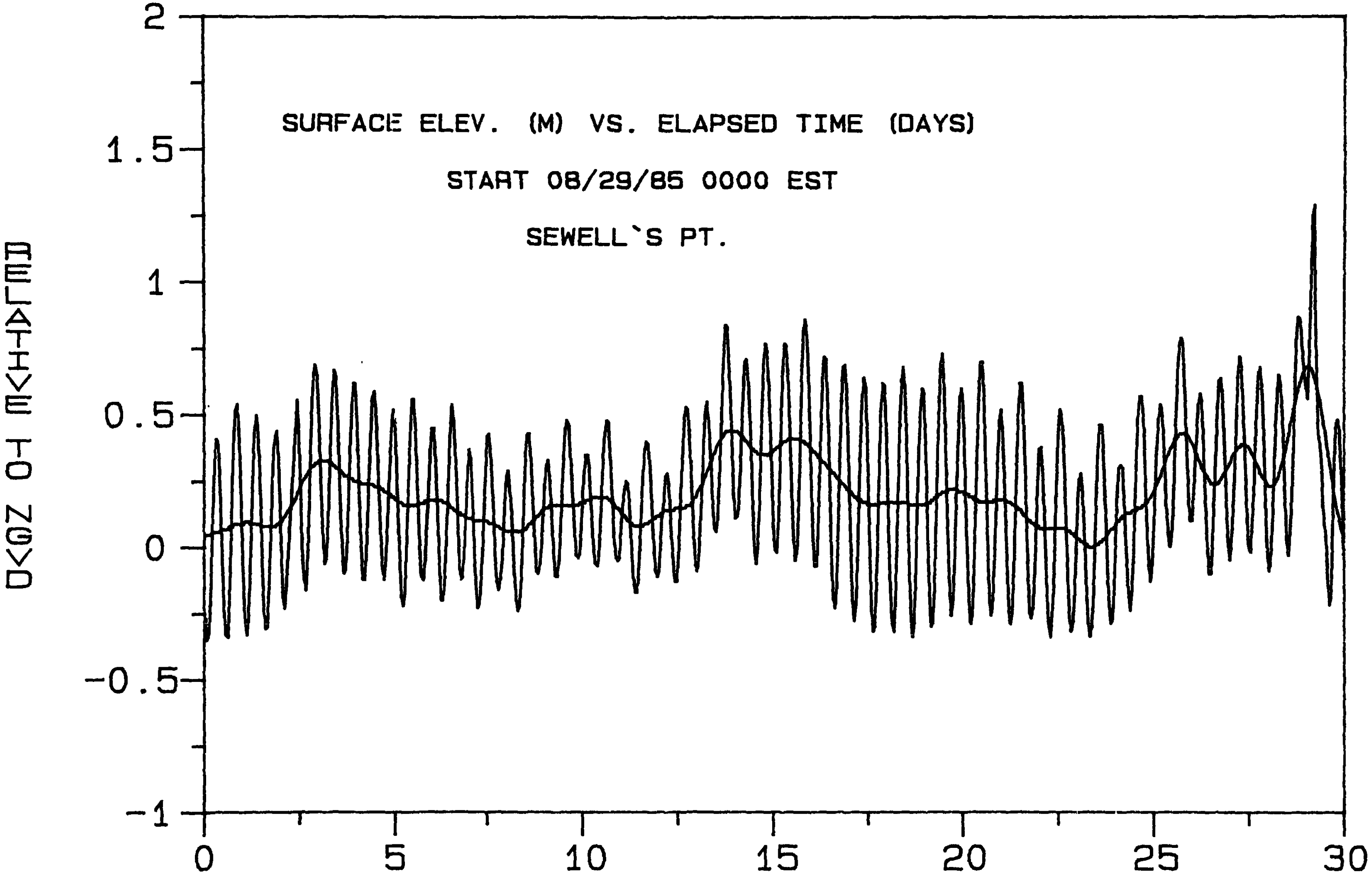
SURFACE ELEV. (M) VS. ELAPSED TIME (DAYS)
START 08/29/85 0000 EST
SEWELL`S PT.
RELATIVE TO NGVD
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0.5
0
−0.5
−1
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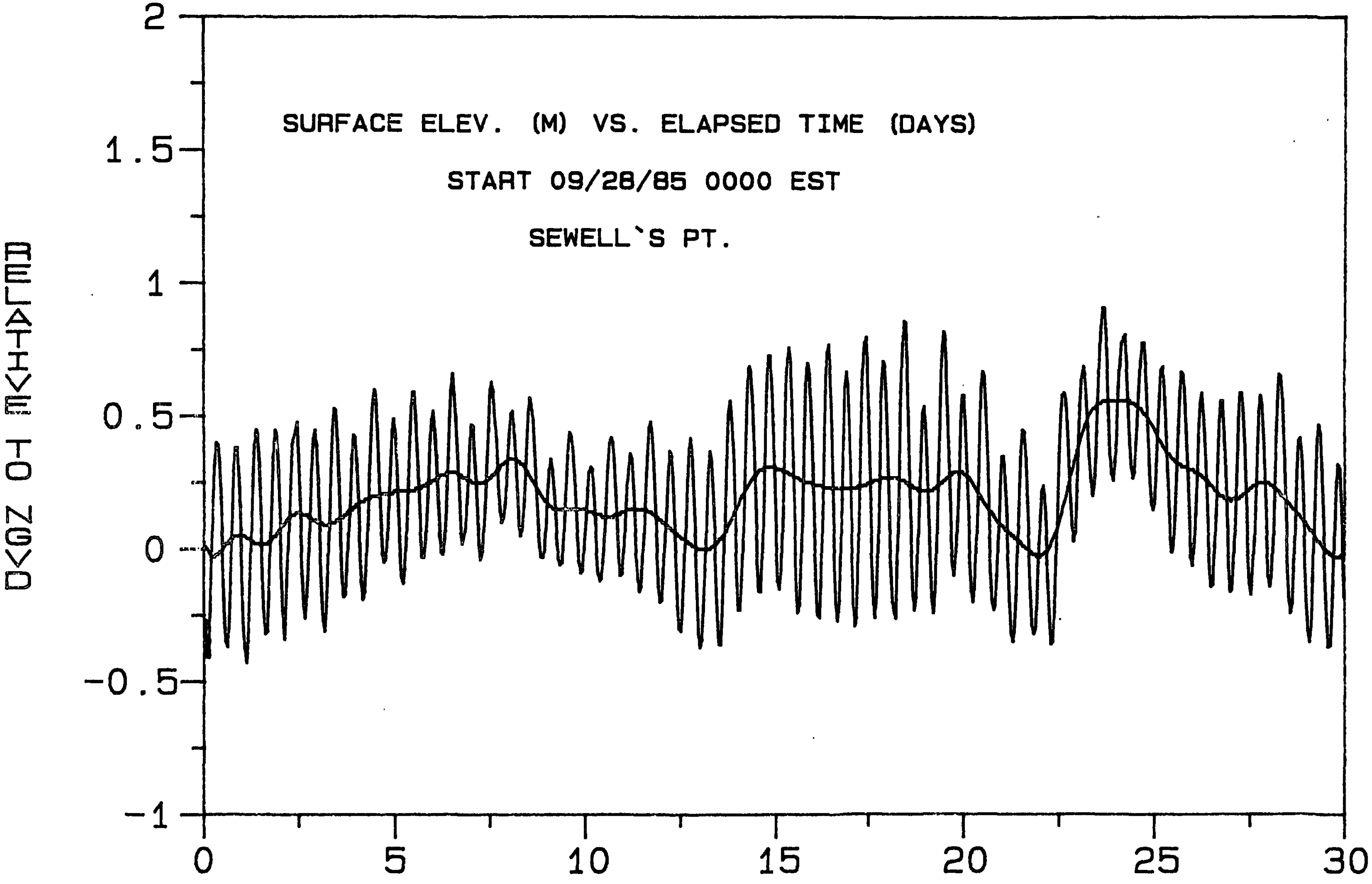
SURFACE ELEV. (M) VS. ELAPSED TIME (DAYS)
START 09/28/85 0000 EST
SEWELL`S PT.
RELATIVE TO NGVD
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-0.5
-1
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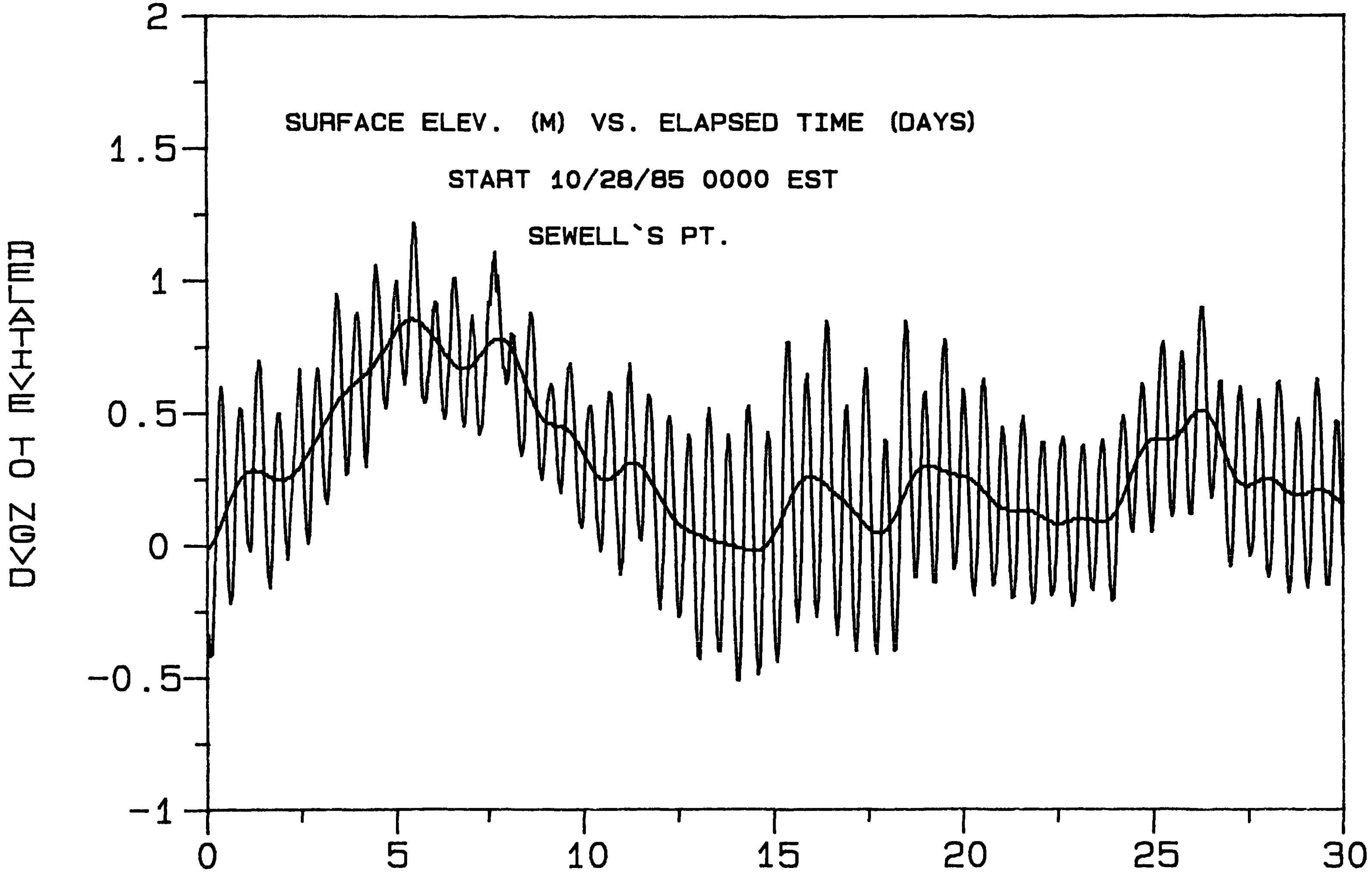
SURFACE ELEV. (M) VS. ELAPSED TIME (DAYS)
START 10/28/85 0000 EST
SEWELL`S PT.
RELATIVE TO NGVD
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-0.5
-1
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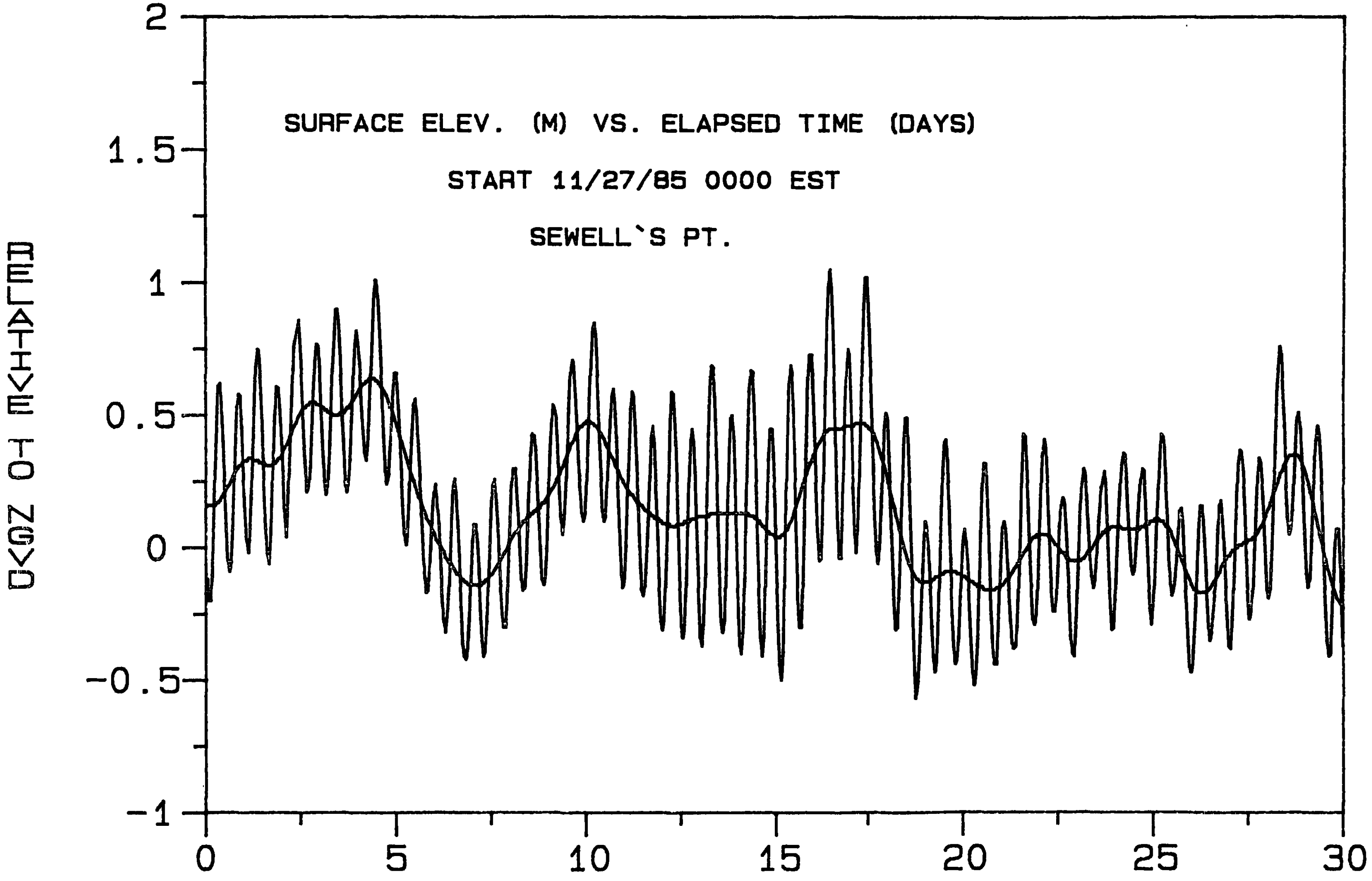
SURFACE ELEV. (M) VS. ELAPSED TIME (DAYS)
START 11/27/85 0000 EST
SEWELL`S PT.
RELATIVE TO NGVD
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0.5
0
−0.5
−1
0
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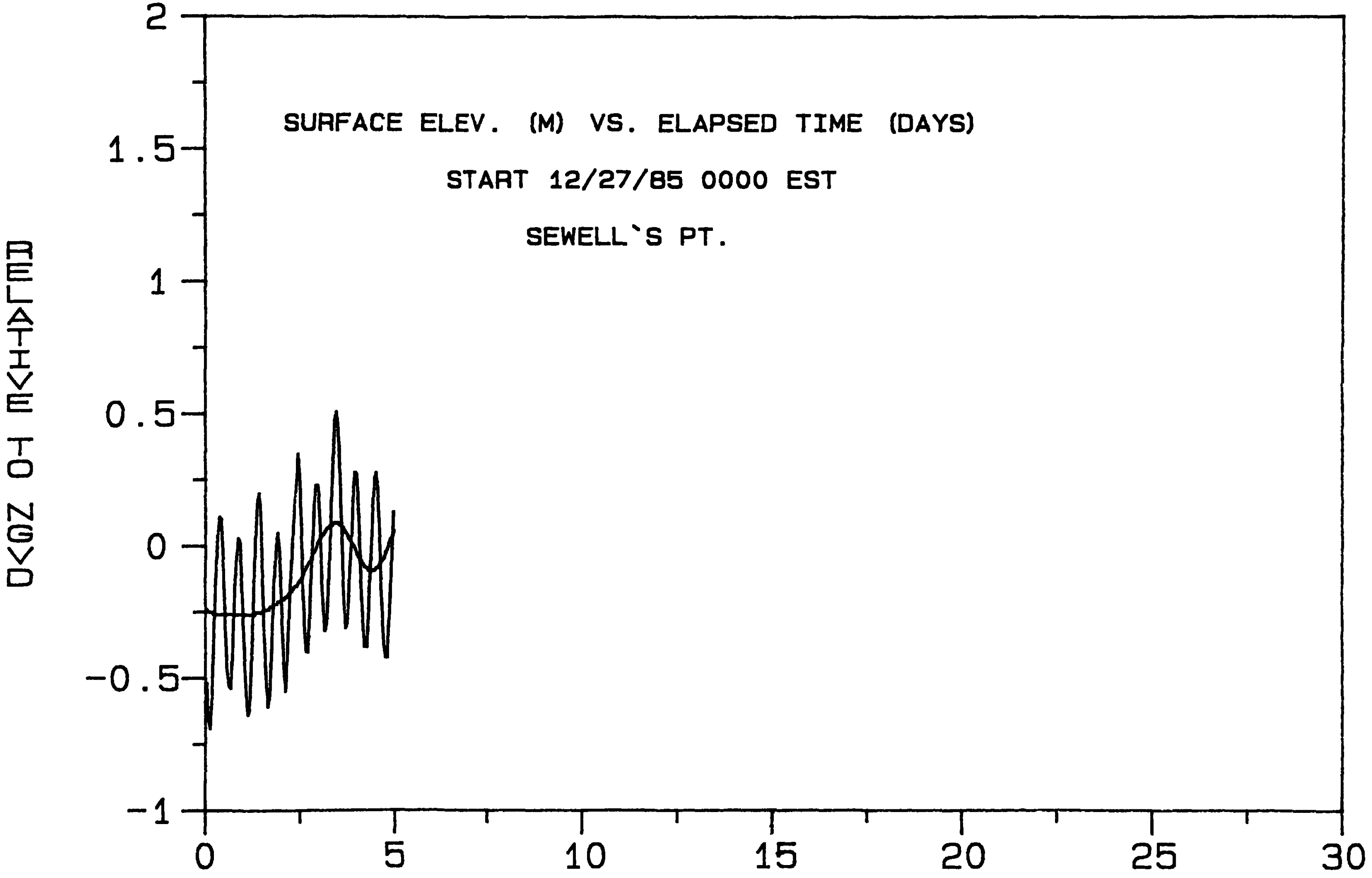
SURFACE ELEV. (M) VS. ELAPSED TIME (DAYS)
START 12/27/85 0000 EST
SEWELL`S PT.
RELATIVE TO NGVD
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0.5
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-0.5
-1
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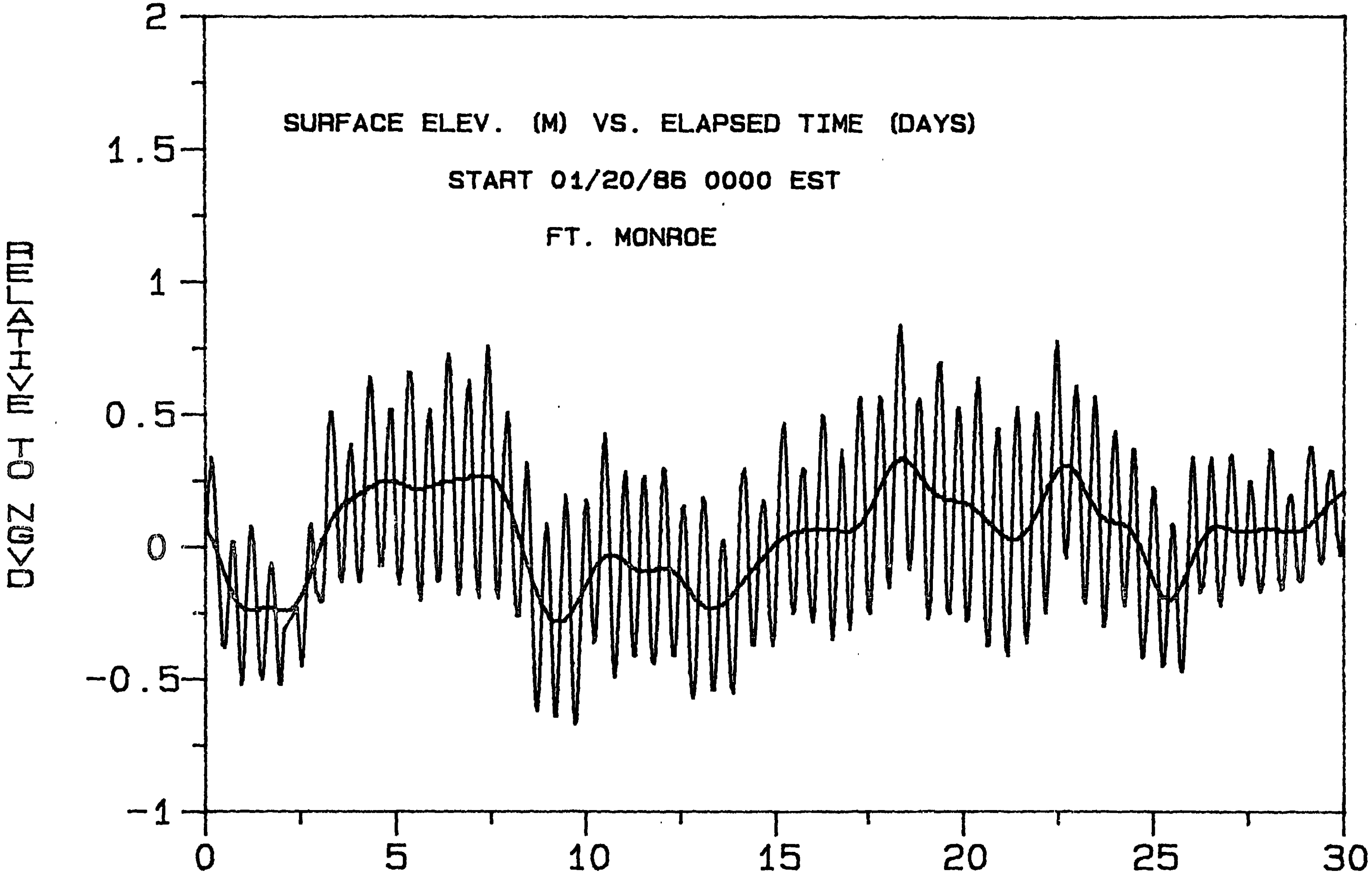
SURFACE ELEV. (M) VS. ELAPSED TIME (DAYS)
START 01/20/86 0000 EST
FT. MONROE
RELATIVE TO NGVD
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0
-0.5
-1
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25
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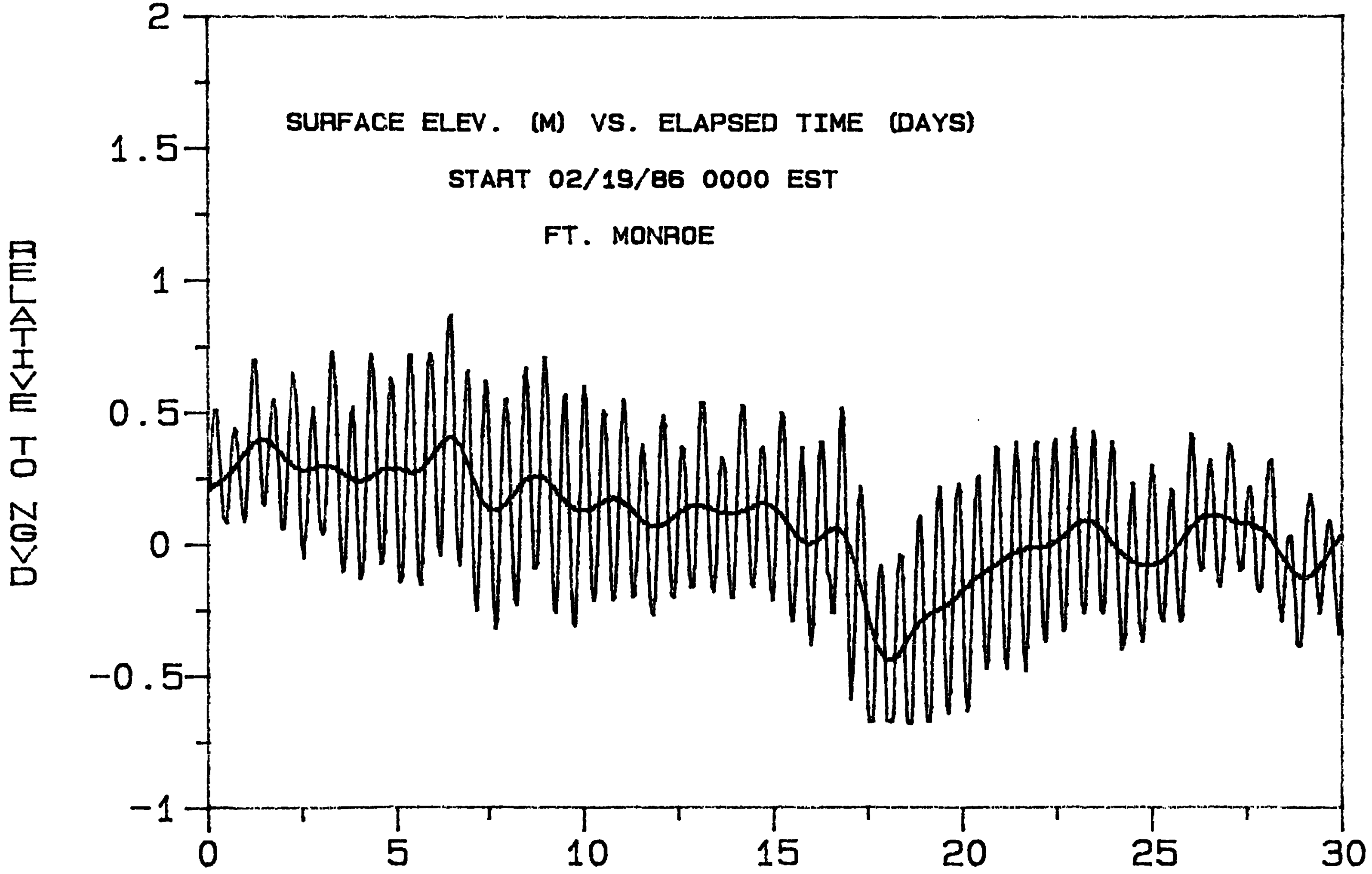
SURFACE ELEV. (M) VS. ELAPSED TIME (DAYS)
START 02/19/86 0000 EST
FT. MONROE
RELATIVE TO NGVD
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1
0.5
0
-0.5
-1
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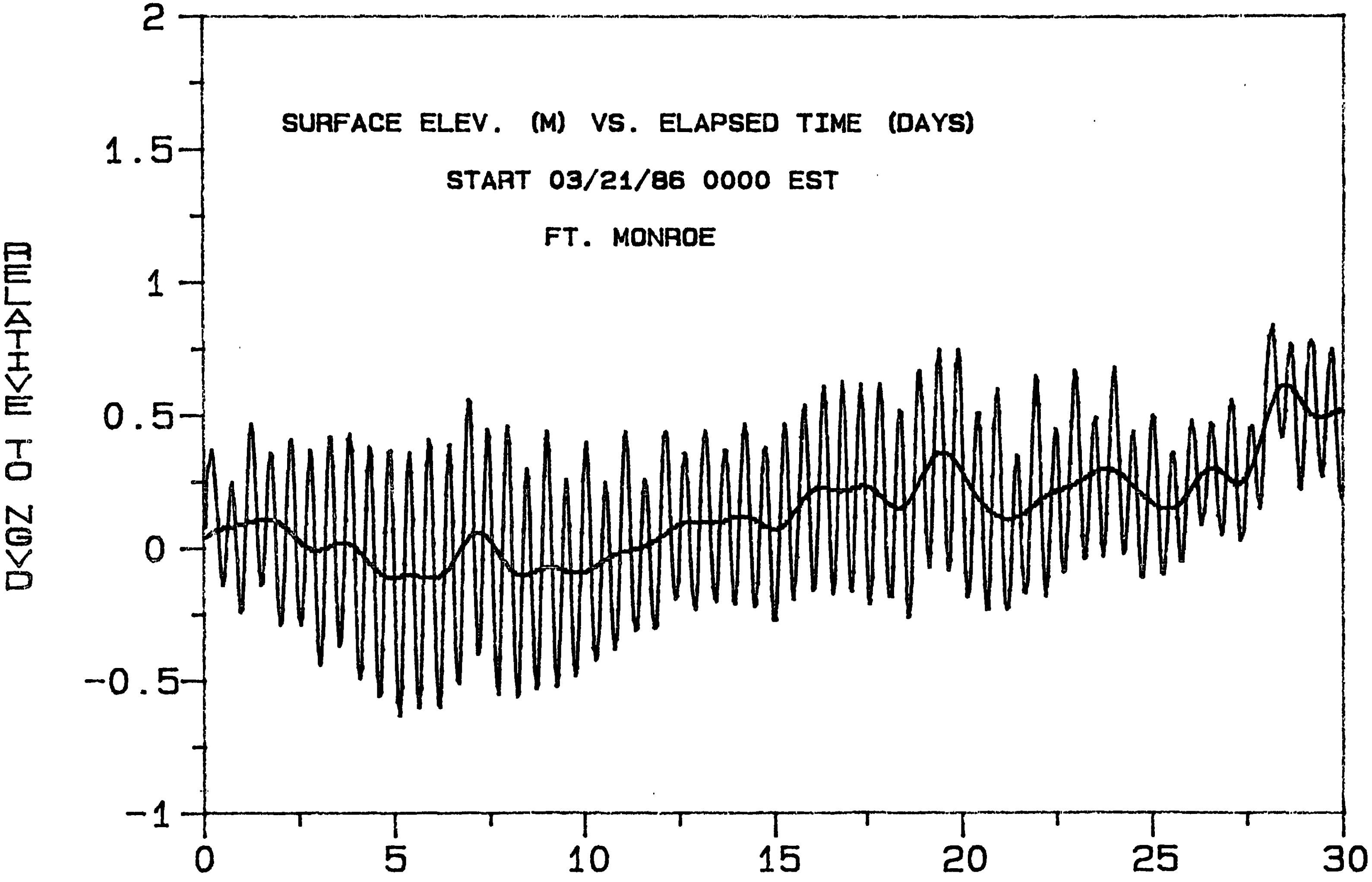
SURFACE ELEV. (M) VS. ELAPSED TIME (DAYS)
START 03/21/86 0000 EST
FT. MONROE
RELATIVE TO NGVD
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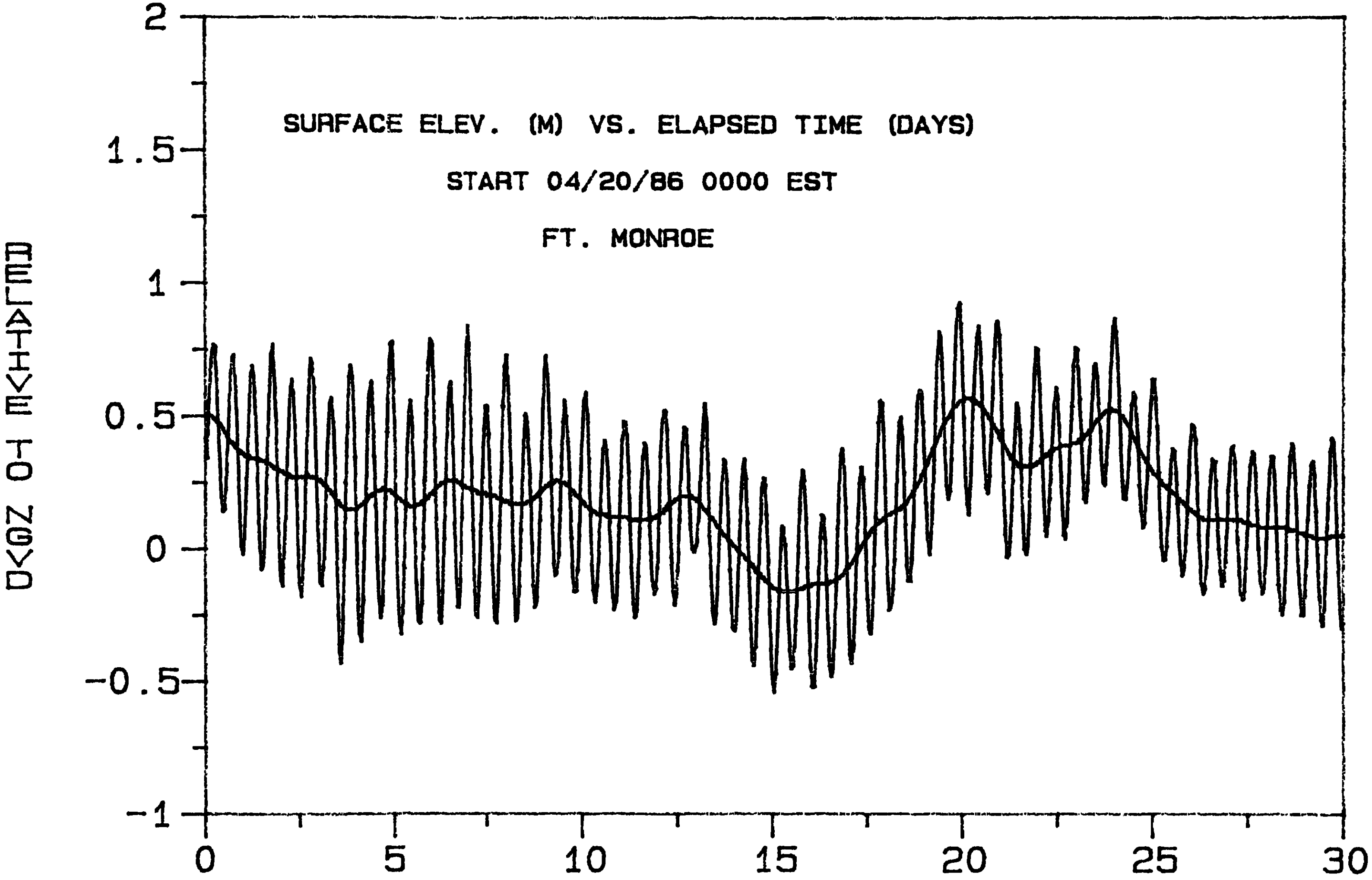
SURFACE ELEV. (M) VS. ELAPSED TIME (DAYS)
START 04/20/86 0000 EST
FT. MONROE
RELATIVE TO NGVD
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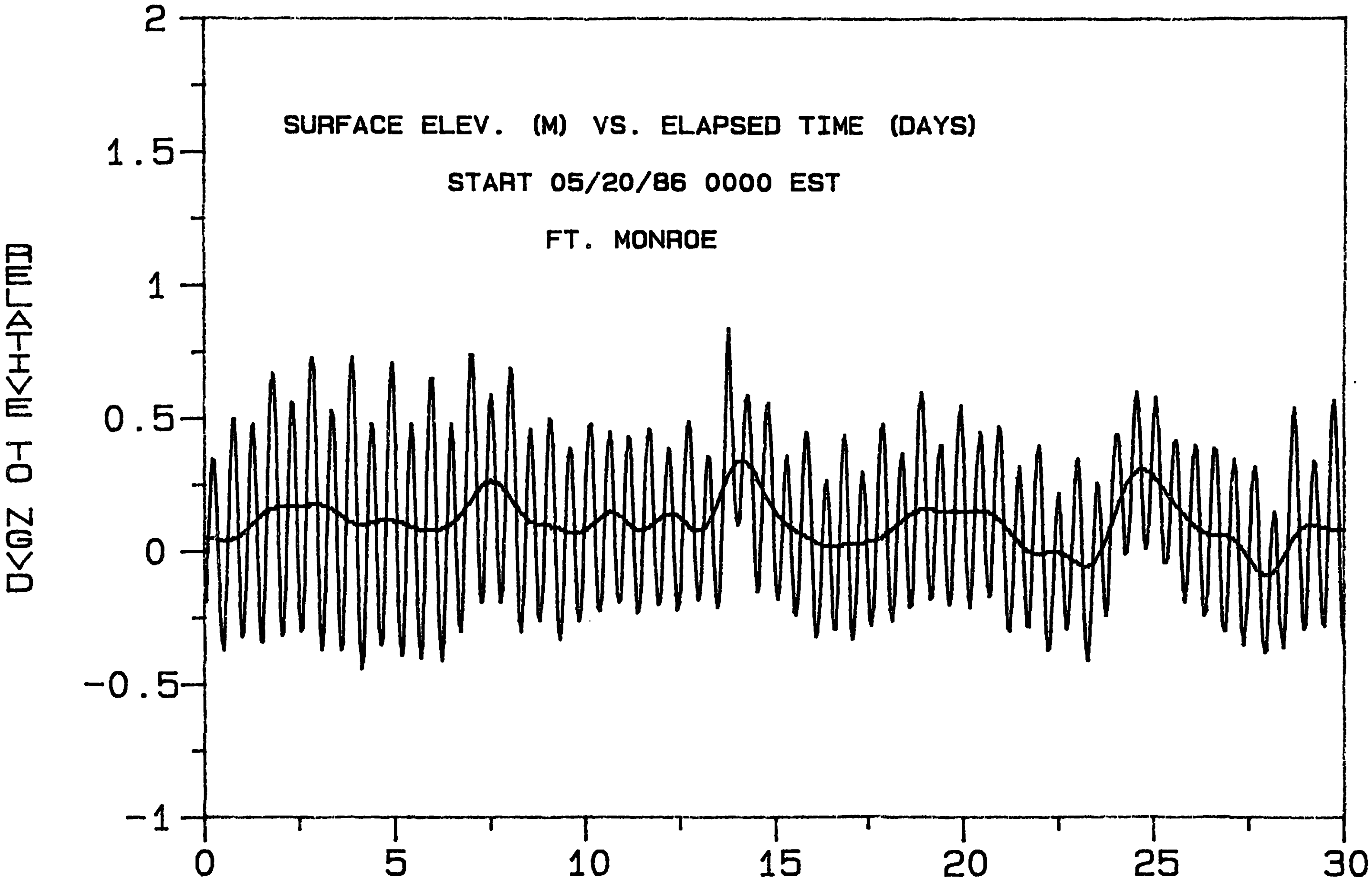
SURFACE ELEV. (M) VS. ELAPSED TIME (DAYS)
START 05/20/86 0000 EST
FT. MONROE
RELATIVE TO NGVD
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0.5
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-0.5
-1
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5
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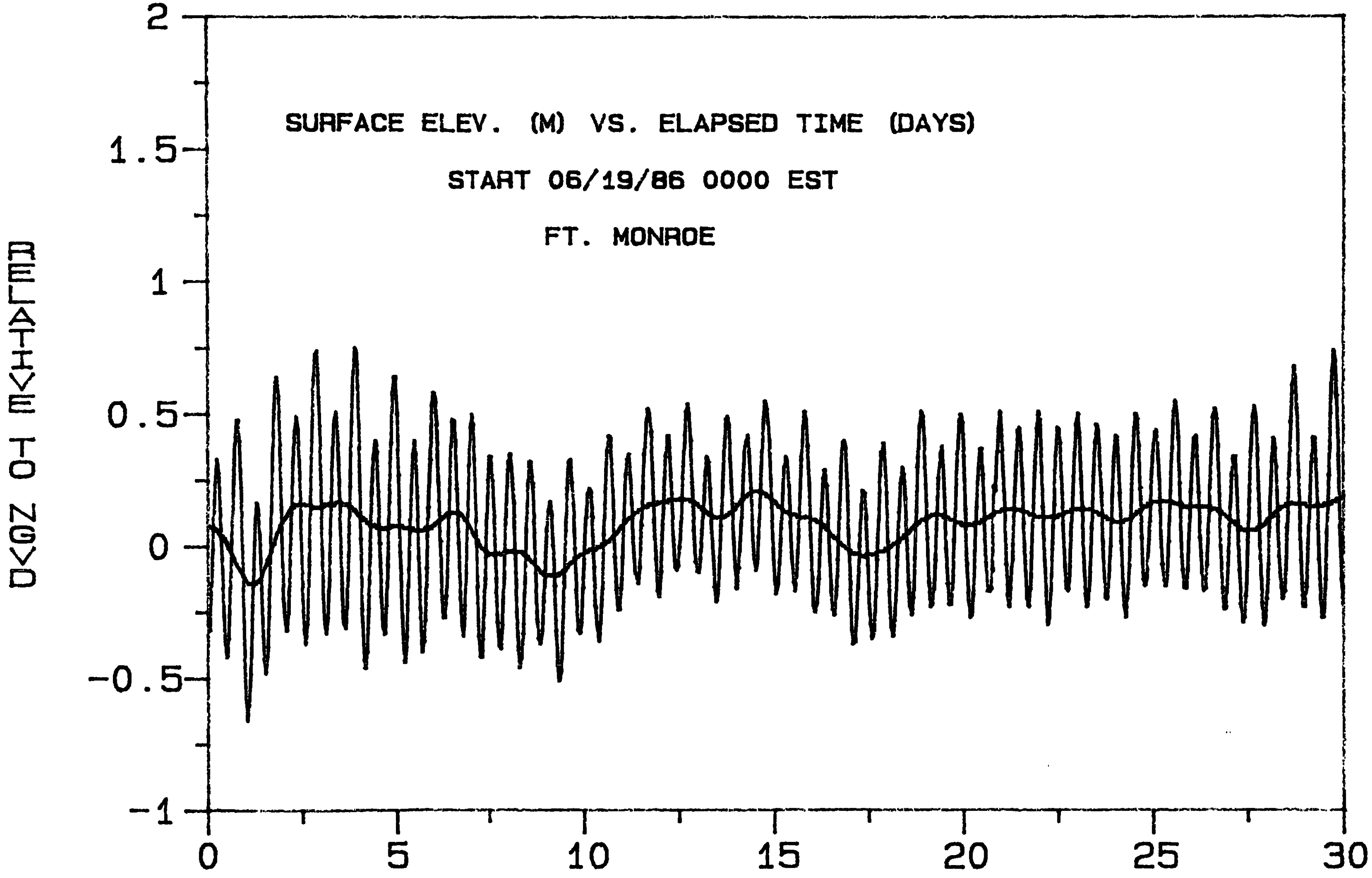
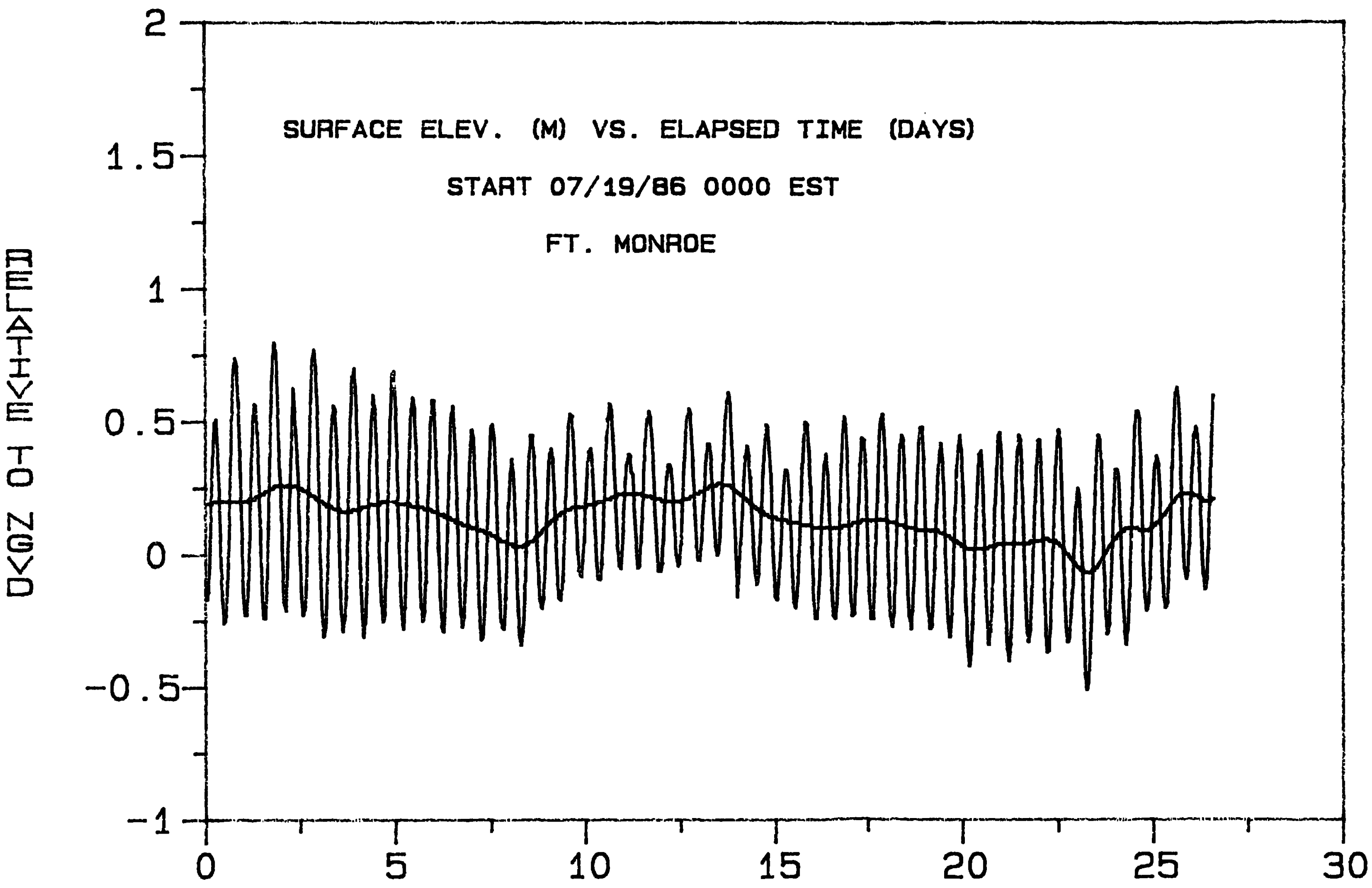
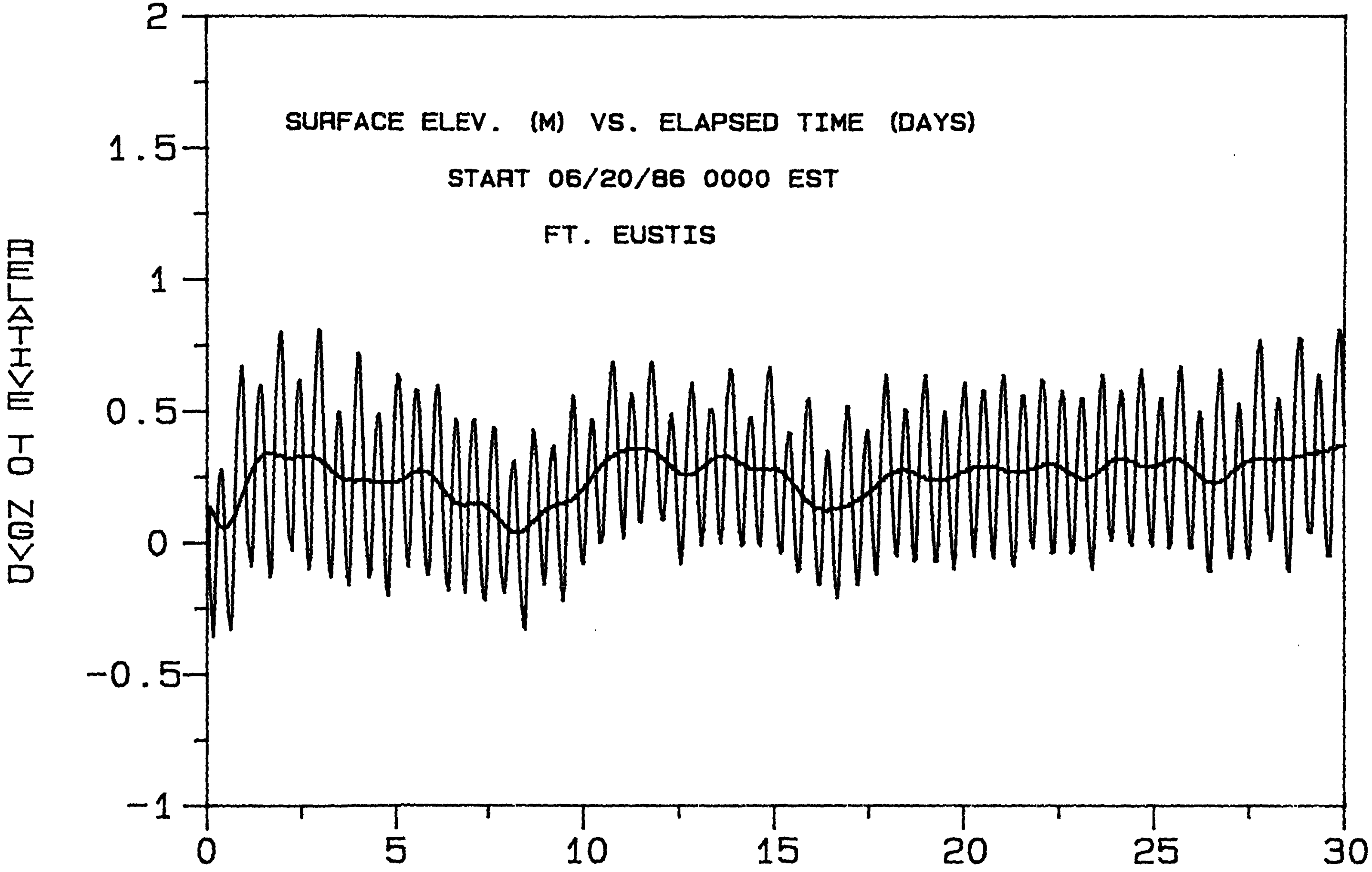
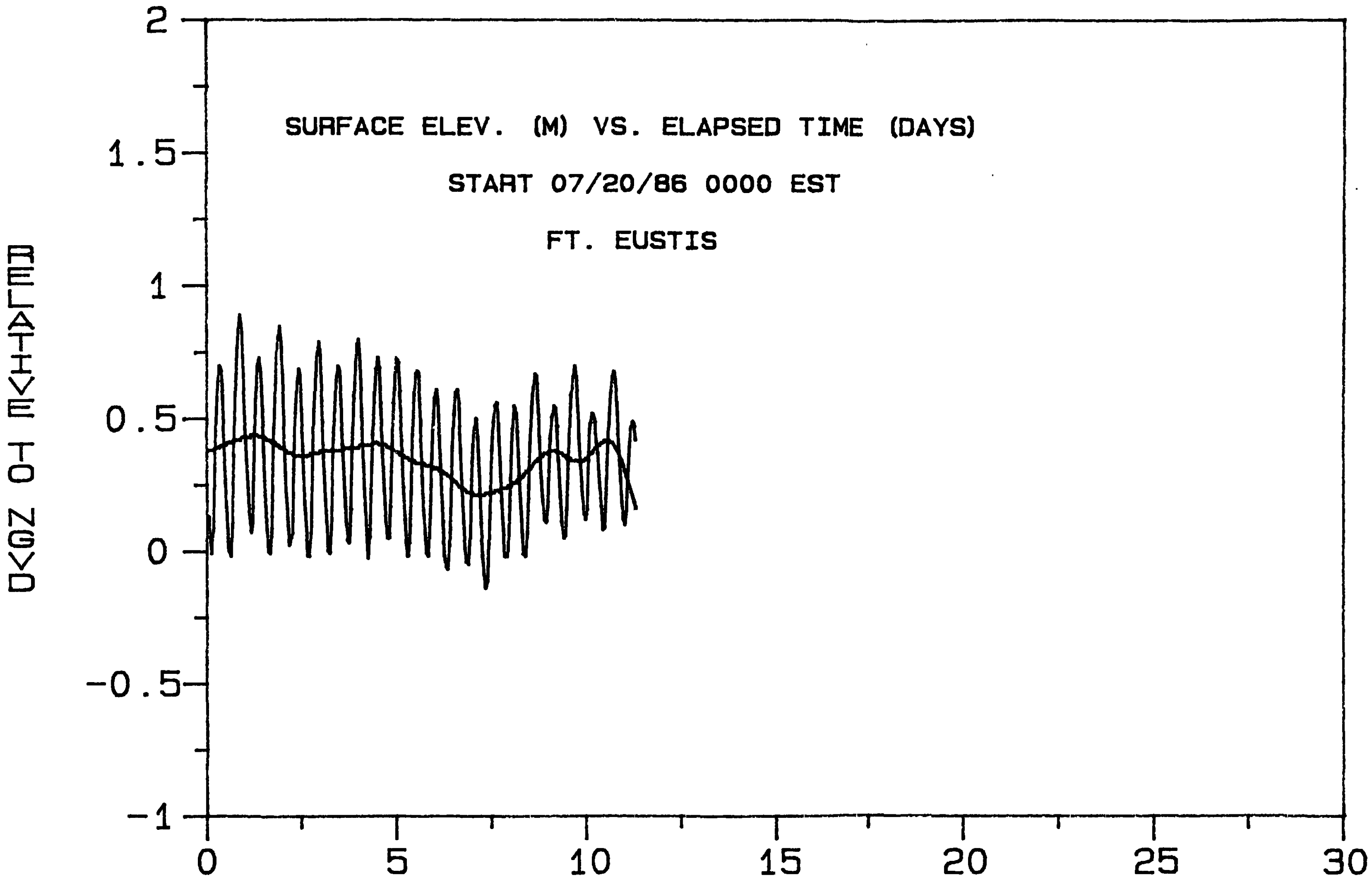
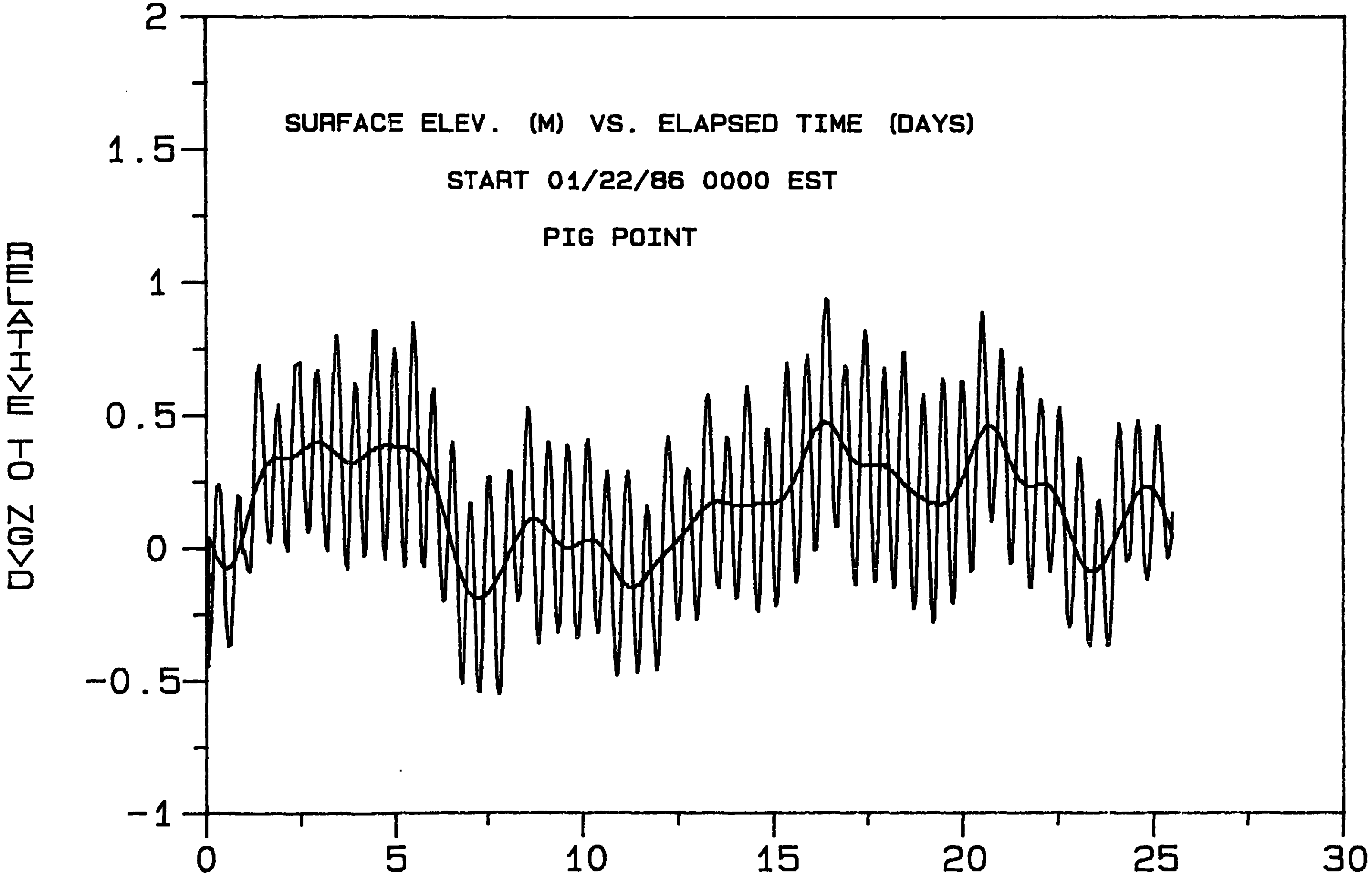
15
20
25
30

