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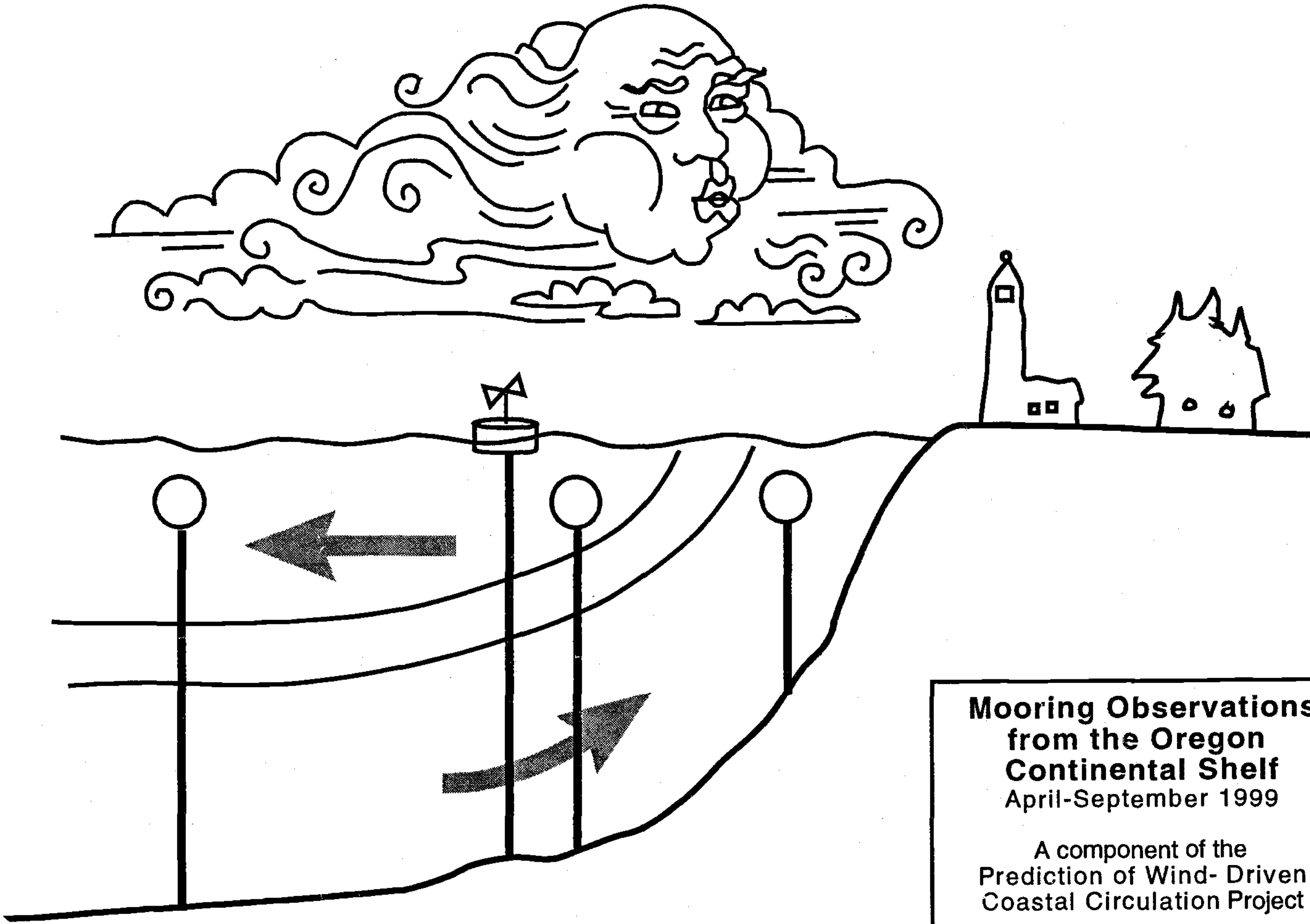

Mooring Observations from the Oregon Continental Shelf
April-September 1999

A component of the Prediction of Wind- Driven Coastal Circulation Project

by
Timothy Boyd
Murray D. Levine
P. Michael Kosro
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Reference 00-1
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Data Report 177

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OREGON STATE UNIVERSITY

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We appreciate the support of this project by the National Ocean Partnership Program (NOPP) through grant N00014-98-1-0787 and the efforts of program manager Scott Sandgathe of the Office of Naval Research.

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INTRODUCTION

This report documents oceanographic and meteorological measurements made from instruments deployed on four moorings over the continental shelf west of Oregon, from spring through summer, 1999. These moorings were a component of an observational and numerical modeling program to study the response of the coastal ocean to wind forcing.

The Dynamics and Prediction of Wind-Driven Coastal Circulation was funded by the National Oceanographic Partnership Program (NOPP) with the principal goal to develop nowcast and forecast systems for wind-driven coastal flow fields. The observational program was designed to provide measurements that would allow testing and improvement of the modeling capability. See http://www.oce.orst.edu/po/research/nopp/, http://diana.OCE.ORST.EDU/cmoweb/nopp/, and Austin et al. (2000) for description of the modeling program and a description of other aspects of the observational program.

This report is divided into two sections. The first section contains descriptions of the instrumentation deployed on the NOPP moorings including locations, sampling rates, and calibrations. The second section contains plots of the observations. Several views of the time series recorded by the moorings are presented. Time series of vertically separated velocity, temperature, and salinity are shown for each mooring. Velocity and temperature observations from the same depth on horizontally separated moorings are also shown. These data are presented as both 40-hour low-pass filtered and 1-hour low-pass filtered time series. Time is given as day of year 1999 in all of the time series plots; conversion to calendar date is provided in Table 5.

DEPLOYMENT HISTORY

Three subsurface oceanographic moorings and one meteorological mooring were deployed from the R/V Wecoma on the continental shelf west of Newport, OR, on 27 April 1999. An Inshore mooring was deployed in 50 m, a Mid-Shelf mooring was deployed 12.5 km farther west in 80 m, and a Shelf-Break mooring was deployed 16.18 km west of the Mid-Shelf mooring in 130 m of water. The meteorological ("Met") mooring was deployed adjacent to the Mid-Shelf mooring in 81 m of water. In Figure 1, the locations of the moorings are shown in relation to the bathymetry of the Oregon shelf. The positions, dates, and instruments supported by each of these moorings are listed in Table 1. The sampling parameters for the acoustic current profilers on the subsurface moorings are listed in Table 2, and the meteorological variables sampled on the Met mooring are listed in Table 3. The locations of the various oceanographic variables sampled are illustrated in Figure 2. Also shown in Figure 2 are the depth bins for which the ADP and ADCP velocities are good.

The subsurface moorings were marked at the surface by a spar buoy with a radar reflector and light located 3.5 m above the surface. The spar buoys were loosely tethered to the main buoyancy, located at roughly 10 m depth. Because these moorings were deployed in a heavily fished region, it was important to bring descriptions and positions of the moorings to the attention of the commercial fishing fleet. To that end, an advertisement was run in National Fisherman, a notice to mariners was posted, posters were displayed at docks frequented by commercial fisherman, and laminated calling cards with mooring positions were distributed at the poster locations. We requested that commercial fishermen steer clear of the moorings and report to us any signs of mooring or instrument damage.

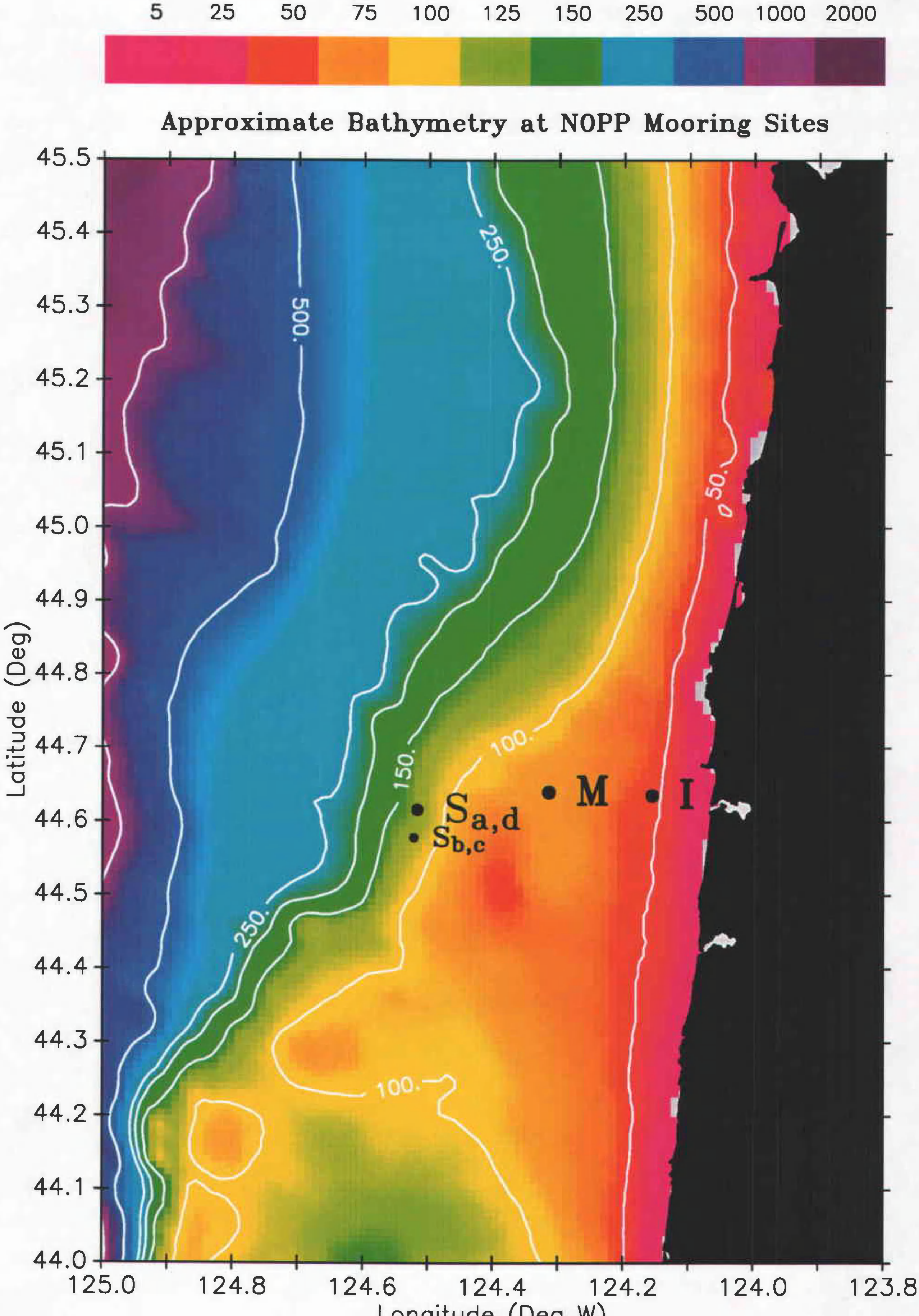
Despite the notices, the M/V Sea Eagle, a trawler under contract to NOAA/NMFS, encountered the Shelf-Break mooring on 22 May. Parts of the mooring were hit by the Sea Eagle's trawling gear as it was being hauled in at the conclusion of a tow. During recovery of the trawl gear, the surface spar buoy was dragged under water. The spar buoy resurfaced near the stern of the Sea Eagle, where the mast was damaged in the subsequent line tangle at the stern. Apparently during this episode, the near-bottom VACM came off the mooring chain and was not recovered later with the remainder of the mooring.

An Argos transmitter (PTT) strapped to the topmost subsurface float was torn free of its bracket during the encounter with the trawler, rose to the surface, and transmitted once before going offline for good. The quality of this single transmission was not sufficiently high to obtain an accurate position. The PTT was later found washed ashore at North Beach, Pt Reyes National Seashore the week of 21 June 1999, and subsequently returned to OSU by mail.

During a day trip aboard the R/V Sacajawea on 3 June to conduct a visual inspection of the mooring damage, the Shelf-Break mooring was found in 120 m of water 4 km south of the deployed position. At this time, the topmost subsurface float was at the surface and attached to the demasted spar buoy. On a second trip to the new mooring site on 19 June, the original spar buoy was recovered and replaced with a smaller, temporary spar buoy.

The Shelf-Break mooring was recovered and redeployed during the main NOPP cruise aboard R/V Wecoma, 13-31 July. Recovery was complicated by the fact that the surface spar buoy was not found at its last recorded position, however successful communication with the acoustic release indicated that at least some part of the mooring remained at that location. Wecoma then returned briefly to Newport to load equipment for a dragging operation: the deep sea traction winch, chain, and various grapnel hooks. During the first dragging attempt, near midnight on 17 July, the mooring chain was grabbed near the middle of the mooring while following a semicircular path around the mooring location. In addition to the spar buoy, one of the subsurface floats was missing. This reduction in buoyancy caused the remaining upper buoy to float at about 10 m depth, leaving the bottom 7-10m of the mooring resting on the bottom. Loss of the flotation was probably due to mechanical wearing of hardware connecting the buoys, which were supposed to be subsurface, but were riding in the wave zone after being dragged. After downloading data and some reconfiguration of instruments, the mooring was redeployed at its original location on 19 July 1999 with replacement flotation buoys, a replacement 500 kHz ADP, and one replacement MTR, but without the SBE 16 SEACAT that had not worked during the first deployment.

The Met mooring located over the Mid-Shelf was deployed with a sturdy wooden fence to prevent access to the surface buoy by seals/sea lions. Visual inspection of the Met mooring from the R/V Sacajawea during the NOPP mini-bat surveys of the mid- and inner-shelf (May-Sept 1999, Austin et al., 2000), revealed the fence gone and seals on the buoy after 1 month.



I = Inshore M = MidShelf & Met S = ShelfBreak periods a,b,c,d

Table 1.

a. NOPP Shelf-Break Mooring – First Deployment – 4/27/99 to 7/16/99 (117 to 197)

Three time periods:

A – 4/27/99 to 5/23/99 (117 to 143) **44°36.99N, 124°30.98W (130 m)**

B – 5/23/99 to 7/6/99 (143 to 187) **44°34.71N, 124°31.30W (120 m)** dragged by fishing boat (mooring became shallower by 9 m)

C – 7/6/99 to 7/16/99 (187 to 197) " " " Lost upper buoyancy (mooring became deeper by 10 m)

Sensor	Serial #	Depth, m			Δ t, min	Comments
		A	B	C		
MTR	3098	2	2		4	on spar buoy; recover 6/19
~~Seacat~~	~~50~~					did not record data
MTR	3075	16	7	17	4	
MDR w/P	100	20	11	21	4	
Microcat	39	28	19	29	2	
SBE 39	88	36	27	37	2	
MTR	3079	48	39	49	4	
Microcat	43	60	51	61	2	
MTR	3093	72	63	73	4	
MTR	3078	82	73	83	4	
MTR	3010	94	85	95	4	
Microcat	41	120	111	120	2	
ADP-250	C12	125			2	no data during B and C
~~VACM~~	~~195037c~~					lost
MTR	3073	128	119	120	4	on release

b. NOPP Shelf-Break Mooring – Second Deployment – 7/19/99 to 9/3/99 (200 to 246)— period D
44°37.17N, 124°30.90W (131 m)

Sensor	Serial #	Depth	Δ t, min	Comments
MTR	3098	2	4	
Microcat	43	13	2	
MTR	3075	17	2	
MDR w/P	100	21	2	
Microcat	39	29	2	
SBE 39	88	37	2	
MTR	3079	49	2	
MTR	3010	61	2	
MTR	3093	73	2	
MTR	3078	83	2	
ADP-500	3	91	2	
~~MTR~~	~~3077~~			on ADP frame; did not record data
Microcat	41	121	2	
MTR	3073	129	2	on release

Table 1 (cont.).

c. NOPP Mid-Shelf Mooring – 4/27/99 to 9/3/99 (117 to 246)
44°38.42N, 124°18.84W (81 m)

Sensor	Serial #	Depth	Δ t, min	Comments
~~Seacat~~	~~51~~			did not record data
MTR	3085	16	4	
MDR w/P	116	20	4	
MTR	3113	24	4	
Microcat	40	28	2	
SBE 39	86	36	2	
MTR	3086	48	4	
MTR	3090	60	4	
Seacat	41	70	4	
ADP-500	4038	74	4	
VACM	1950869	76	16	
MTR	3080	78	4	on release

d. NOPP Meteorological Mooring – 4/27/99 to 9/3/99 (117 to 246)
44°38.60N, 124°19.02W (80 m)