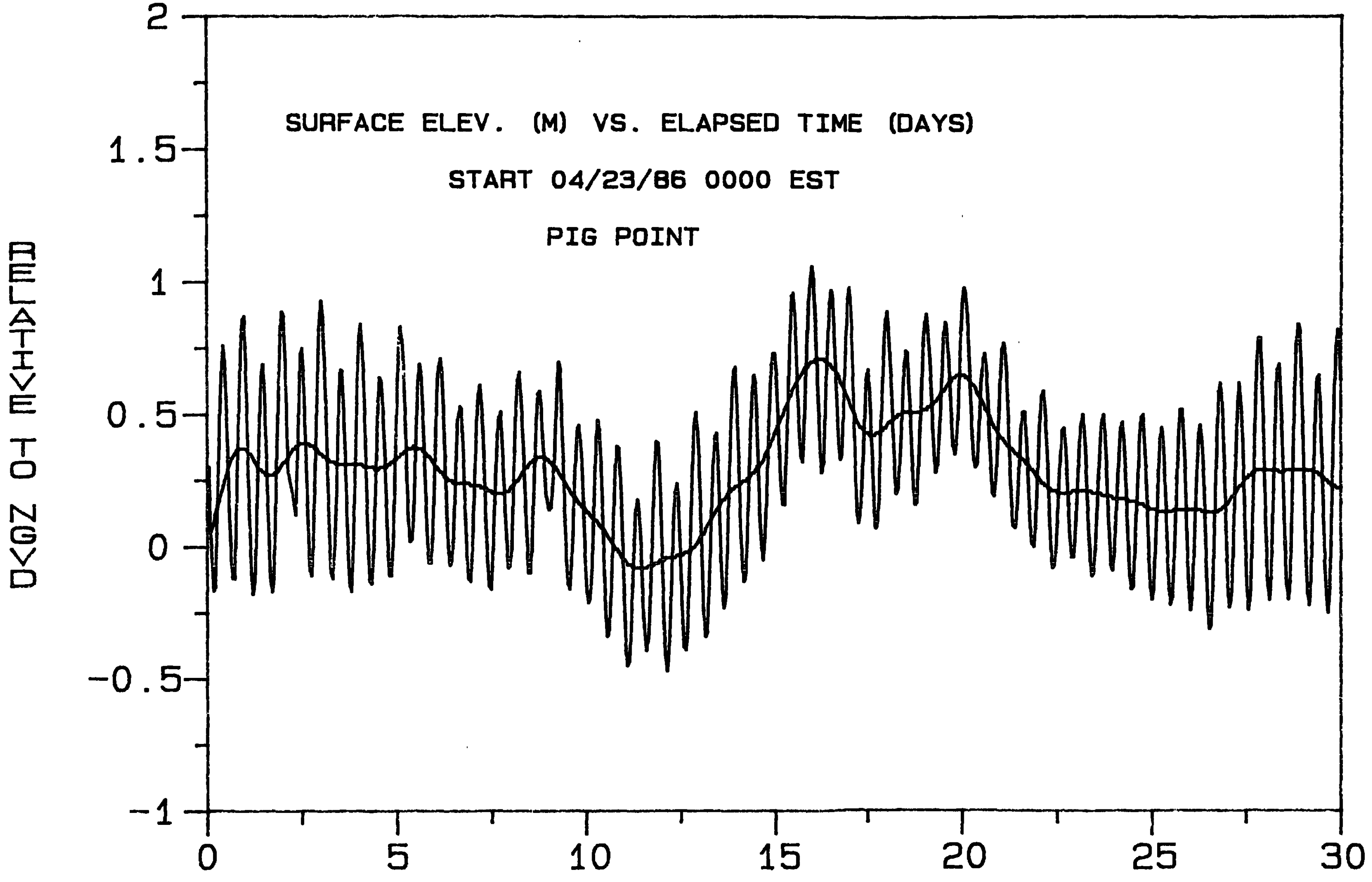

SURFACE ELEV. (M) VS. ELAPSED TIME (DAYS)
START 06/19/86 0000 EST
FT. MONROE
RELATIVE TO NGVD
2
1.5
1
0.5
0
-0.5
-1
0
5
10
15
20
25
30

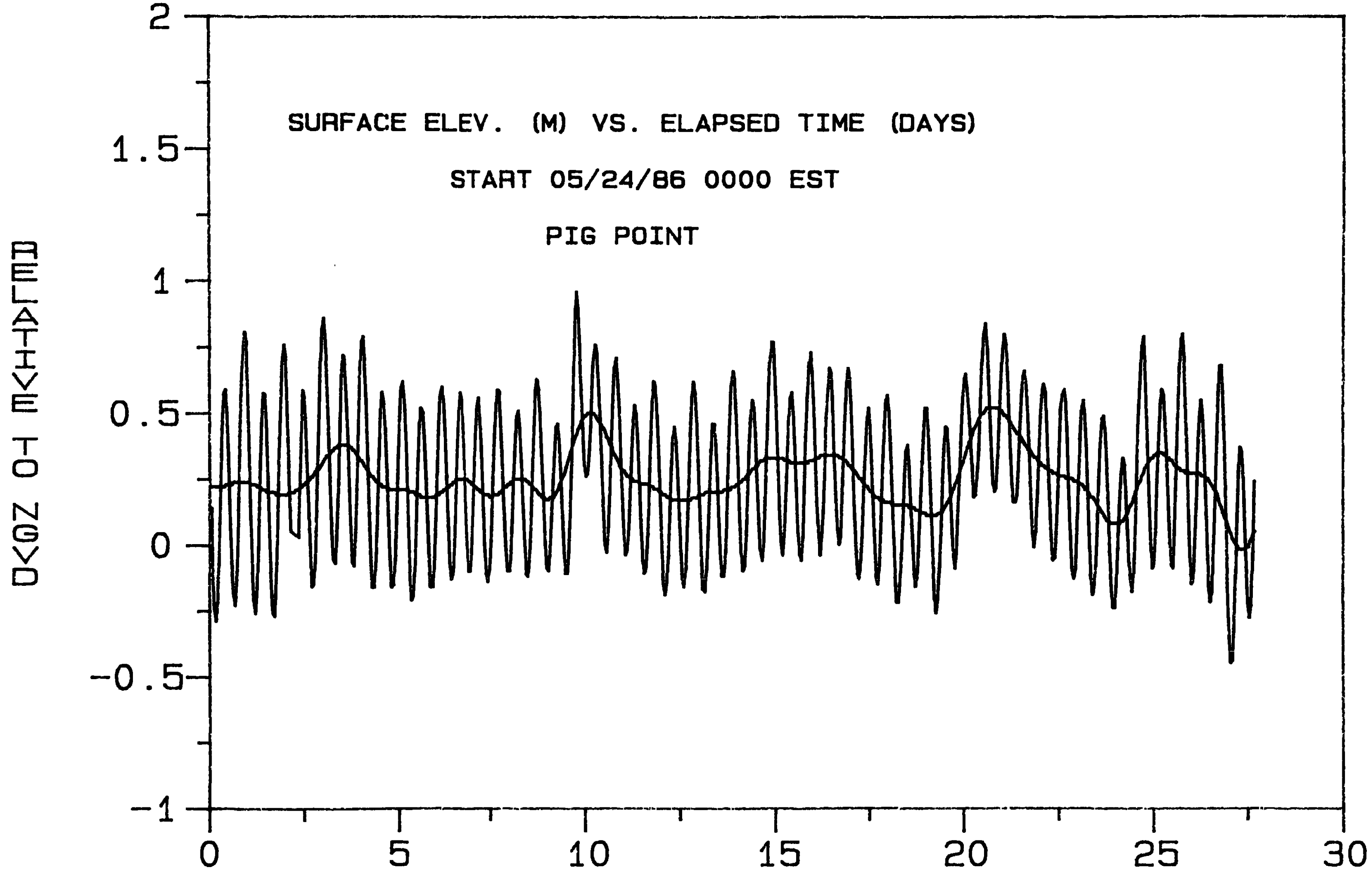

SURFACE ELEV. (M) VS. ELAPSED TIME (DAYS)
START 07/19/86 0000 EST
FT. MONROE
RELATIVE TO NGVD
2
1.5
1
0.5
0
-0.5
-1
0
5
10
15
20
25
30

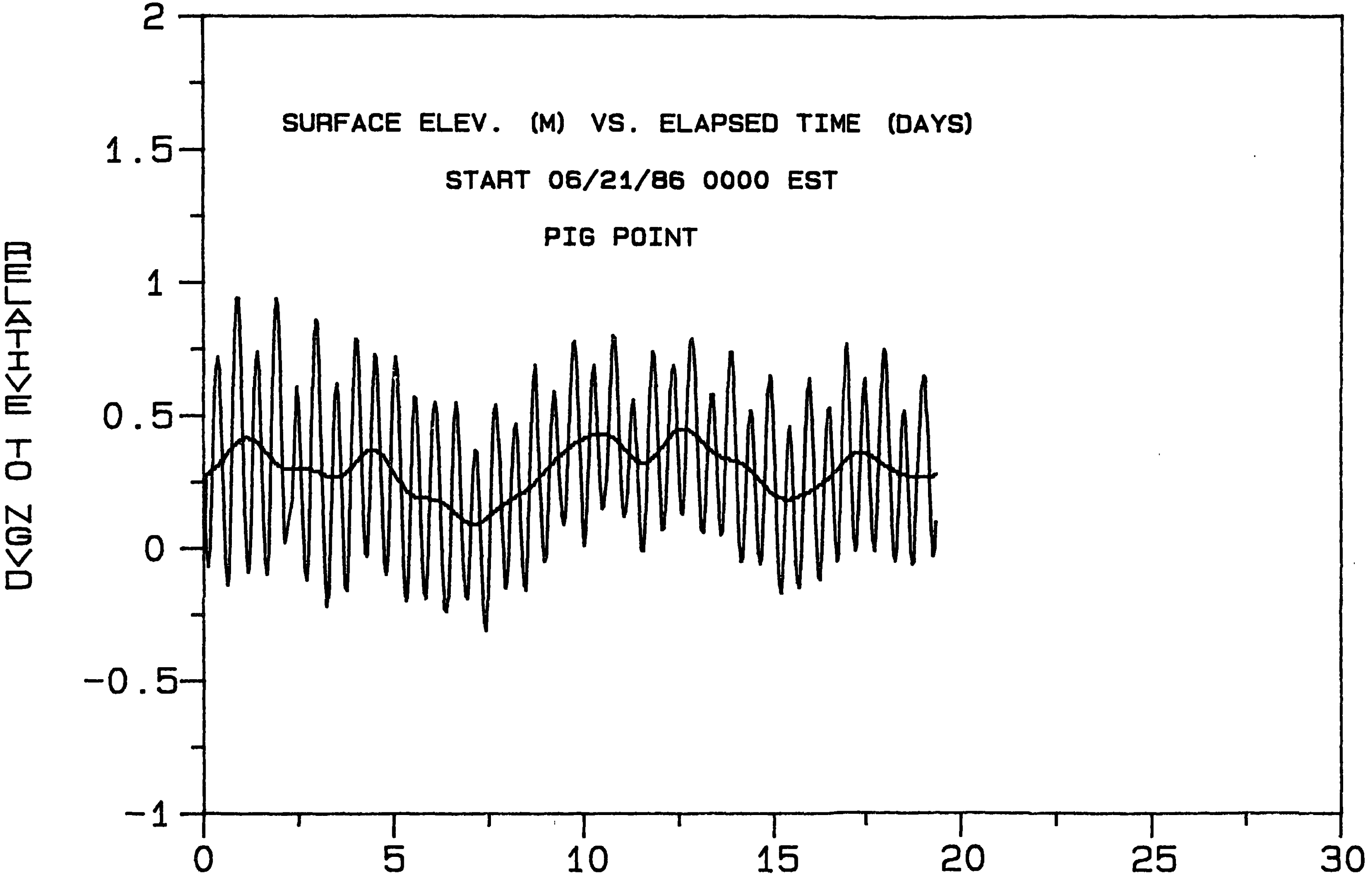

SURFACE ELEV. (M) VS. ELAPSED TIME (DAYS)
START 06/20/86 0000 EST
FT. EUSTIS
RELATIVE TO NGVD
2
1.5
1
0.5
0
-0.5
-1
0
5
10
15
20
25
30


SURFACE ELEV. (M) VS. ELAPSED TIME (DAYS)
START 07/20/86 0000 EST
FT. EUSTIS
RELATIVE TO NGVD
2
1.5
1
0.5
0
-0.5
-1
0
5
10
15
20
25
30


SURFACE ELEV. (M) VS. ELAPSED TIME (DAYS)
START 01/22/86 0000 EST
PIG POINT
RELATIVE TO NGVD
2
1.5
1
0.5
0
-0.5
-1
0
5
10
15
20
25
30

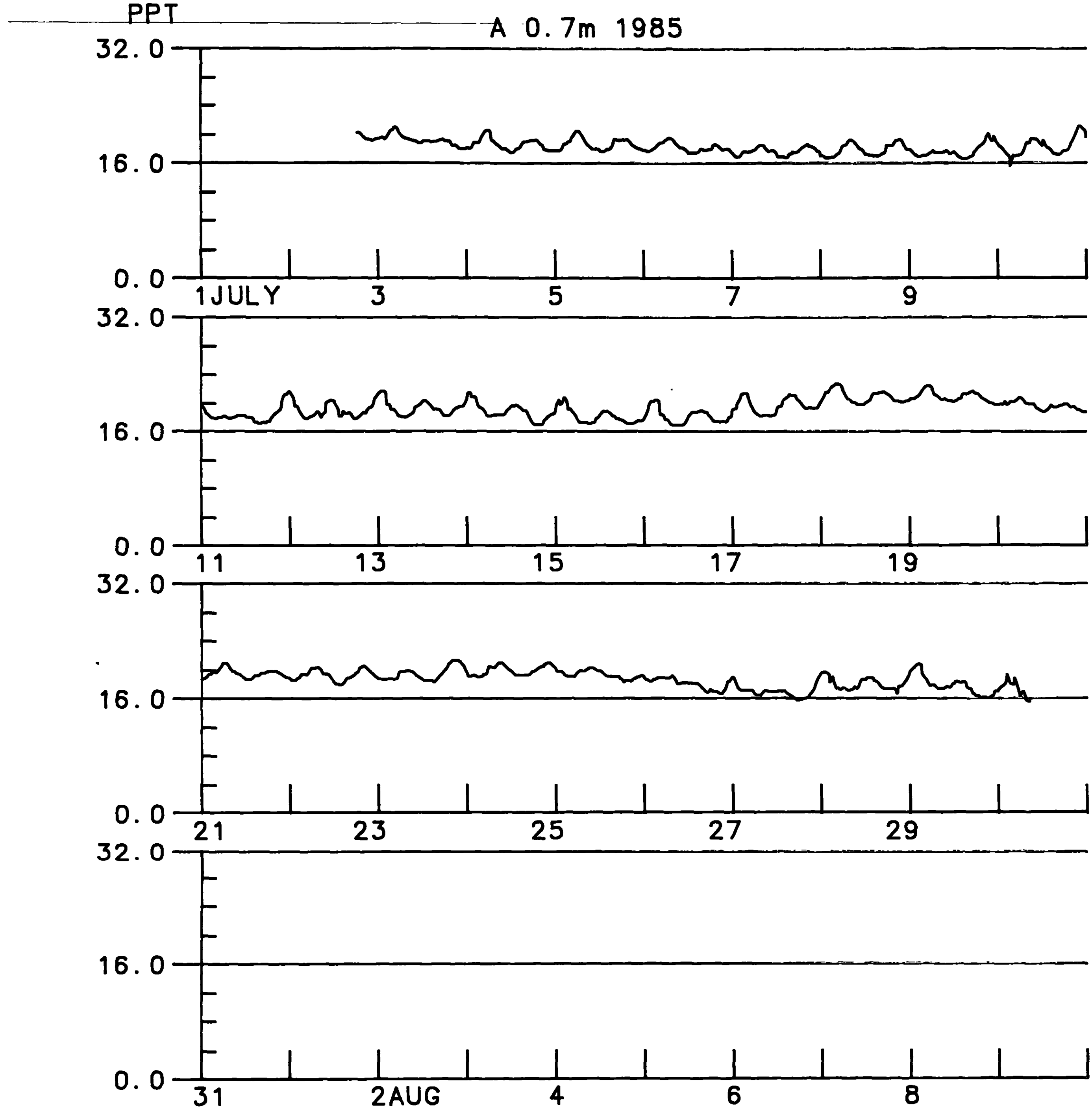
SURFACE ELEV. (M) VS. ELAPSED TIME (DAYS)
START 04/23/86 0000 EST
PIG POINT
RELATIVE TO NGVD
2
1.5
1
0.5
0
-0.5
-1
0
5
10
15
20
25
30


SURFACE ELEV. (M) VS. ELAPSED TIME (DAYS)
START 05/24/86 0000 EST
PIG POINT
RELATIVE TO NGVD
2
1.5
1
0.5
0
-0.5
-1
0
5
10
15
20
25
30

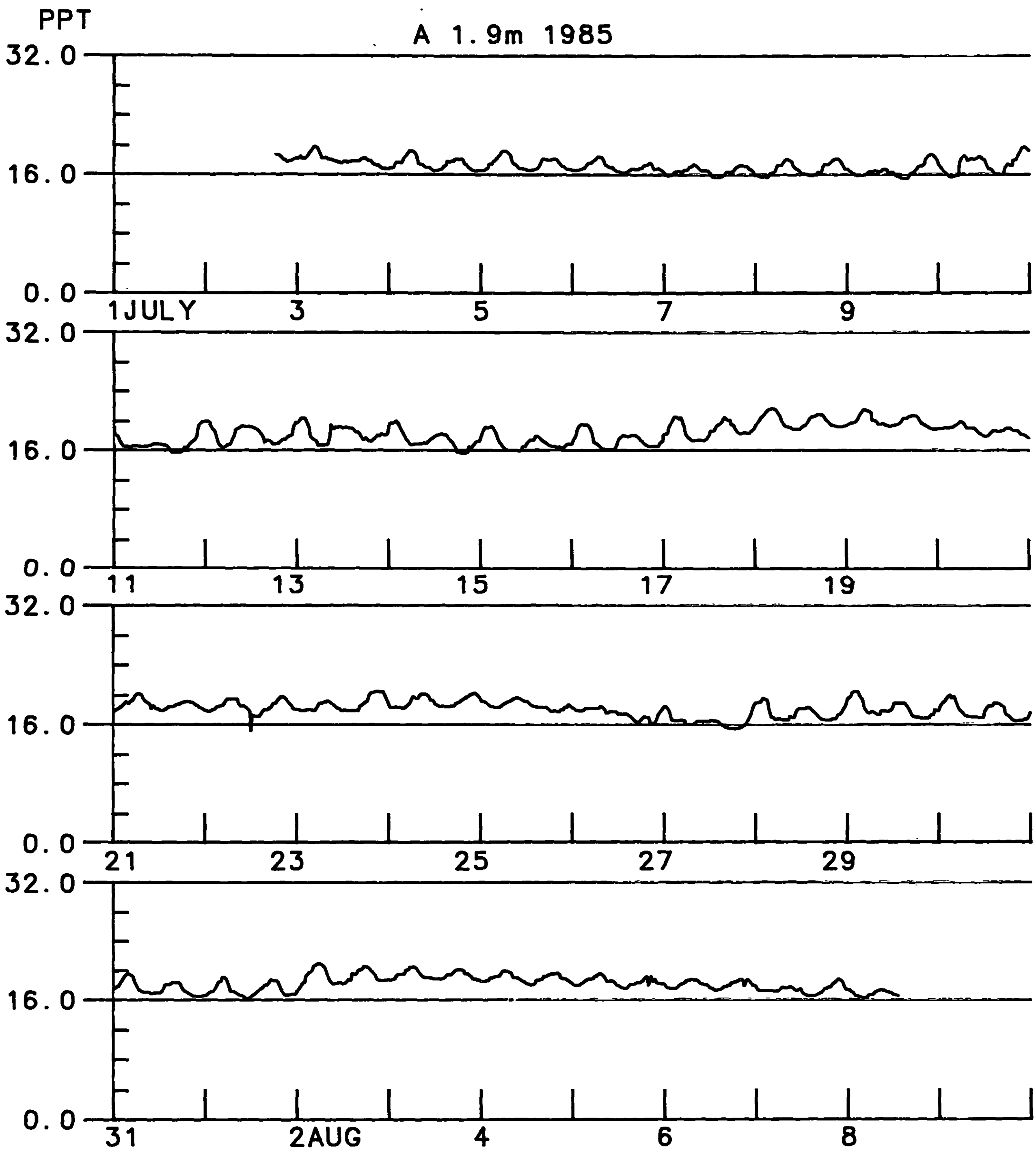
SURFACE ELEV. (M) VS. ELAPSED TIME (DAYS)
START 06/21/86 0000 EST
PIG POINT
RELATIVE TO NGVD
2
1.5
1
0.5
0
-0.5
-1
0
5
10
15
20
25
30

APPENDIX I

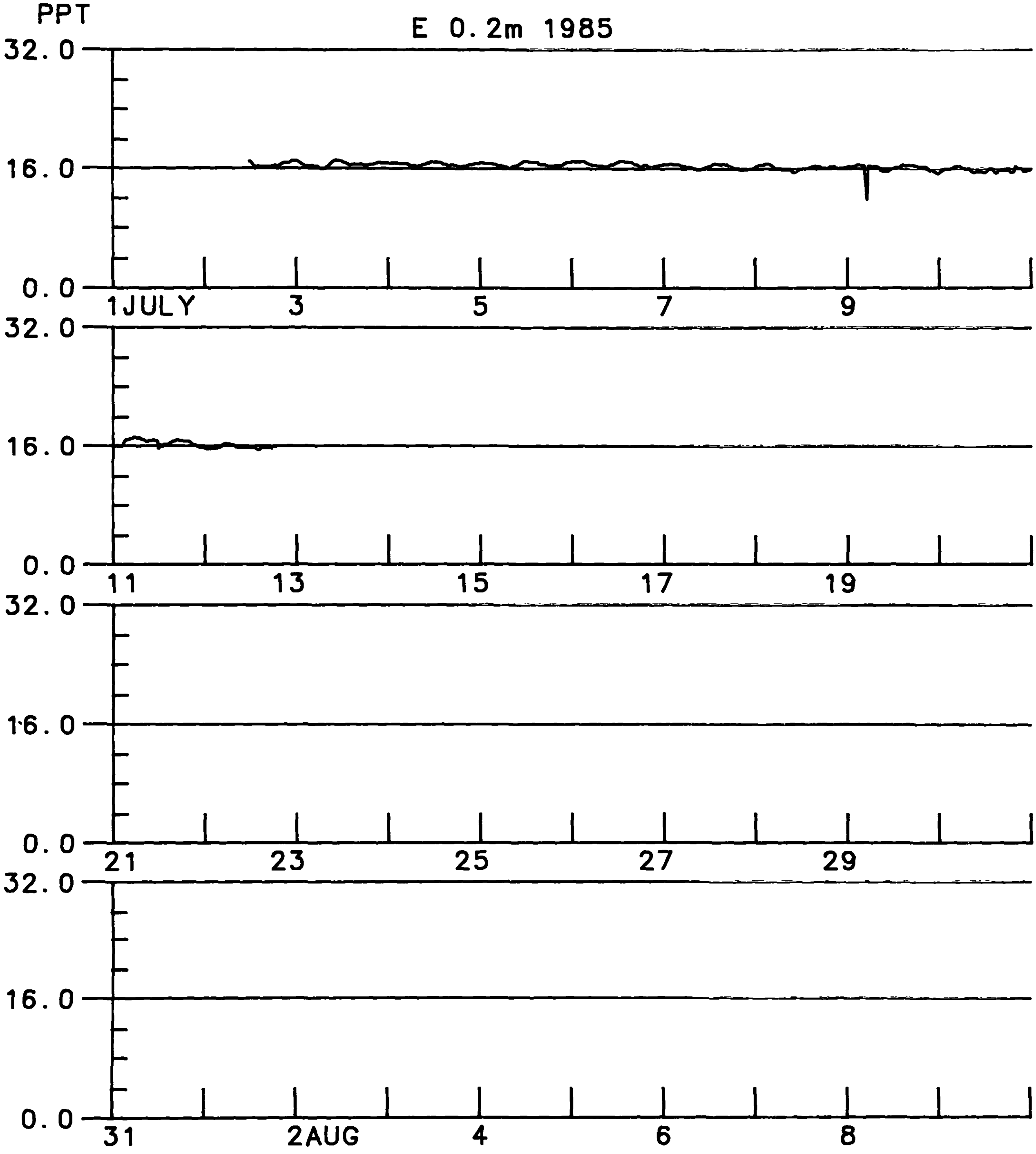
OBSERVED SALINITIES



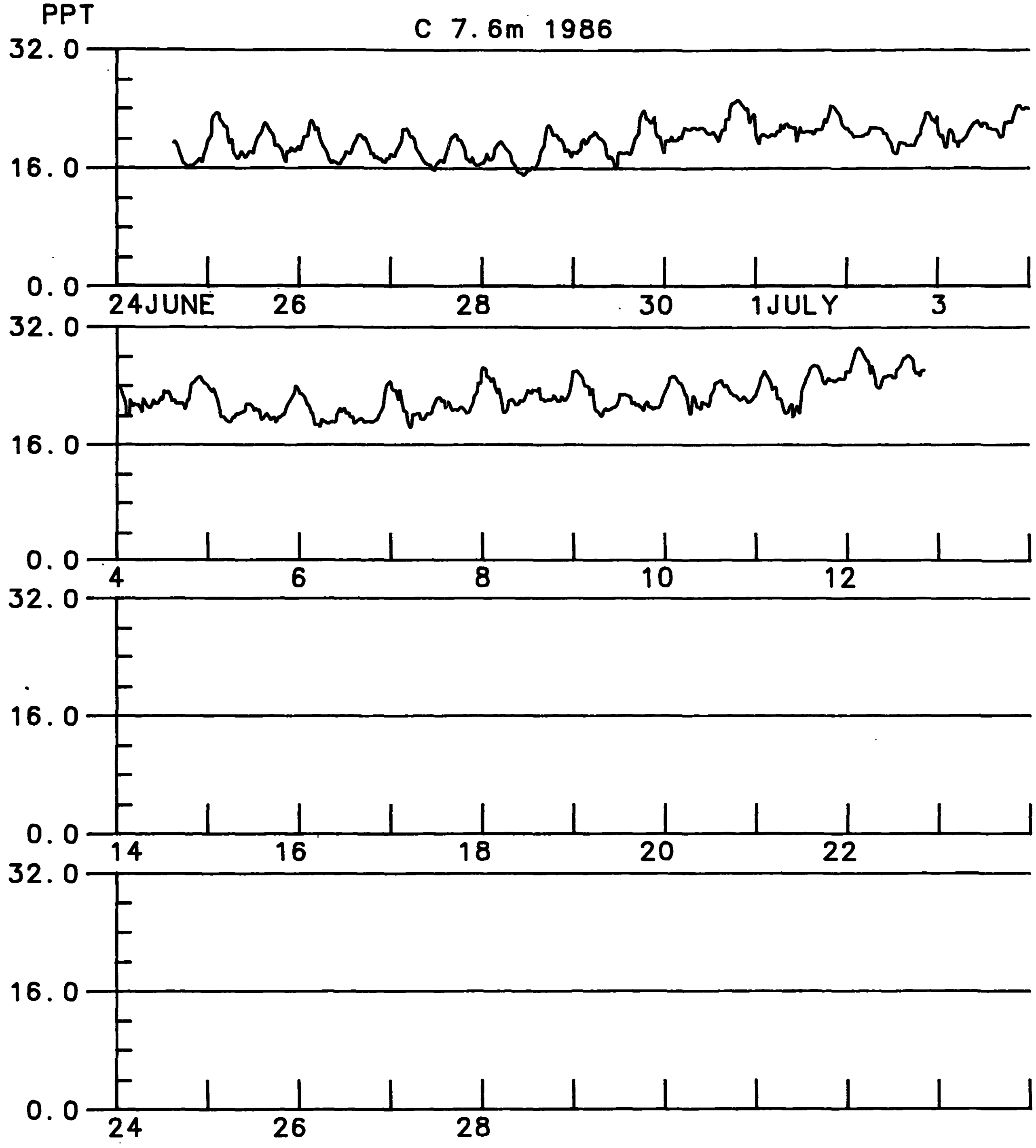
James River Bridge Station A, 0.7 m below surface



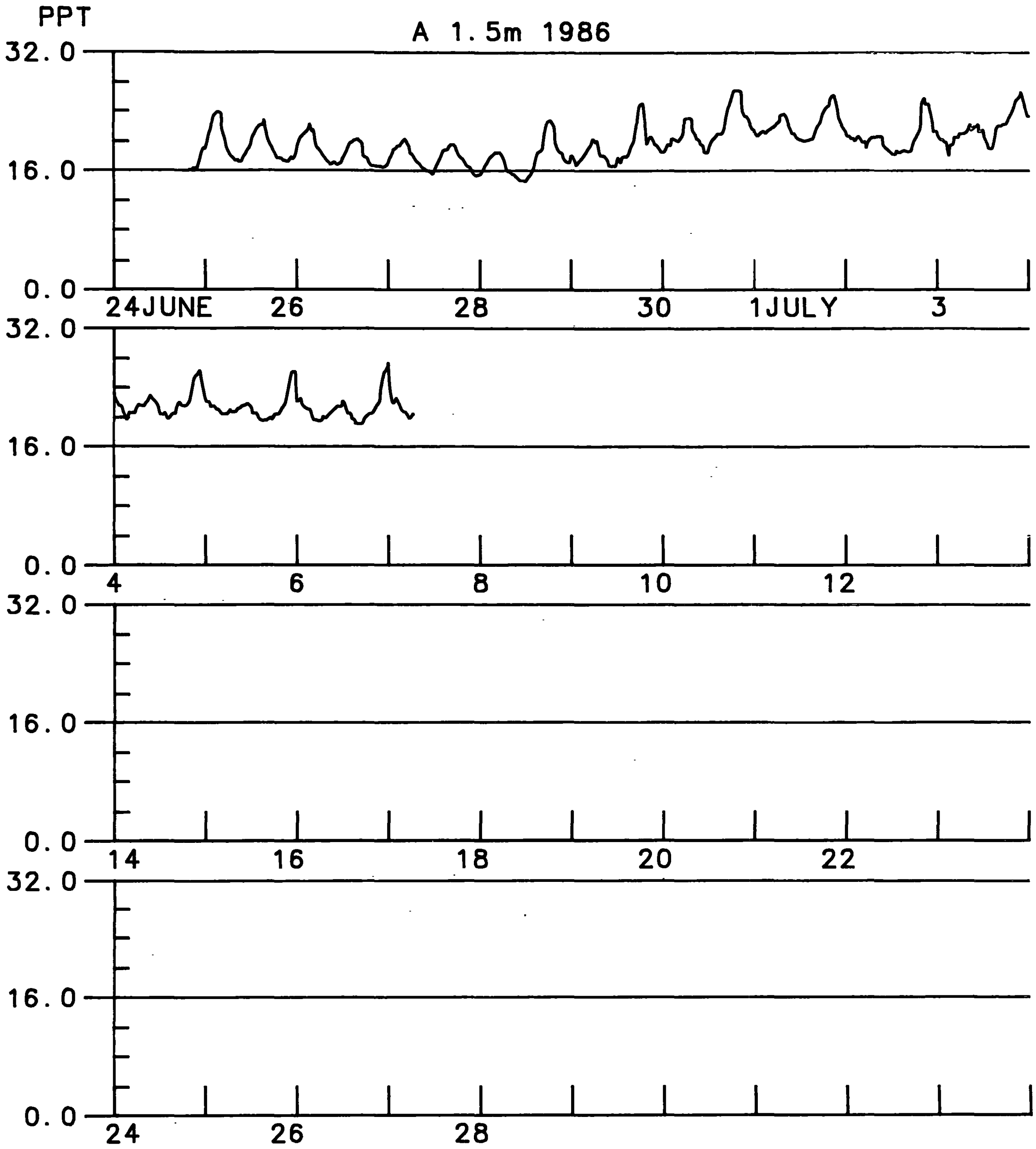
James River Bridge Station A, 1.9 m below surface



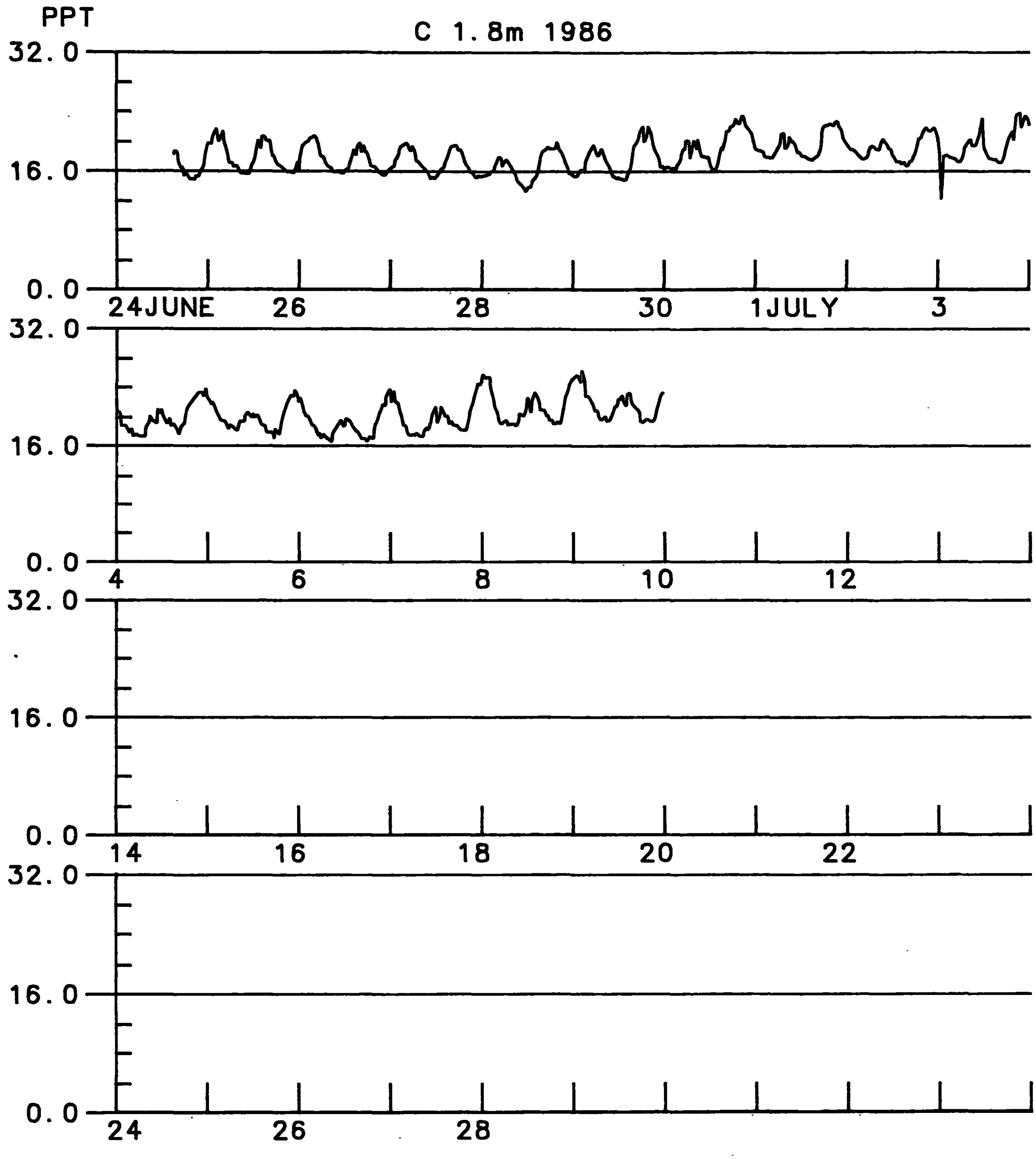
James River Bridge Station E, 0.2 m below surface



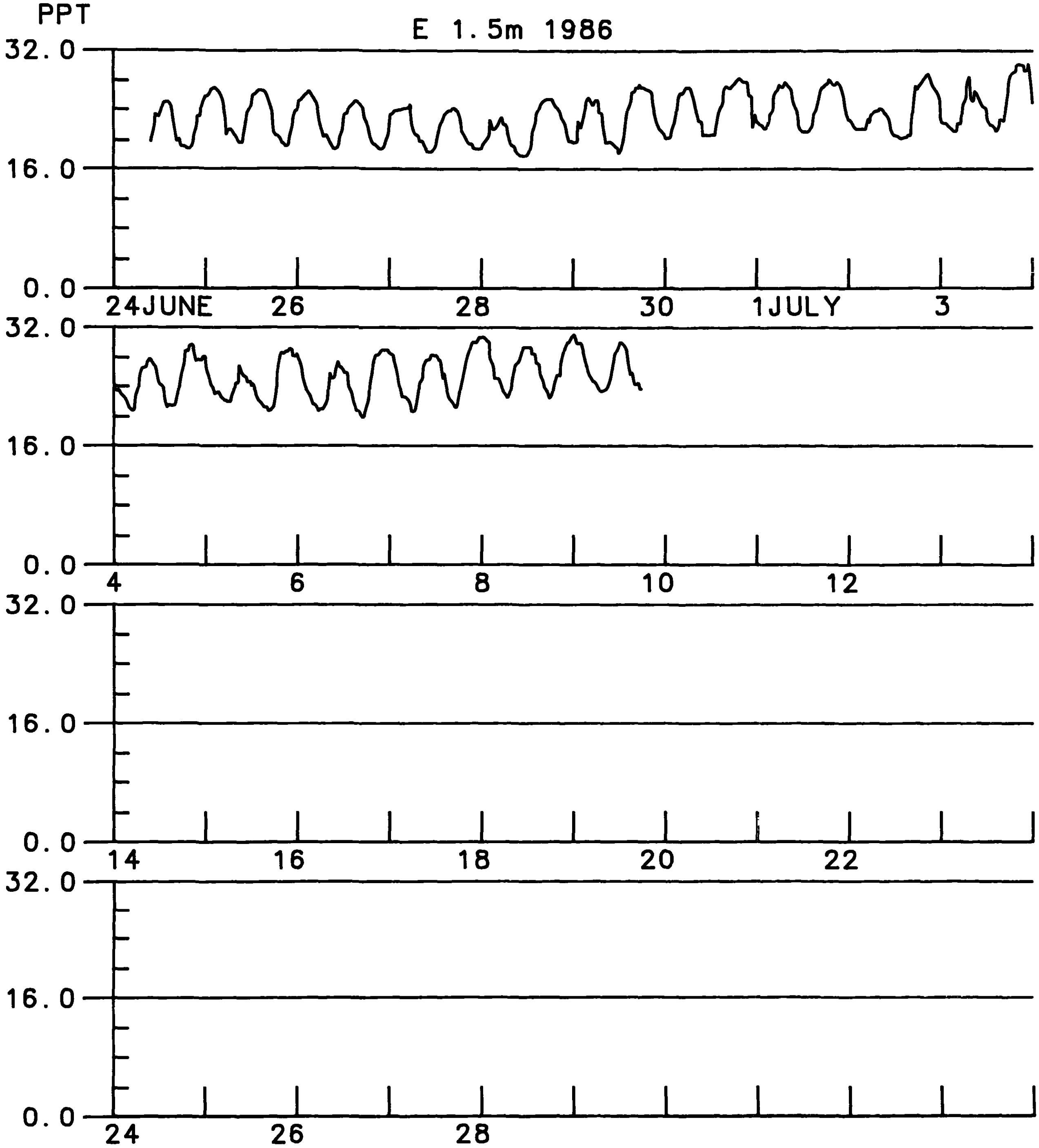
Burwell Bay Station C, 7.6 m below surface



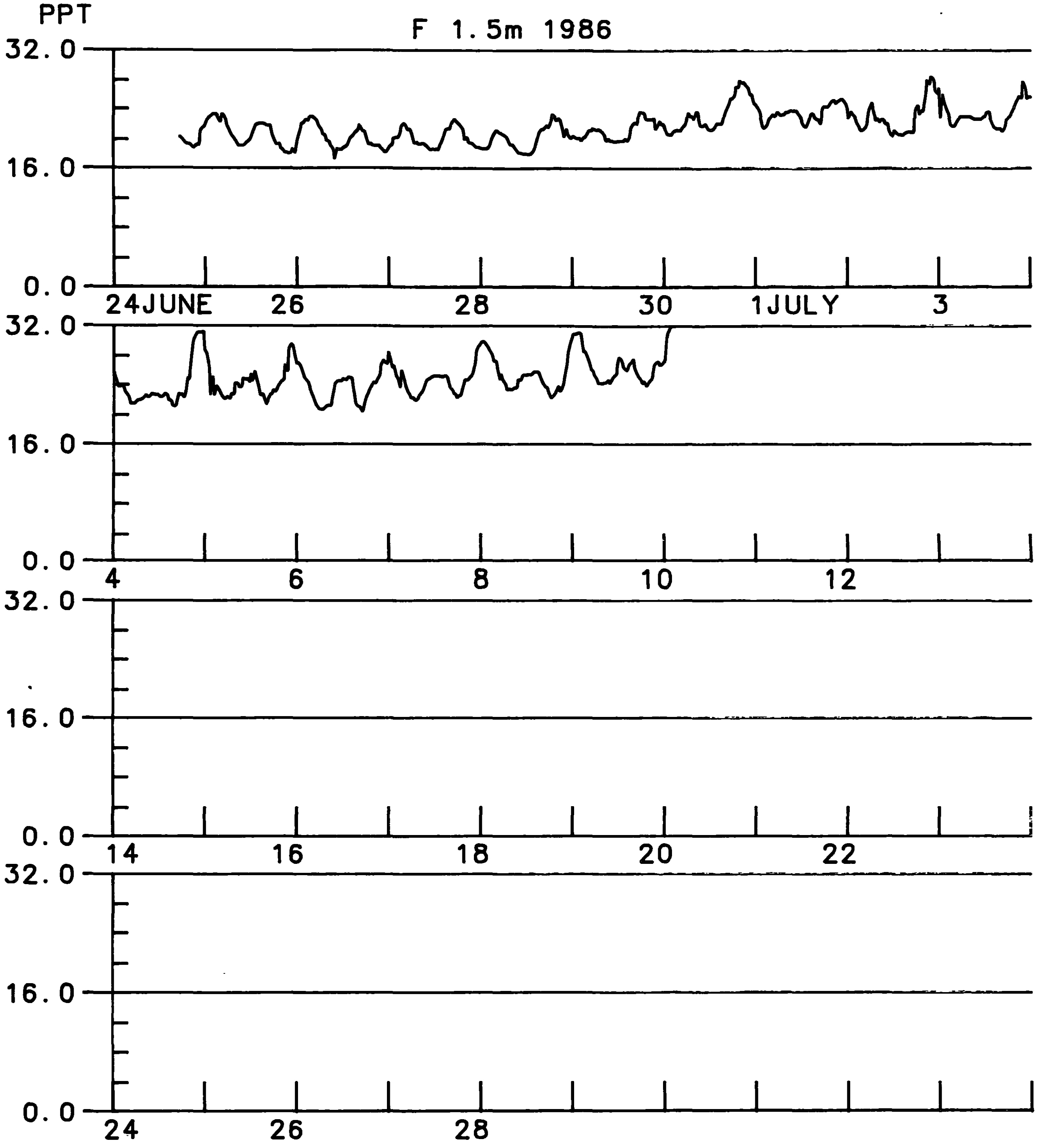
Burwell Bay Station C, 1.5 m below surface