Sensor	Serial #	Depth	Δ t, min	Comments
Seacat	43	2	4	on surface buoy bridle
MTR	3074	4	4	
MTR	3084	6	4	
MTR	3081	10	4	calibration bias .01 to .015 (see Table 4)

e. NOPP Inshore Mooring – 4/27/99 to 9/3/99 (117 to 246)
44°38.14N, 124°9.33W (50 m)

Sensor	Serial #	Depth	Δ t, min	Comments
MTR	3082	2	4	on spar buoy
Seacat	40	13	4	
MTR	3094	16	4	
MTR	3099	20	4	
SBE 39	87	28	2	
Microcat	42	40	2	
ADCP-300	1552	46	4	
~~VACM~~	~~1950a94~~			did not record data
MTR	3095	48	4	on release

Table 2a. Sampling Parameters for Acoustic Doppler (Current) Profilers

Shelf-break Mooring; first deployment—periods A, B, C

Parameter	Value	Comment
Manufacturer	Sontek, Inc.	Acoustic Doppler Profiler (ADP)
Acoustic frequency	250 kHz / 3 beams	simultaneous pinging
Model / serial no.	Stand-alone ADP / C12	purchased by Kosro
CPU / DSP Versions	ADP 4.6 / DSP 5.0	Board Rev. D
Slant angle	25 degrees	
Cell size / number of cells	4 m / 35 cells	3.2 W @ 100% duty cycle
Averaging interval	40 s	
Number of pings / sample	160	
Sampling interval	120 s	duty cycle = 40/120 = 0.333
Blanking distance	2 m	
Coordinate system	ENU	
Data filename (binary)	N9904001.ADP	11,130,866 bytes
First profile Last profile	0340 4/25/99 GMT 1828 6/6/99 GMT	Time of center of pinging
Number of profiles	22,172	
Location	Shelfbreak Mooring at 125 m depth	44 deg 36.99' N; 124 deg 30.98'W
Cell depths (center) ~~strikeout~~ = unreliable	~~119~~, 115, 111, 107, 103, 99, 95, 91, 87, 83, 79, 75, ~~71, 67, 63, 59, 55, 51, 47, 43, 39, 35, 31, 27, 23, 19, 15, 11, 7, 3~~	
Salinity used in c_{sound}	33.5 ppt	not very sensitive to S; 1.2 m/s per ppt
Auxiliary sensors	temperature, tilt (2), compass heading	
Battery type	lithium (3 packs)	
Energy available (est.)	5442 Wh	= 3 x 21.6 V x 84 Ah
Energy used (est.)	1074 Wh	= 3.2 W x 0.33 x 42 days x 24 h/day

Table 2b. Sampling Parameters for Acoustic Doppler (Current) Profilers

Shelf-break Mooring; second deployment— period D

Parameter	Value	Comment
Manufacturer	Sontek, Inc.	Acoustic Doppler Profiler (ADP)
Acoustic frequency	500 kHz / 3 beams	sequential pinging
Model / serial no.	Stand-alone ADP / 3	purchased by Kosro
CPU / DSP Versions	ADP 5.3 / DSP 4.0	Board Rev. D
Slant angle	25 degrees	
Cell size / number of cells	2 m / 50 cells	2 W @ 100% duty cycle
Averaging interval	48 s	
Number of pings / sample	96	
Sampling interval	120 s	duty cycle = 48/120 = 0.4
Blanking distance	1 m	
Coordinate system	ENU	
Data filename (binary)	N9907001.ADP	28,411,854 bytes
First profile Last profile	0000 7/13/99 GMT 2036 9/8/99 GMT	Time of center of pinging
Number of profiles	41,659	
Location	Shelfbreak Mooring at 91 m depth	44 deg 37.17' N; 124 deg 30.90'W
Cell depths (center)	88, 86, 84, 82, 80, 78, 76, 74, 72, 70, 68, 66, 64, 62, 60, 58, 56, 54, 52, 50, 48, 46, 44, 42, 40, 38, 36, 34, 32, 30, 28, ~~26, 24, 22, 20, 18, 16, 14, 12, 10, 8, 6, 4, 2, 0~~	
Salinity used in c_{sound}	33.0 ppt	not very sensitive to S; 1.2 m/s per ppt
Auxiliary sensors	temperature, tilt (2), compass heading	
Battery type	alkaline	
Energy available (est.)	2268 Wh	= 3 x 18 V x 24 Ah
Energy used (est.)	1114 Wh	= 2 W x 0.4 x 58 day x 24 h/day

Table 2c. Sampling Parameters for Acoustic Doppler (Current) Profilers

Mid-Shelf Mooring

Parameter	Value	Comment
Manufacturer	Sontek, Inc.	Acoustic Doppler Profiler (ADP)
Acoustic frequency	500 kHz / 3 beams	sequential pinging
Model / serial no.	Stand-alone ADP / 4038	purchased by Levine / Boyd
CPU / DSP Versions	ADP 4.2 / DSP 4.0	Board Rev. D
Slant angle	25 degrees	
Cell size / number of cells	2 m / 40 cells	2 W @ 100% duty cycle
Averaging interval	150 s	
Number of pings / sample	300	
Sampling interval	240 s	duty cycle = 150/240 = 0.625
Blanking distance	1 m	
Coordinate system	ENU	
Data filename (binary)	N9904002.ADP	27,250,672 bytes
First profile Last profile	0552 4/27/99 GMT 2220 9/8/99 GMT	Time of center of pinging
Number of profiles	48,488	
Location	Mid-Shelf Mooring at 74 m depth	44 deg 38.42' N; 124 deg 18.84'W
Cell depths (center) ~~strikeout~~ = unreliable	~~71~~, 69, 67, 65, 63, 61, 59, 57, 55, 53, 51, 49, 47, 45, 43, 41, 39, 37, 35, 33, 31, 29, 27, 25, 23, 21, 19, 17, 15, 13, 11, 9, ~~7, 5, 3, 1~~	
Salinity used in c_{sound}	33.5 ppt	not very sensitive to S; 1.2 m/s per ppt
Auxiliary sensors	temperature, tilt (2), compass heading	
Battery type	lithium (3 packs)	
Energy available (est.)	5442 Wh	= 3 x 21.6 V x 84 Ah
Energy used (est.)	4080 Wh	= 2 W x 0.625 x 136 day x 24 h/day

Table 2d. Sampling Parameters for Acoustic Doppler (Current) Profilers

Inshore Mooring

Parameter	Value	Comment
Manufacturer	RDI, Inc.	Acoustic Doppler Current Profiler (ADCP)
Acoustic frequency	300 kHz / 4 beams	purchased by Levine / Boyd
Model / serial no.	Workhorse / 0067	Firmware: 8.27 operating; 1.13 boot
Slant angle	20 degrees	
Bin length / number of bins	2 m / 28 bins	
% good minimum	25%	
Number of pings / sample	25	
Sampling interval	240 s	
Blanking distance	1.76 m	
Coordinate system	Earth	
Data filename (binary)	N9904000.000	34,146,032 bytes
First profile Last profile	0630 4/27/99 GMT 1218 9/9/99 GMT	
Number of profiles	48,838	
Location	Inner Shelf Mooring at 46 m depth	40 deg 29.50' N; 70 deg 30.46'W
Bin depths (center) ~~strikeout~~ = unreliable	~~42, 40~~, 38, 36, 34, 32, 30, 28, 26, 24, 22, 20, 18, 16, 14, 12, 10, ~~8, 6, 4, 2, 0~~	
Salinity used in c_{sound}	34 ppt	not very sensitive to S; 1.2 m/s per ppt
Auxiliary sensors	temperature, tilt (2), compass heading	
Battery type	alkaline	source: RDI
Energy available (est.)	400 Wh	specified by RDI
Energy used (est.)	395 Wh	from RDI "Plan" program – 136 days; powered 30 more days @ 7°C before full memory; final: 32 VDC

Table 3. Meteorological Buoy (components purchased from Campbell Scientific Inc.)

Sensors:	
Air Temperature & Relative Humidity	(Model HMP45C; Vaisala, Inc.)
Wind Speed & Direction	(Model 05106-5; RM Young)
Barometric Pressure	(Model CS105; Vaisala, Inc.)
Pyranometer (solar radiation)	(Model LI200X; Li-Cor)
Buoy Compass	(Model C100; KVH)
Controller:	
Data Logger	(Model CR10X; Campbell Scientific Inc.)
Sampling Program (NOPP2)–written by Dennis Root.	
Data are averaged over 15 minutes, using samples taken every:	
5 seconds (wind speed, vane direction, & buoy compass)	
1 minute (air temperature, relative humidity, barometric pressure, & radiation)	
Battery voltage is sampled and recorded once per day.	
Communication:	
Cell phone package	(Model CDM100; Motorola)
Cell phone system is turned on between 1600 and 1700 UT each day.	

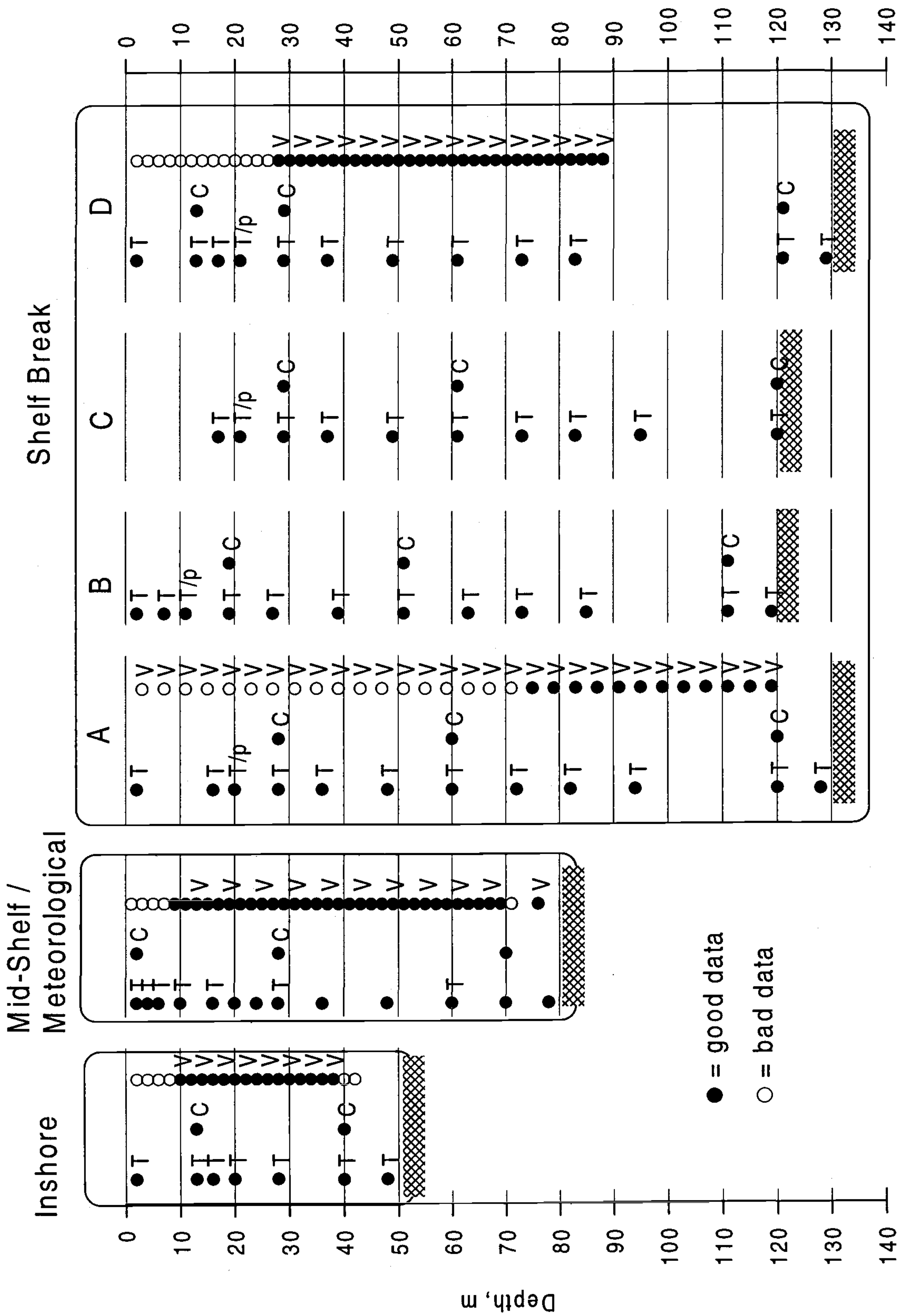
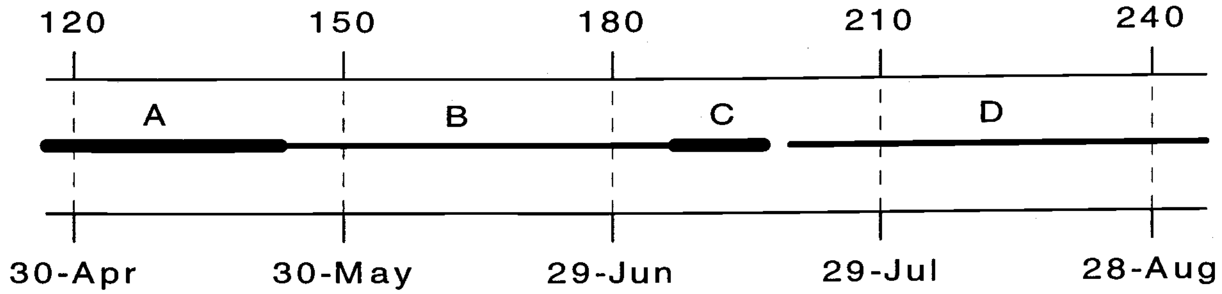

Inshore
Mid-Shelf / Meteorological
Shelf Break
A
B
C
D
● = good data
○ = bad data
Depth, m

Figure 2.

Beginning 22 July, cellular phone downloads of meteorological data showed that the anemometer had failed. Subsequent visual inspection of the Met buoy conducted by R/V Wecoma during the NOPP intensive survey revealed the anemometer absent, and the anemometer cable extracted to full length suspended in the water, consistent with either vandalism or contact with a fishing boom. The anemometer was replaced and one guy wire was repaired on 3 August 1999. Shortly after replacement of the anemometer, all other meteorological sensors failed. The failure was due to an internal short of the temperature sensor circuitry for reasons that remain a mystery.

The mooring field work concluded when the three subsurface moorings and surface Met mooring were recovered at their deployed locations without incident on 3 September 1999. In the figures that follow, we refer to the period of time between the initial deployment and the trawler accident as Period A, the time between the trawler accident and the loss of Shelf-Break mooring buoyancy as Period B, and the time between loss of buoyancy and the recovery of the first Shelf-Break mooring as Period C. Period D refers to the entire duration of the second deployment of the Shelf-Break mooring. These periods are illustrated in the following time line.



MOORINGS and INSTRUMENTATION

Mooring Construction

The primary strength member of all the moorings was 1/2" long-link chain. The buoyancy for the subsurface moorings was provided by steel spheres: two 37" diameter spheres provided 1280 lbs net buoyancy on the Shelf-Break mooring, one 48" sphere provided 1370 lbs net buoyancy on the Mid-Shelf mooring, and one 37" sphere provided 640 lbs net buoyancy on the Inshore mooring. The subsurface mooring sites were marked by spar buoys with radar reflectors and lights at 3.5m above the water. The spar buoys netted about 250 lbs of buoyancy and were filled with foam to minimize the consequences of a leak. The spar buoys were loosely tethered to the subsurface spheres, and were not intended to support the mooring in the event of a failure of the primary buoyancy.

The Met buoy is a 1.78m diameter toroid constructed of DuPont Surlyn foam (Gilman Corp.), providing a maximum 2580 lbs of buoyancy (i.e., at the point of total submergence). The Met mooring total length was 114 m, resulting in a scope of 1.4 (length of chain/depth of water).

The anchor for each mooring was composed of three railroad wheels welded to an axial pipe with a lower flange, weighing approximately 2500 lbs.