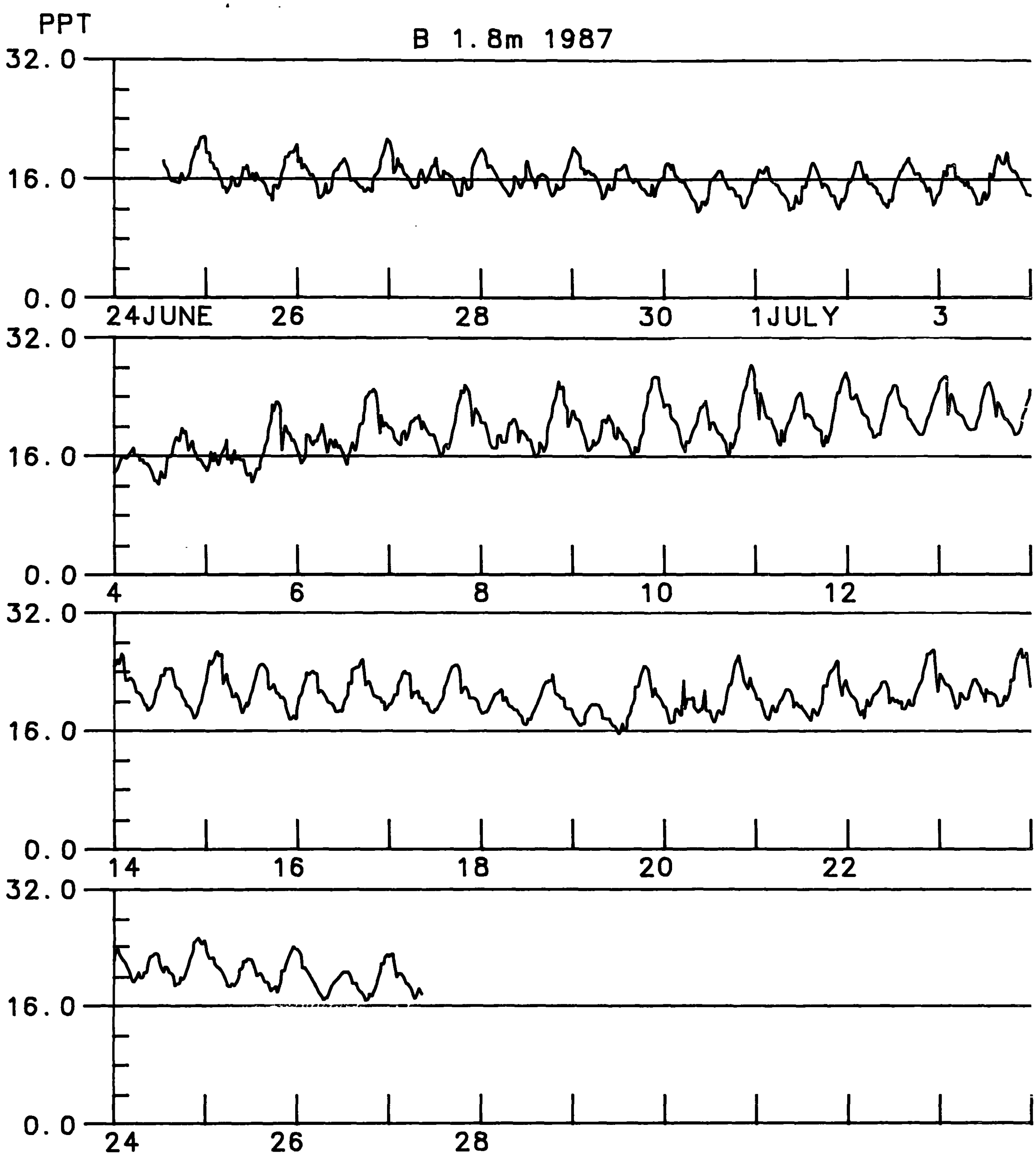
Burwell Bay Station C, 1.8 m below surface



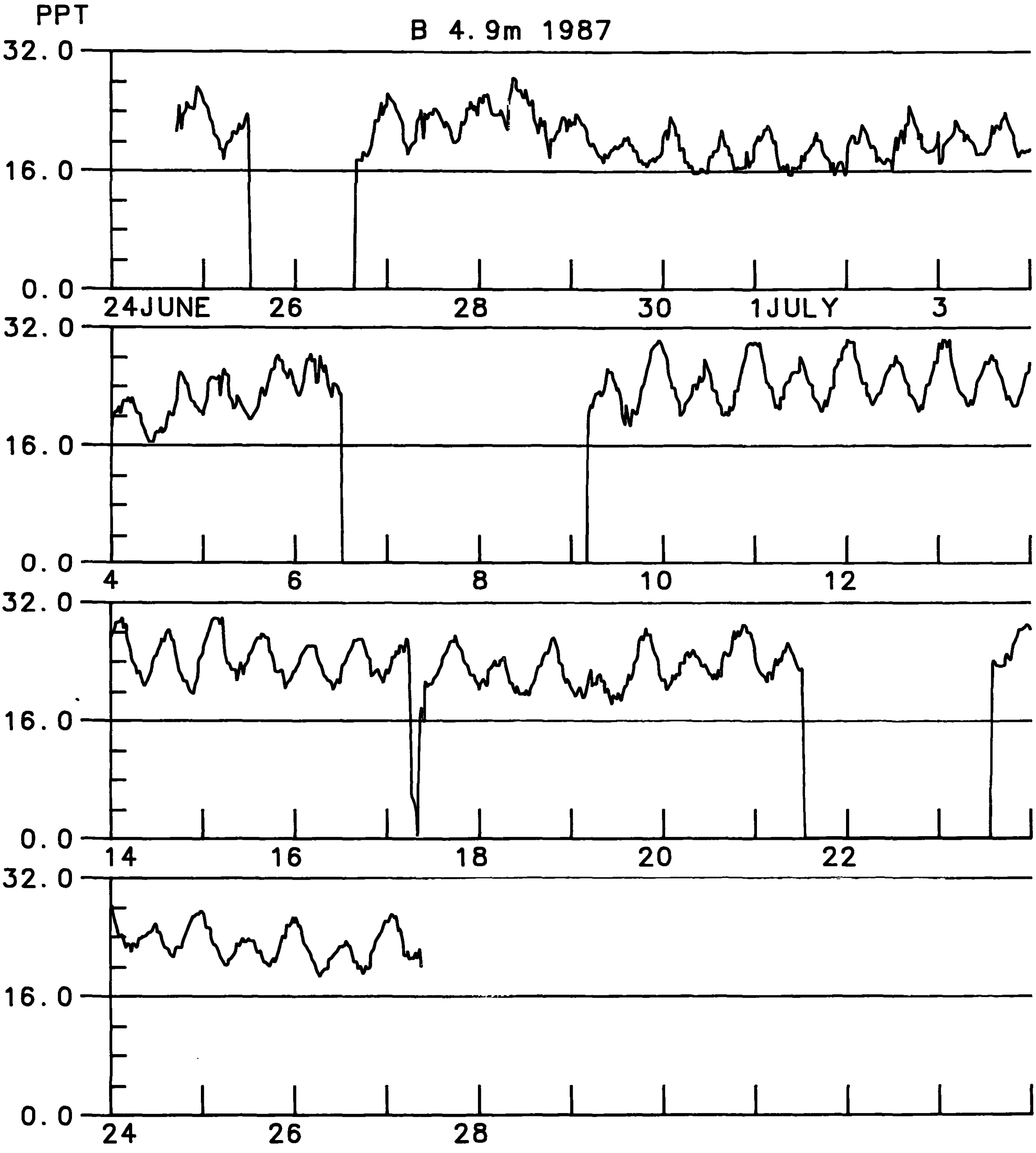
Burwell Bay Station E, 1.5 m below surface



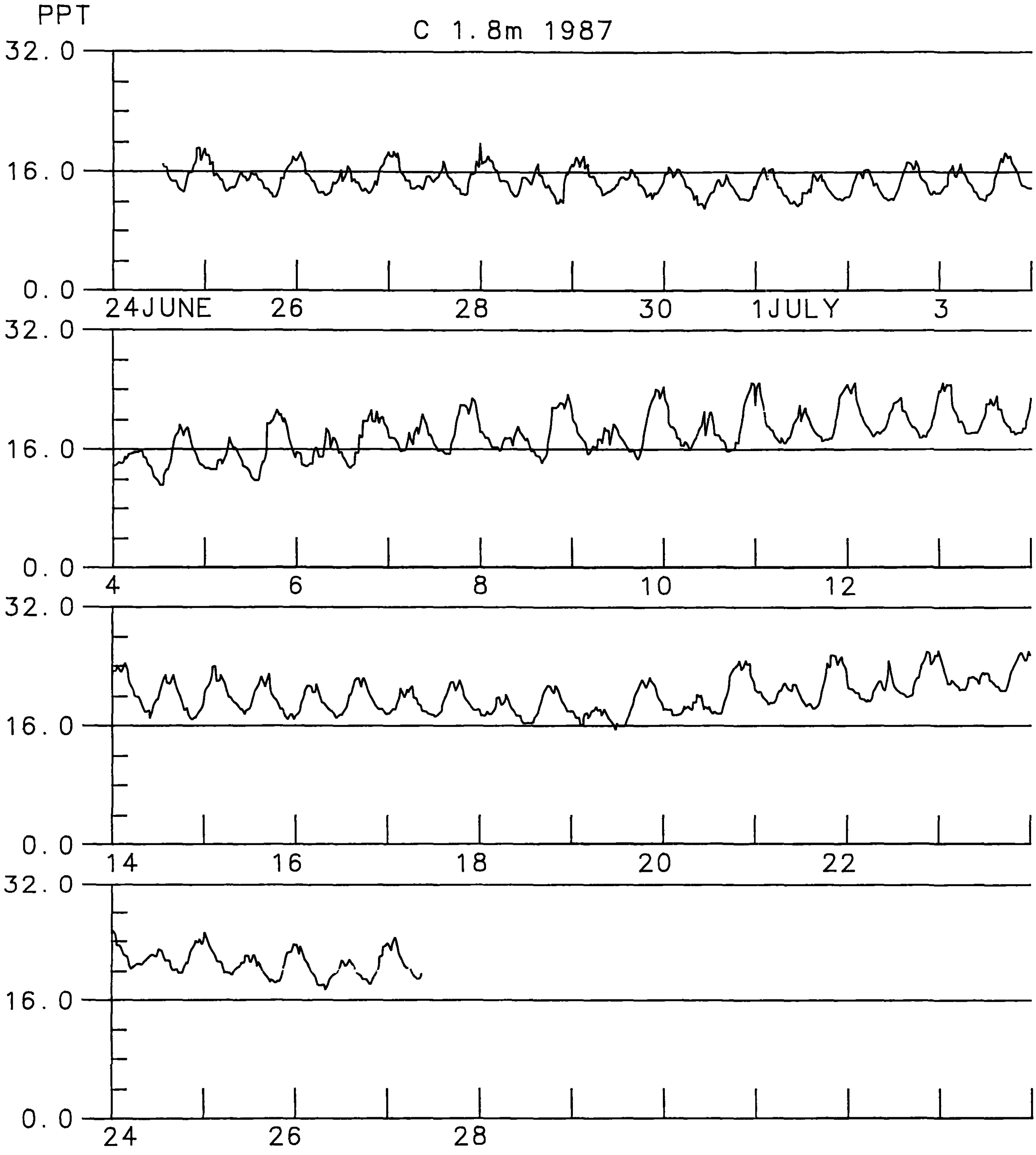
Burwell Bay Station F, 1.5 m below surface



Burwell Bay Station B, 1.8 m below surface



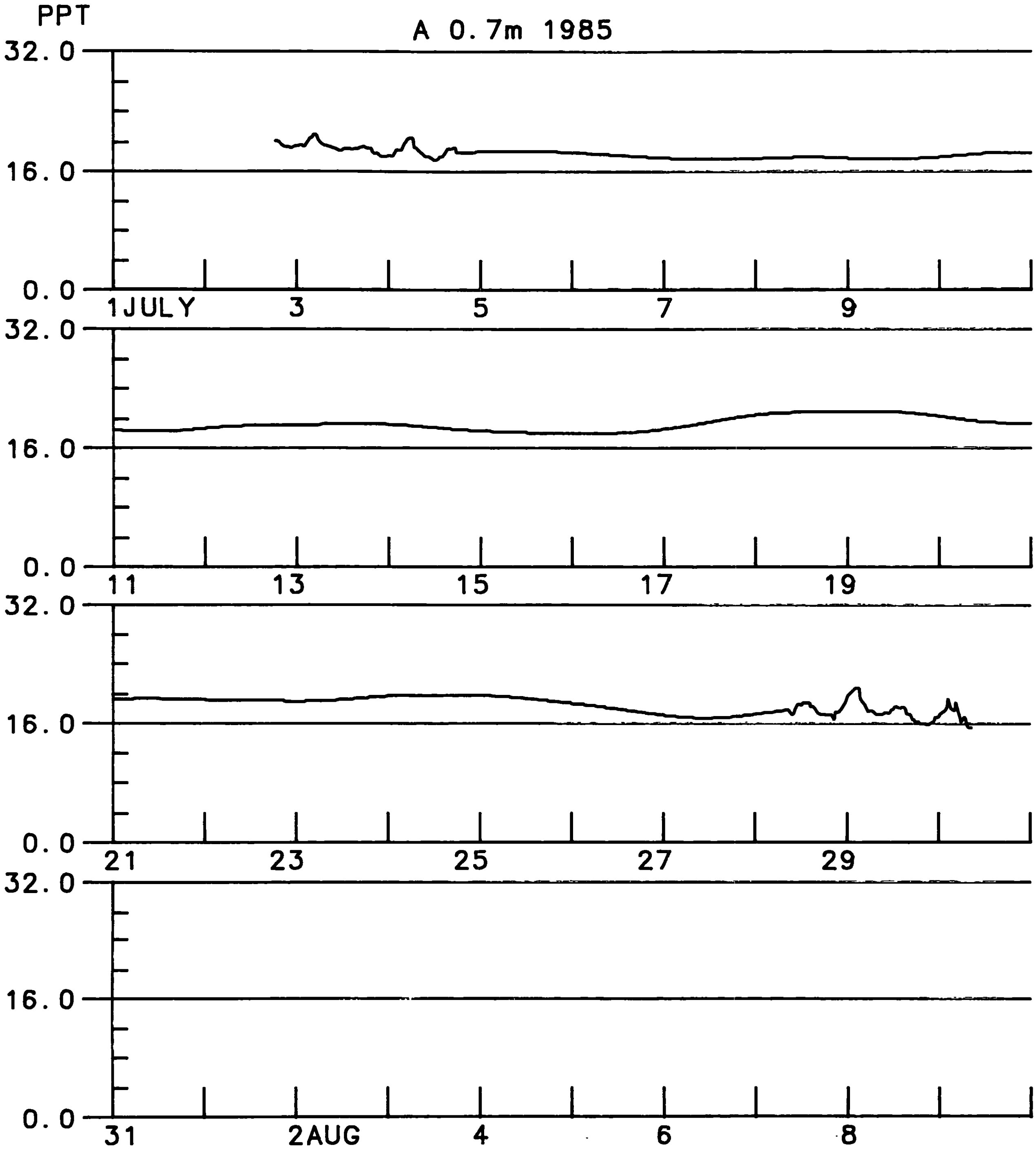
Burwell Bay Station B, 4.9 m below surface



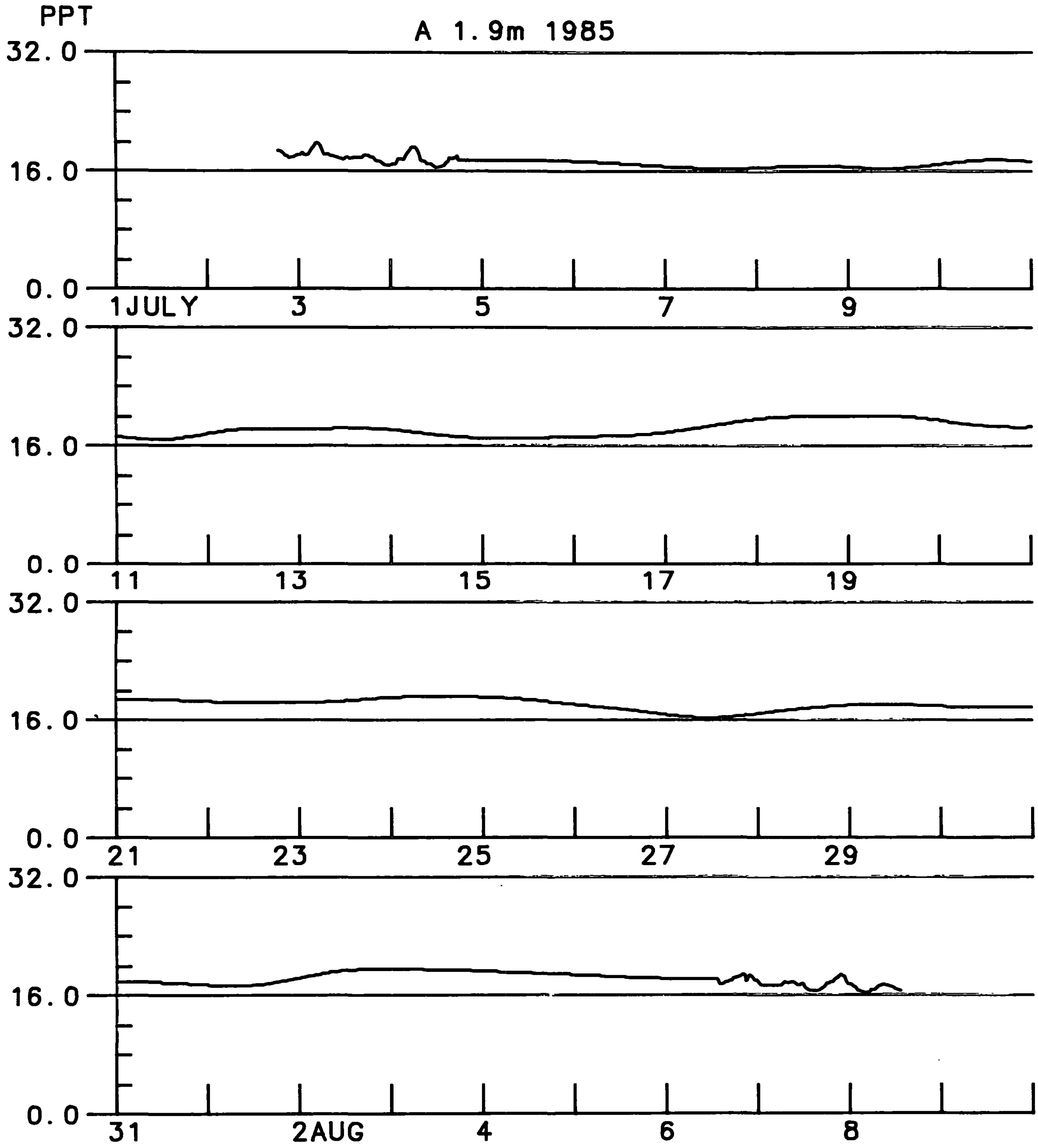
Burwell Bay Station C, 1.8 m below surface

APPENDIX J

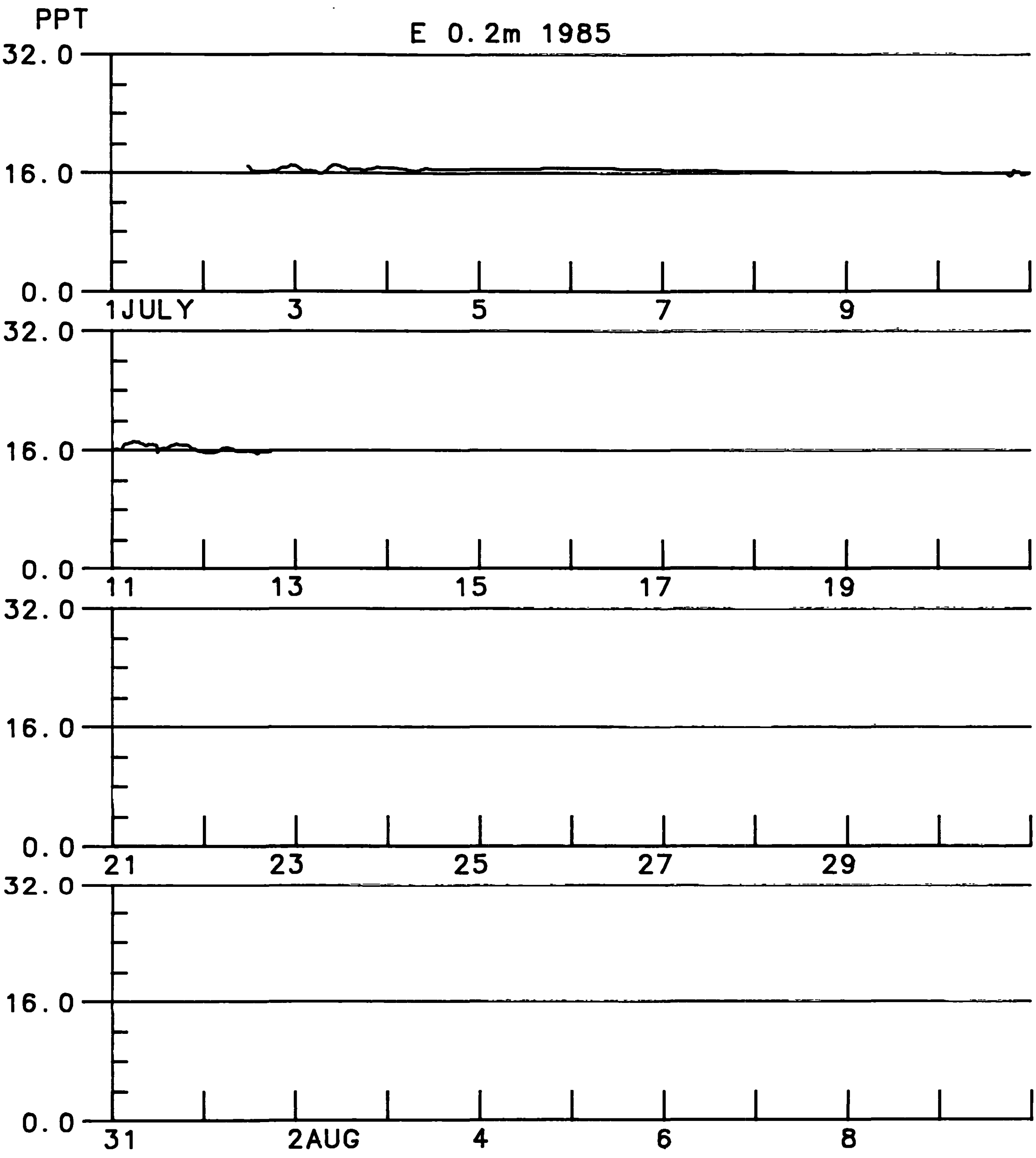
LOW PASS FILTERED SALINITIES



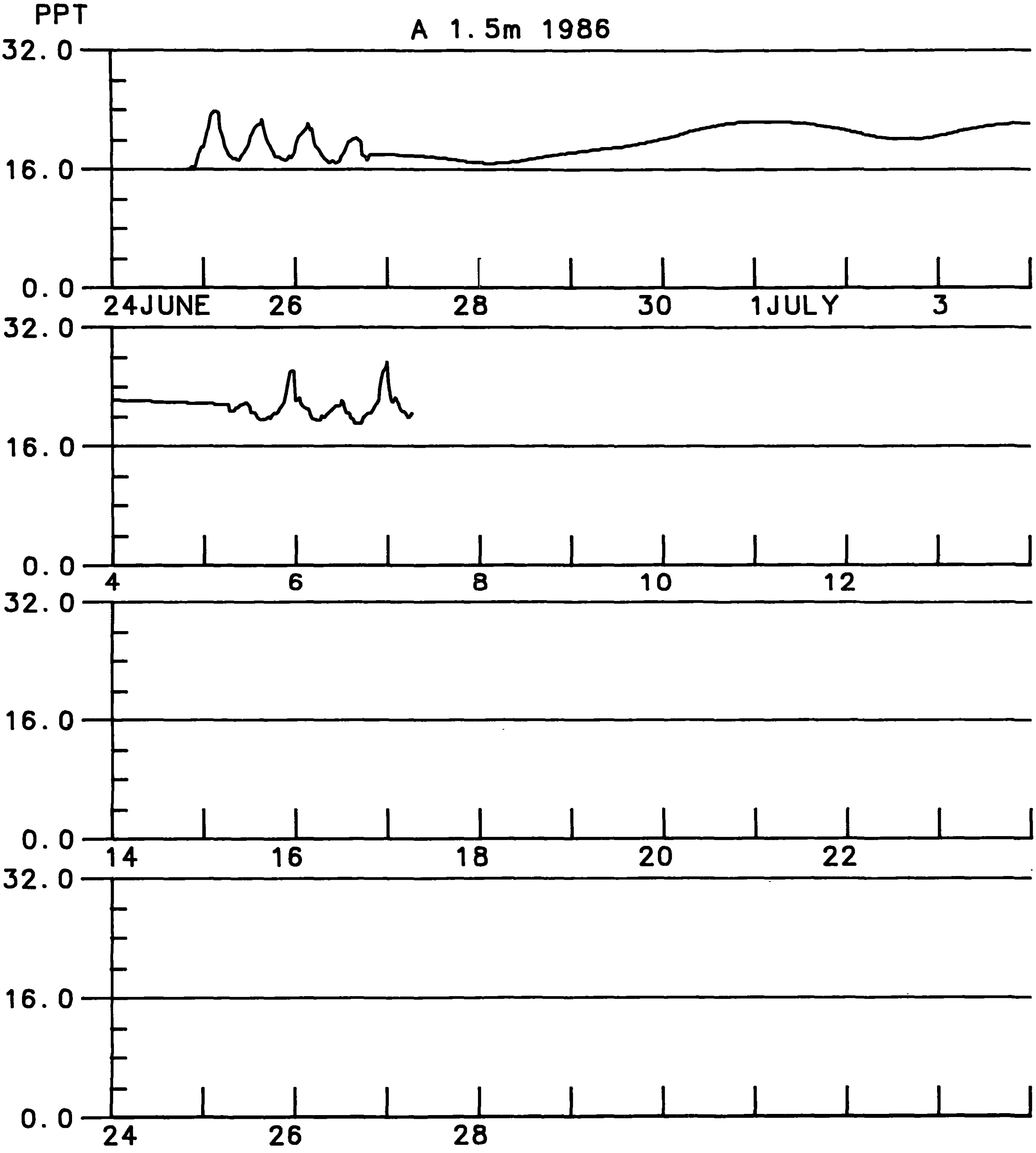
James River Bridge Station A, 0.7 m below surface



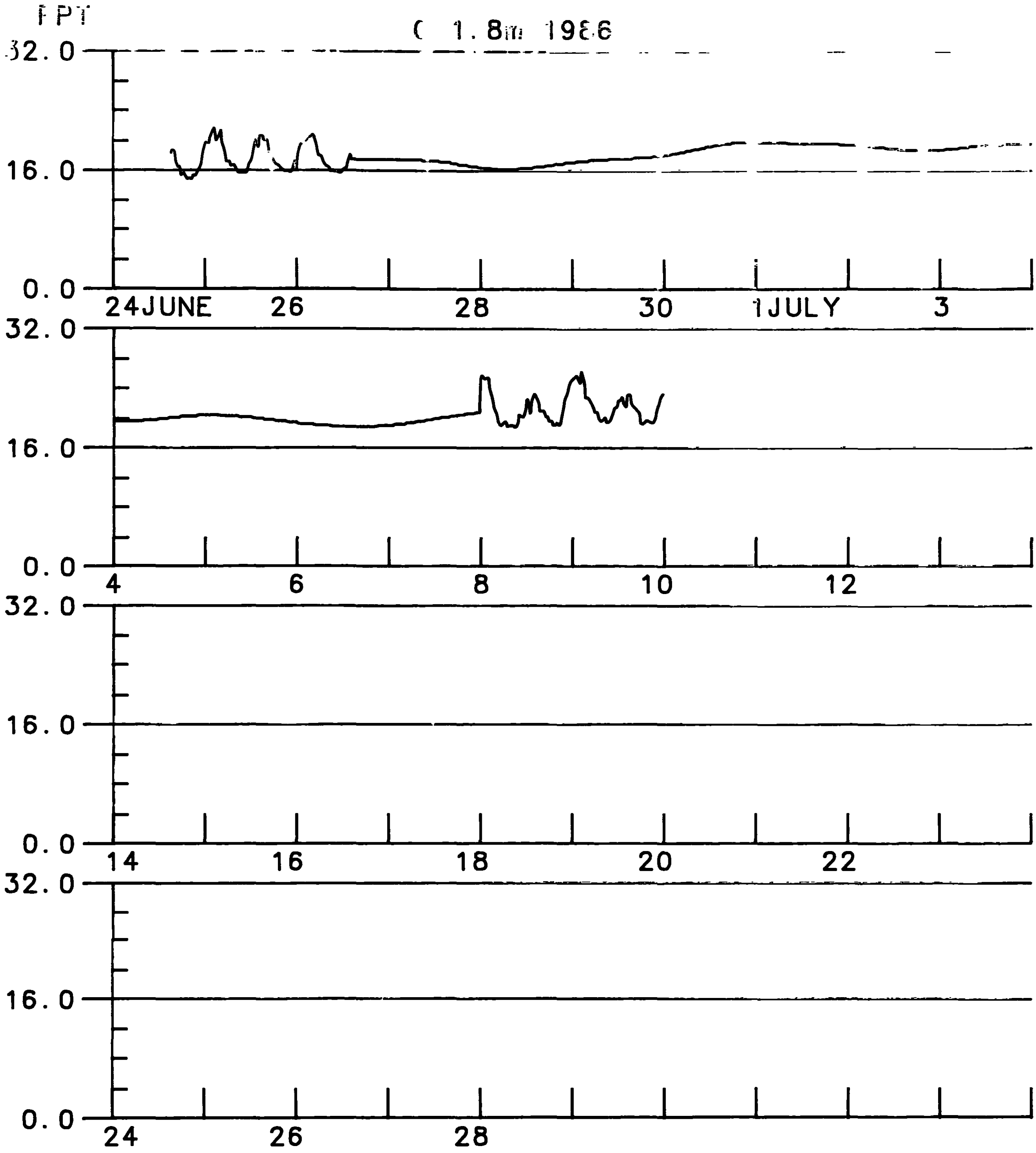
James River Bridge Station A, 1.9 m below surface



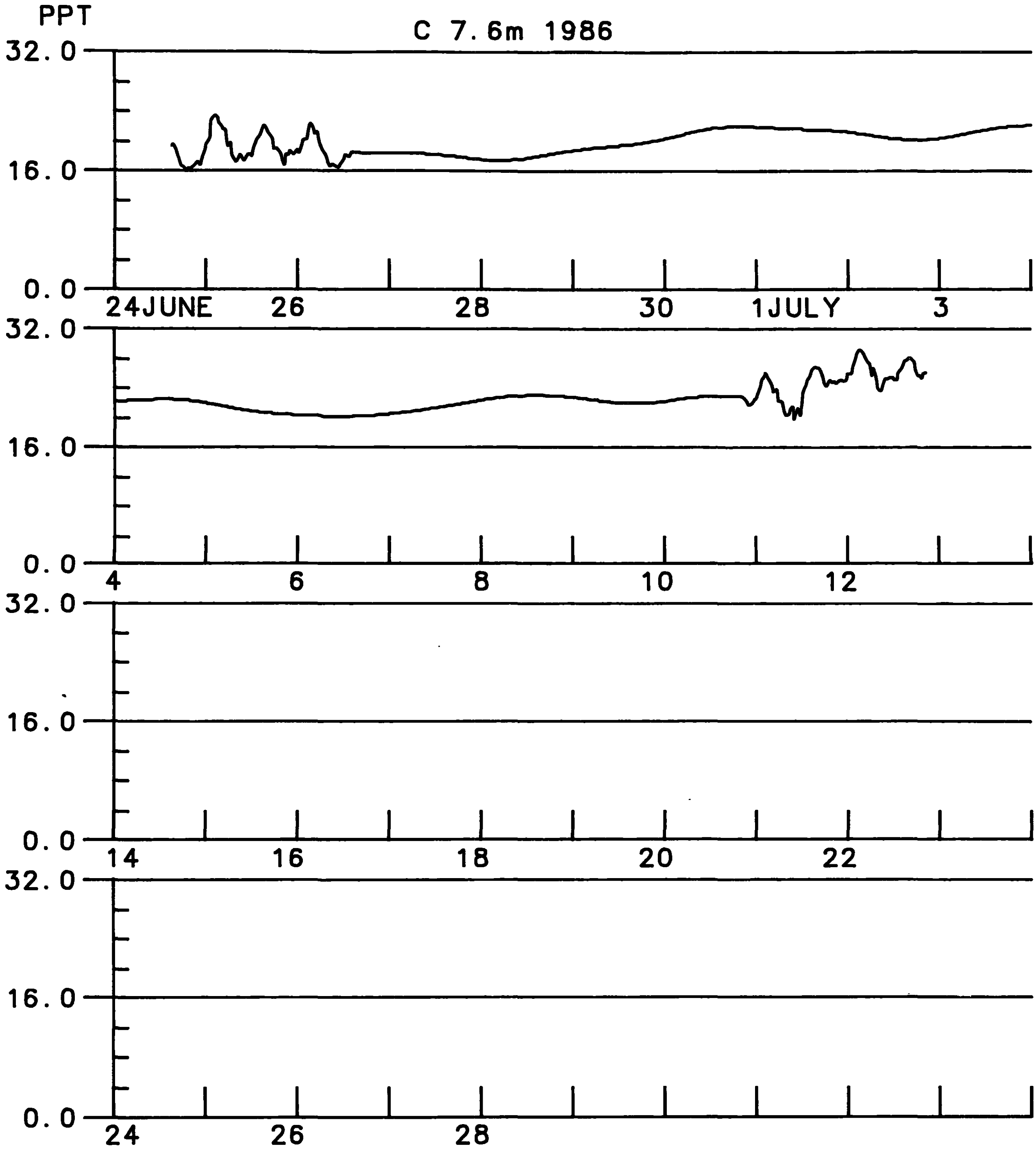
James River Bridge Station E, 0.2 m below surface



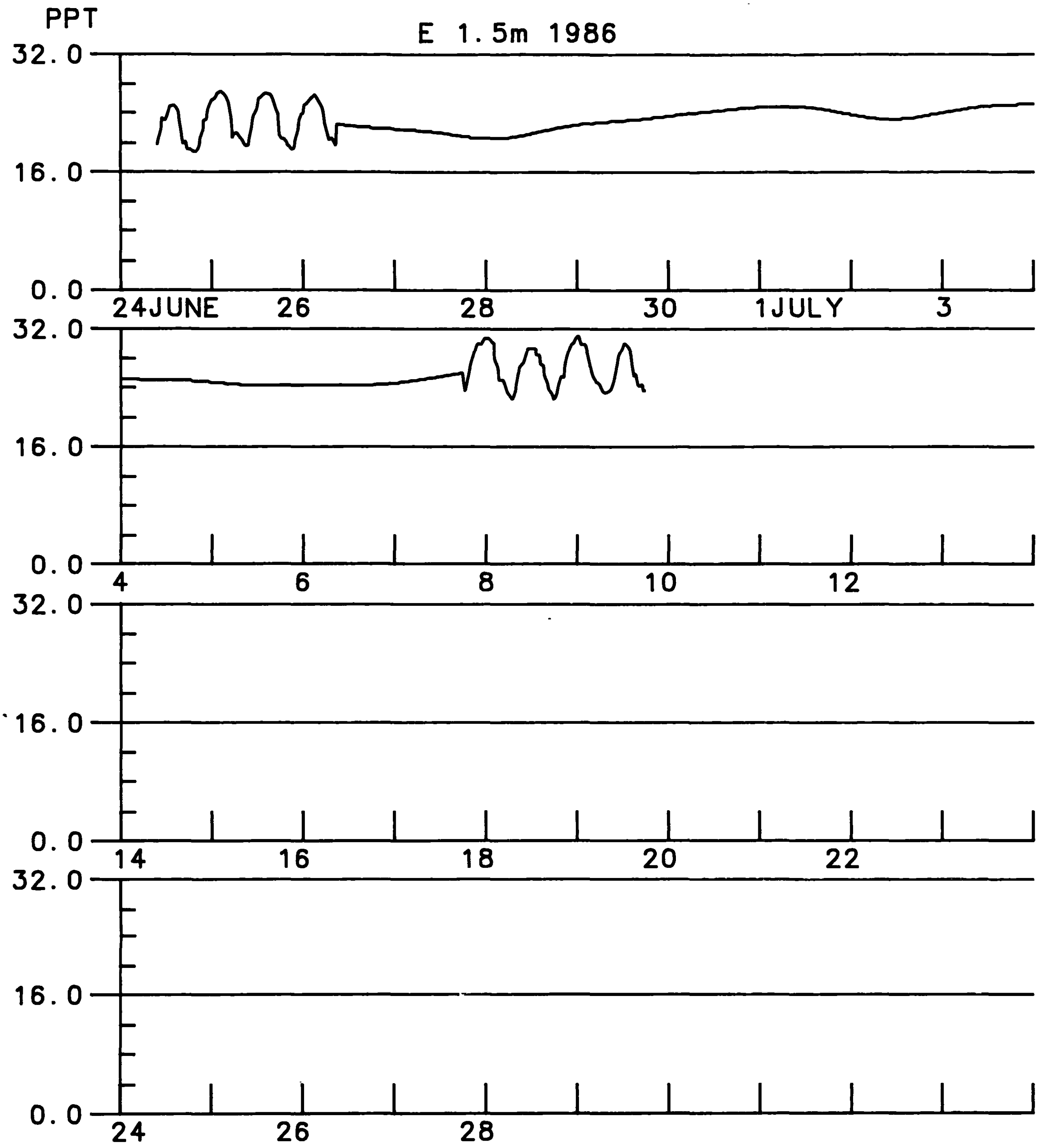
Burwell Bay Station A, 1.5 m below surface



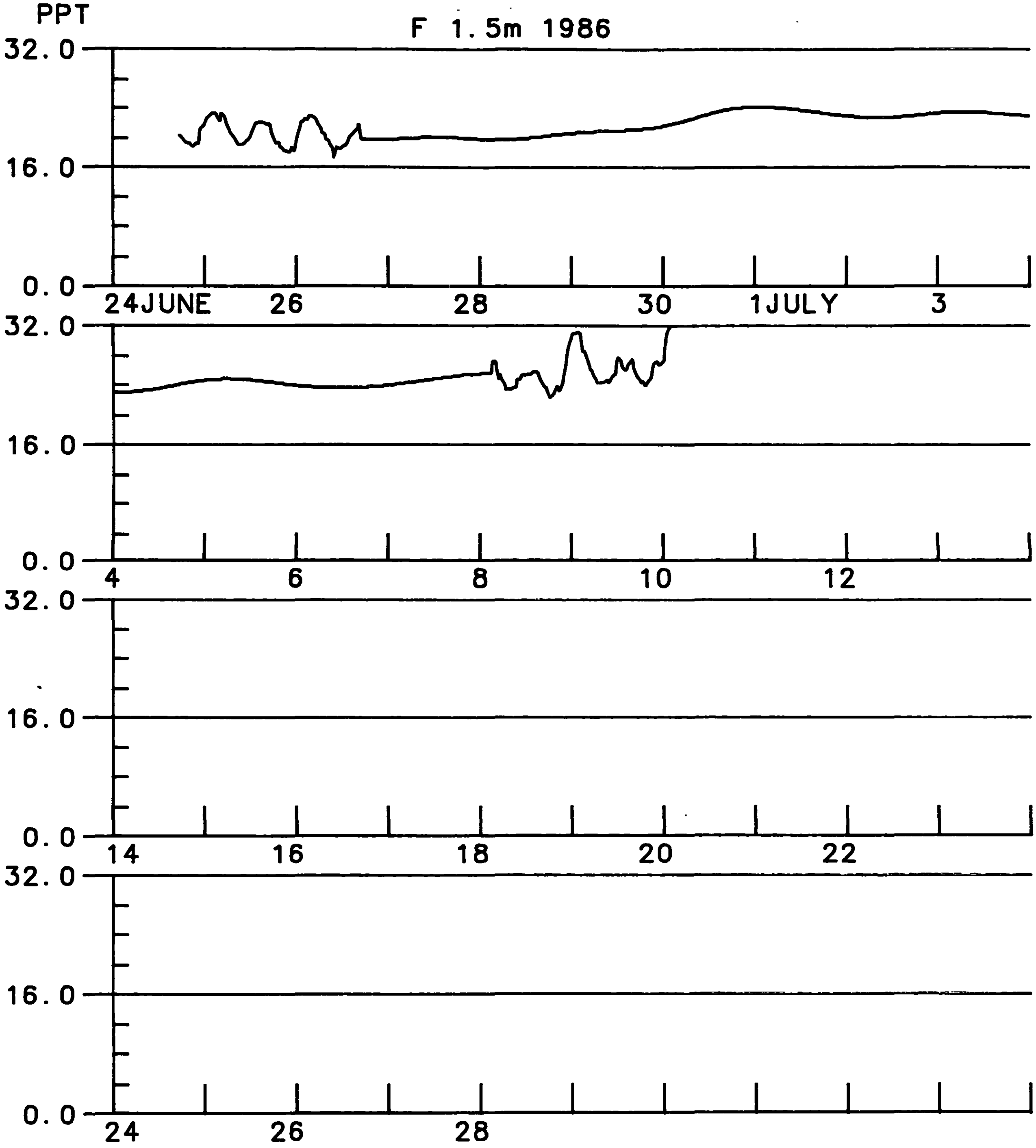
Burwell Bay Station C, 1.8 m below surface



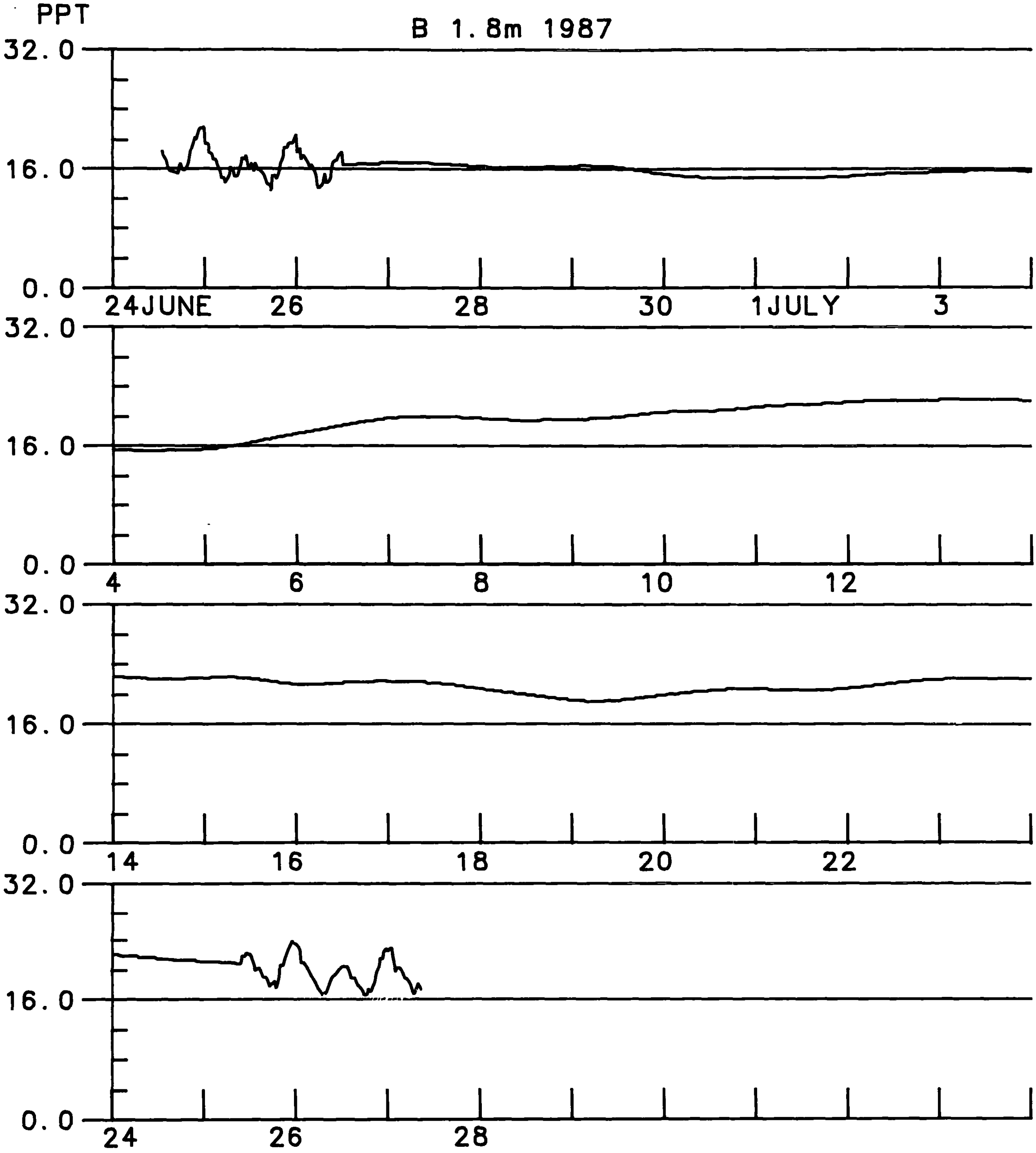
Burwell Bay Station C, 7.6 m below surface



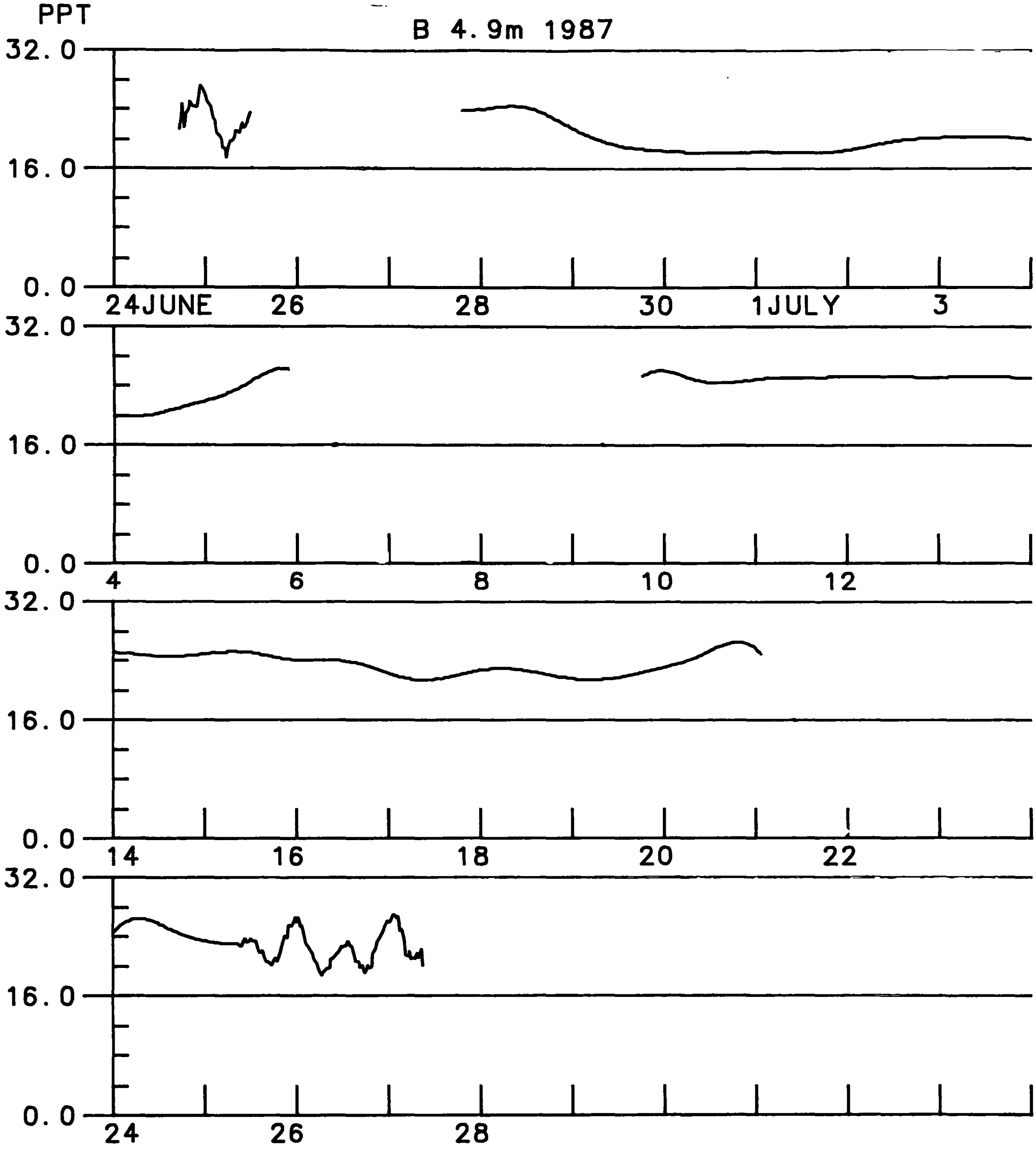
Burwell Bay Station E, 1.5 m below surface



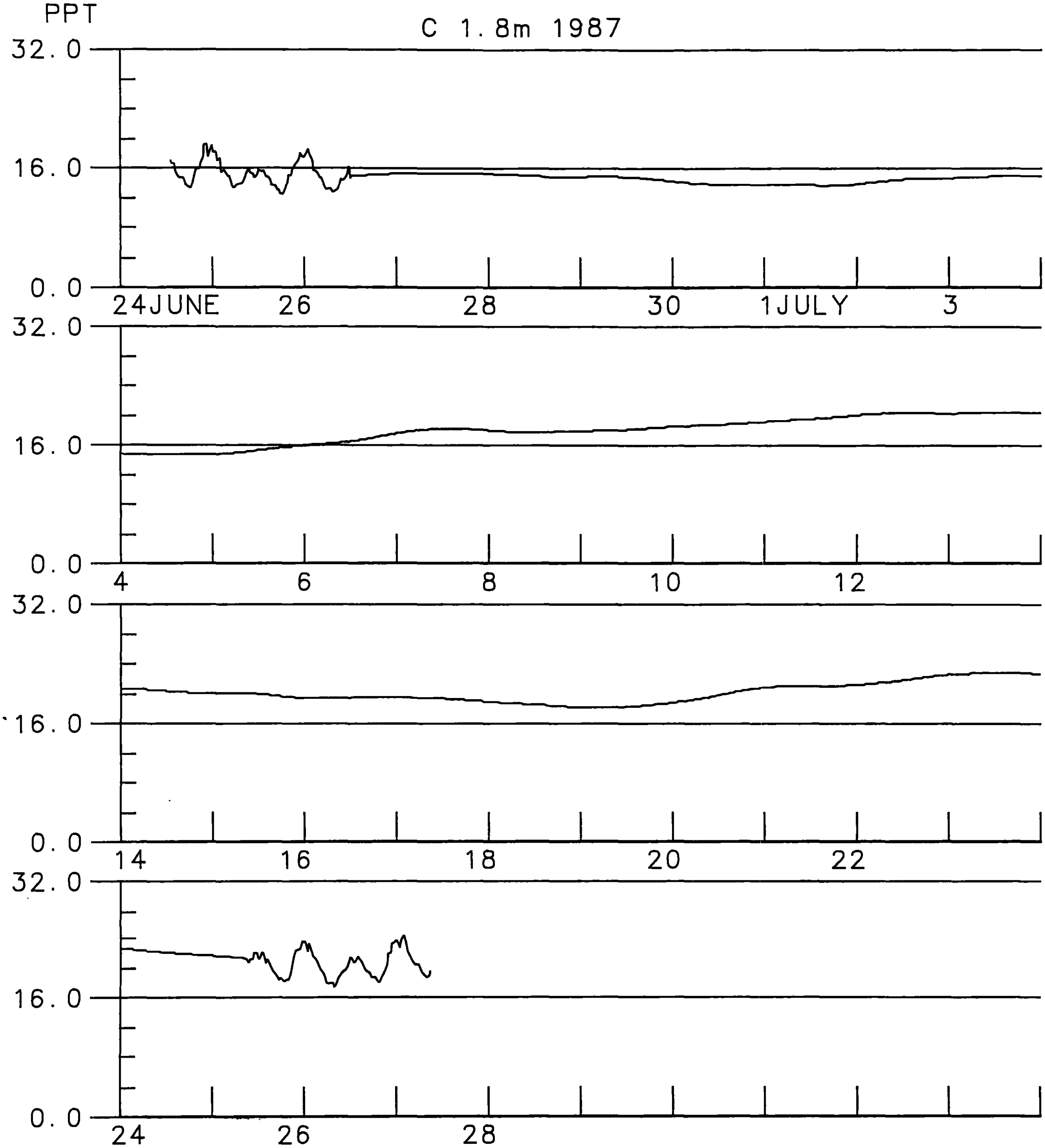
Burwell Bay Station F, 1.5 m below surface



Burwell Bay Station B, 1.8 m below surface



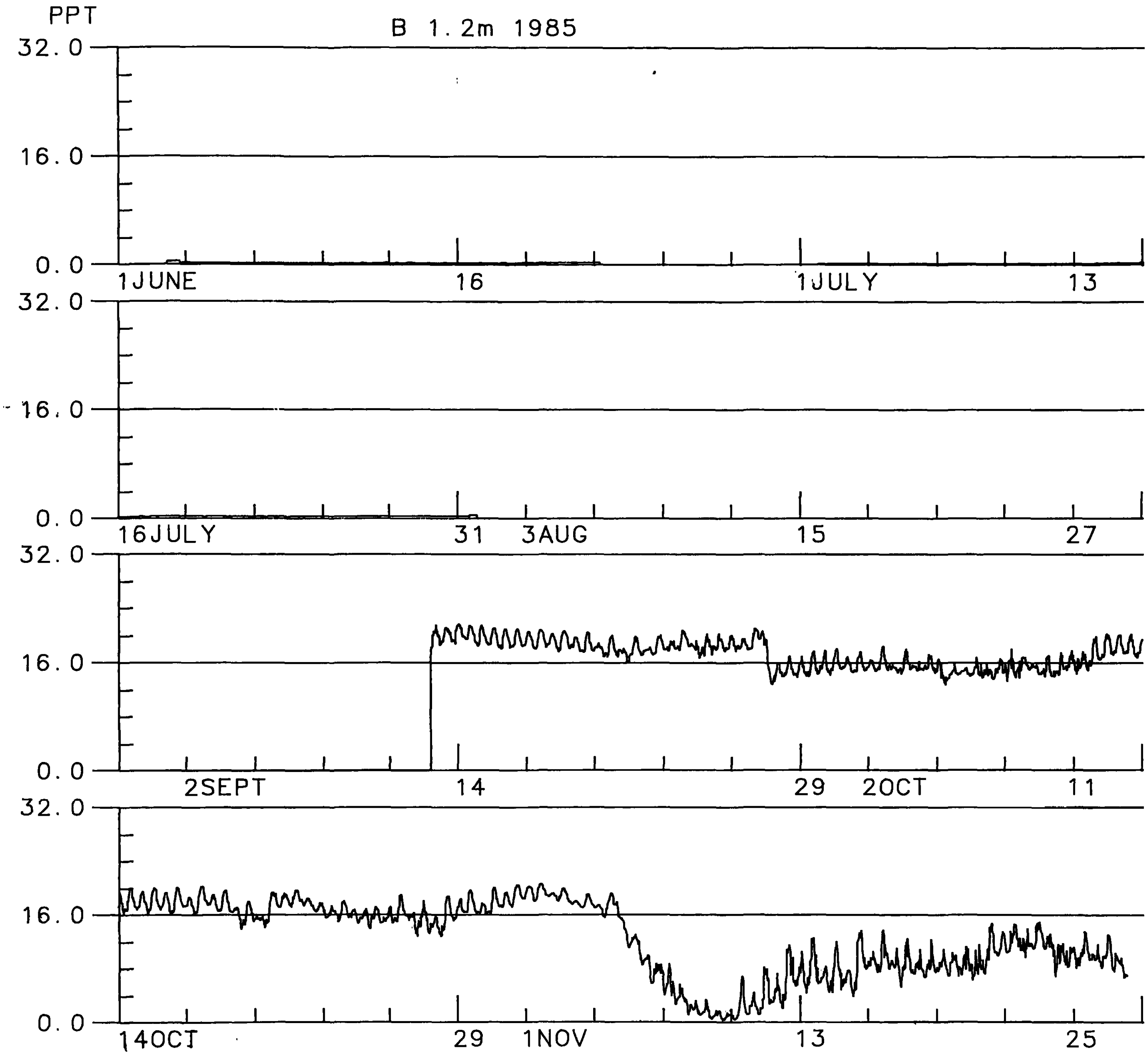
Burwell Bay Station B, 4.9 m below surface



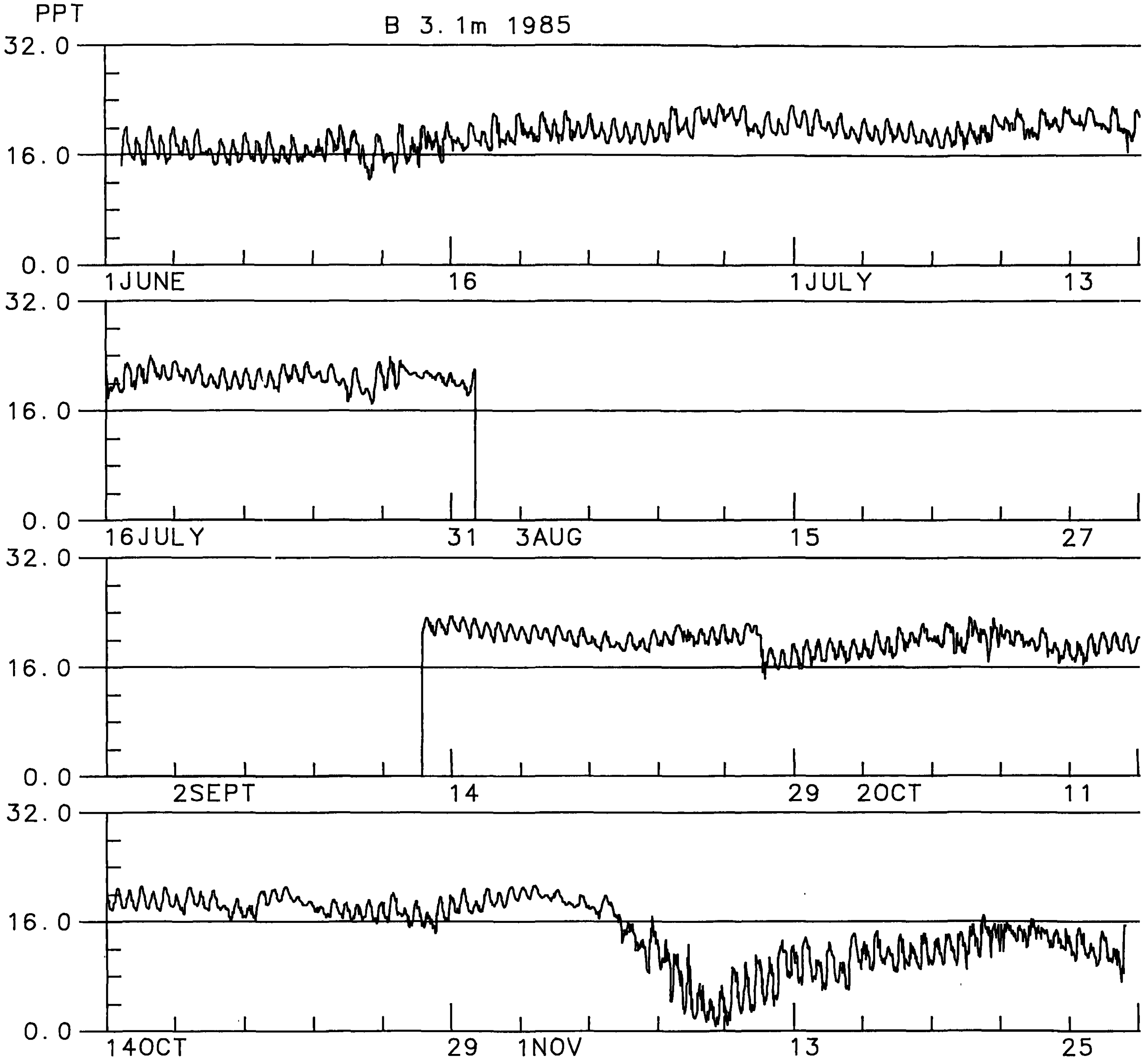
Burwell Bay Station C, 1.8 m below surface

APPENDIX K

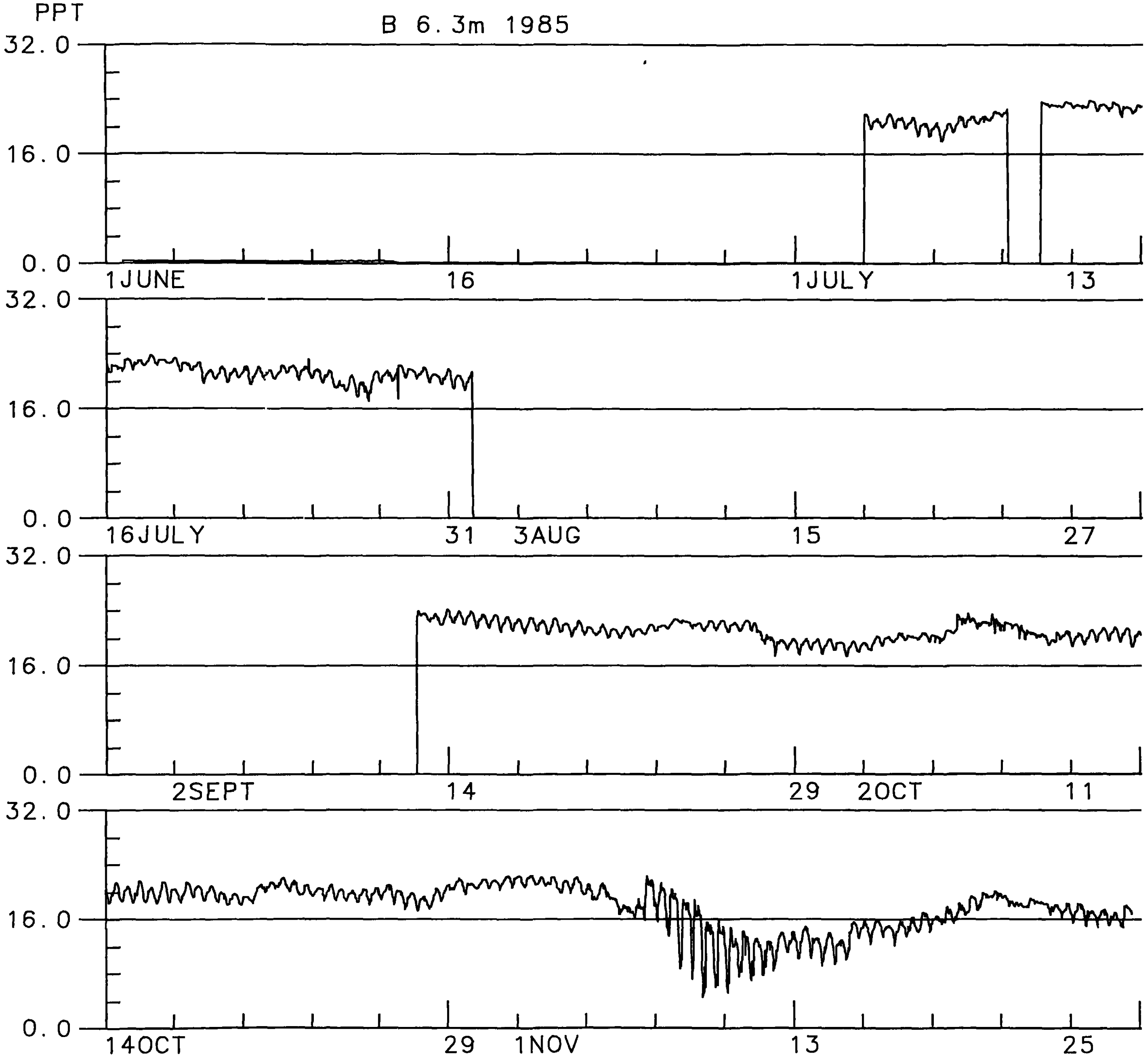
SALINITIES AT STATION B
(JAMES RIVER BRIDGE TRANSECT)
JUNE THROUGH NOVEMBER 1985