Instrument Calibration

The SBE 16 (SEACAT) and SBE 37-SM (MicroCAT) conductivity/temperature sensors were calibrated by Sea-Bird Electronics (SBE) in February 1999. The SBE 39 Temperature Recorders were factory calibrated by SBE in January 1999. Both SBE 39 Temperature Recorders and SBE 37 MicroCats output data in engineering units using these most recent SBE-installed coefficients. The February 1999 coefficients were used to convert to SBE 16 temperature and salinity

The most recent thorough calibration of the MTR and MDR temperature recorders was completed in October 1996 at OSU following the PRIMER/CM&O mooring deployment of July-September, 1996 (see Boyd et al., 1997 for a discussion of the temperature calibration). Prior to the NOPP deployment in April 1999, the MTR & MDR temperature coefficients were validated by comparison to a bath standard in three steps over the temperature range 5-18°C. The bath reference temperature was measured by an SBE-38 Digital Immersion Thermometer, which was calibrated by SBE in September 1997. The instrumental temperature errors (sensor minus bath reference temperature) were computed separately for the three temperature steps, over which the bath temperature drifted upward by 0.33 °C/day. The MTR step-averaged errors, shown in Table 4, are biased toward positive values and larger at the highest temperature step. The average MTR error is 0.004°C at 18°C. The average MDR error, which is not obviously correlated to the bath temperature, is 0.008°C.

All pressure measurements in NOPP were made by MDRs, which were calibrated at OSU following the NOPP deployment in September 1996, using a dead-weight tester and a Paroscientific pressure standard.

Self-calibrations of the compasses on the Sontek ADP Doppler current profilers were performed per manufacturer specification at OSU with the instruments suspended from a tree as configured for deployment within their respective mooring frames. Self-calibration of the RDI ADCP was conducted per manufacturer specifications at OSU with the instrument in the mooring frame. All calibrations were checked by comparison of instrument magnetic north to local magnetic north

An Alpha-Omega model 9407 Vector Averaging Current Meter was deployed two meters above the acoustic release on each mooring. The VACM on the Inshore mooring didn't start, and the VACM on the initial Shelf-Break mooring was missing at the time of recovery. Verification of the compass calibration for Mid-Shelf VACM was performed after recovery at OSU in the VACM mounting bracket and with a short section of steel chain attached. The VACM compass error varied sinusoidally over 360° of compass heading with amplitude of 10°, and was used to correct the velocity data (G. Gunderson, personal communication).

ADCP/ADP Data Quality

The upward-looking RDI 300kHz Workhorse ADCP (WH300) mounted at 46m depth on the Inshore mooring returned reasonable data throughout most of the water column for the entire

Table 4. Temperature differences between existing sensor output (T_{MTR}) and calibration bath ($T_{calibration}$) at 3 tempertures.

MTR Sensor #	Average (T_{MTR} - $T_{calibration}$) / 10^{-3} °C $T_{calibration}$ = 18.16	5.00	6.00
3010	3.7	1.6	0.5
3073	0.8	-0.7	-1.2
3074	3.6	1.2	0.5
3075	5.6	2.4	1.8
3078	4.1	0.8	-0.1
3079	2.2	0	-0.6
3080	-1.0	-1.3	-1.8
3081	-10.1	-17.2	-18.0
3082	1.8	0	-0.8
3084	0.5	0.3	-0.7
3085	3.5	1.4	1.1
3086	2.6	1.2	0.5
3090	3.4	1.5	0.6
3093	2.9	0.7	0.1
3094	6.8	4.6	3.6
3095	5.5	3.4	2.7
3098	3.4	2.3	1.8
3099	6.5	3.0	2.0
3113	1.1	0.1	-0.5

MDR Sensor #	Average (T_{MDR} - $T_{calibration}$) / 10^{-3} °C $T_{calibration}$ = 18.16	5.00	6.00
100	8.2	10.3	8.5
116	5.1	8.2	7.1

Table 5. Day of year calendar for 1999.

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	
Day # 1	1	32	60	91	121	152	182	213	244	274	305	335	Day # 1
Day # 2	2	33	61	92	122	153	183	214	245	275	306	336	Day # 2
Day # 3	3	34	62	93	123	154	184	215	246	276	307	337	Day # 3
Day # 4	4	35	63	94	124	155	185	216	247	277	308	338	Day # 4
Day # 5	5	36	64	95	125	156	186	217	248	278	309	339	Day # 5
Day # 6	6	37	65	96	126	157	187	218	249	279	310	340	Day # 6
Day # 7	7	38	66	97	127	158	188	219	250	280	311	341	Day # 7
Day # 8	8	39	67	98	128	159	189	220	251	281	312	342	Day # 8
Day # 9	9	40	68	99	129	160	190	221	252	282	313	343	Day # 9
Day #10	10	41	69	100	130	161	191	222	253	283	314	344	Day #10
Day #11	11	42	70	101	131	162	192	223	254	284	315	345	Day #11
Day #12	12	43	71	102	132	163	193	224	255	285	316	346	Day #12
Day #13	13	44	72	103	133	164	194	225	256	286	317	347	Day #13
Day #14	14	45	73	104	134	165	195	226	257	287	318	348	Day #14
Day #15	15	46	74	105	135	166	196	227	258	288	319	349	Day #15
Day #16	16	47	75	106	136	167	197	228	259	289	320	350	Day #16
Day #17	17	48	76	107	137	168	198	229	260	290	321	351	Day #17
Day #18	18	49	77	108	138	169	199	230	261	291	322	352	Day #18
Day #19	19	50	78	109	139	170	200	231	262	292	323	353	Day #19
Day #20	20	51	79	110	140	171	201	232	263	293	324	354	Day #20
Day #21	21	52	80	111	141	172	202	233	264	294	325	355	Day #21
Day #22	22	53	81	112	142	173	203	234	265	295	326	356	Day #22
Day #23	23	54	82	113	143	174	204	235	266	296	327	357	Day #23
Day #24	24	55	83	114	144	175	205	236	267	297	328	358	Day #24
Day #25	25	56	84	115	145	176	206	237	268	298	329	359	Day #25
Day #26	26	57	85	116	146	177	207	238	269	299	330	360	Day #26
Day #27	27	58	86	117	147	178	208	239	270	300	331	361	Day #27
Day #28	28	59	87	118	148	179	209	240	271	301	332	362	Day #28
Day #29	29		88	119	149	180	210	241	272	302	333	363	Day #29
Day #30	30		89	120	150	181	211	242	273	303	334	364	Day #30
Day #31	31		90		151		212	243		304		365	Day #31

duration of the deployment. Data at 42 m was mostly error values and has not been included in any plots or distributed data files. The WH300 has 4 transducers at 20° angles from vertical, and uses data from all 4 beams to derive horizontal velocities when possible. The separation at the surface between oppositely facing beams was 33.5 m. Among the error statistics reported by the WH300 is the percentage of good 4-beam solutions used in each ensemble average, as well as the percentage of good 3-beam solutions per ensemble. The record-mean for ensemble percentage of good 4-beam solutions was greater than 98% for depths greater than 8 m, and the mean for good 3- or 4-beam solutions was greater than 99.5% for those depths. The error velocity is the difference between the estimates of vertical velocity from orthogonal pairs of transducers. Ideally, the two estimates of vertical velocity would be the same if the velocity field were homogeneous over the beam separations. The magnitude of the record-mean of the ensemble error velocity was less than 0.1 cm/s for depths greater than 8 m, with the exception of high error velocities at 40 m depth. Velocity data at 40 m depth otherwise appears reasonable. Mean vertical velocity is nearly constant -0.1 to -0.2 cm/s throughout most of the water column, with the exception of the top two bins, which are strongly influenced by surface reflections. RMS vertical velocity fluctuations increase gradually towards the surface, but are significantly larger in the bin closest to the surface due to the surface reflections. In summary, velocities at depths shallower than 10 m are suspect.

The 500kHz Sontek ADP deployed on the Mid-Shelf mooring returned reasonable data throughout most of the water column for the duration of the experiment. A different suite of error diagnostics is available for the Sontek ADPs than the RDI ADCP. The Sontek ADPs have 3 transducers mounted at 25° angles from vertical, and thus have no redundant information on velocity components. The 3 beams of the Mid-Shelf ADP were separated by 59.8 m at the surface. With the exception of the deepest bin and the four bins closest to the surface, the mean vertical velocity from the Mid-Shelf ADP is –0.6 to –0.9 cm/s. Data from the bins with larger vertical velocities, the bin at 71 m and the bins at depths shallower than 9 m, are suspect. In addition, the rms vertical velocity fluctuations increase gradually towards the surface, with the exception of the bottom bin (71 m) and the top three bins (1, 3, and 5 m), for which the vertical velocity standard deviation is larger (Figure 3). Data from these bins should probably be disregarded for this reason. The standard deviation over each ensemble of single-ping velocity components is recorded for each depth bin. The record-mean of the vertical velocity standard deviation is less than 0.65 cm/s for all depths greater than 9 m. Above 9 m, the mean of ensemble standard deviations increases toward the surface, rising to a maximum of 1.2 cm/s for the 1 m bin. The record-mean signal-to-noise ratios for each beam are nearly identical and decrease gradually by a factor of almost 4 towards the surface, with the exception of the 1 to 5-m and 71-m bins (Figure 4a). The signal-to-noise ratios (s/n) for the 1 to 5-m bins are significantly impacted by surface reflection, to a degree that varies with beam and presumably depends on mean tilt of the ADP. The s/n ratio at 71-m is lower than at the next shallower bin, but is still substantially larger than the near-surface values. Sontek ADP beam amplitudes and signal-to-noise ratios are completely correlated, thus containing no independent information.

The upward-looking 250kHz Sontek ADP used in the first deployment of the Shelf-Break mooring was located at 125 m and had its three beams separated by 101 m at the surface. Data was recorded only up to the time the mooring was struck by the M/V Sea Eagle. Standard deviations of the horizontal and vertical components of velocity show local maxima at 60 m and 30 m, which interrupt the otherwise monotonically increasing with range standard deviation

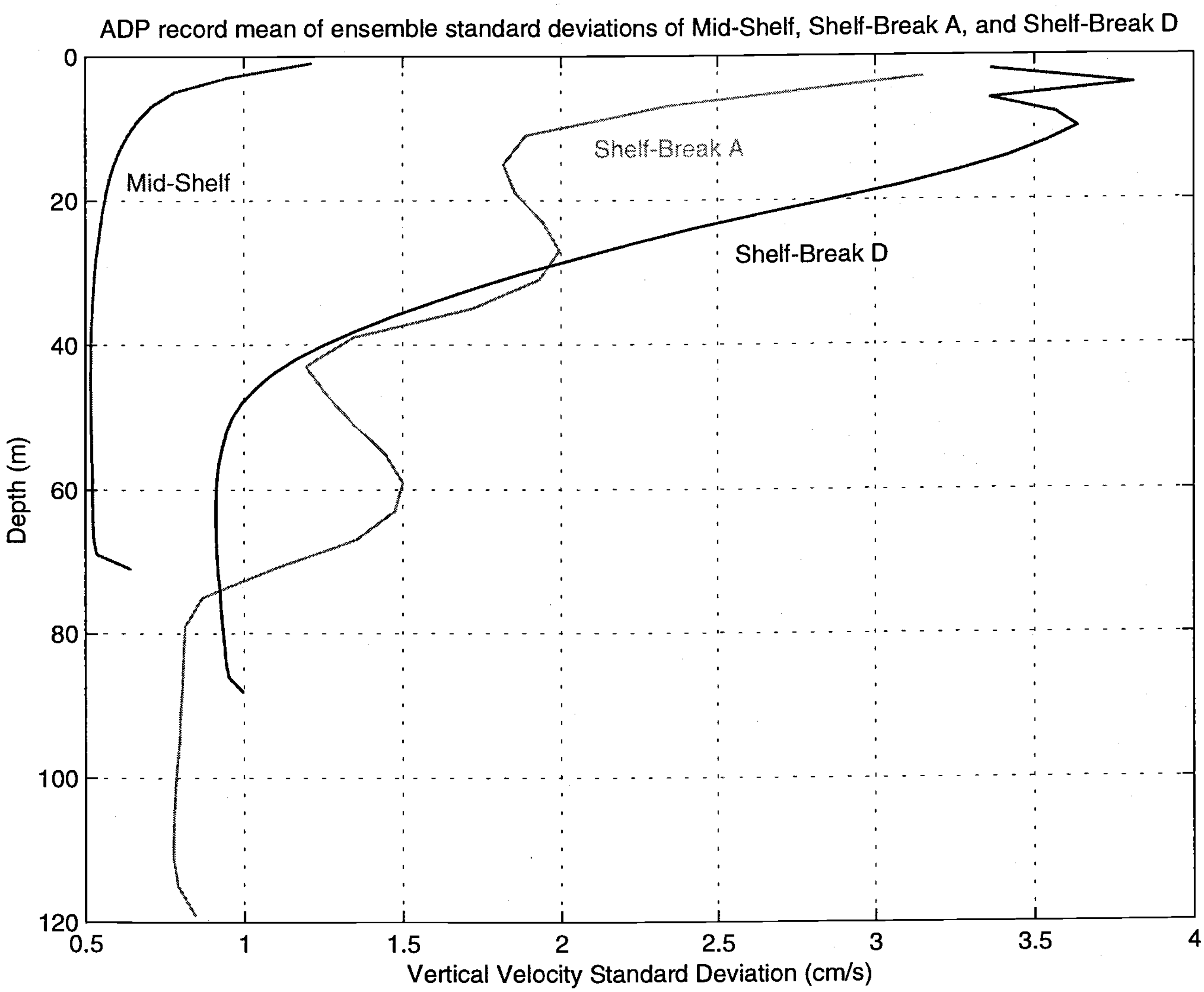

ADP record mean of ensemble standard deviations of Mid-Shelf, Shelf-Break A, and Shelf-Break D
Mid-Shelf
Shelf-Break A
Shelf-Break D
Depth (m)
0
20
40
60
80
100
120
0.5
1
1.5
2
2.5
3
3.5
4
Vertical Velocity Standard Deviation (cm/s)

Figure 3a.

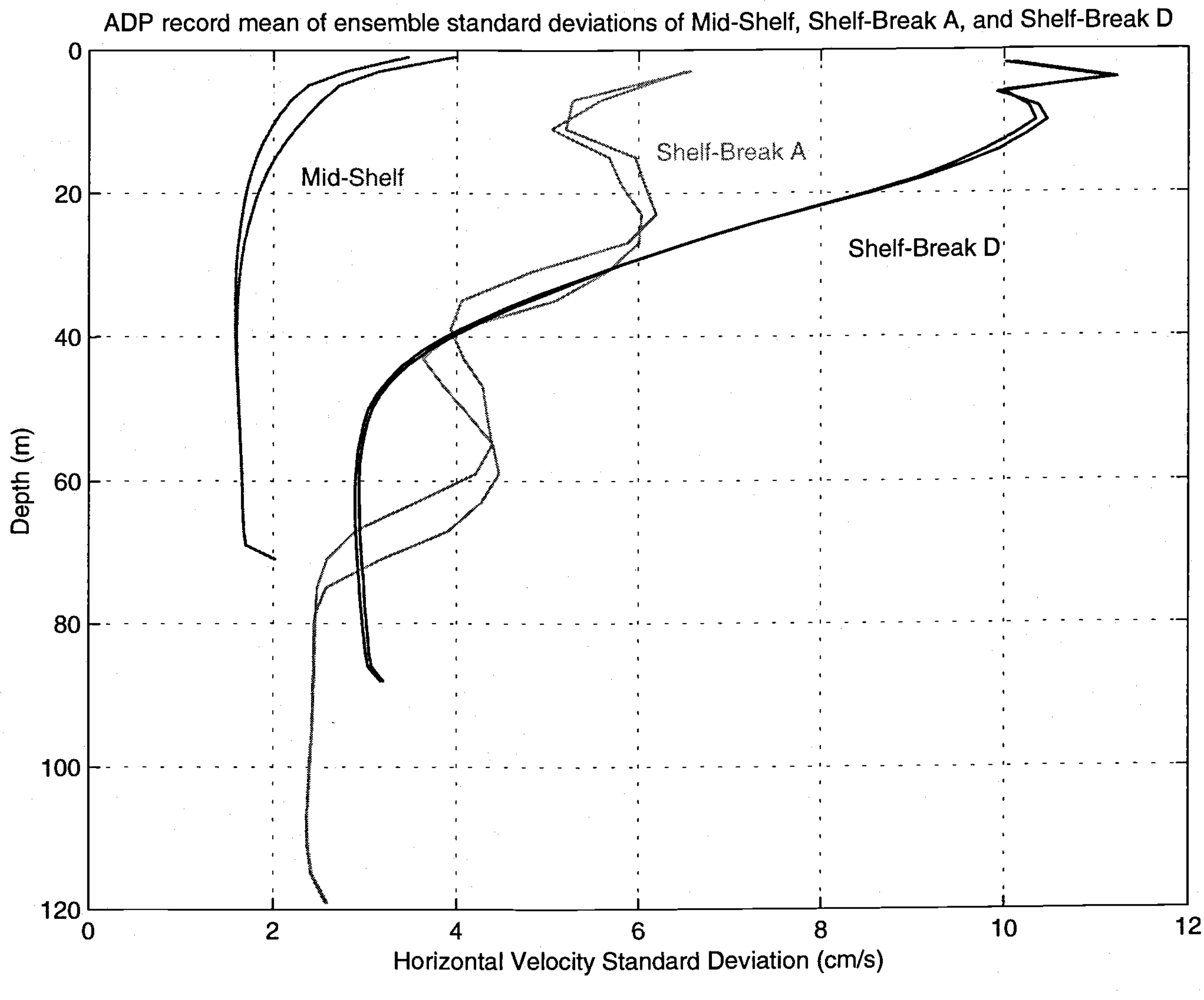

ADP record mean of ensemble standard deviations of Mid-Shelf, Shelf-Break A, and Shelf-Break D
Mid-Shelf
Shelf-Break A
Shelf-Break D
Depth (m)
0
20
40
60
80
100
120
0
2
4
6
8
10
12
Horizontal Velocity Standard Deviation (cm/s)

Figure 3b.