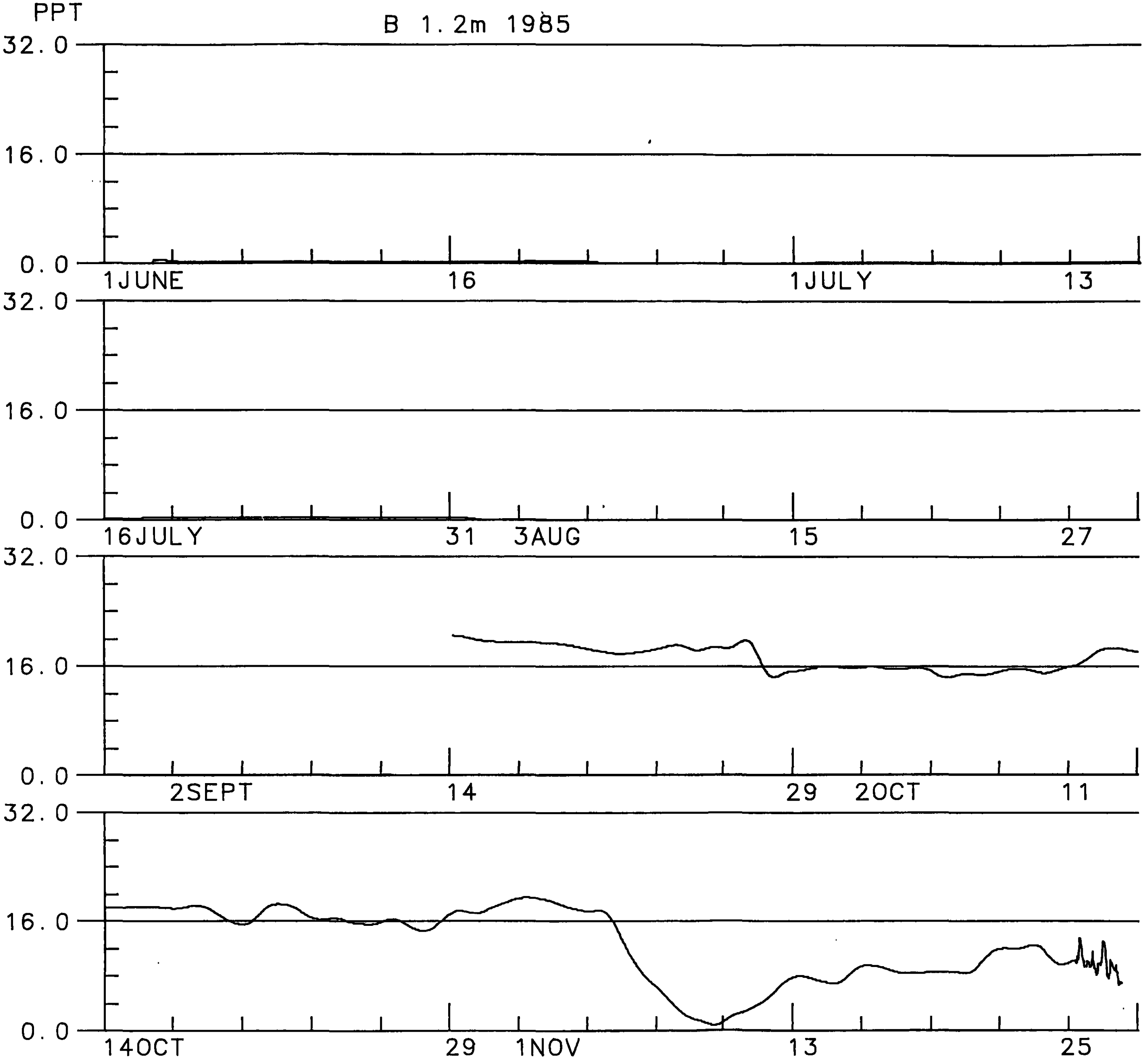
Salinity at 1.2 m below surface



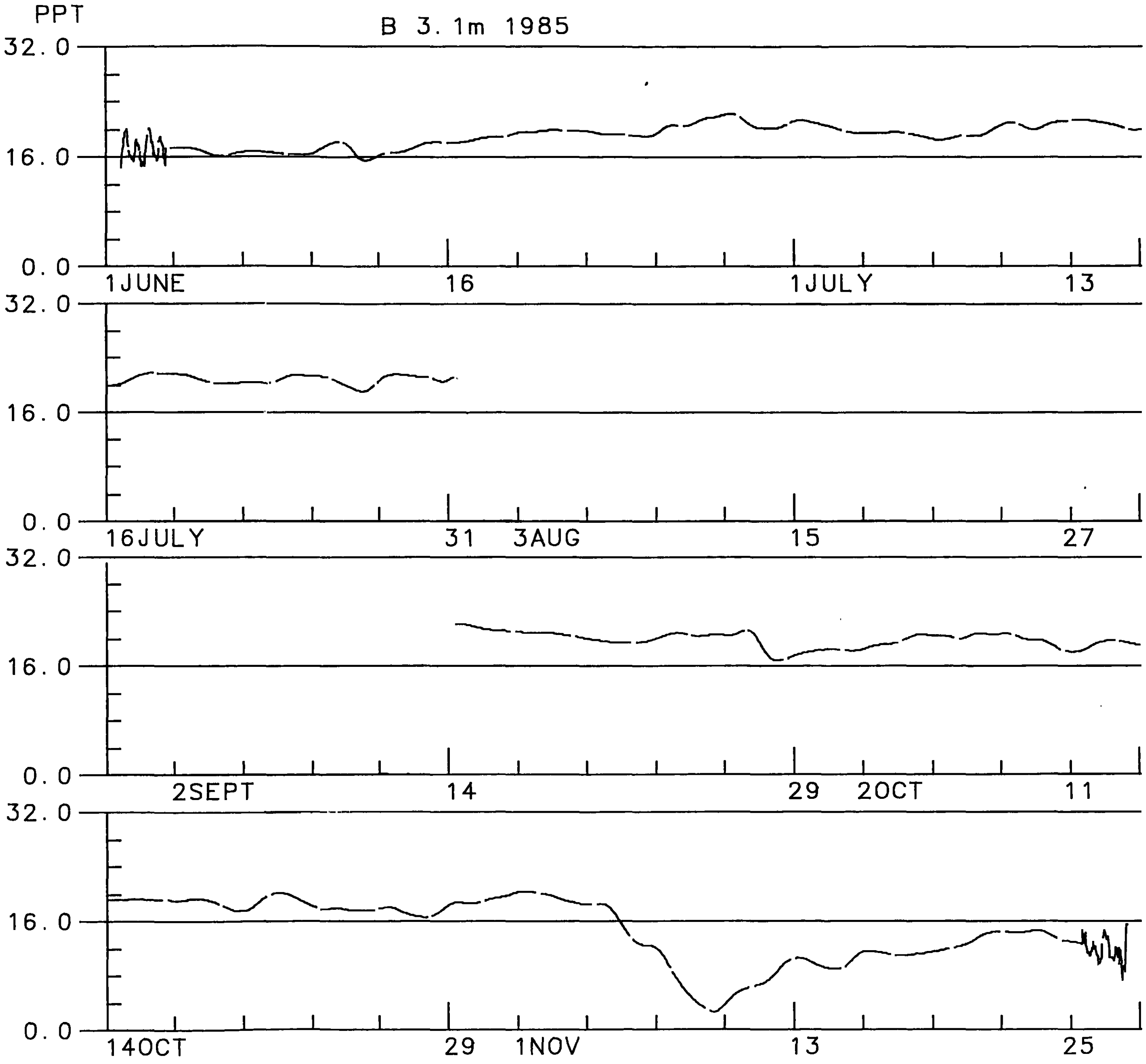
Salinity at 3.1 m below surface



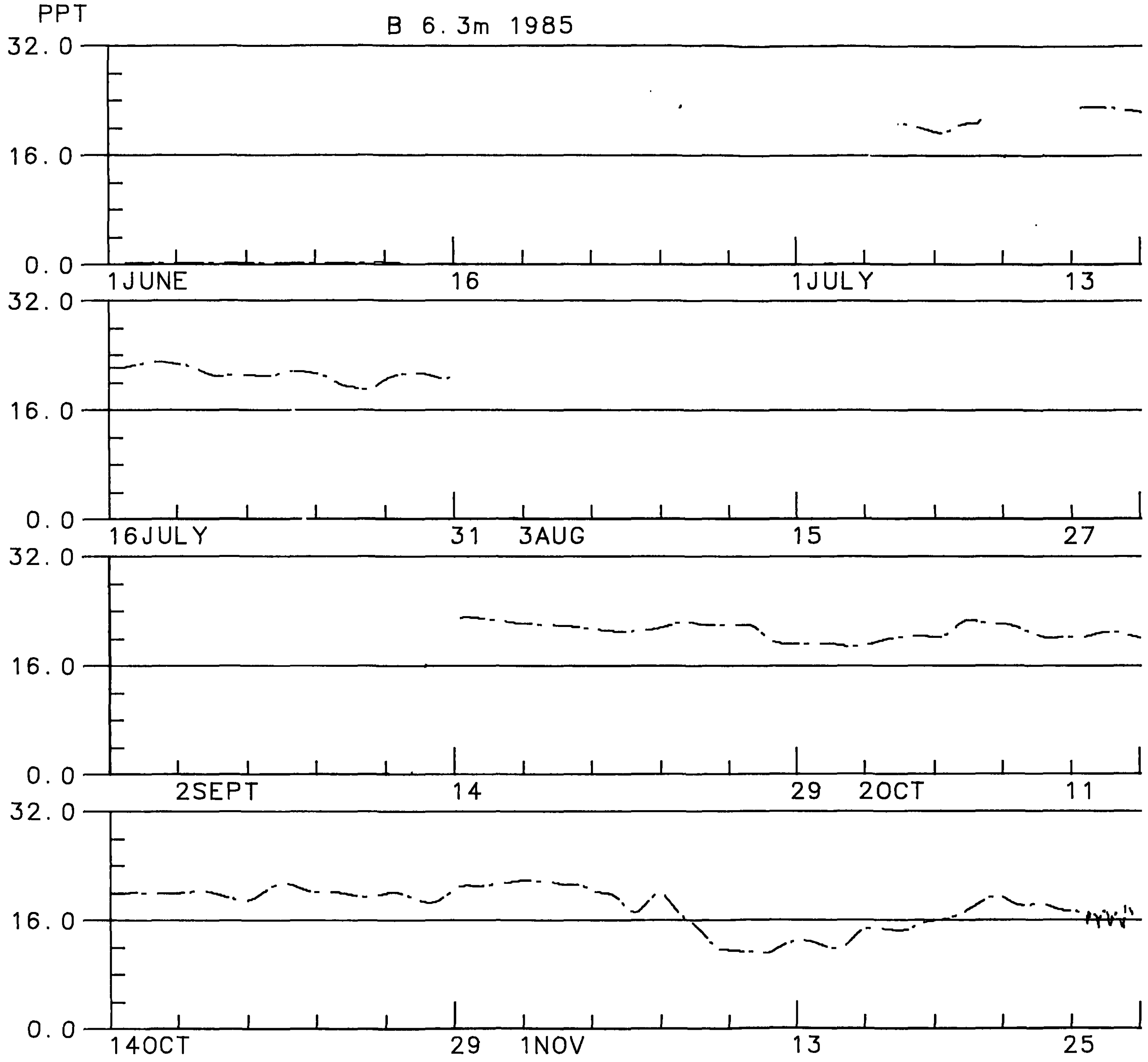
Salinity at 6.3 m below surface



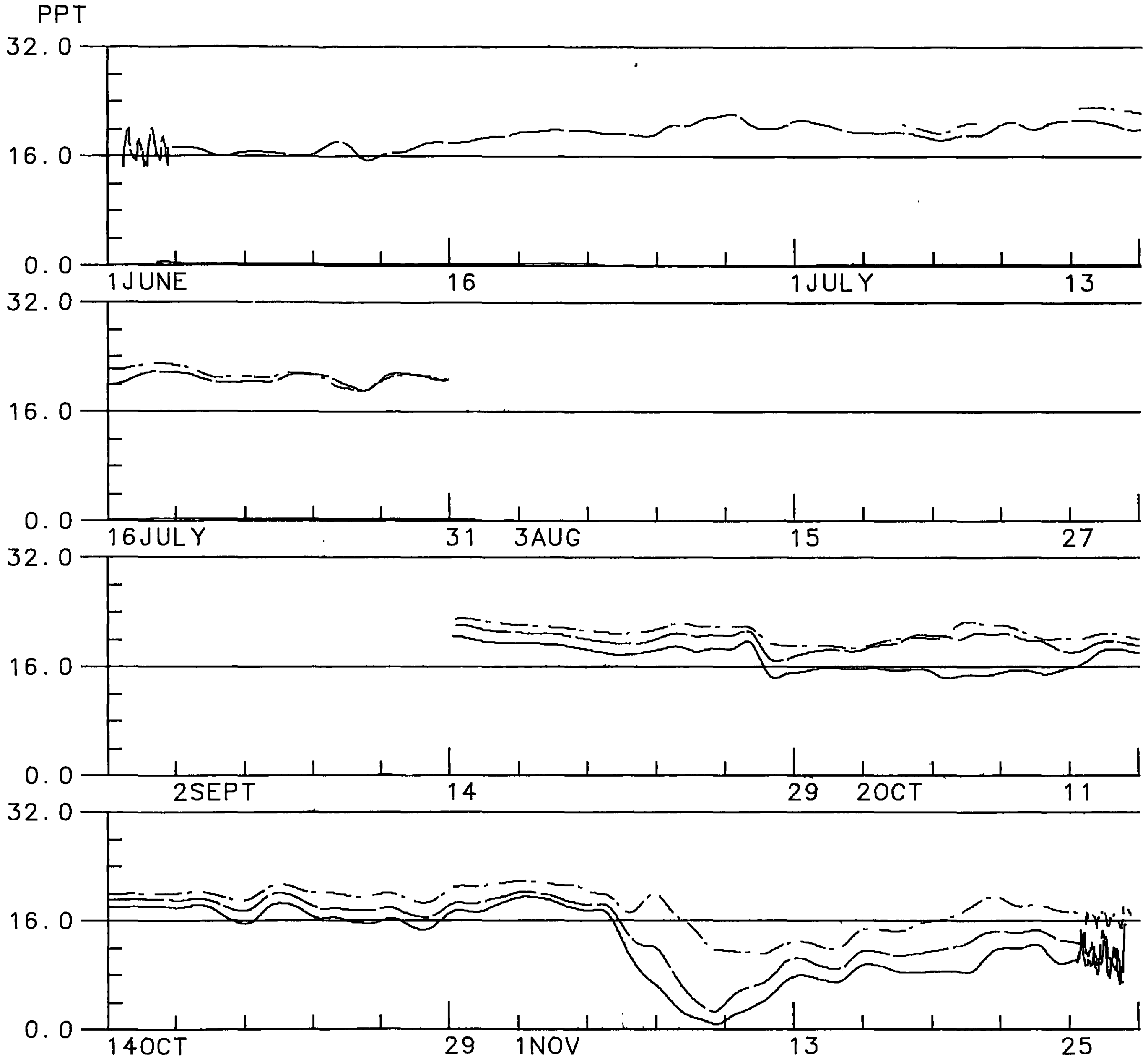
Low pass filtered salinity at 1.2 m below surface



Low pass filtered salinity at 3.1 m below surface



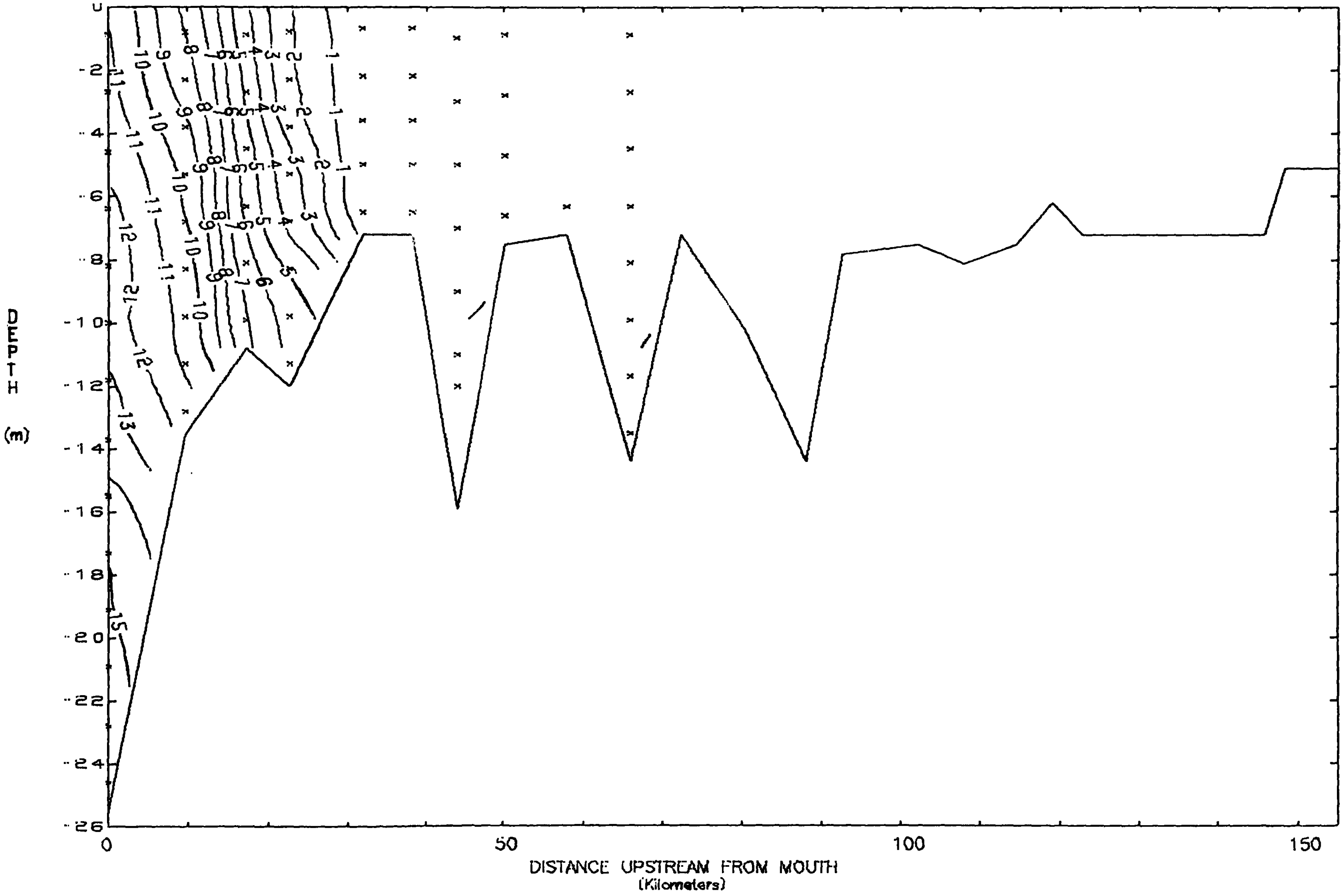
Low pass filtered salinity at 6.3 m below surface



Low pass filtered salinity at various depths

APPENDIX L

GROSS SCALE SALINITY DISTRIBUTION

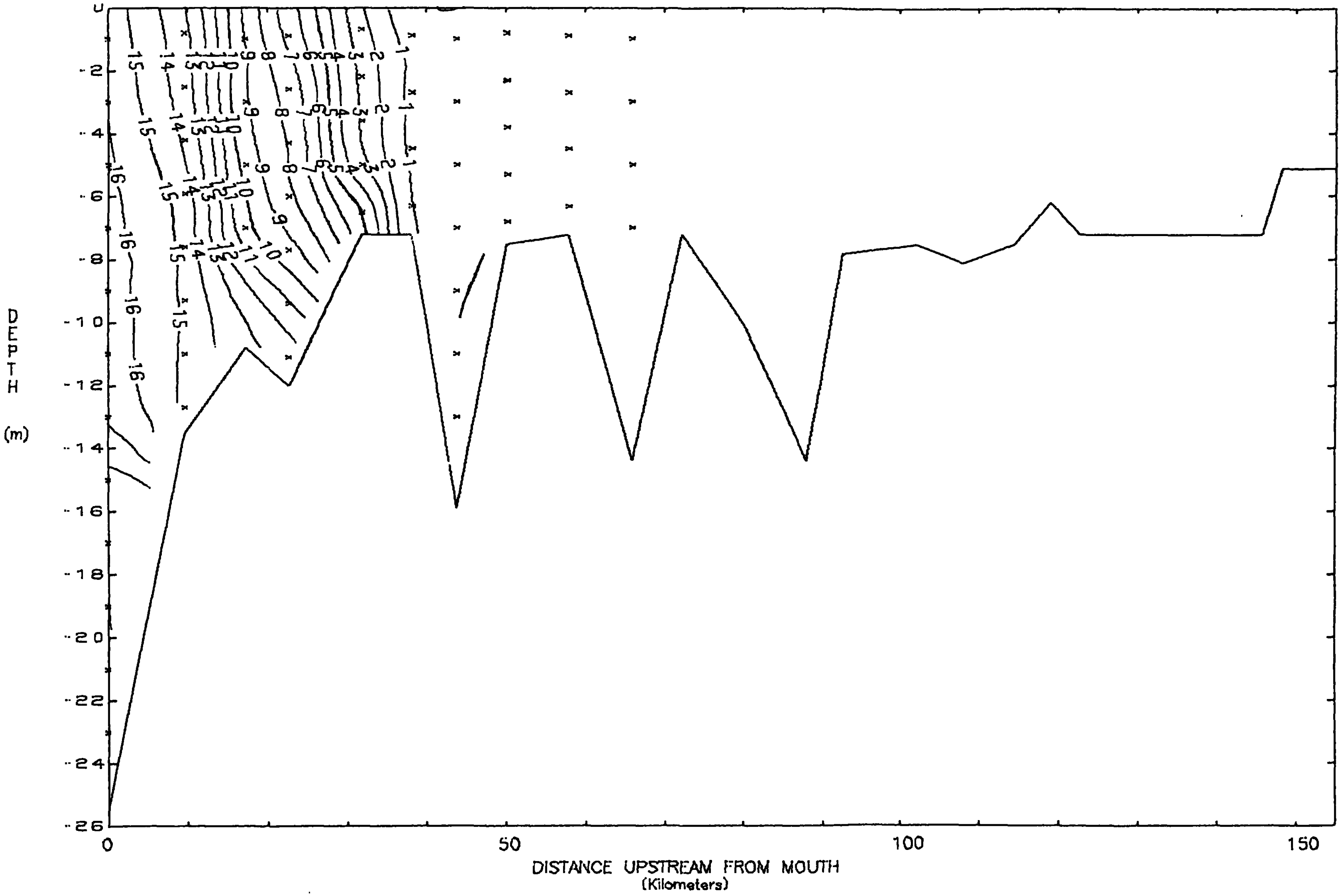


JAMES RIVER 17 APRIL 1984

SALINITY SLACK BEFORE FLOOD

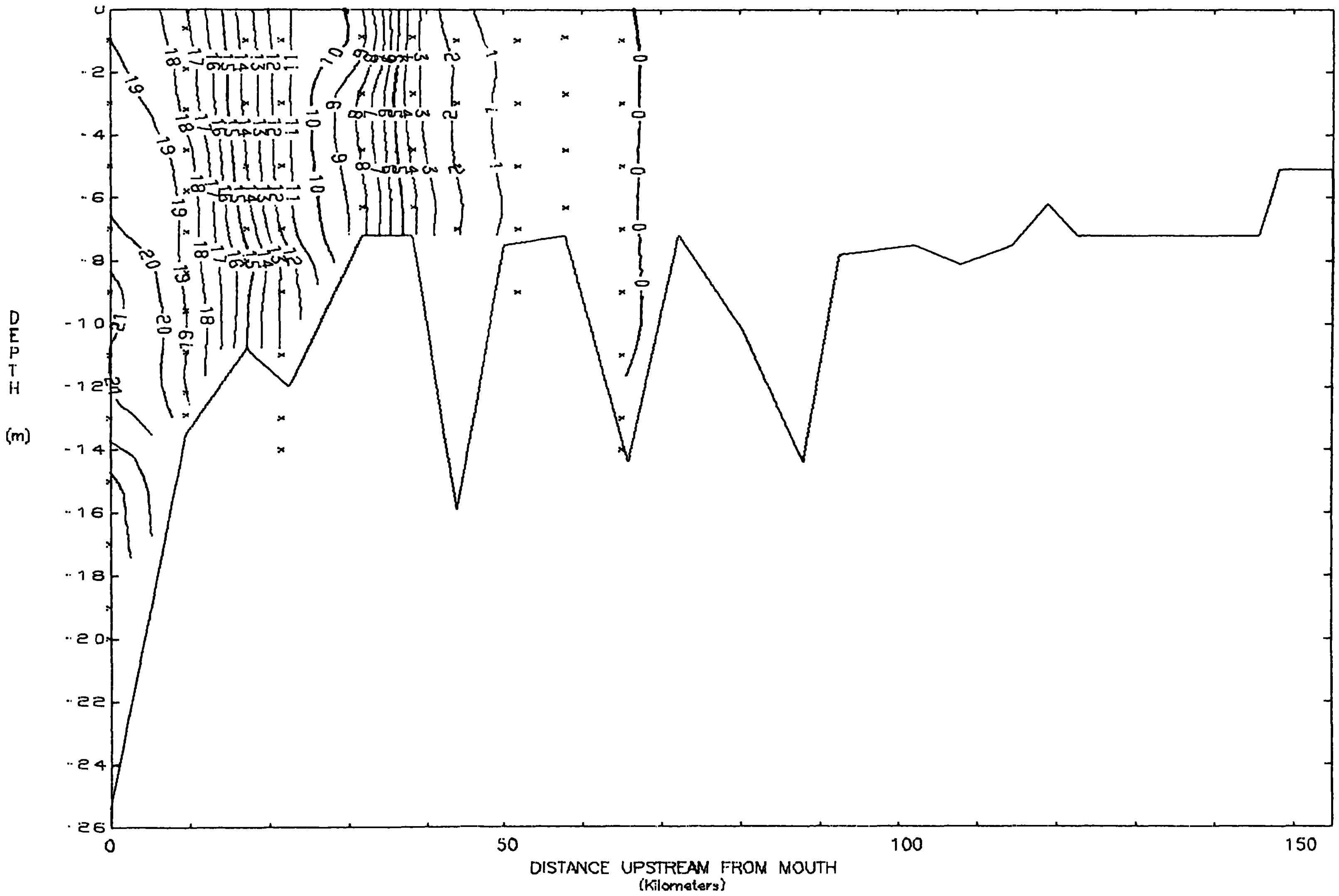
JAMES RIVER 15 MAY 1984

SALINITY SLACK BEFORE FLOOD



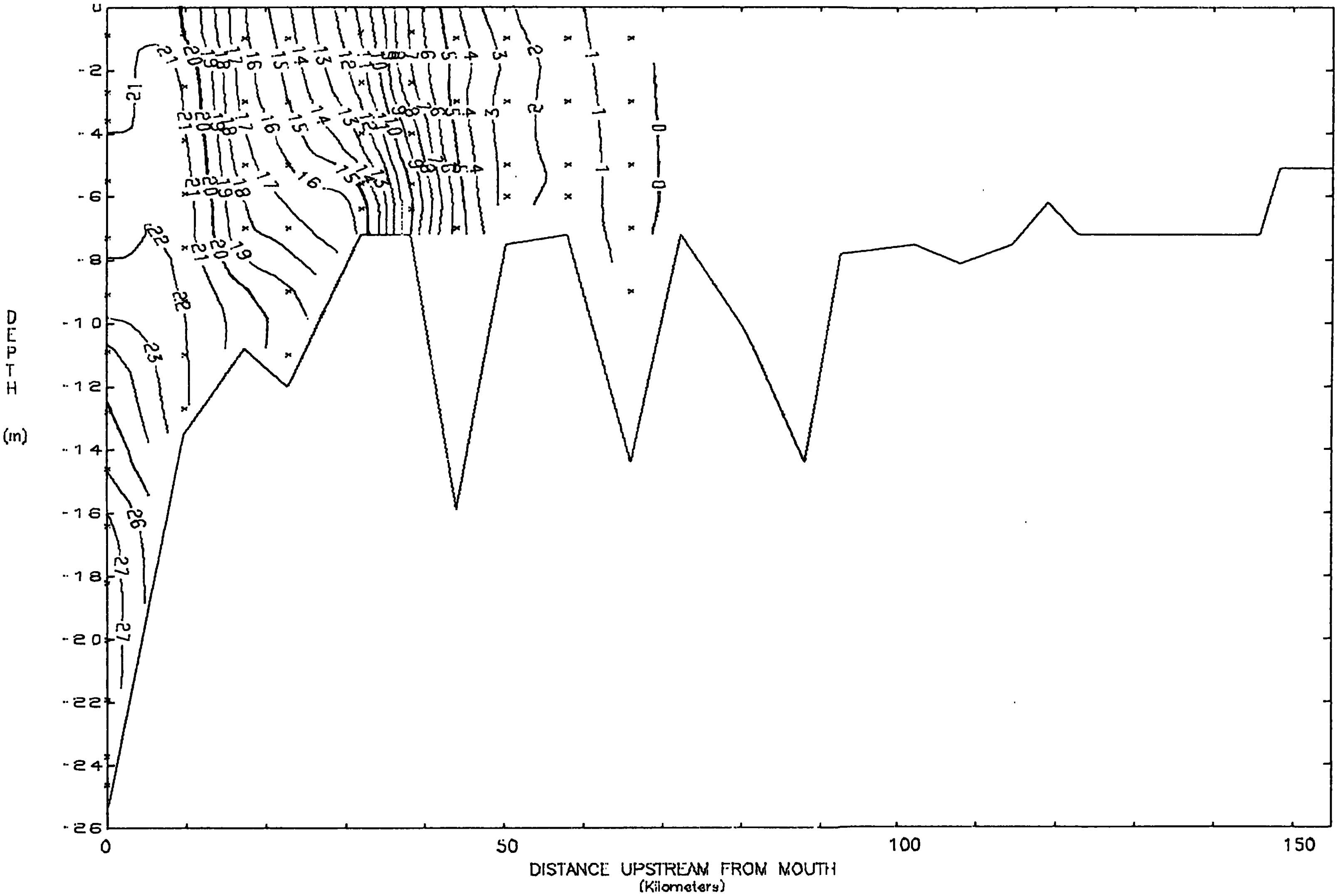
JAMES RIVER 14 JUNE 1984

SALINITY SLACK BEFORE FLOOD



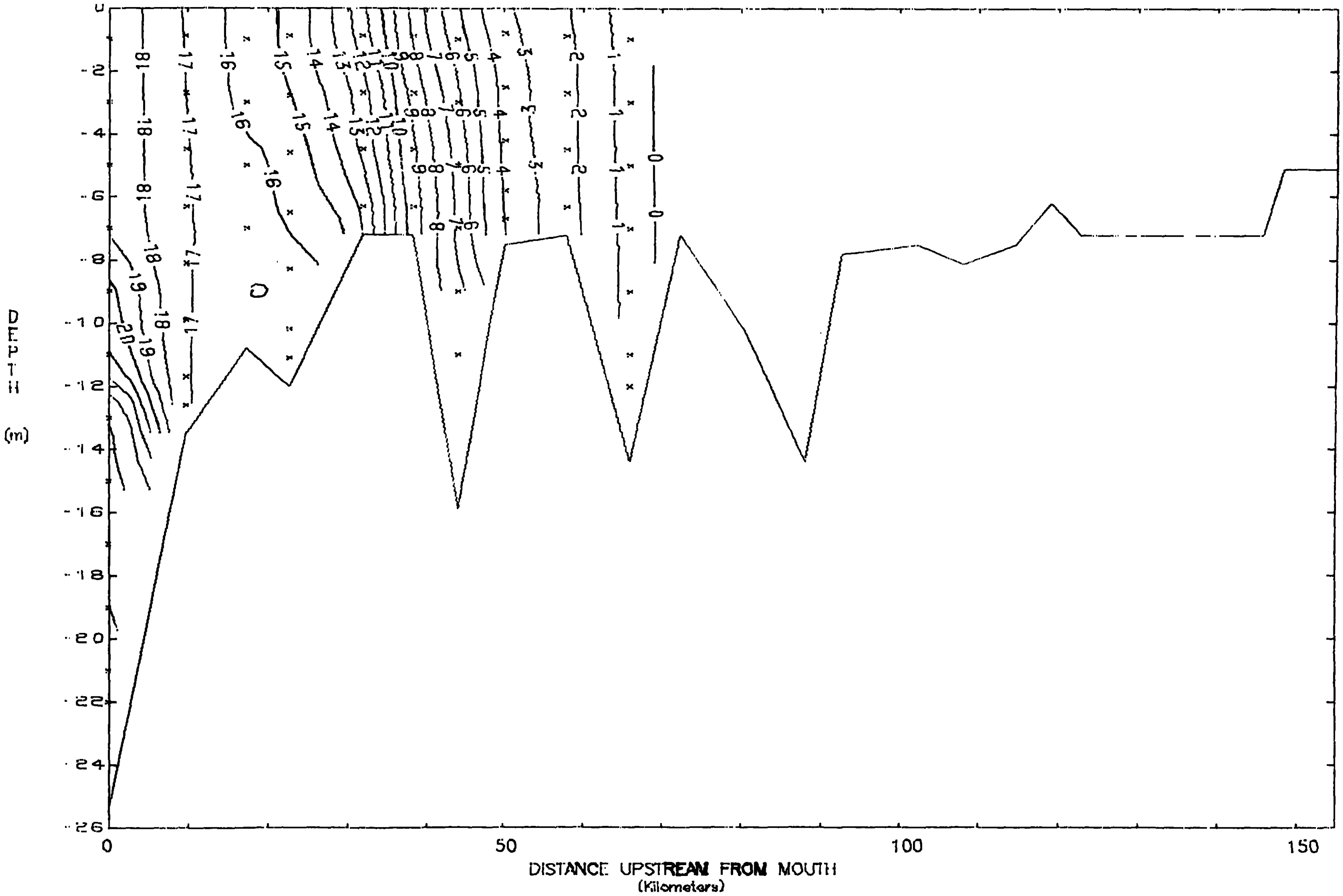
JAMES RIVER . 12 JULY 1984

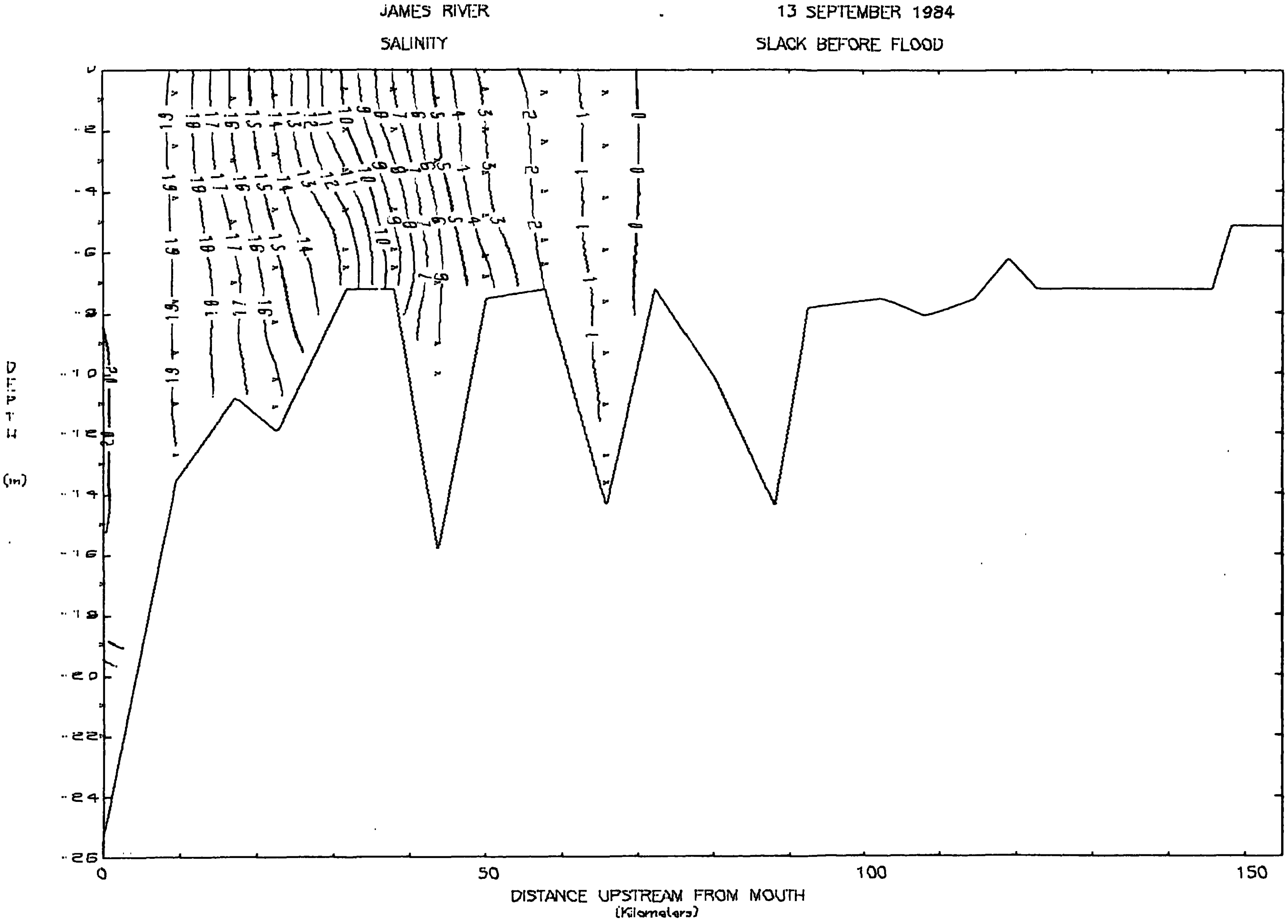
SALINITY SLACK BEFORE FLOOD

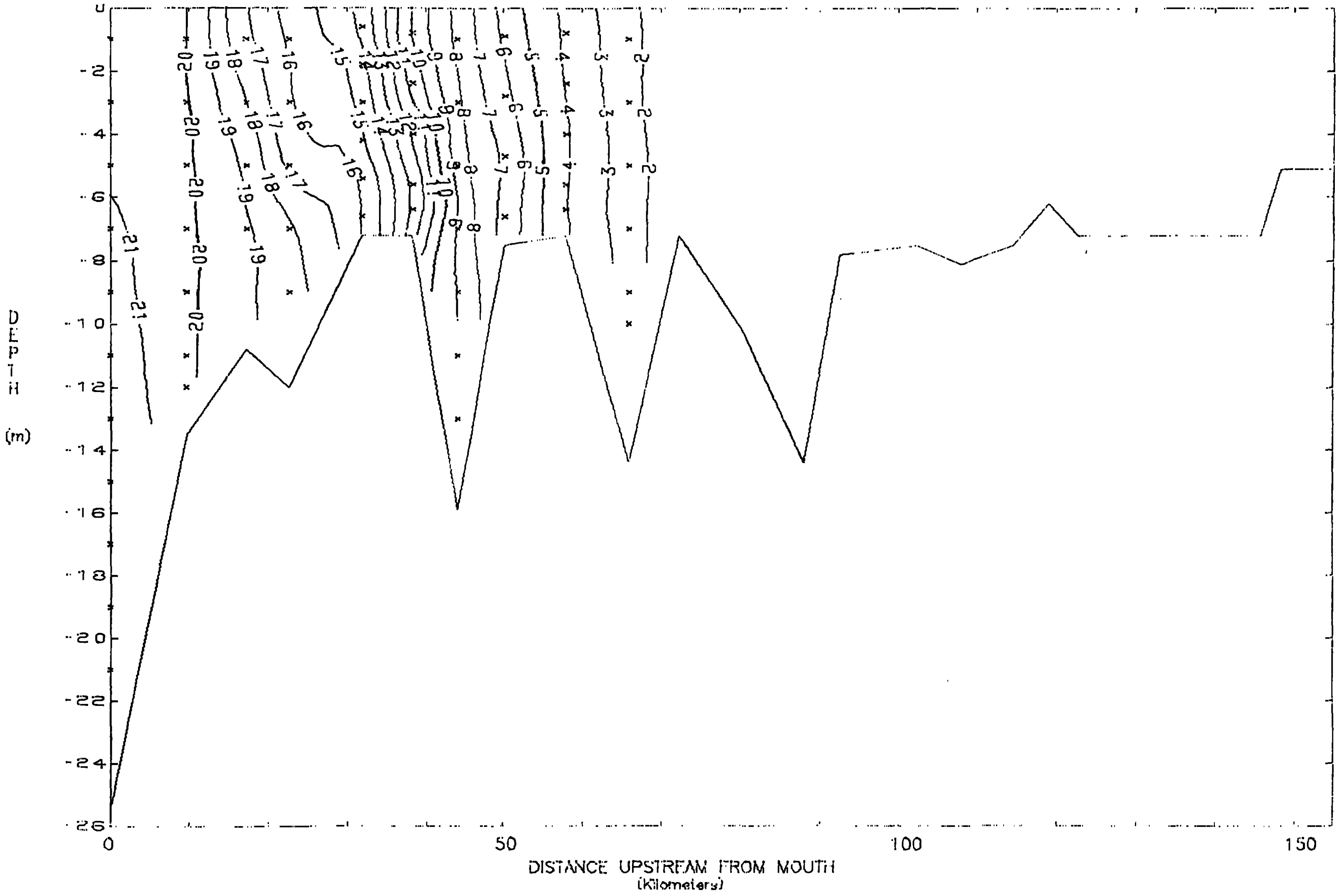


JAMES RIVER 13 AUGUST 1984

SALINITY SLACK BEFORE FLOOD




JAMES RIVER
13 SEPTEMBER 1984
SALINITY
SLACK BEFORE FLOOD
DEPTH
(m)
0
-2
-4
-6
-8
-10
-12
-14
-16
-18
-20
-22
-24
-26
0
50
100
150
DISTANCE UPSTREAM FROM MOUTH
(Kilometers)
20
19
18
17
16
15
14
13
12
11
10
9
8
7
6
5
4
3
2
1
0