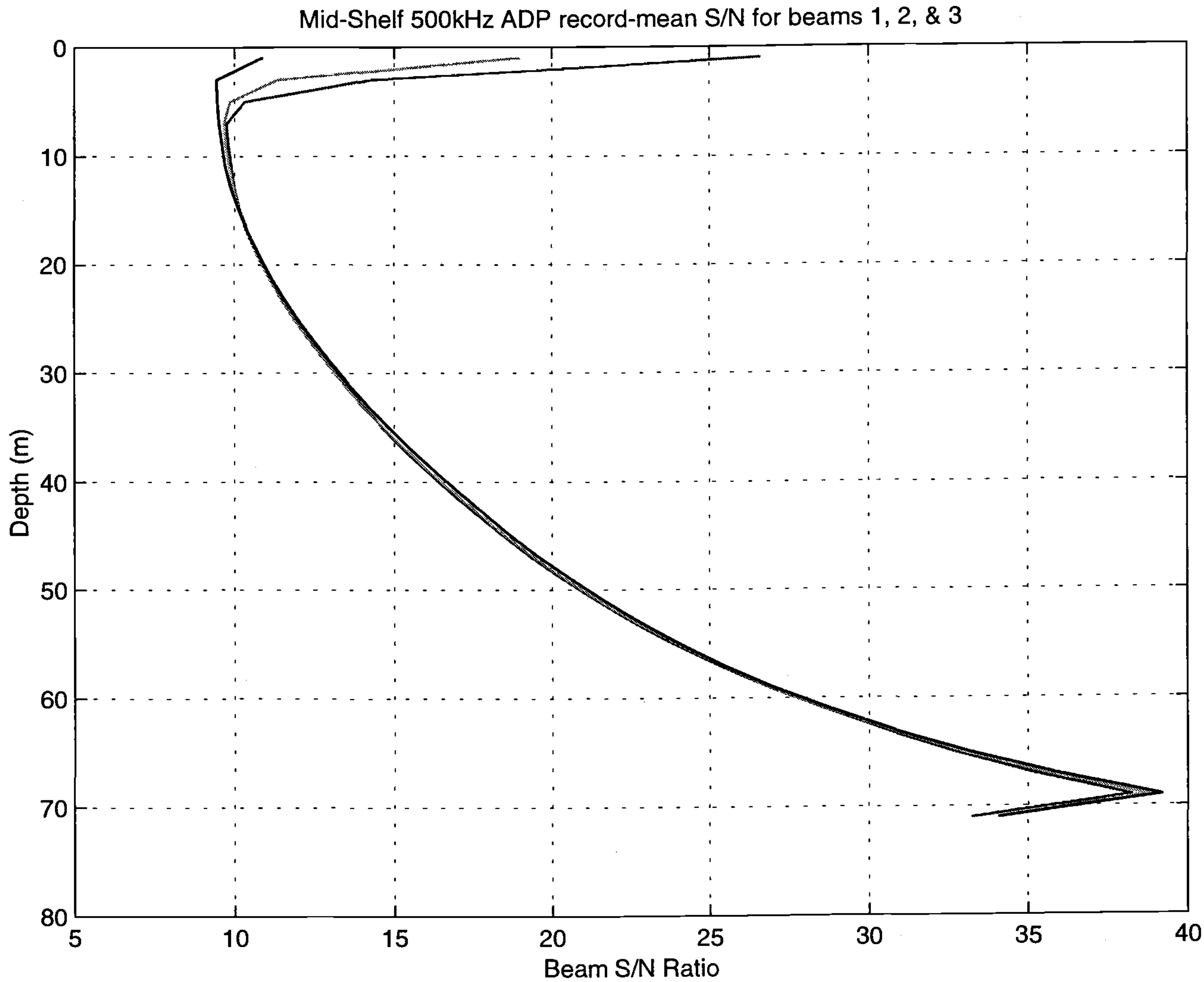

Mid-Shelf 500kHz ADP record-mean S/N for beams 1, 2, & 3
Depth (m)
0
10
20
30
40
50
60
70
80
5
10
15
20
25
30
35
40
Beam S/N Ratio

Figure 4a.

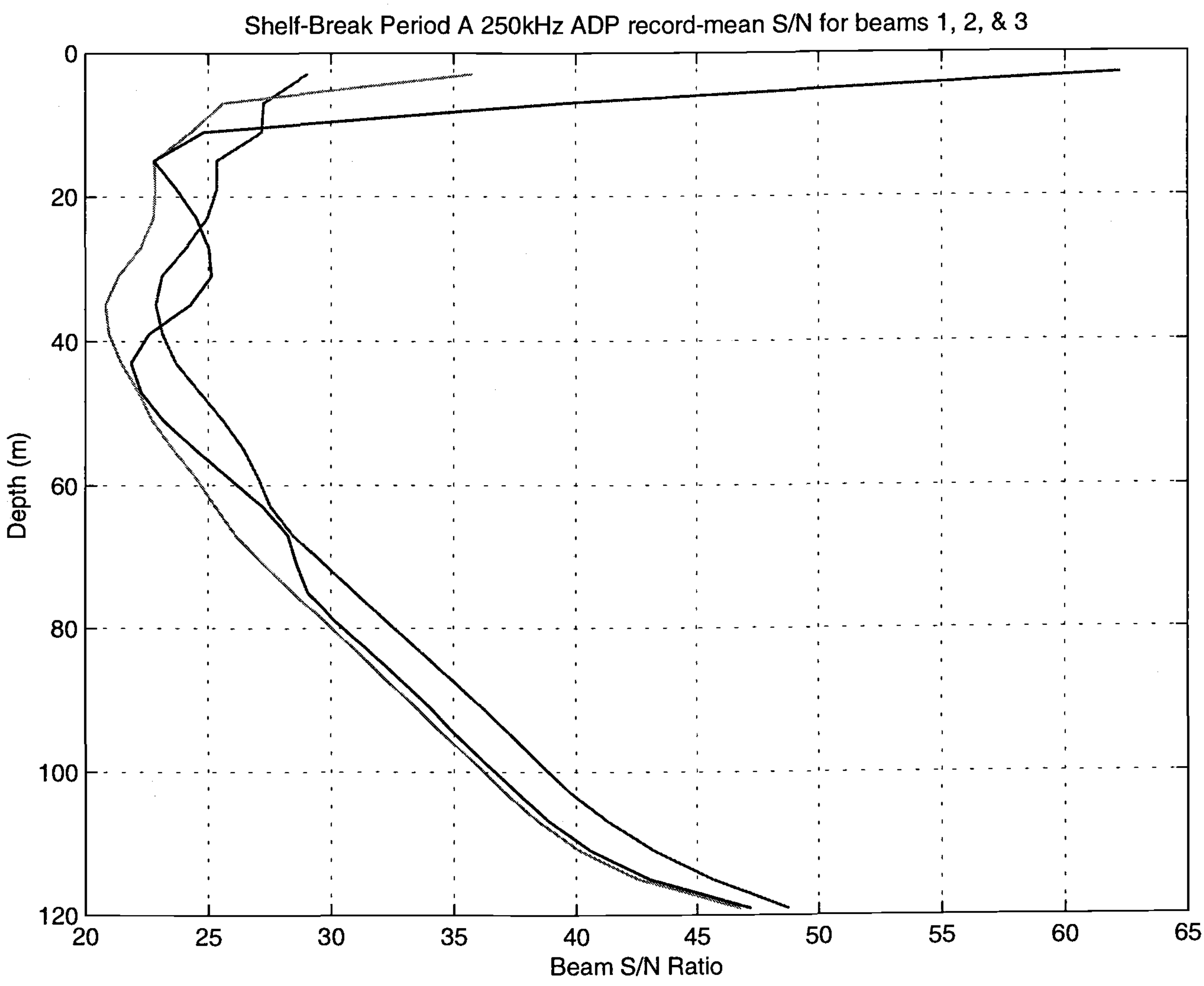
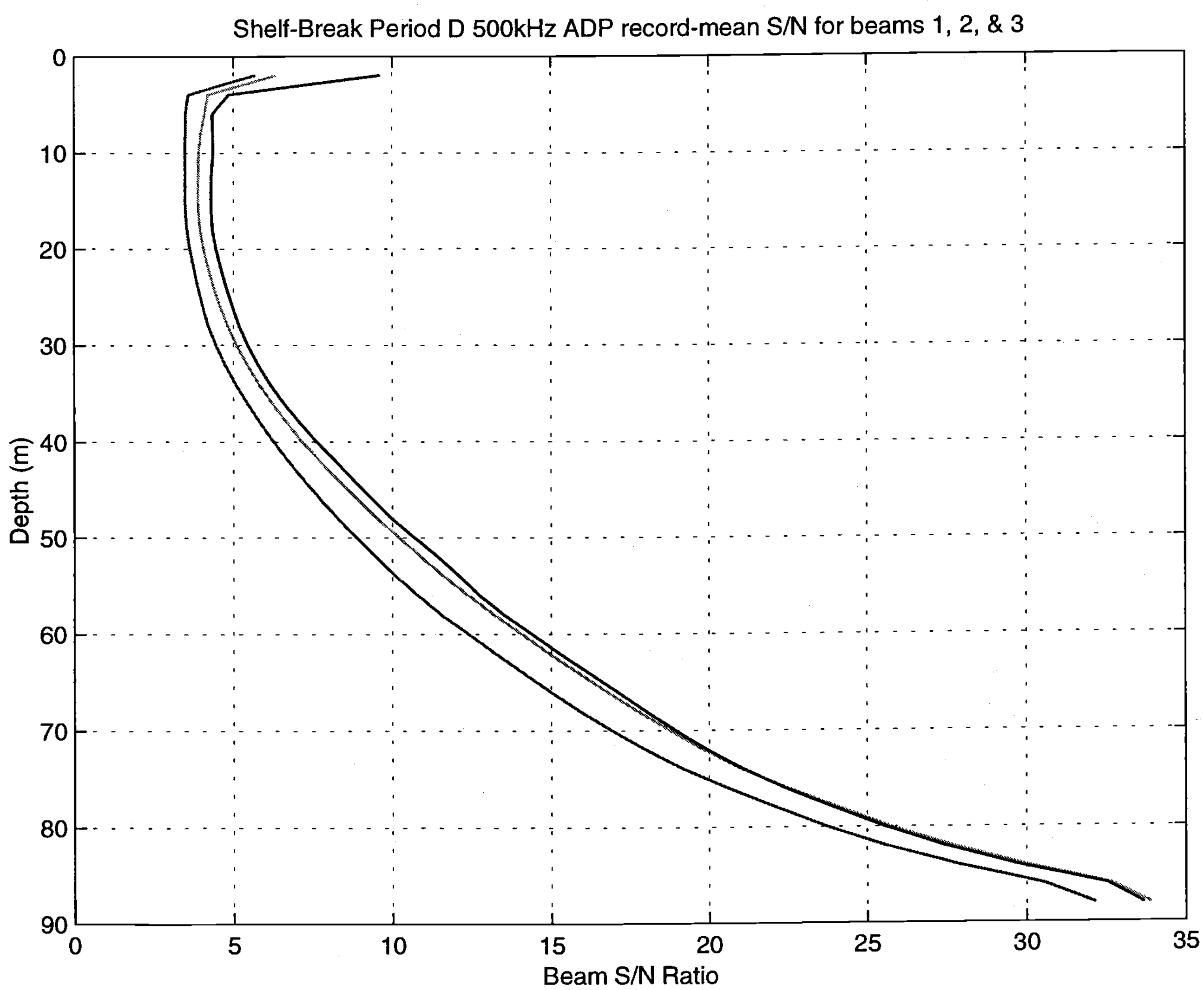

Shelf-Break Period A 250kHz ADP record-mean S/N for beams 1, 2, & 3
Depth (m)
0
20
40
60
80
100
120
20
25
30
35
40
45
50
55
60
65
Beam S/N Ratio

Figure 4b.



Shelf-Break Period D 500kHz ADP record-mean S/N for beams 1, 2, & 3
Depth (m)
0
10
20
30
40
50
60
70
80
90
0
5
10
15
20
25
30
35
Beam S/N Ratio

Figure 4c.

(Figure 3). A similar structure is observed in both the beam amplitude and signal-to-noise ratios, and is especially strong for one of the three beams (Figure 4b). The depth ranges of these peculiarities in the ADP diagnostics correspond to the depth ranges of strange behavior in the velocity fields. We consider only velocity data below 71 m to be reasonable for period A of the first deployment.

The upward-looking 500kHz Sontek ADP used in the second deployment of the Shelf-Break mooring was located at 91 m and had its three beams separated by 73.5 m at the surface. During this deployment, the Shelf-Break ADP exhibited vertically coherent diurnal variations in signal-to-noise ratio on all three beams. The diurnal increase in s/n corresponds to decreases in ensemble standard deviation of both near-surface vertical and horizontal components of velocity (Figure 5). Variations in solar radiation recorded on the Met mooring were roughly in phase with the near-surface ensemble standard deviation of all velocity components, and thus out of phase with beam signal-to-noise (Figure 6). Signal-to-noise would thus appear to improve (increase) as solar radiation went to zero each day, due to increased scatterer concentration in the near-surface layer, thus reducing the standard deviation of the velocity estimates.