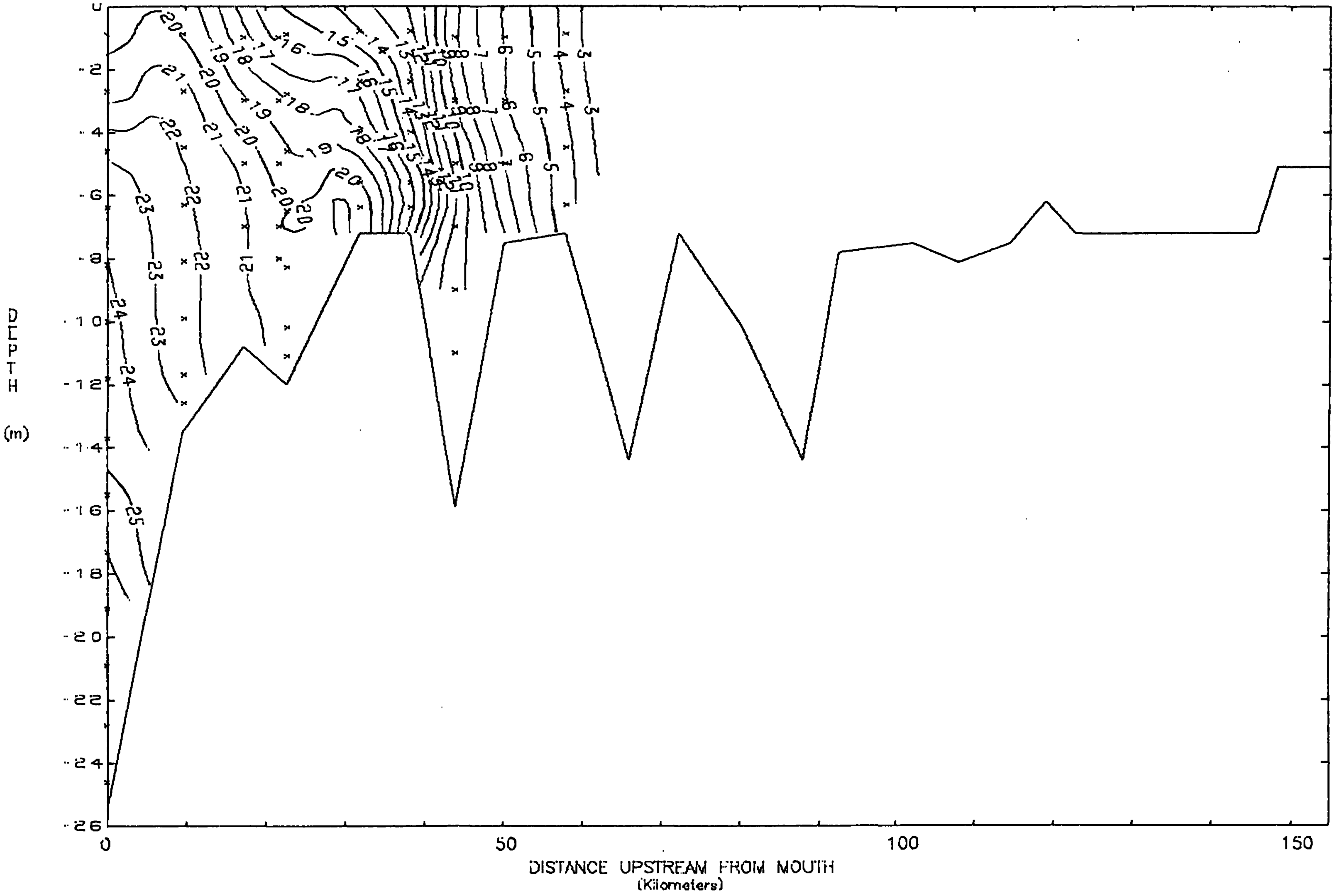


JAMES RIVER 11 OCTOBER 1984

SALINITY SLACK BEFORE FLOOD

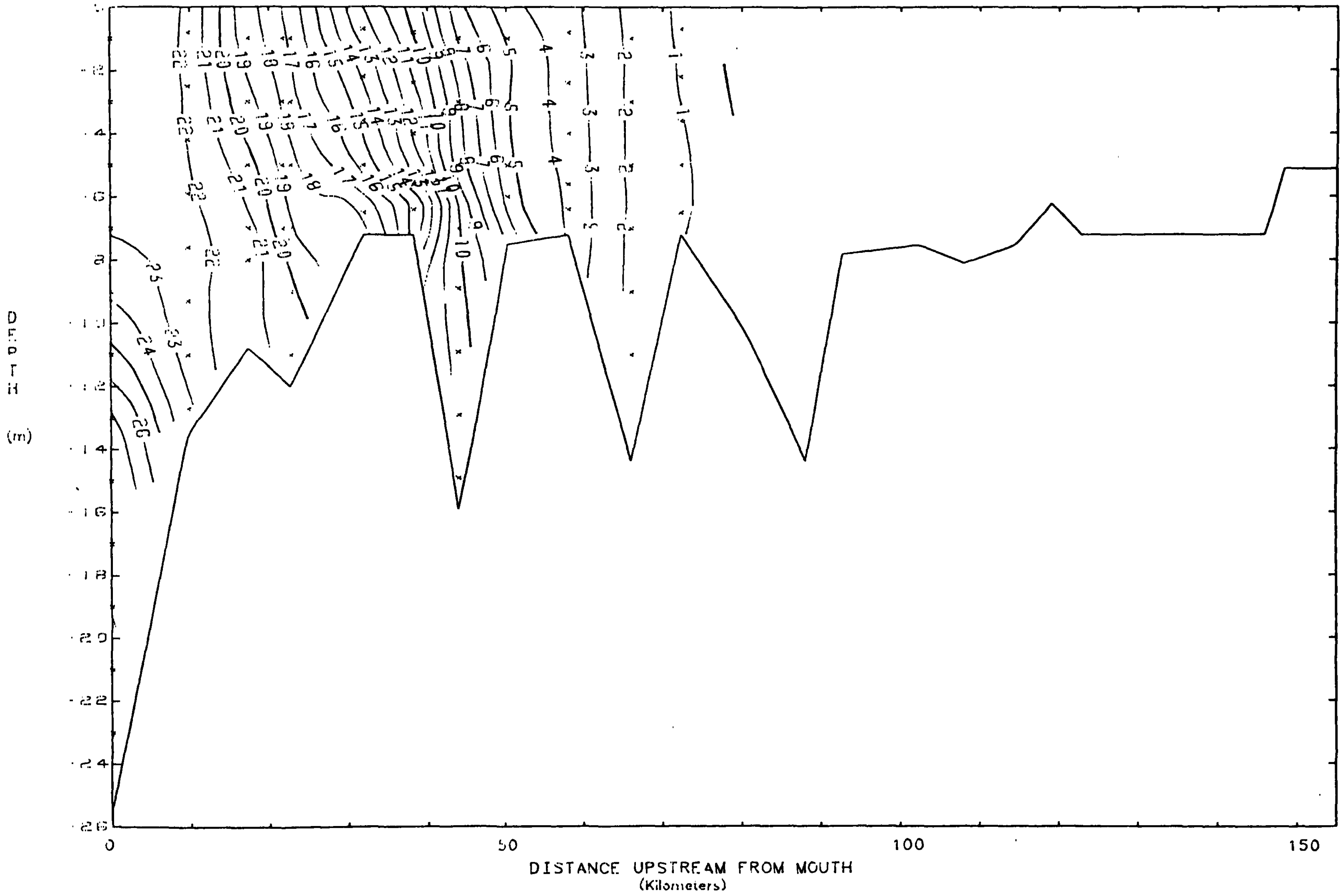
JAMES RIVER 15 NOVEMBER 1984

SALINITY SLACK BEFORE FLOOD



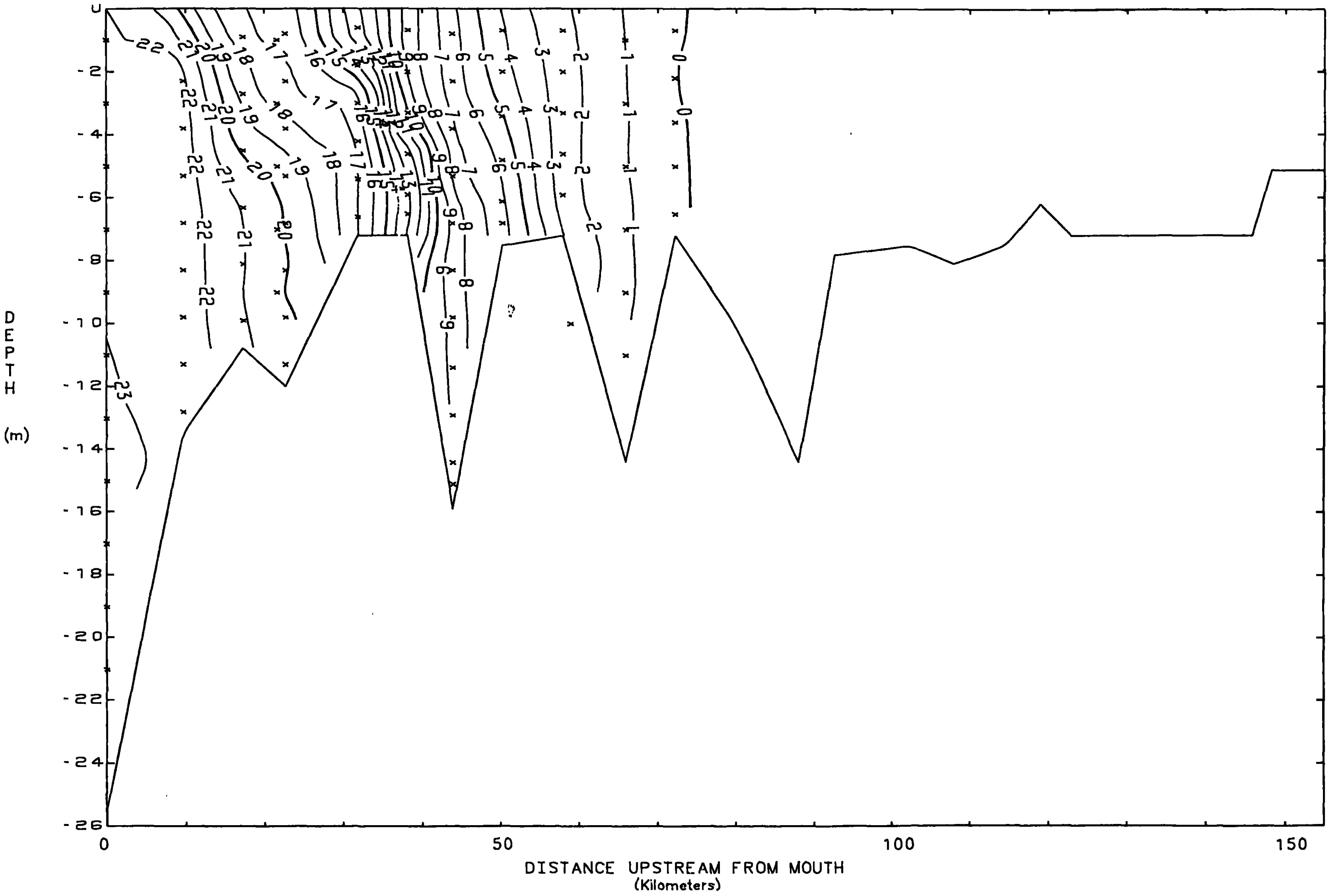
JAMES RIVER 24 APRIL 1985

SALINITY SLACK BEFORE FLOOD



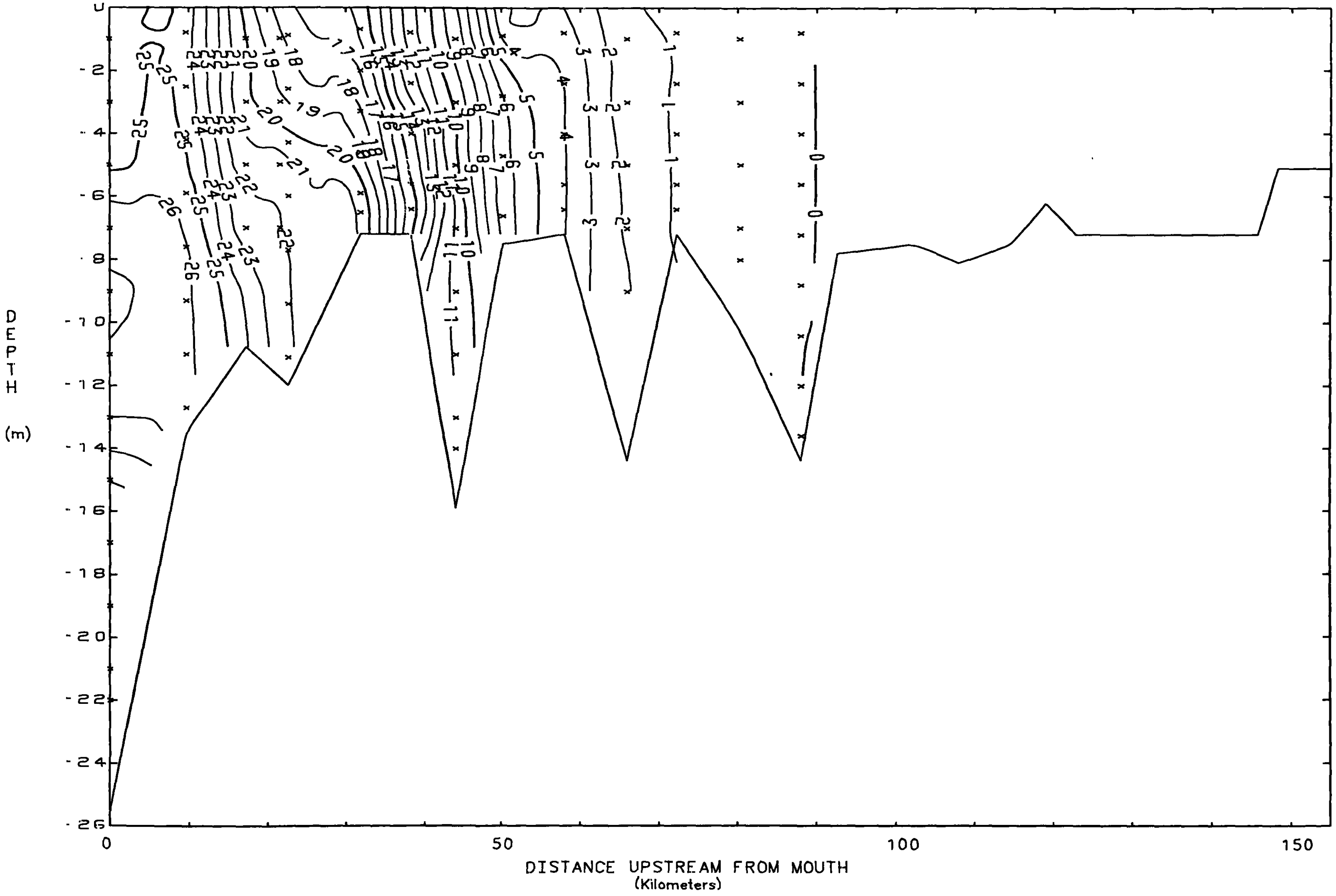
JAMES RIVER 22 MAY 1985

SALINITY SLACK BEFORE FLOOD



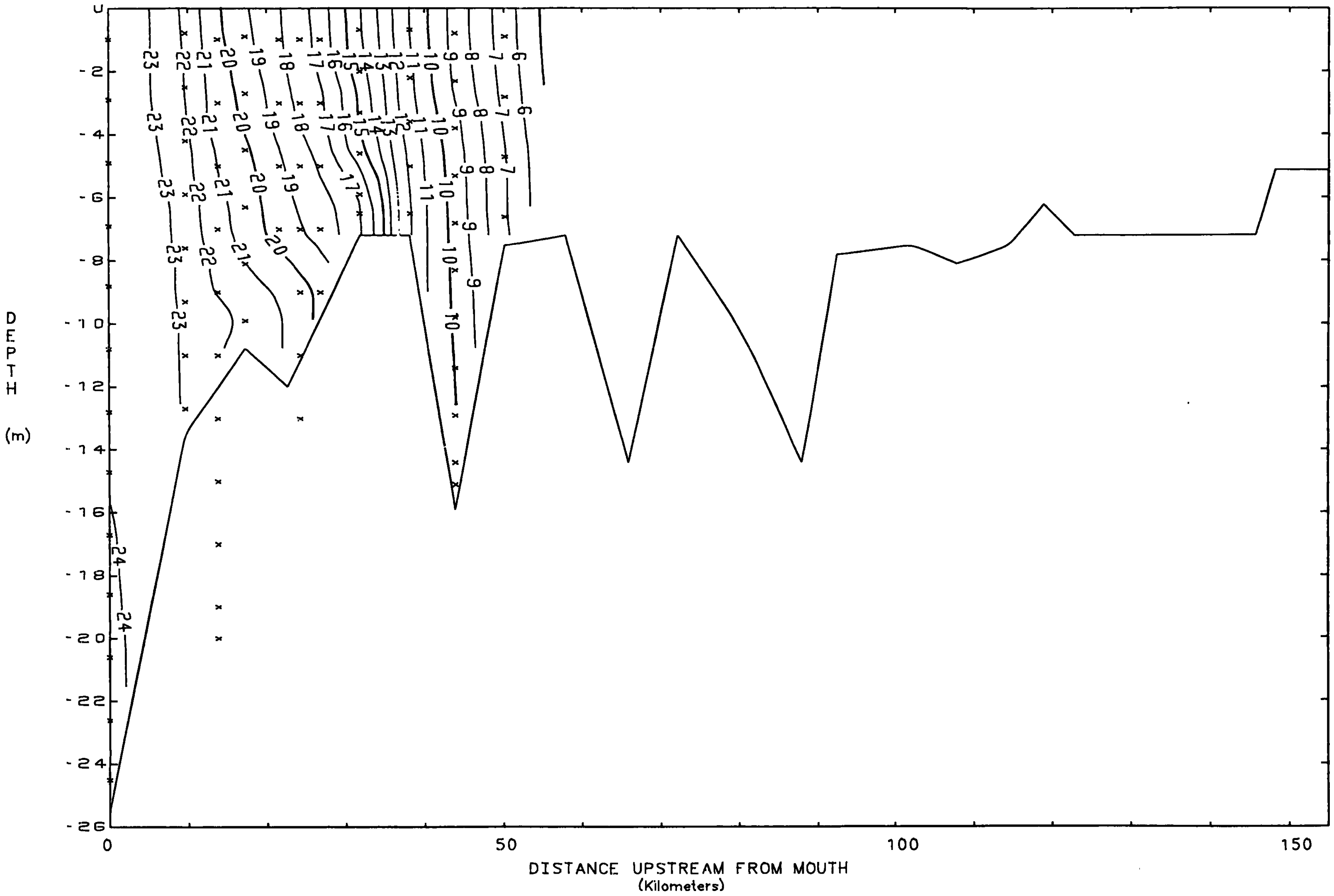
JAMES RIVER 19 JUNE 1985

SALINITY SLACK BEFORE FLOOD



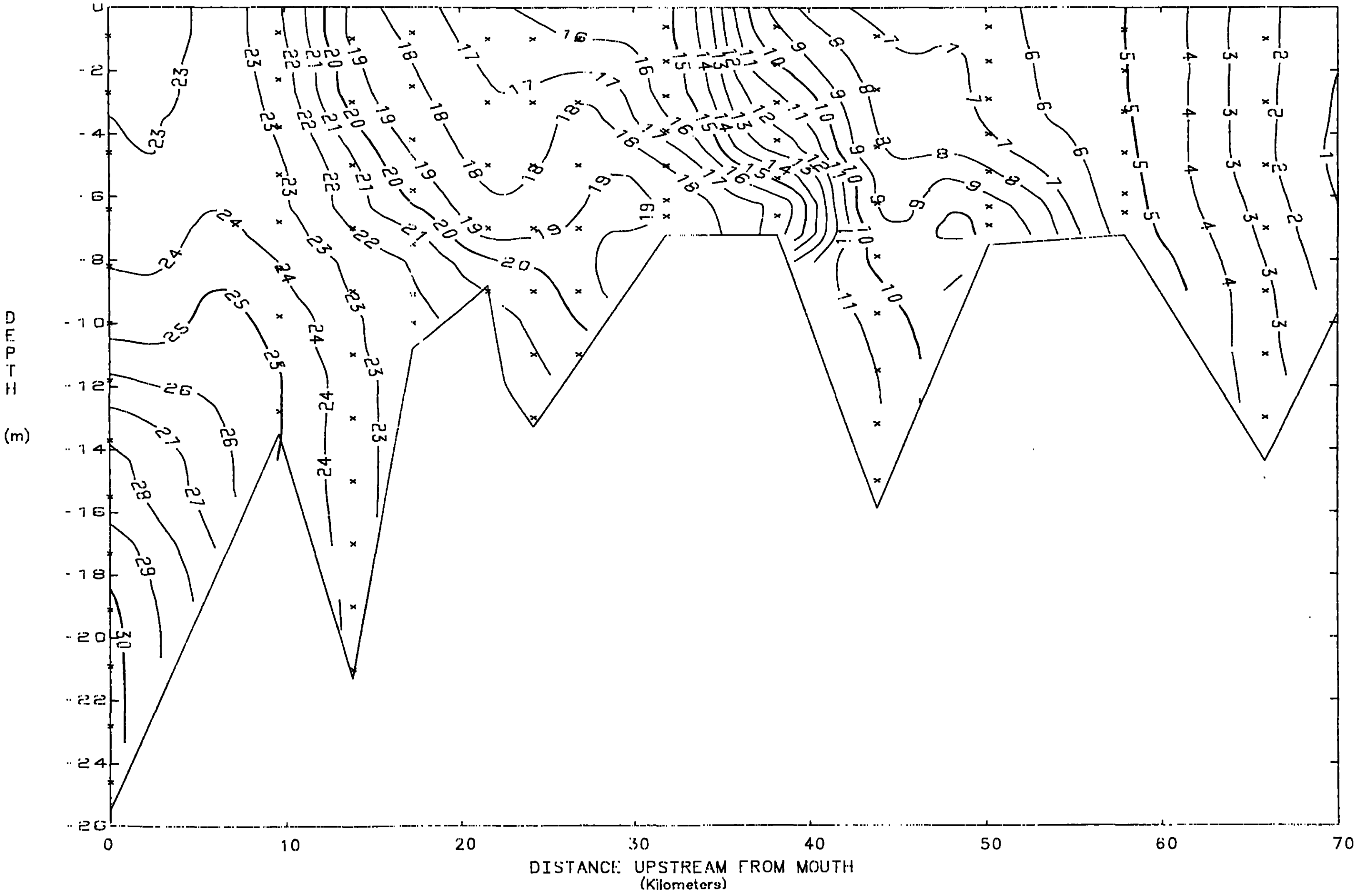
JAMES RIVER 03 JULY 1985

SALINITY SLACK BEFORE FLOOD



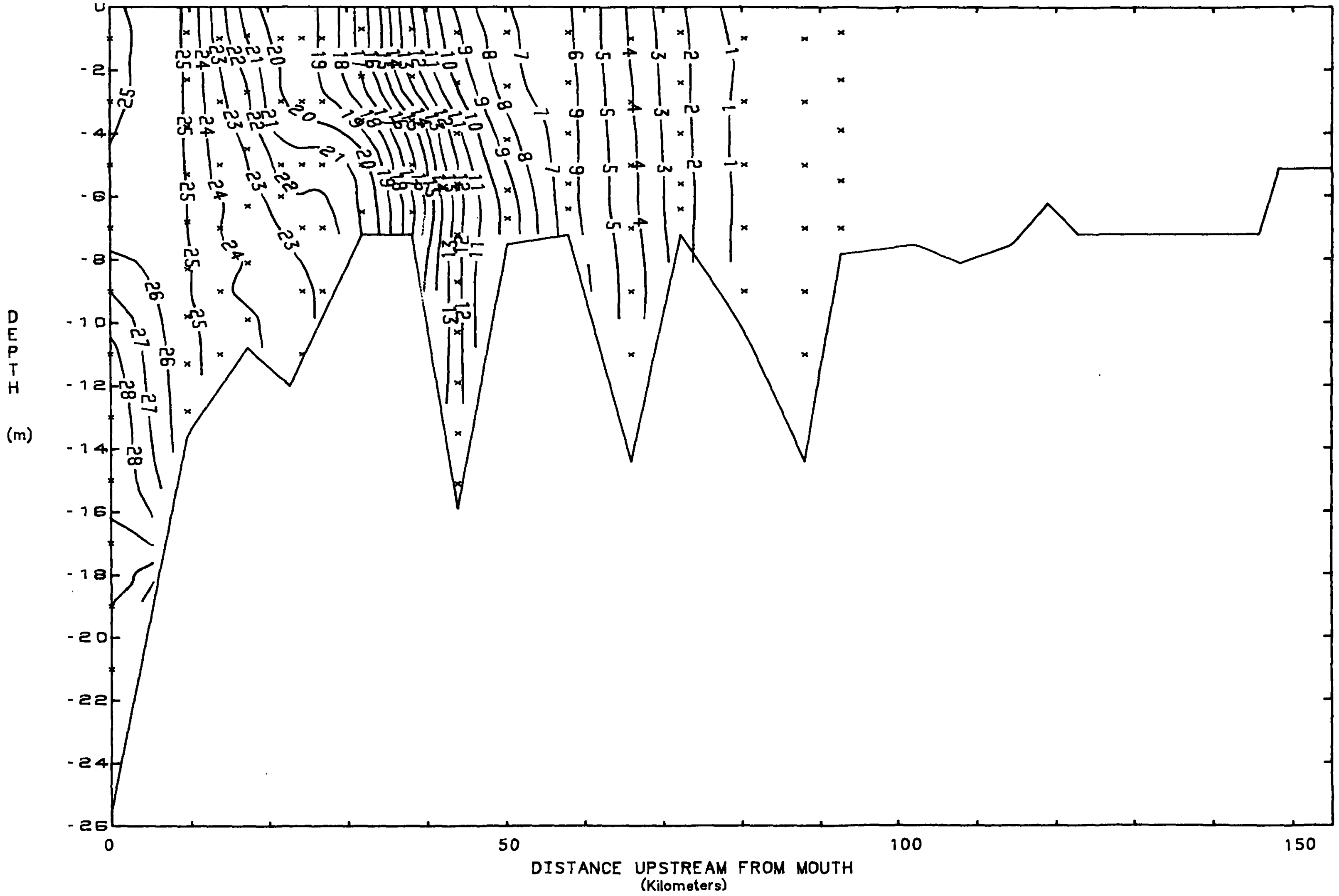
JAMES RIVER 09 JULY 1985

SALINITY SLACK BEFORE FLOOD



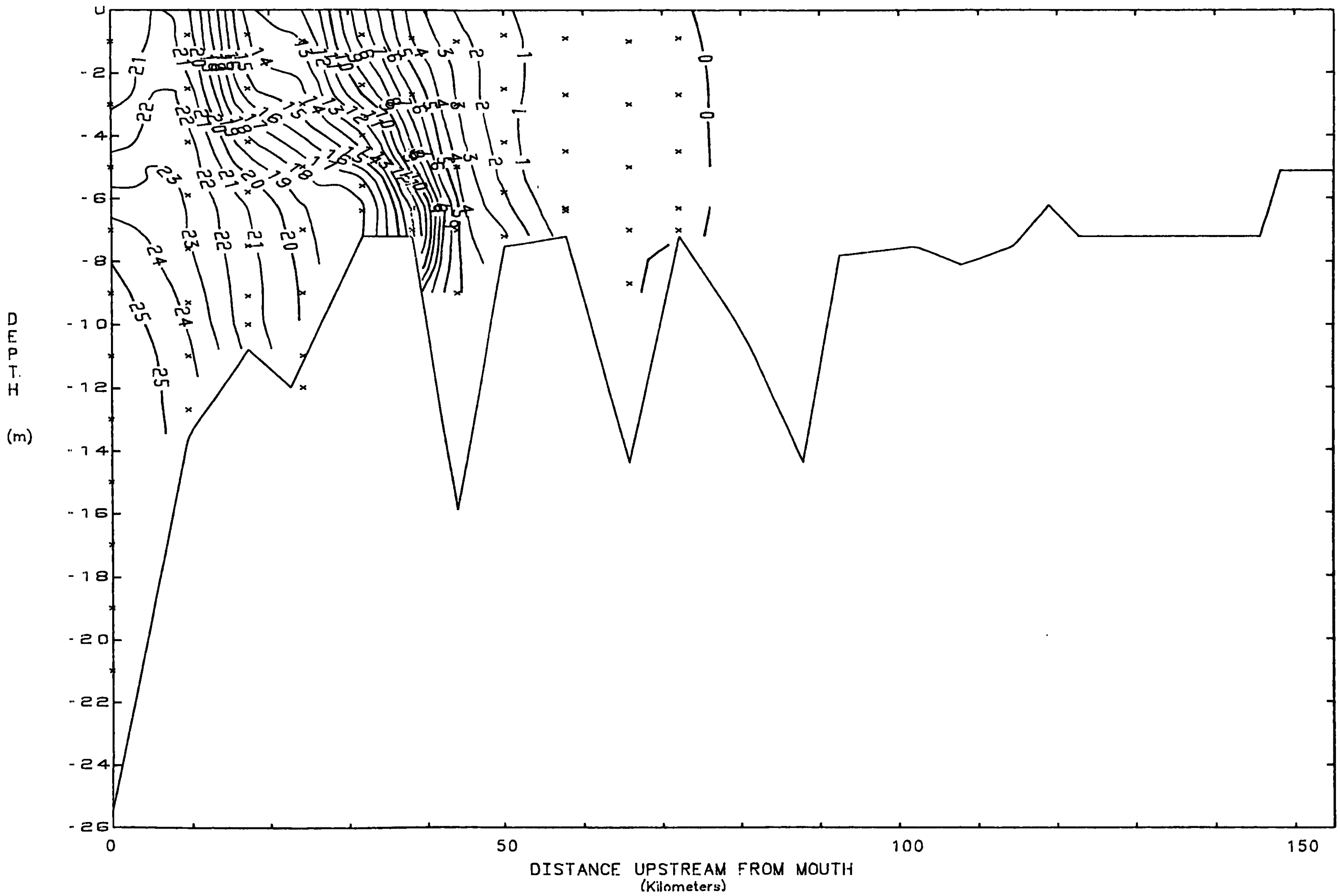
JAMES RIVER 17 JULY 1985

SALINITY SLACK BEFORE FLOOD



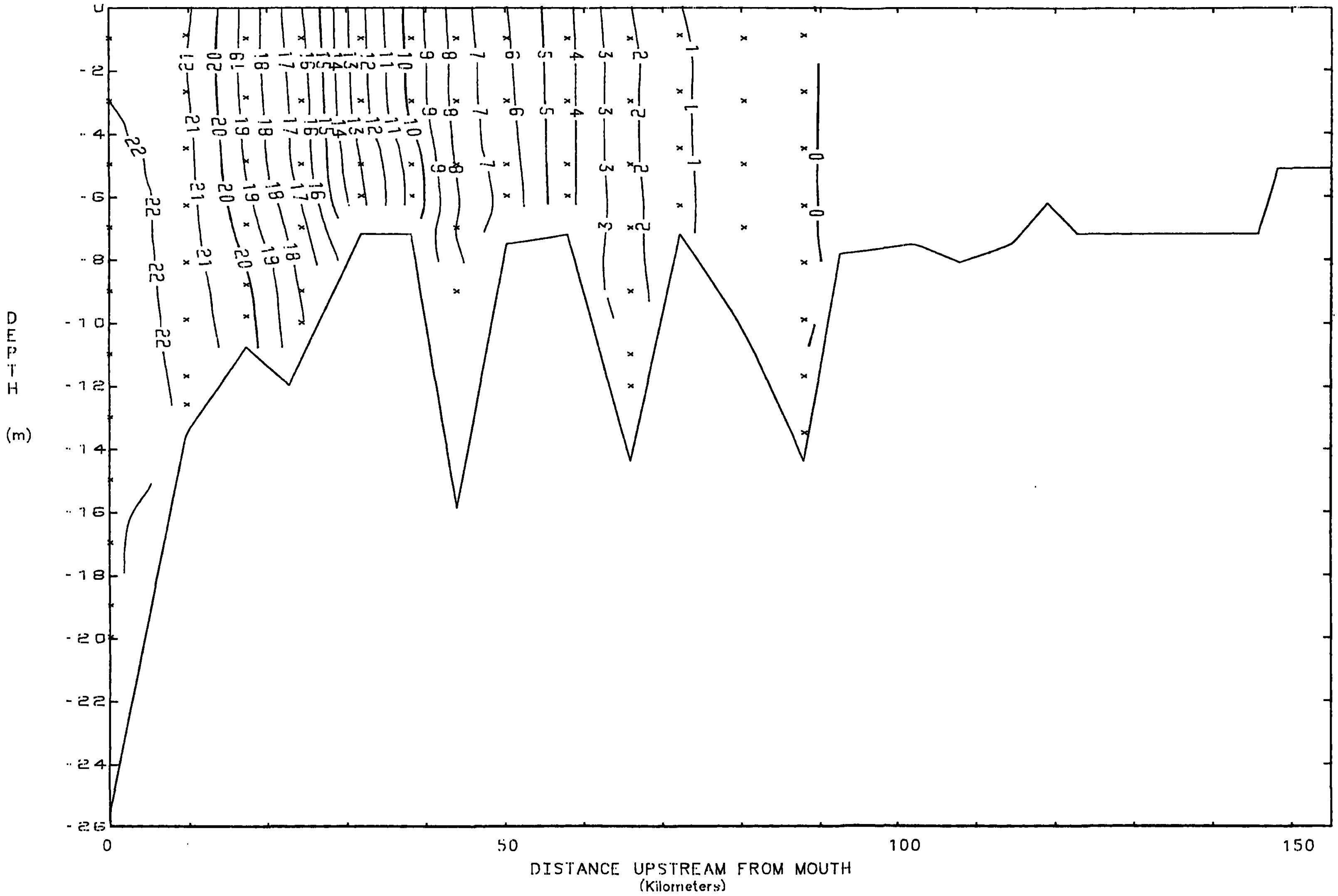
JAMES RIVER 04 SEPTEMBER 1985

SALINITY SLACK BEFORE FLOOD