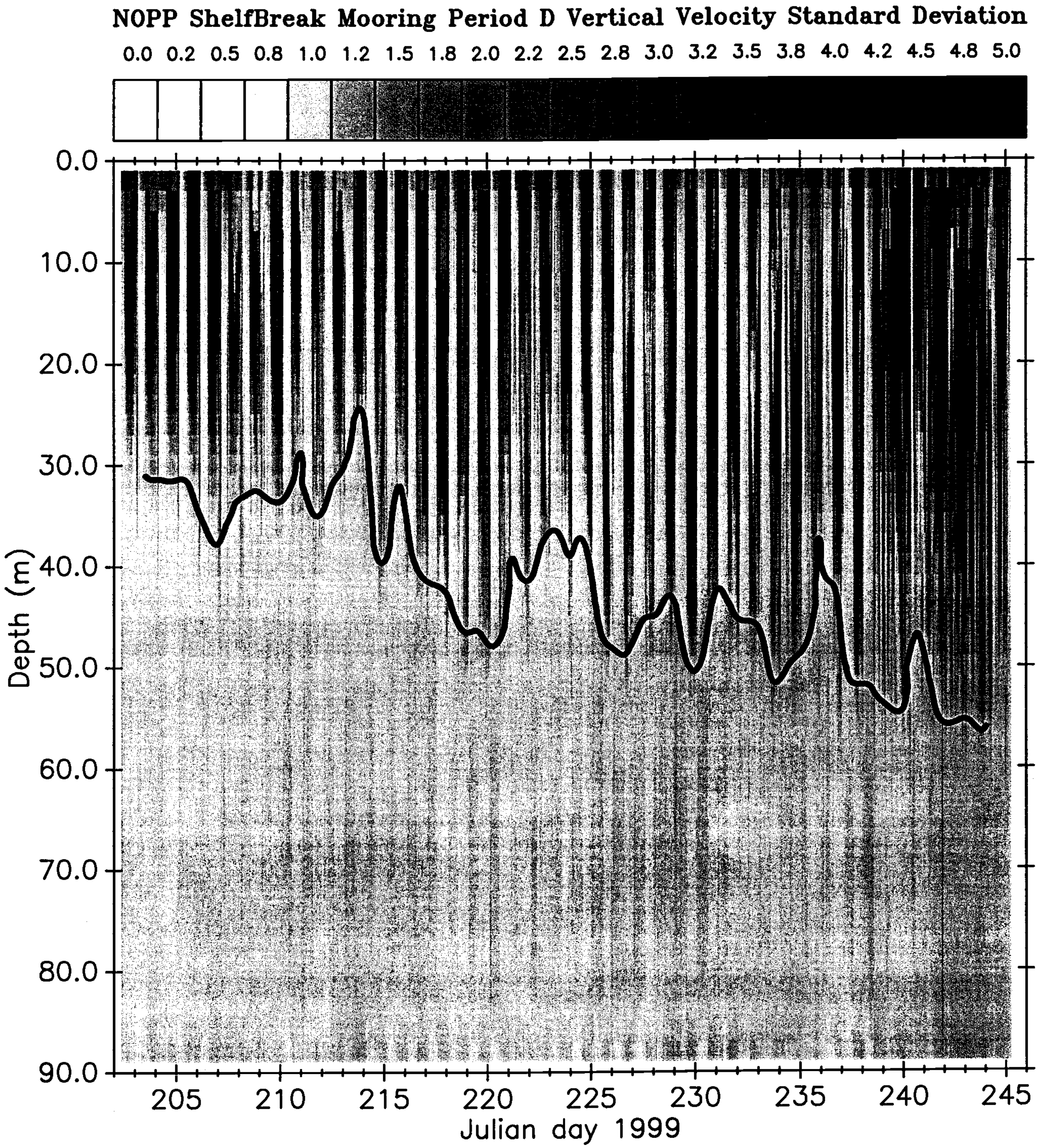
Throughout most of the period D Shelf-Break velocity record, low levels of s/n above 40-60 m are interrupted on a daily basis by vertically coherent higher levels of s/n. Toward the end of the record, the diurnal variation in the near-surface signal-to-noise ratio and velocity standard deviation is neither as clear nor regular as earlier in the record. After day 232, low levels of s/n extend from the surface to below 60 m, and diurnal increases in s/n do not extend all the way to the surface, suggesting loss of transmission power near the end of the record. At the same time, high values of velocity standard deviation, which extended down to only 20 m early in the record, extended to 30 – 40 m and, following day 239, continuously in time (Figure 5).

Early in the period D Shelf-Break velocity record, the coincident periods of low vertical velocity standard deviation and high s/n are bounded by short periods of large vertical velocity magnitude: upward at the leading edge of the low solar radiation period and downward at the trailing edge. Examples of the early period D temporal relationships between solar radiation, beam s/n, velocity component standard deviation, and vertical velocity are shown in figure 5. In Figure 6, we show the hourly averaged vertical velocity standard deviation (VVSD) in gray-scale for each depth bin together with the 1 cm/s contour of the low-pass filtered VVSD. Velocity from bins above this contour are not good a significant fraction of the time.

Estimates of the total energy consumption over the course of the deployment for each of the Doppler current profilers are shown in Table 2. Estimates of the maximum possible sampling time for the NOPP ADCP/ADP sampling parameters with the battery types used in NOPP are also shown in Table 2.

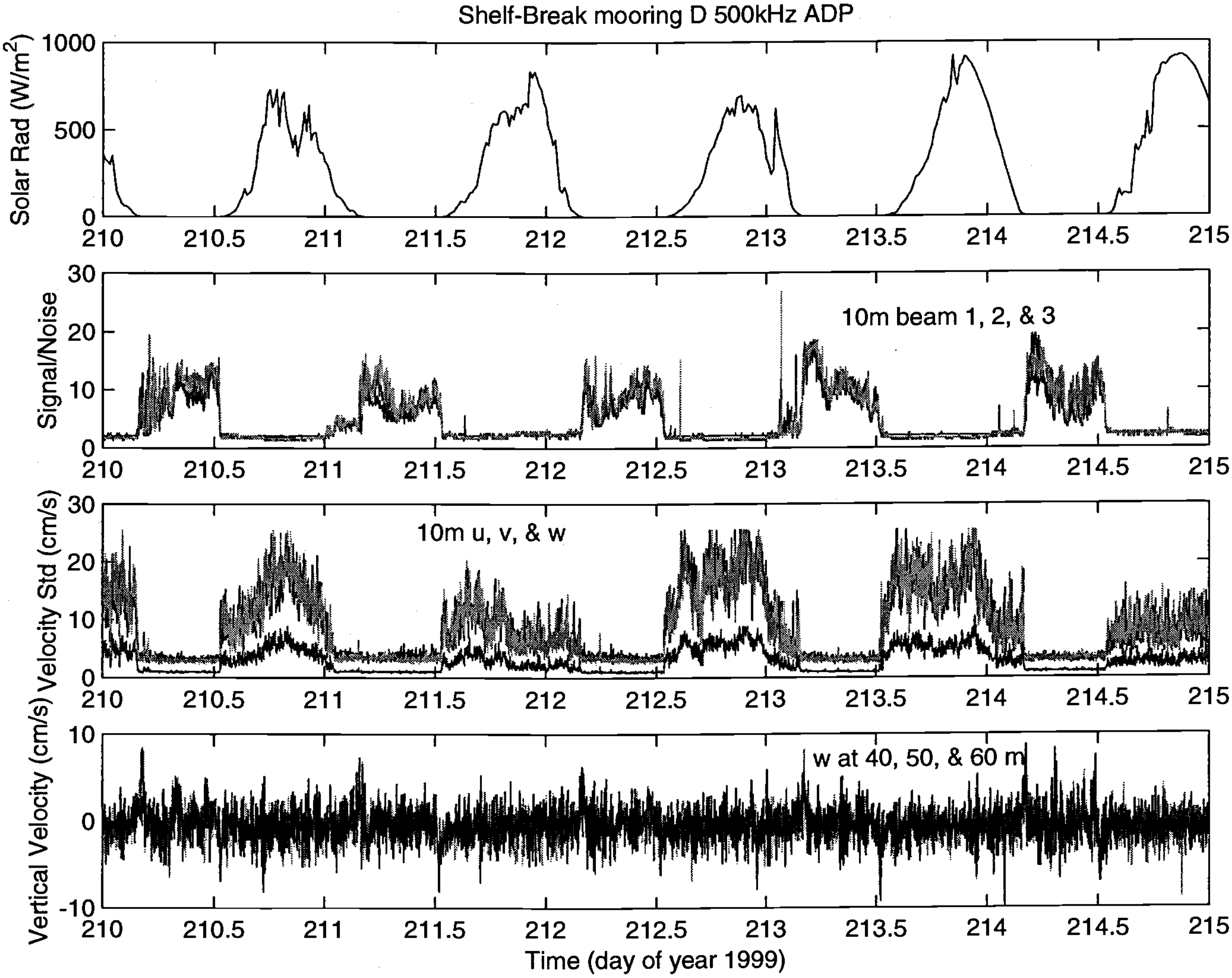
Conversion of Velocities from Magnetic to Geographic Coordinates

Vector currents were rotated from magnetic coordinates to geographic coordinates using the magnetic declination of 18° 12' E. This value was obtained from the web site of the Geological Survey of Canada (http://www.geolab.nrcan.gc.ca/) for the Mid-Shelf deployment location: 44° 38' N; 124° 19'W.



NOPP ShelfBreak Mooring Period D Vertical Velocity Standard Deviation
0.0 0.2 0.5 0.8 1.0 1.2 1.5 1.8 2.0 2.2 2.5 2.8 3.0 3.2 3.5 3.8 4.0 4.2 4.5 4.8 5.0
0.0
10.0
20.0
30.0
40.0
50.0
60.0
70.0
80.0
90.0
Depth (m)
205
210
215
220
225
230
235
240
245
Julian day 1999

Figure 5.



Shelf-Break mooring D 500kHz ADP
Solar Rad (W/m^2)
1000
500
0
210
210.5
211
211.5
212
212.5
213
213.5
214
214.5
215
Signal/Noise
30
20
10
10m beam 1, 2, & 3
Velocity Std (cm/s)
10m u, v, & w
Vertical Velocity (cm/s)
-10
w at 40, 50, & 60 m
Time (day of year 1999)

Figure 6.

Data Filtering

Only plots of 1-hour and 40-hour low pass filtered data are presented in this report. The 1-hour low-pass filter has a window ½ width of16 hours, and ¼ power point of 1 hour. The 40-hour low-pass filter has a window ½ width of 122 hours, and ¼ power point of 40 hours. The low pass filter is a symmetric, finite impulse response filter with a Lanczos taper. The filter output is $\overline{T_i} = \frac{\sum_{k=-M}^{M} h_k T_{k+i}}{\sum h_k}$, where the kth filter weight is $h_k = \frac{\sin(\pi F_c / F_N k \Delta t)}{(\pi F_c / F_N \Delta t)}$, in which F_c is the cutoff frequency, F_N is the Nyquist frequency and Δt is the sample interval. Because there is no filter output within one filter ½ width of the start or stop times of the time series, the 40-hour low pass filtered records from the short period C of the Shelf-Break mooring are extremely short.

REFERENCES

Boyd, T., M. D. Levine and S. R. Gard, Mooring observations from the Mid-Atlantic Bight, July-September 1996, Synthetic Aperture Sonar Primer and Coastal Mixing & Optics Programs, Ref. 97-2, Data Report 164, Oregon State University, 226 pp., 1997.

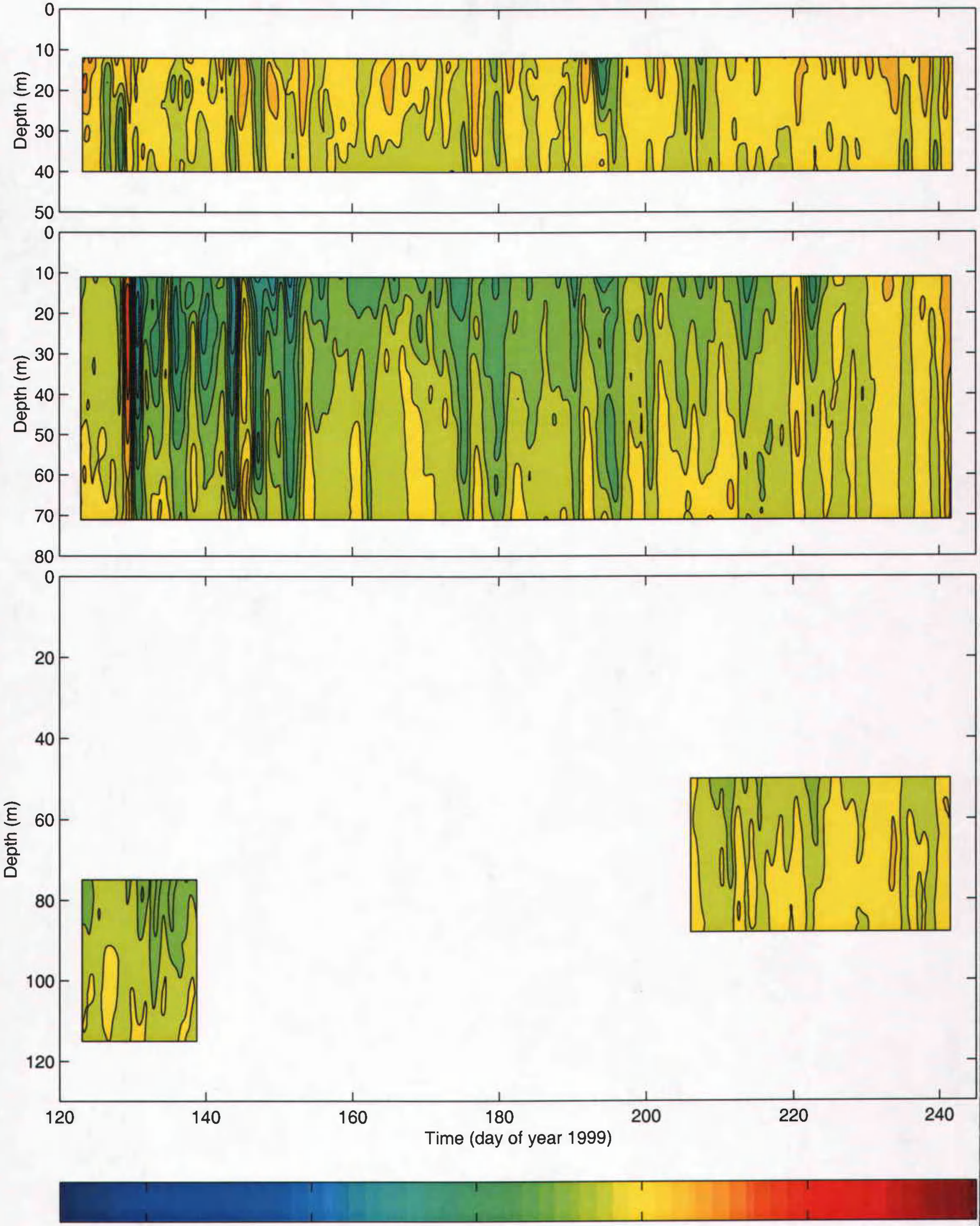
Austin, J. A., S. D. Pierce, and J. A. Barth, Small-Boat Hydrographic Surveys of the Oregon Mid-to-Inner Shelf, May-September 1999, A component of the Prediction of Wind-Driven Coastal Circulation Project, COAS ref 00-2, Data Report 178, 2000.

CONTOUR PLOTS of VELOCITY and TEMPERATURE

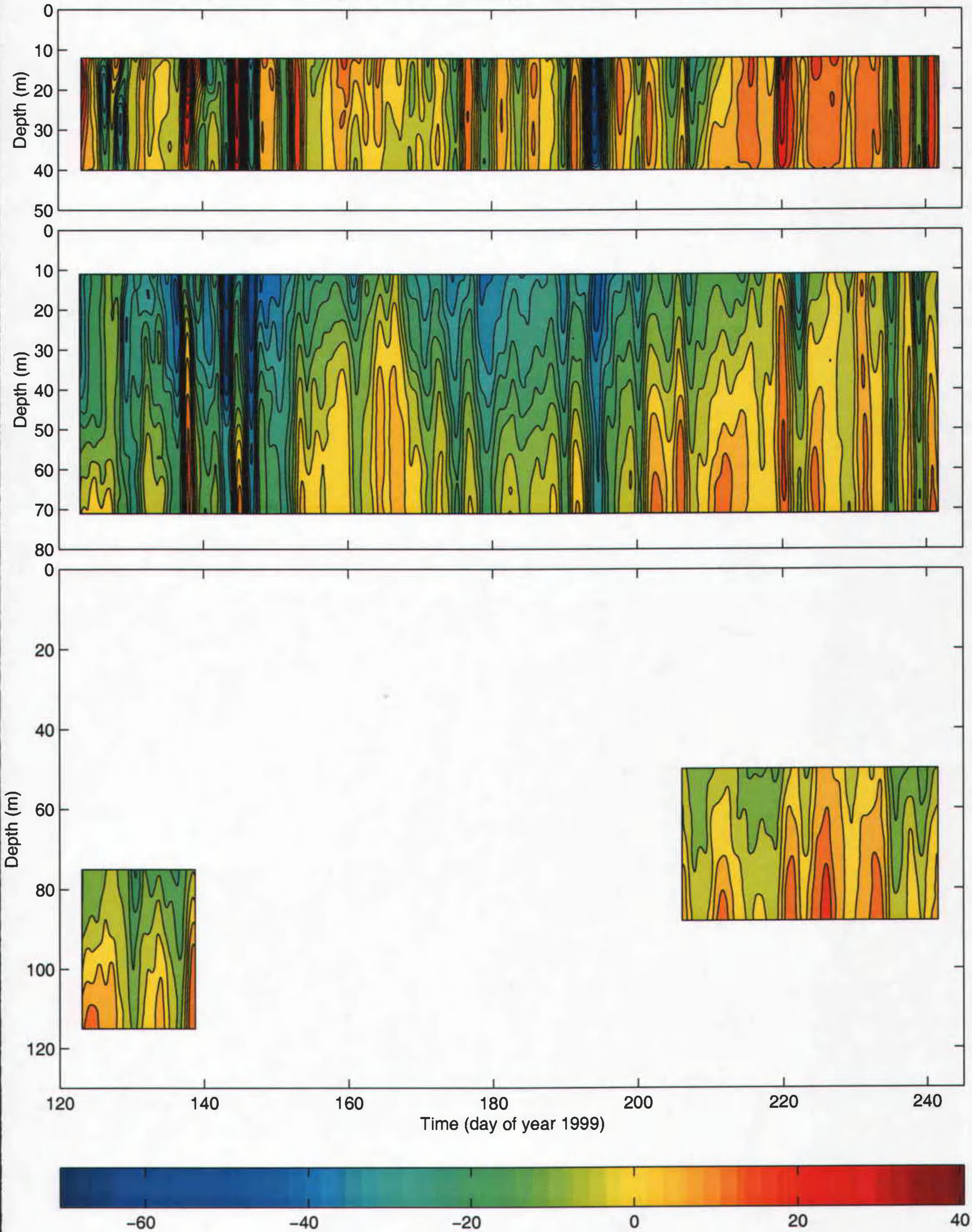
40-hour Low-Pass Filtered

Color contour plots of east and north components of velocity from the Inshore, Mid-Shelf, and Shelf-Break moorings. Color contour plots of temperature from the Inshore, Mid-Shelf, and Shelf-Break moorings. Note that the large gaps at the start and end of each record as well as the gaps between periods A, B, and C of the Shelf-Break records are due to the half-width of the low-pass filter.

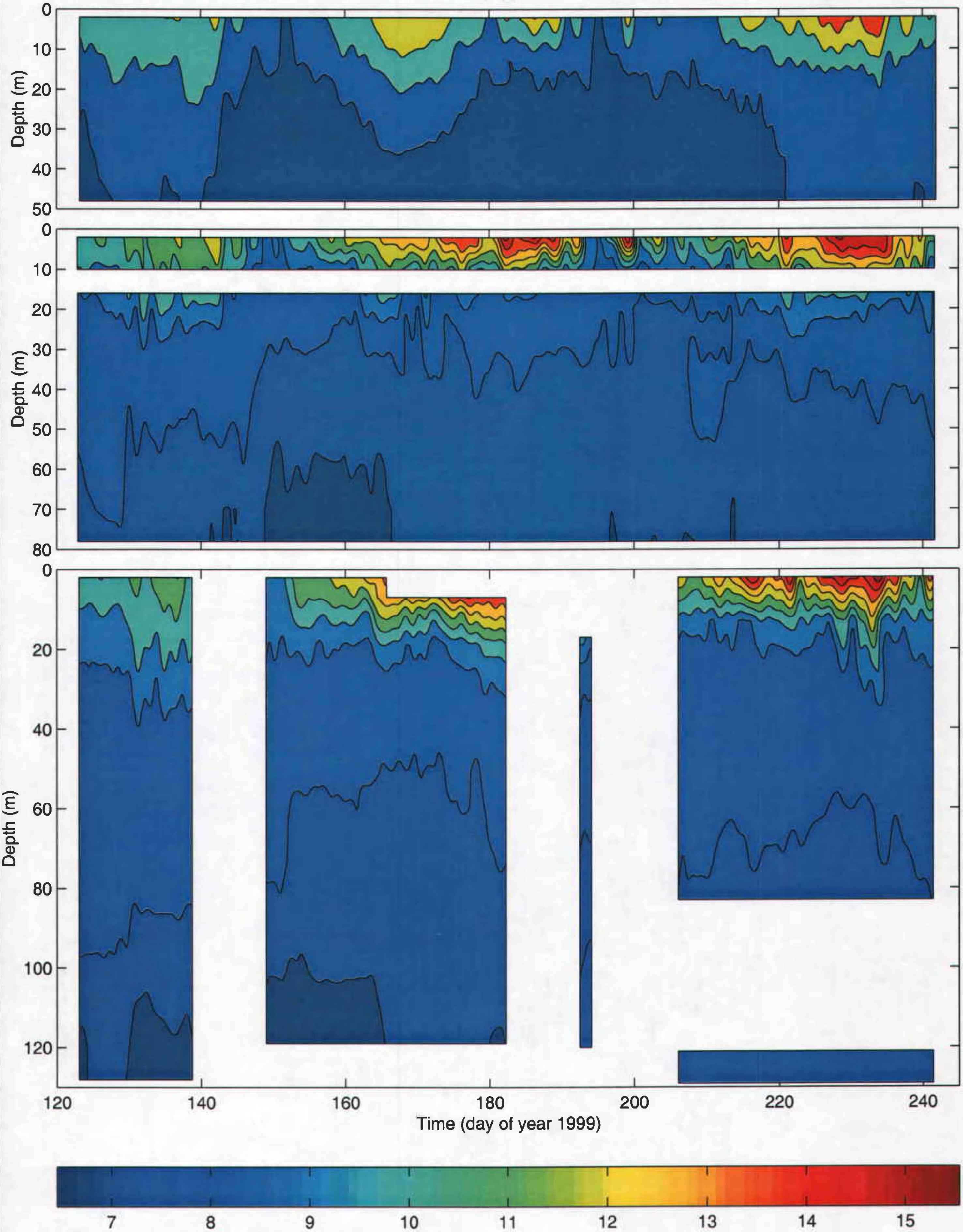
East Component of Velocity (cm/s) for Inshore(top), Mid-Shelf(mid), and Shelf-Break(bot) Moorings



North Component of Velocity (cm/s) for Inshore(top), Mid-Shelf(mid), and Shelf-Break(bot) Moorings



40-hour filtered Temperature (°C) for Shelf-Break(top), Mid-Shelf/Met(mid), and Inner-Shelf(bot) Moorings

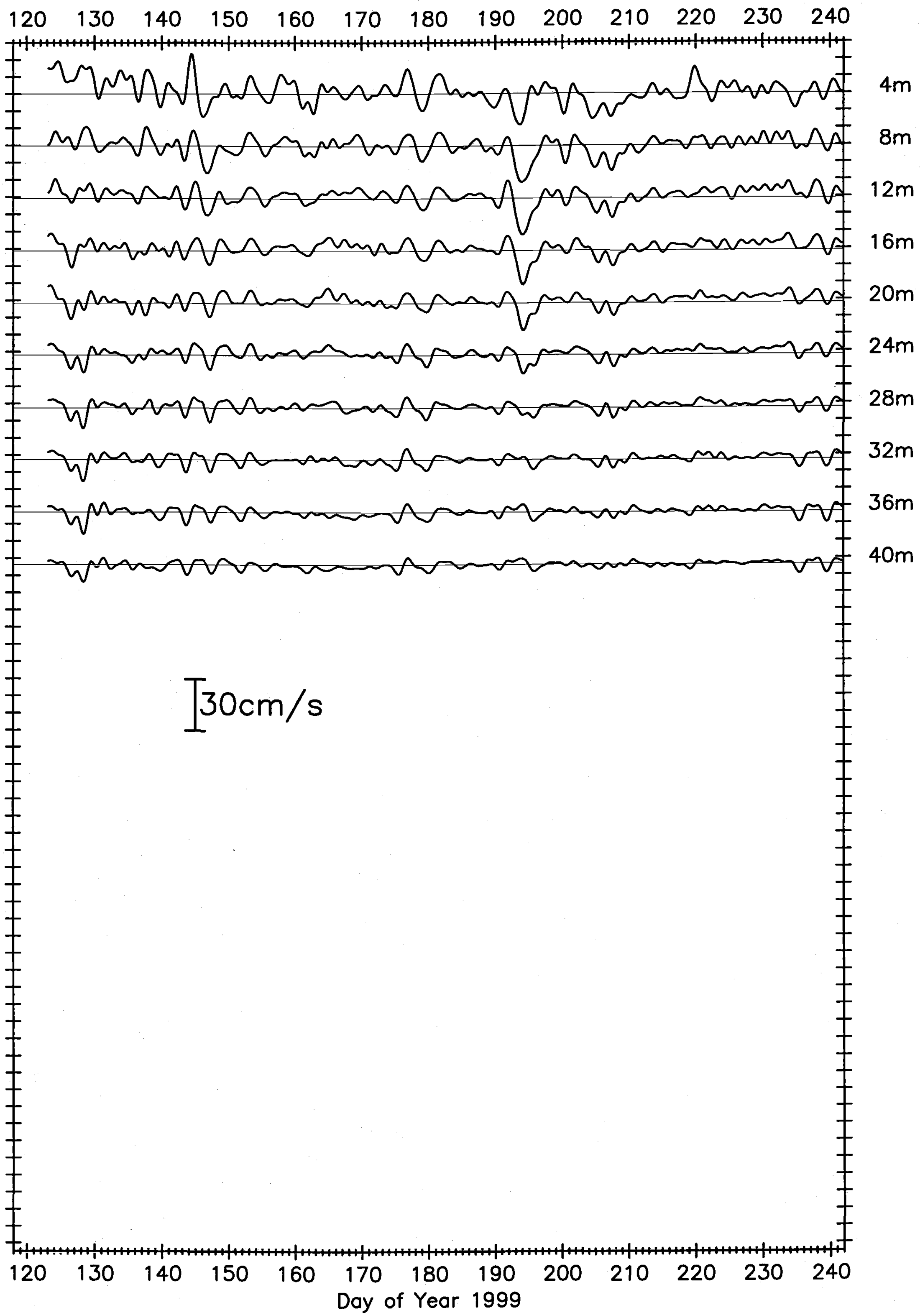


VELOCITY Time Series

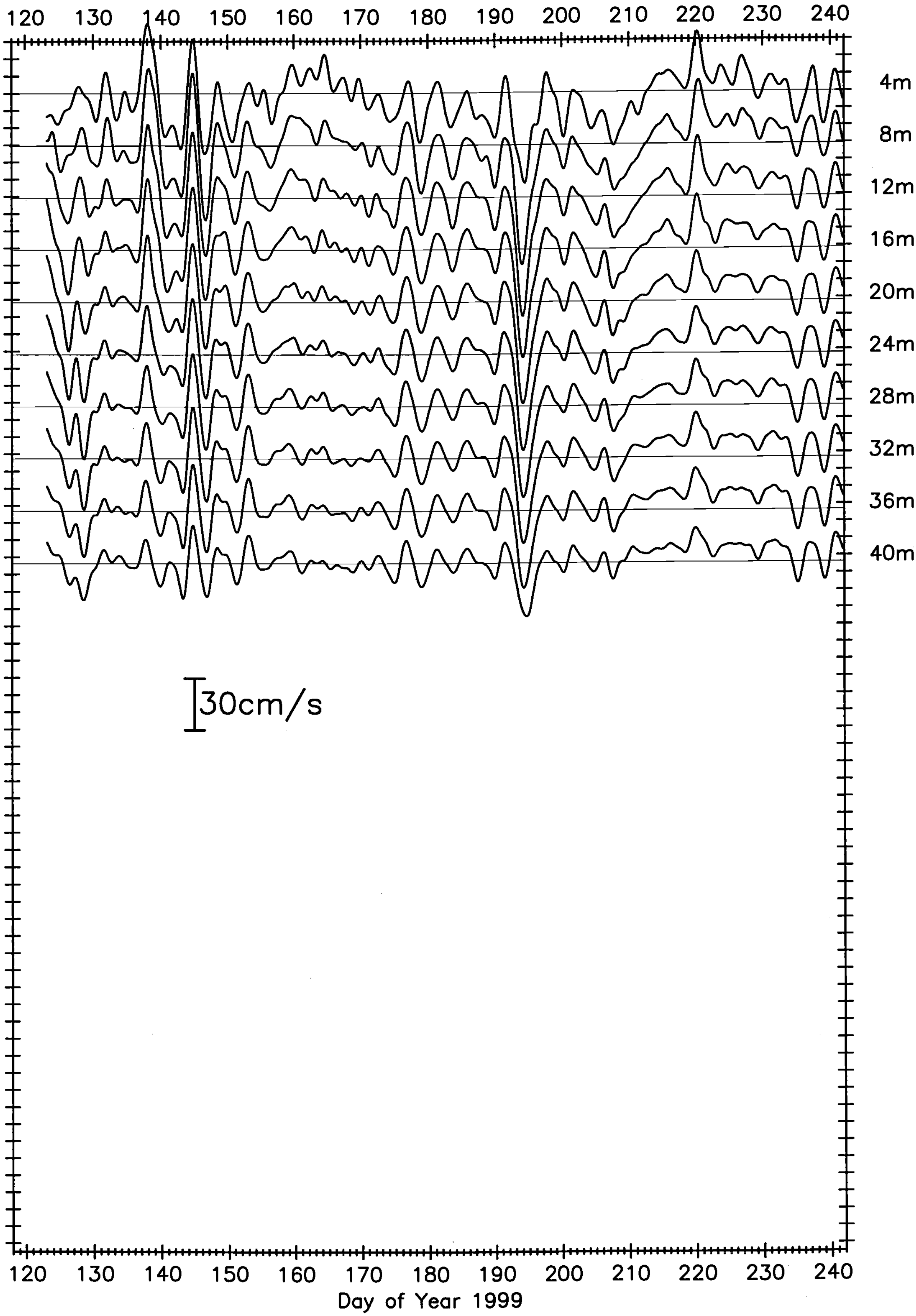
40-hour Low-pass Filtered

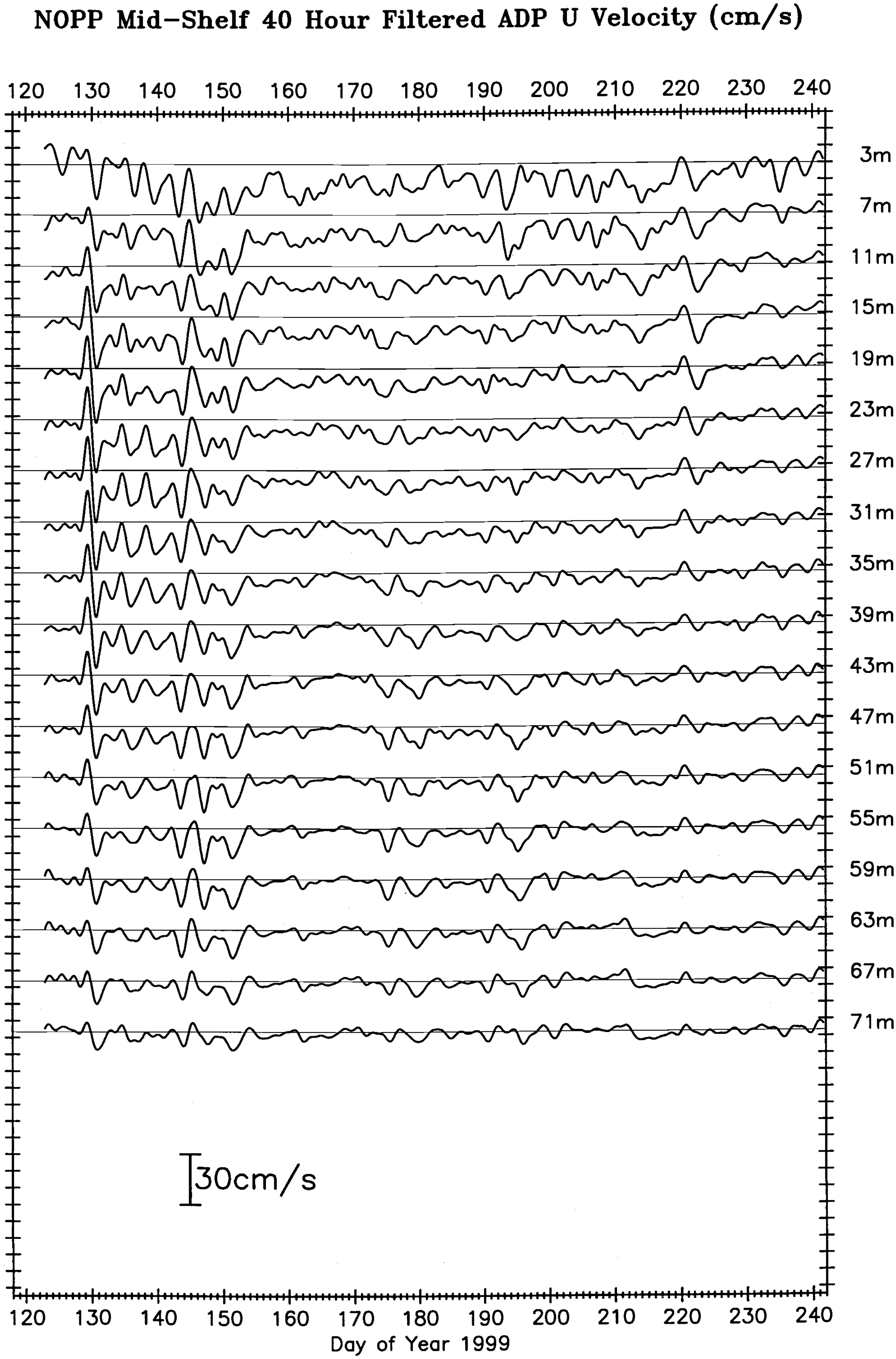
Plots of east and north components of velocity from the Inshore, Mid-Shelf, and Shelf-Break moorings. Velocity components from each mooring are shown every 4 m (every other depth bin), offset by 30 cm/s. Although velocity signals from depths less than 10 m should be regarded with caution, we show filtered velocity components from depths less than 10m for both the Mid-Shelf and Shelf-Break moorings. Velocity from the Shelf-Break mooring period A is shown only for the depth range over which the mean vertical velocity is under 1 cm/s. Velocity components from each mooring are also shown separately for depths 10, 20, 30, 40, 50, 60, and 70 m. Note that the Mid-Shelf bins are actually at 9, 19, 29, 39, 49, 59, and 69 m.