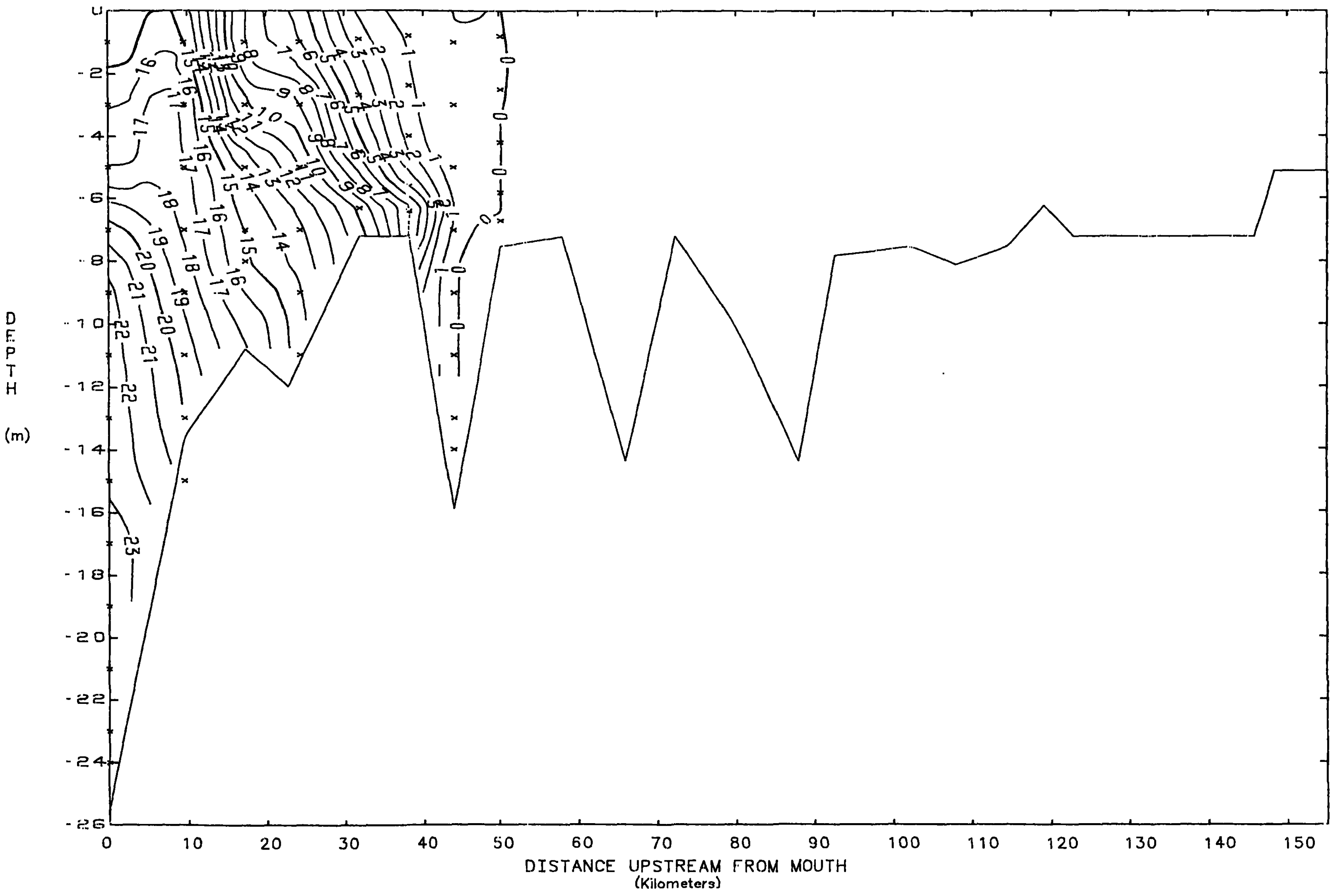
JAMES RIVER 17 OCTOBER 1985

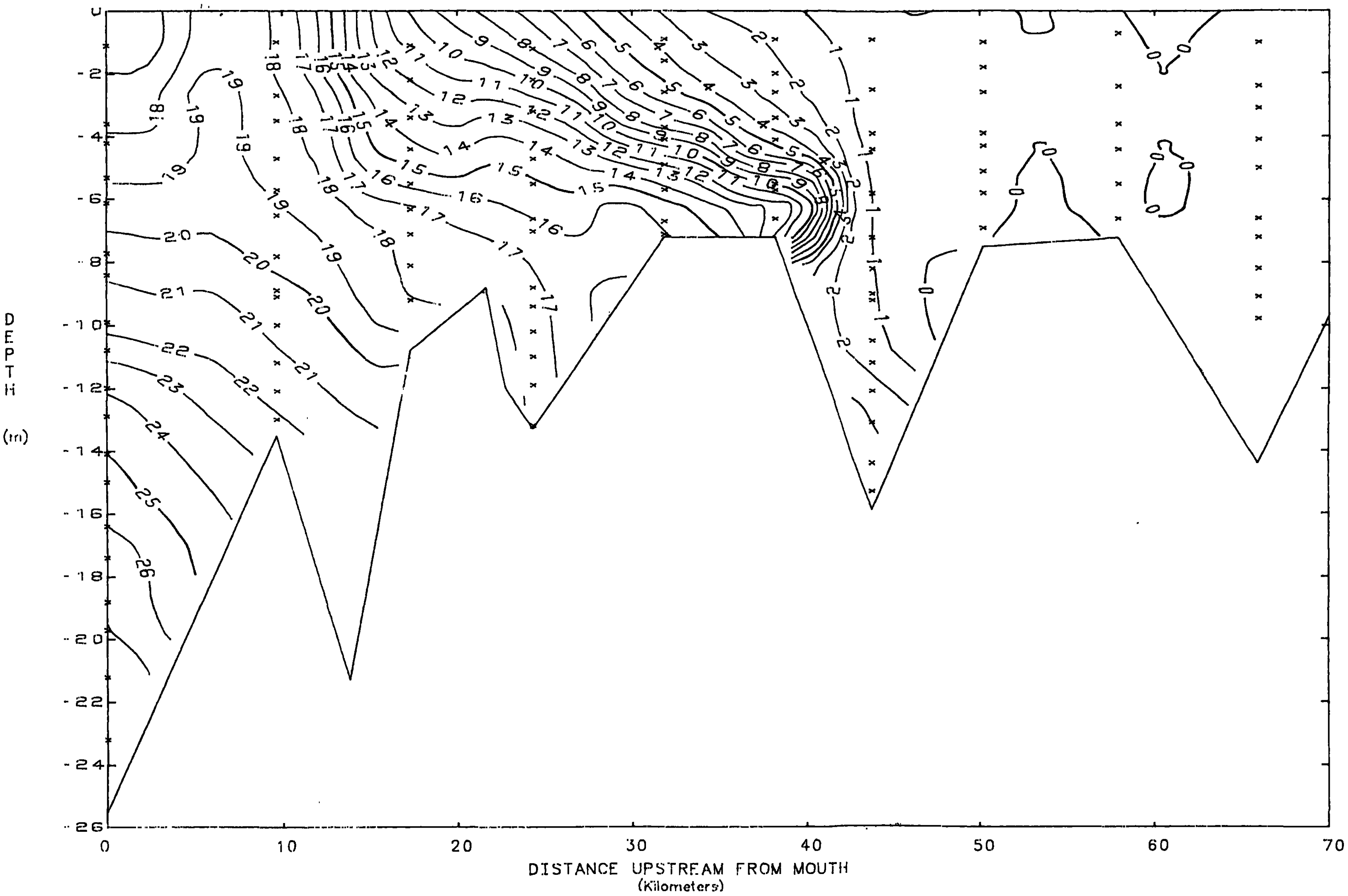
SALINITY SLACK BEFORE FLOOD



JAMES RIVER 18 NOVEMBER 1985

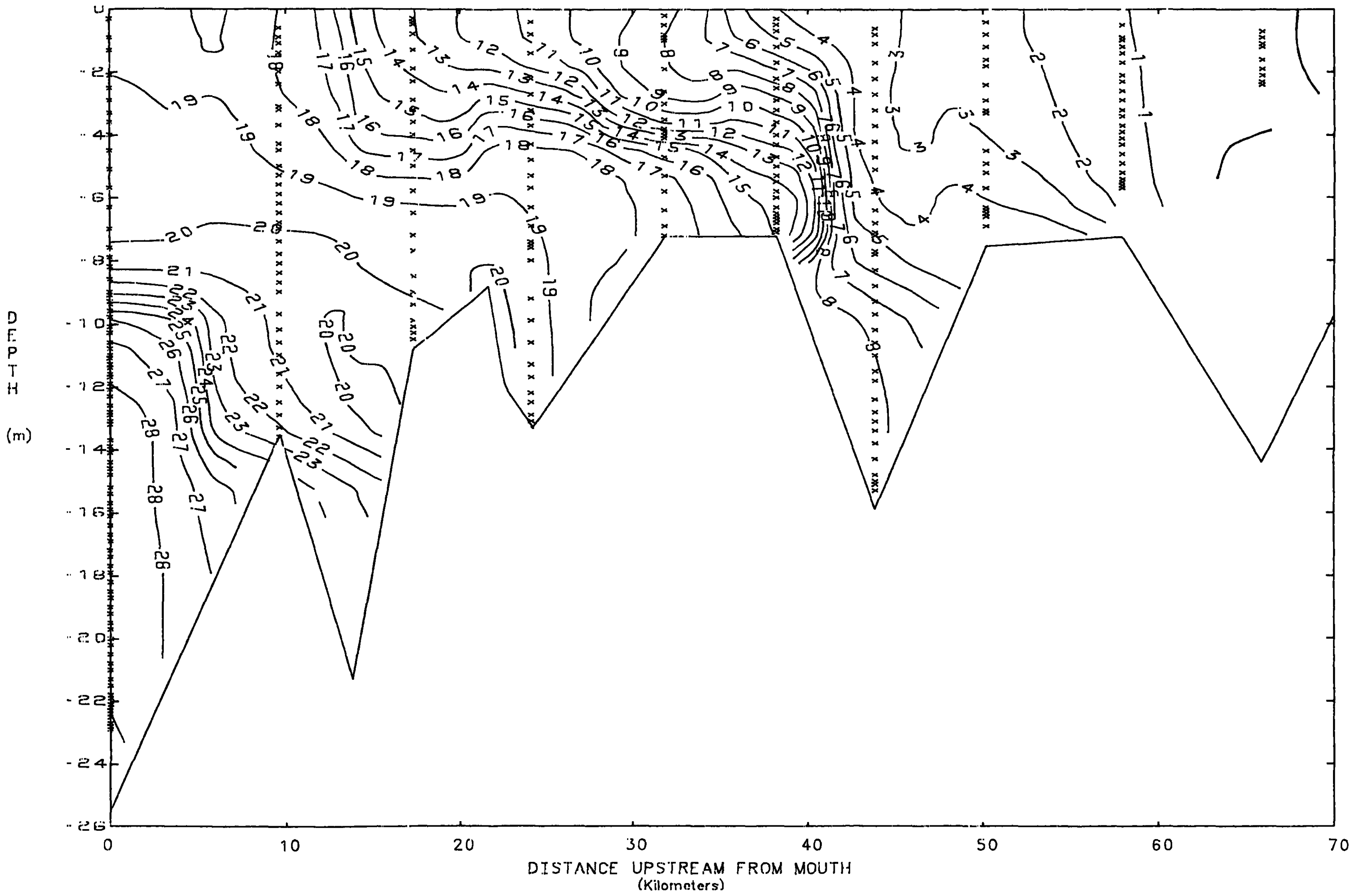
SALINITY SLACK BEFORE FLOOD





JAMES RIVER 18 MARCH 1986

SALINITY SLACK BEFORE FLOOD

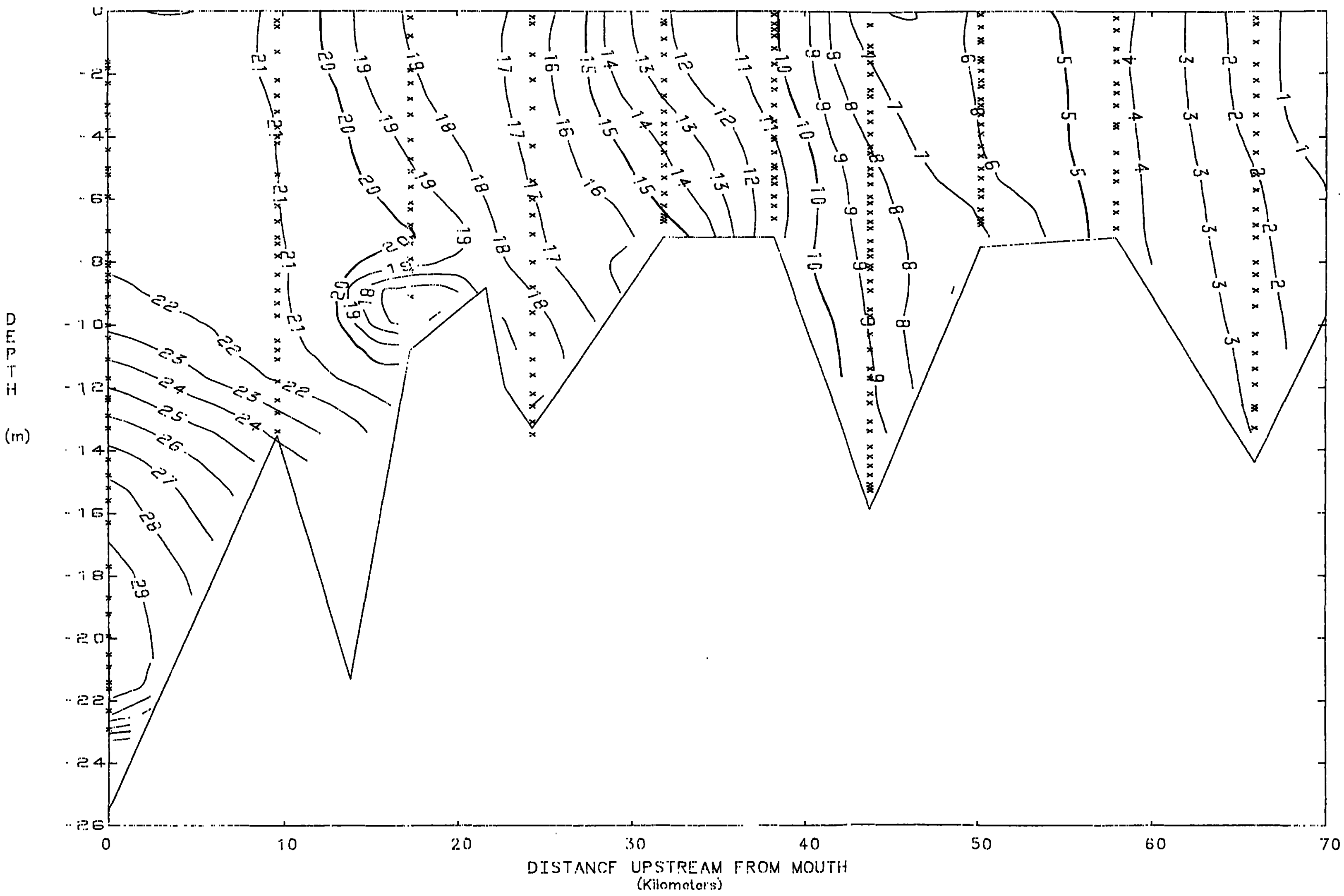


JAMES RIVER 17 APRIL 1986

SALINITY SLACK BEFORE FLOOD

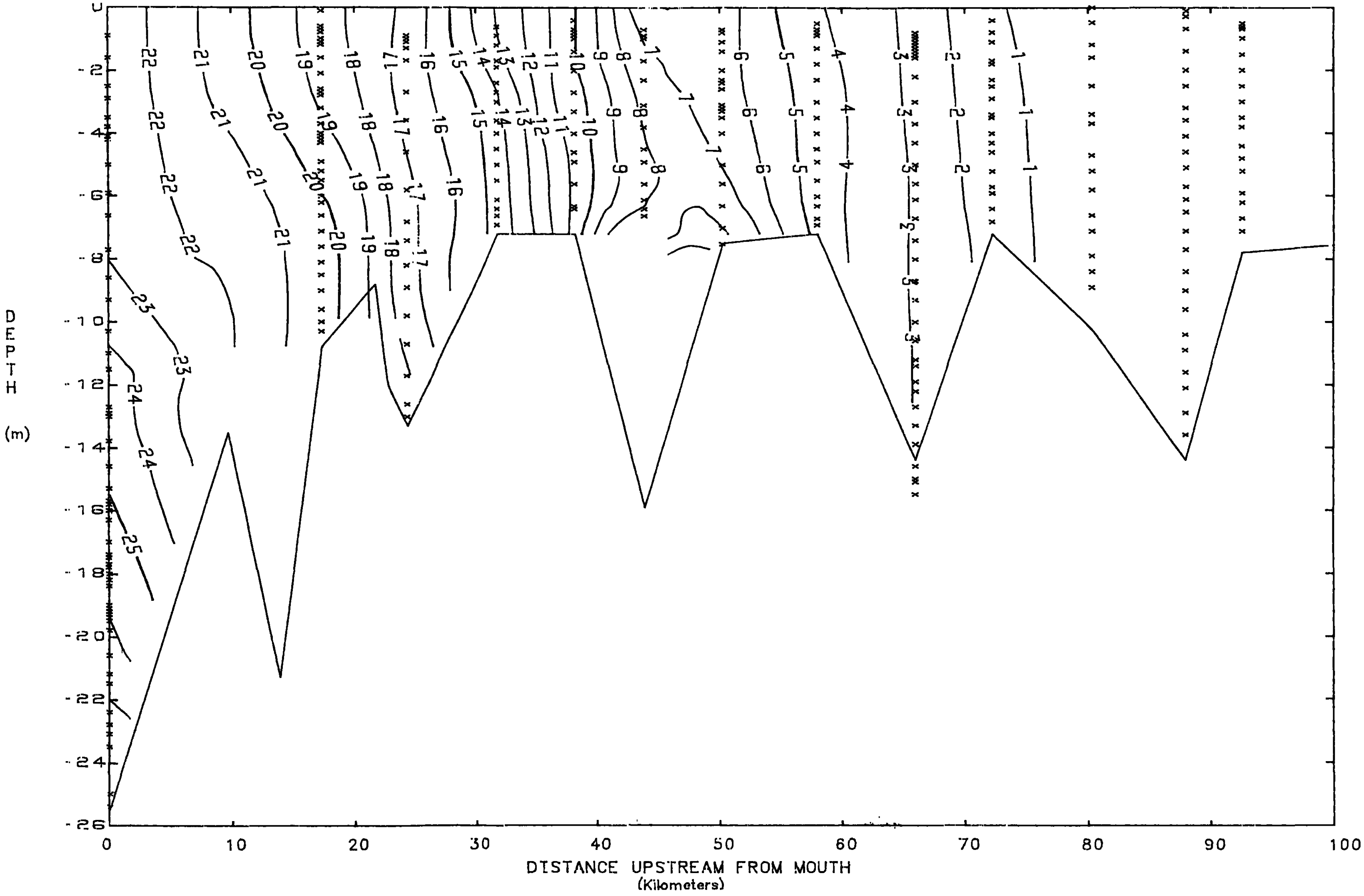
JAMES RIVER 14 MAY 1986

SALINITY SLACK BEFORE FLOOD



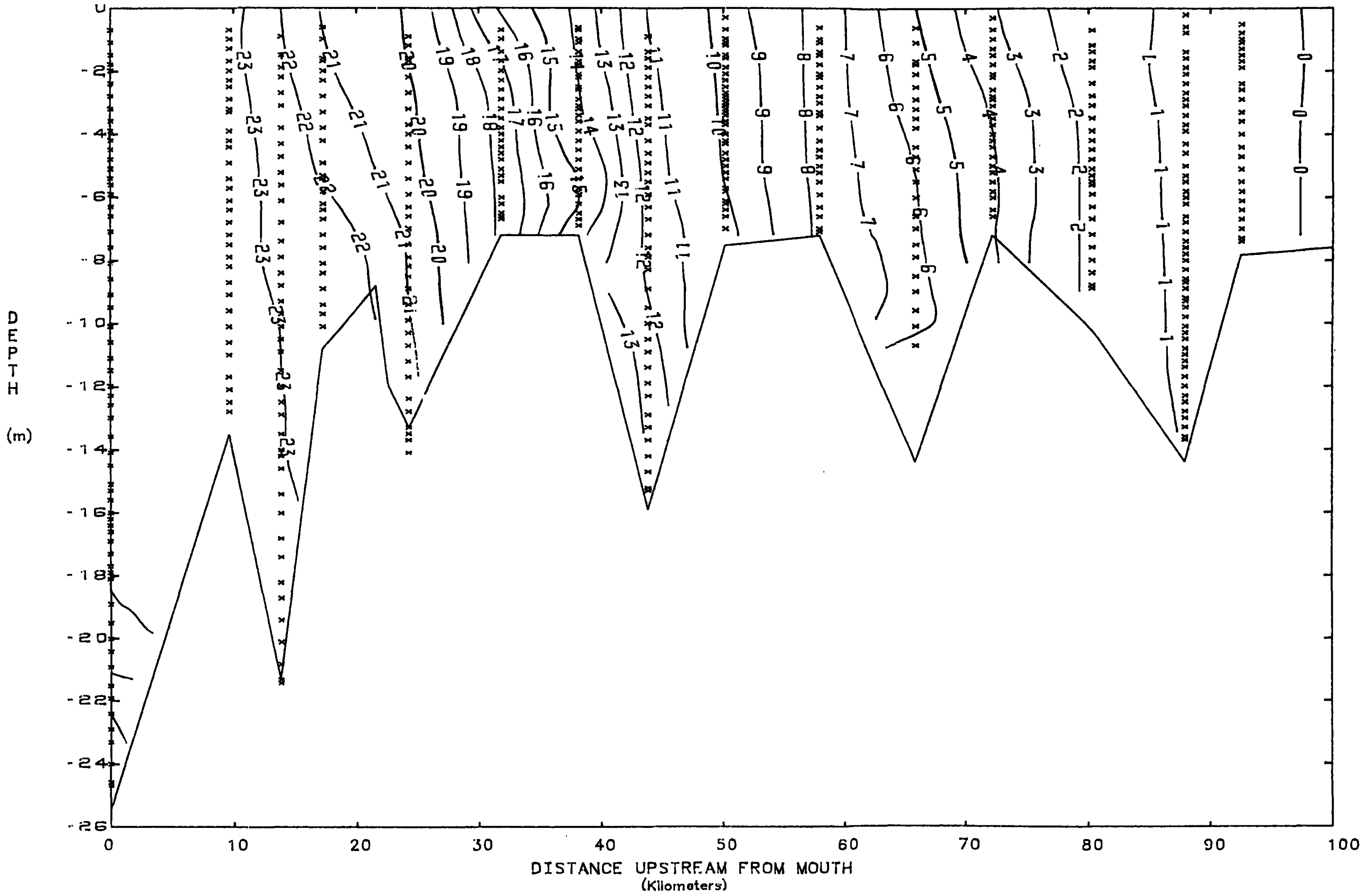
JAMES RIVER 27 JUNE 1986

SALINITY SLACK BEFORE FLOOD



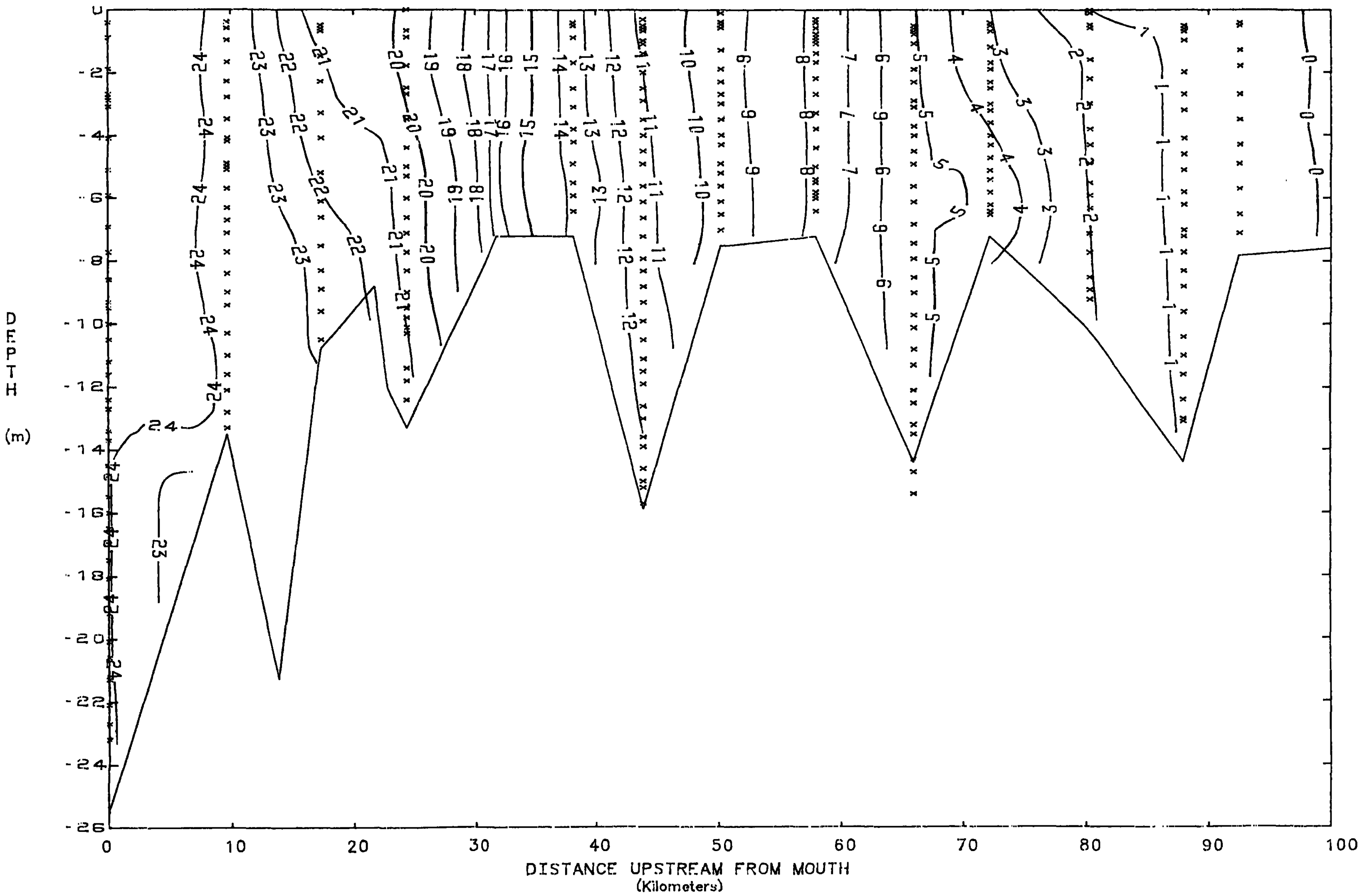
JAMES RIVER 22 JULY 1986

SALINITY SLACK BEFORE FLOOD



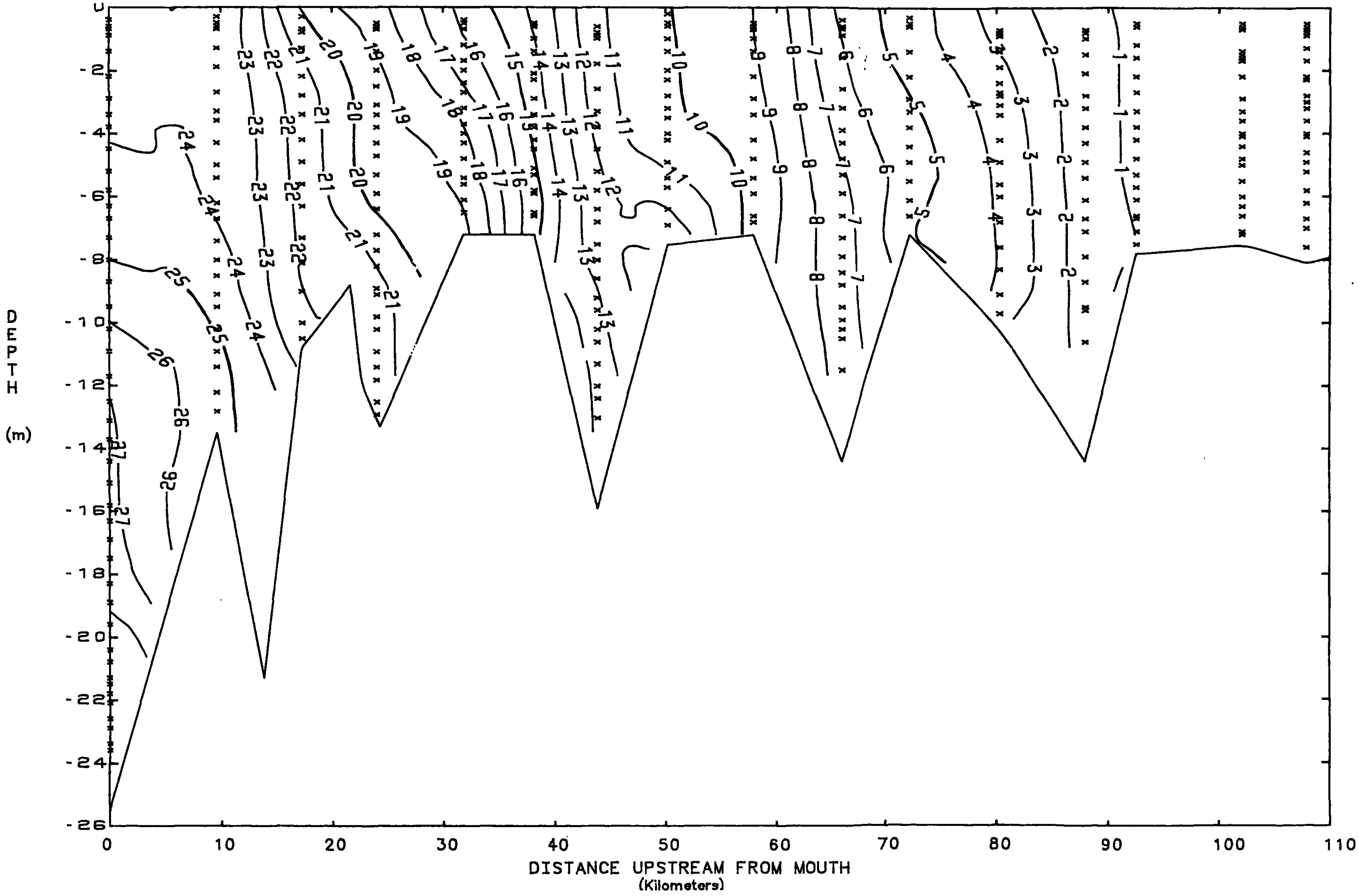
JAMES RIVER 21 AUGUST 1986

SALINITY SLACK BEFORE FLOOD



JAMES RIVER 23 OCTOBER 1986

SALINITY SLACK BEFORE FLOOD



JAMES RIVER 24 NOVEMBER 1986

SALINITY SLACK BEFORE FLOOD