NOPP Inshore 40 Hour Filtered ADCP U Velocity (cm/s)

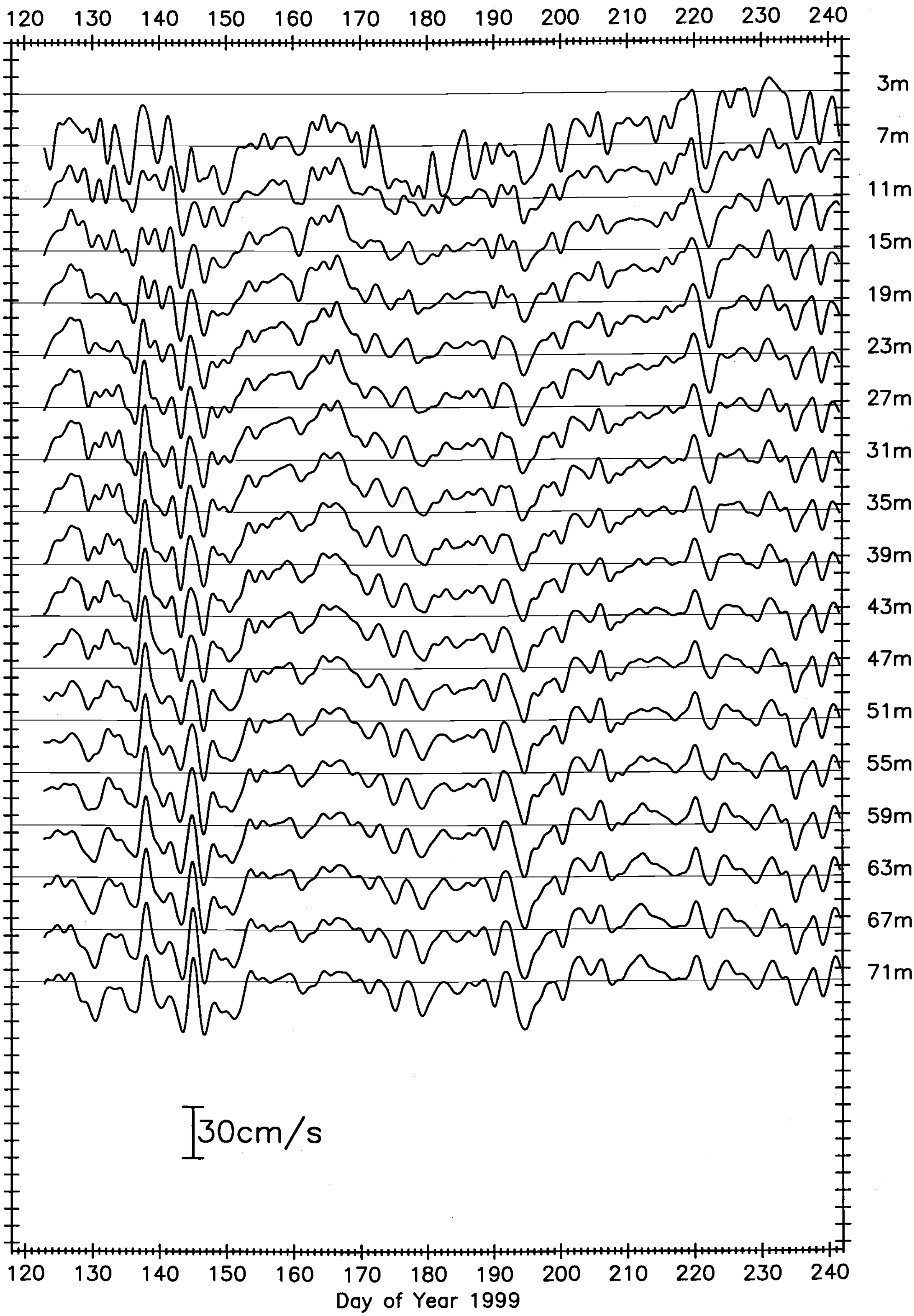


NOPP Inshore 40 Hour Filtered ADCP V Velocity (cm/s)

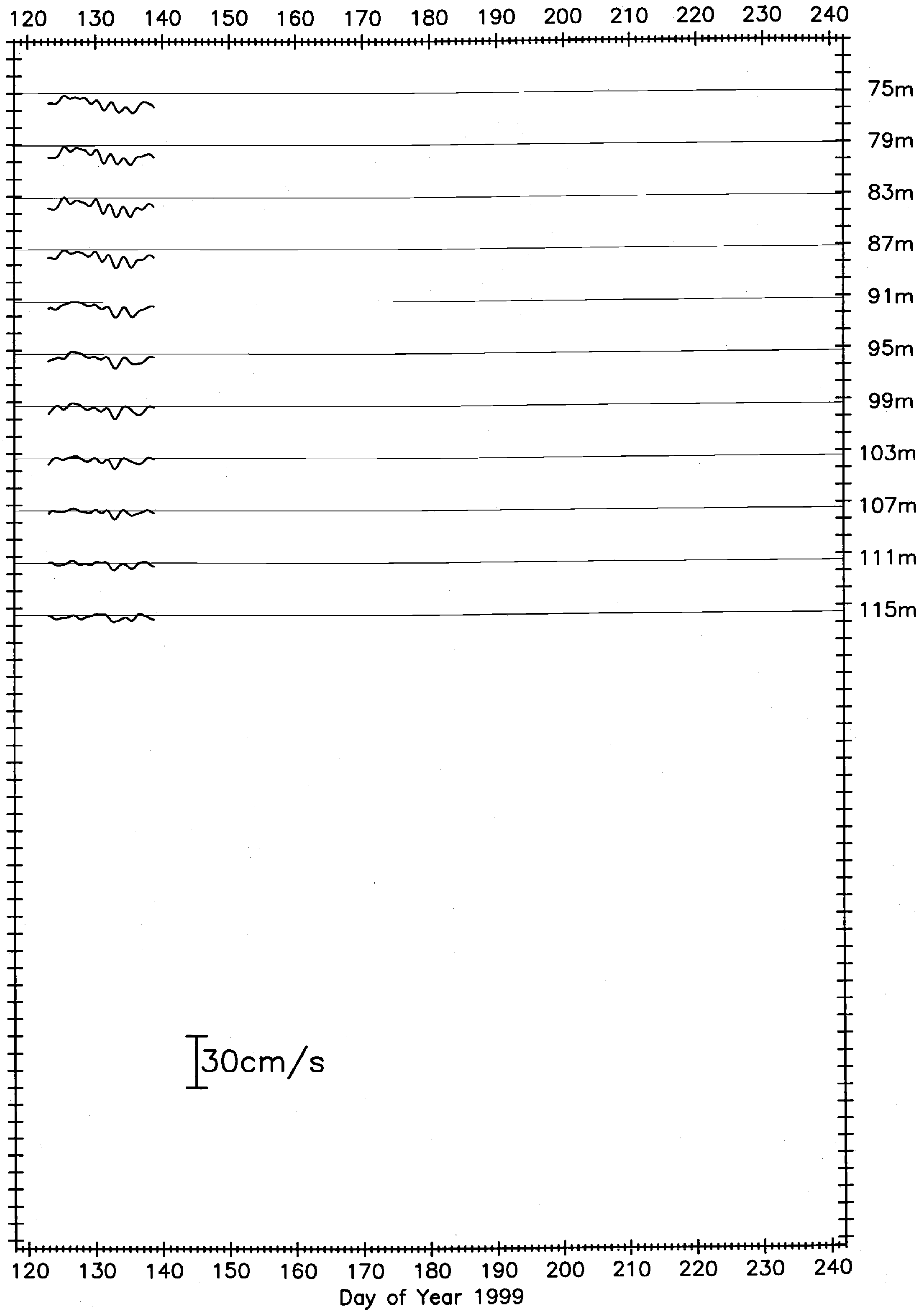



NOPP Mid–Shelf 40 Hour Filtered ADP U Velocity (cm/s)
120 130 140 150 160 170 180 190 200 210 220 230 240
3m
7m
11m
15m
19m
23m
27m
31m
35m
39m
43m
47m
51m
55m
59m
63m
67m
71m
30cm/s
Day of Year 1999

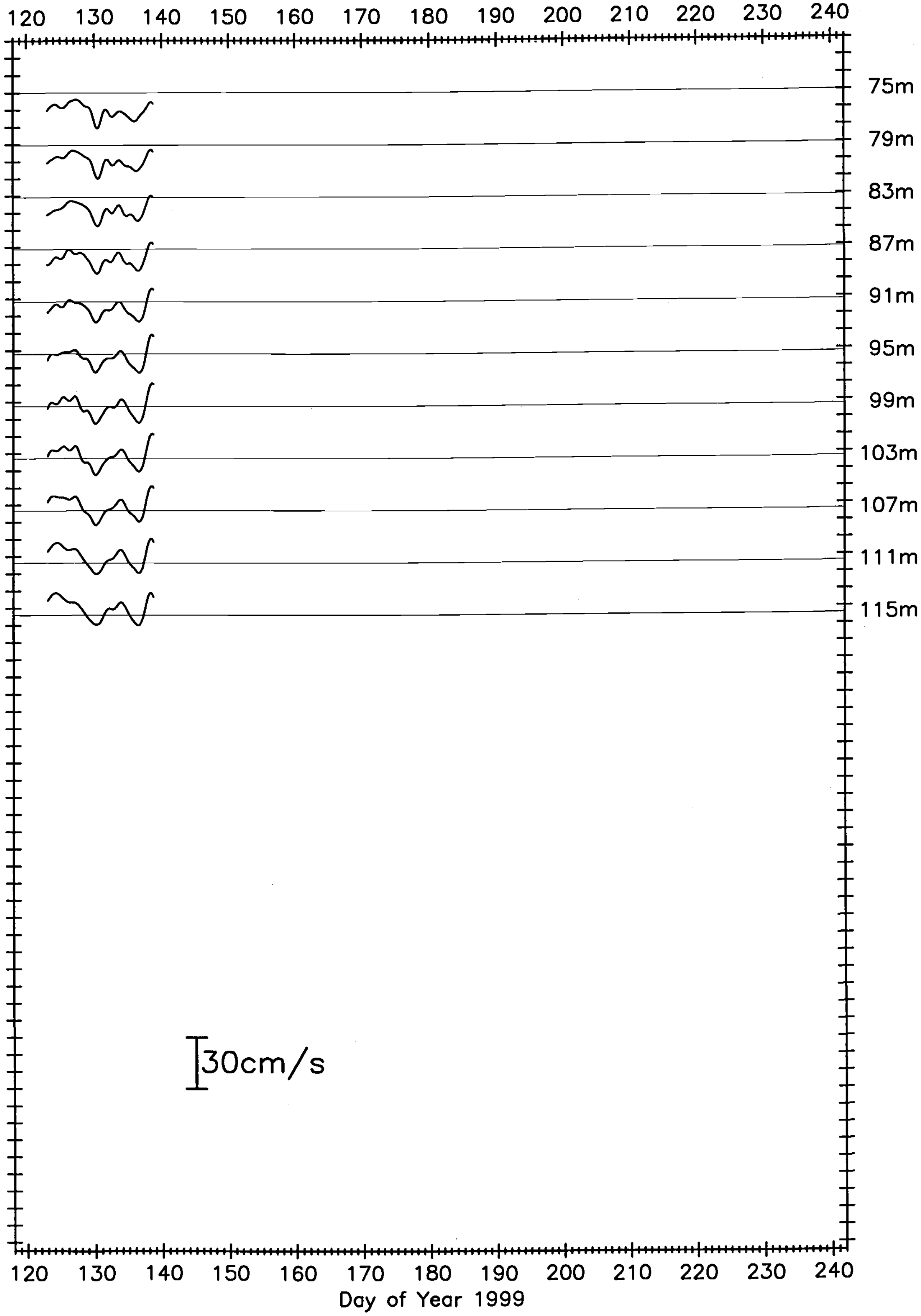
NOPP Mid-Shelf 40 Hour Filtered ADP V Velocity (cm/s)



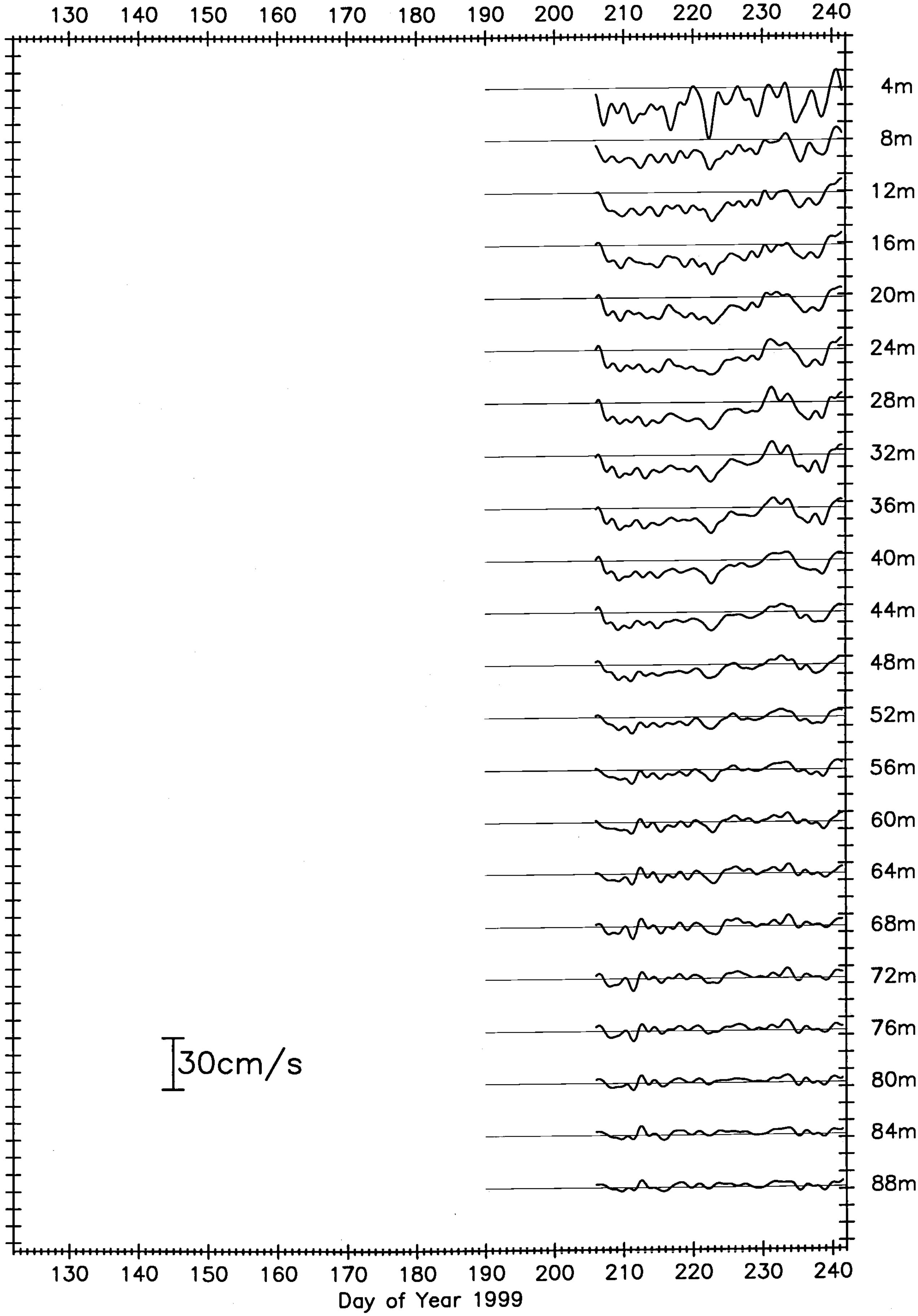
NOPP Shelf-Break period A 40 Hour Filtered ADP U Velocity (cm/s)



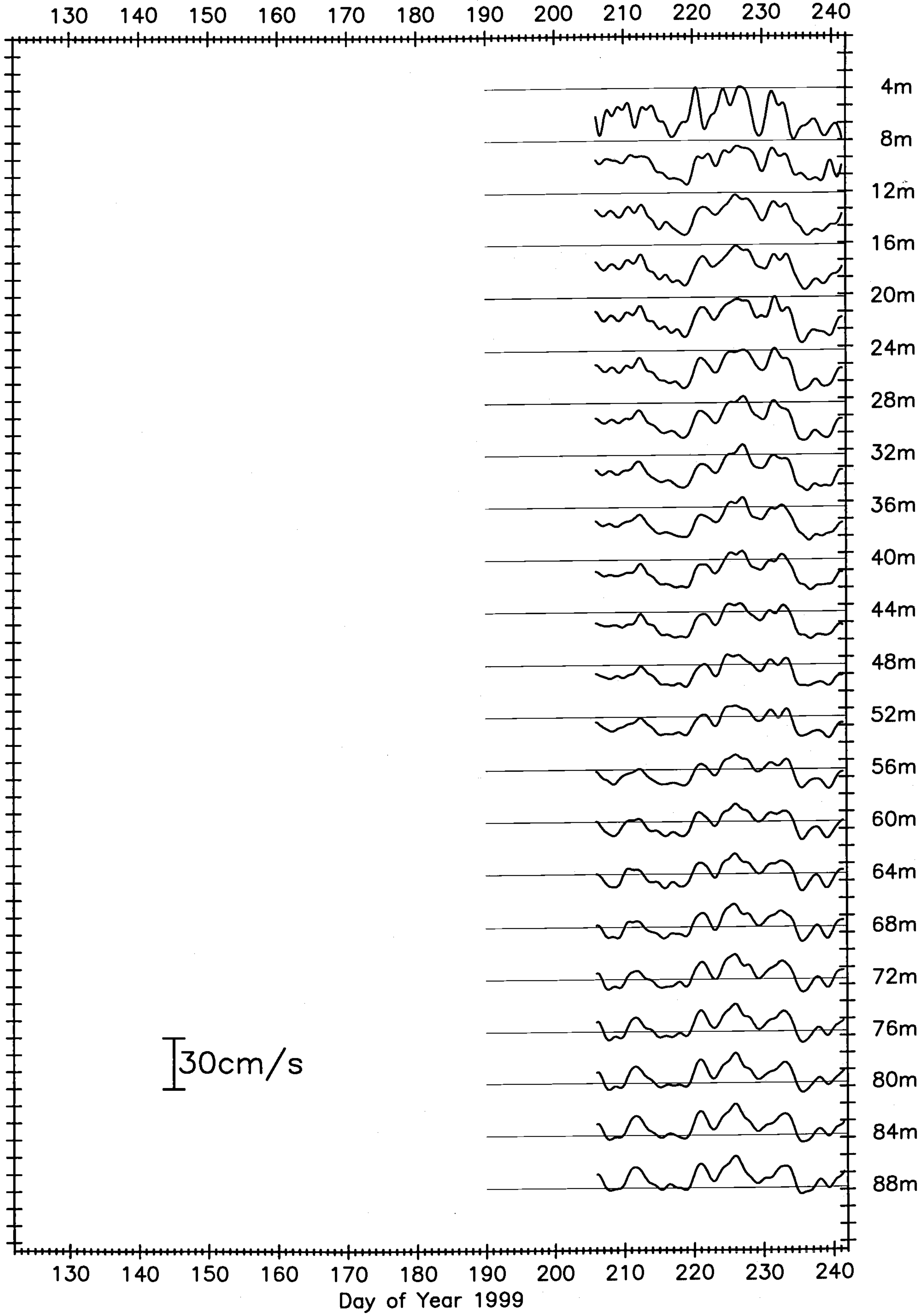
NOPP Shelf–Break period A 40 Hour Filtered ADP V Velocity (cm/s)



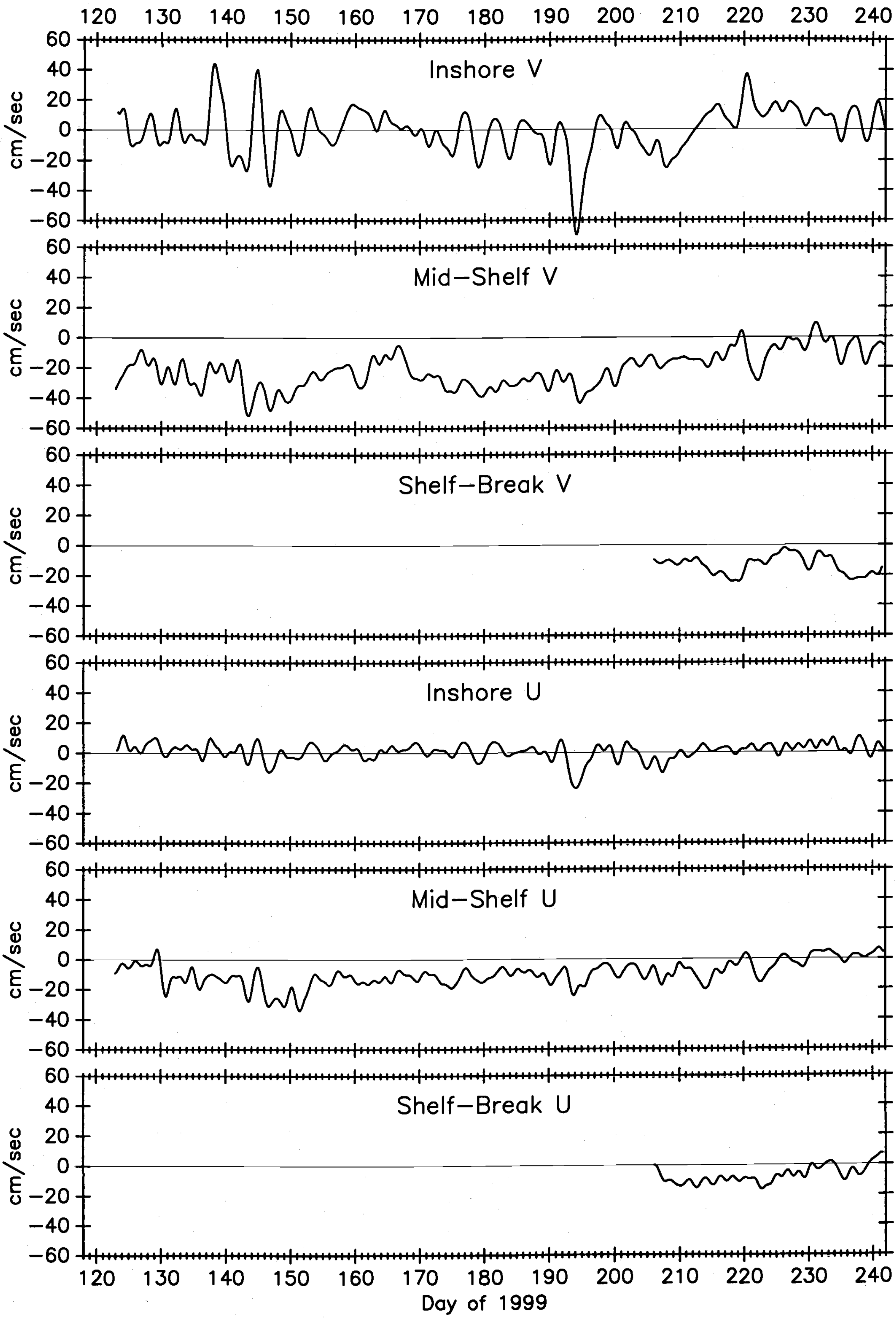
NOPP Shelf–Break period D 40 Hour Filtered ADP U Velocity (cm/s)



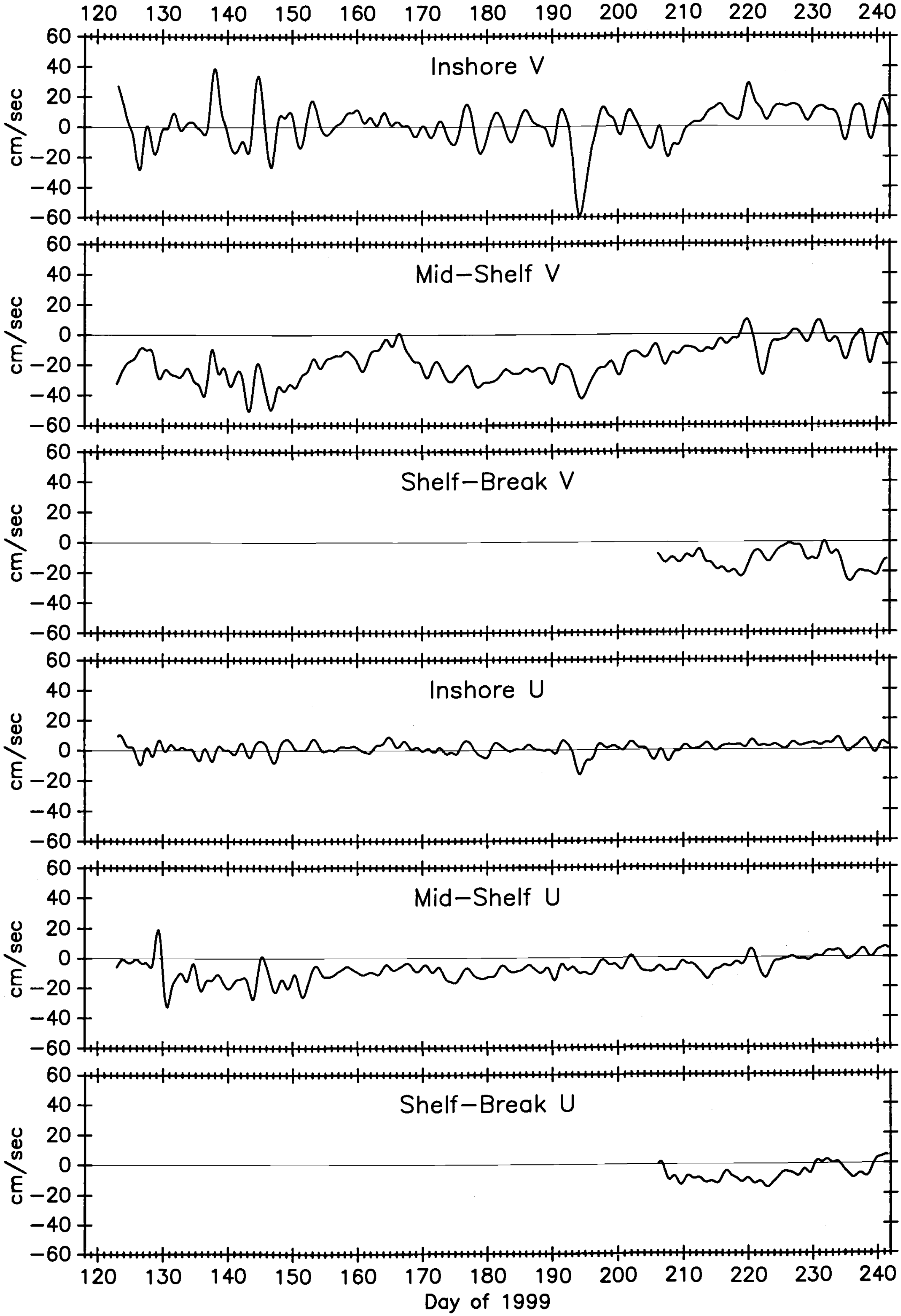
NOPP Shelf-Break period D 40 Hour Filtered ADP V Velocity (cm/s)



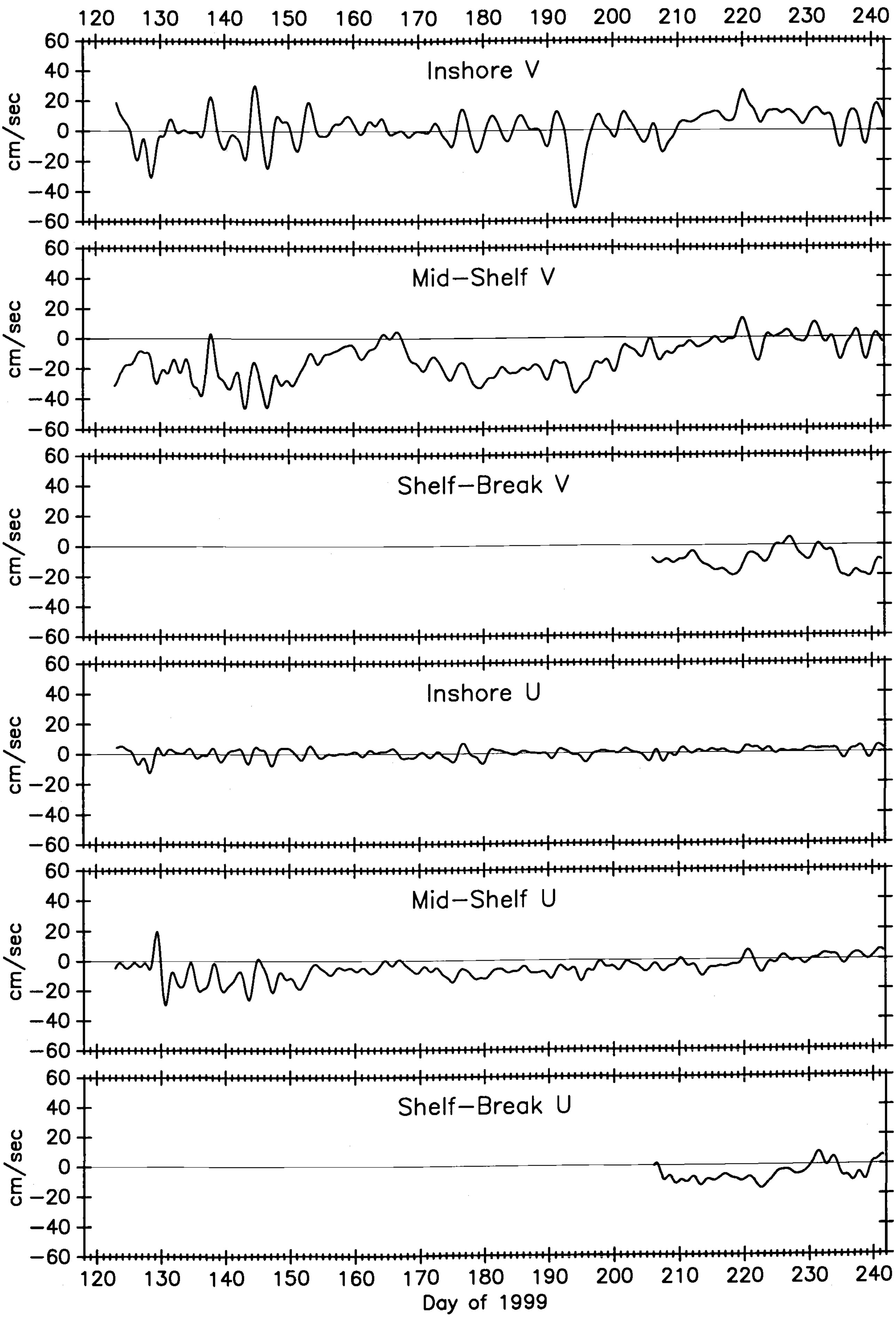
NOPP 40 Hour Filtered 10m Velocity



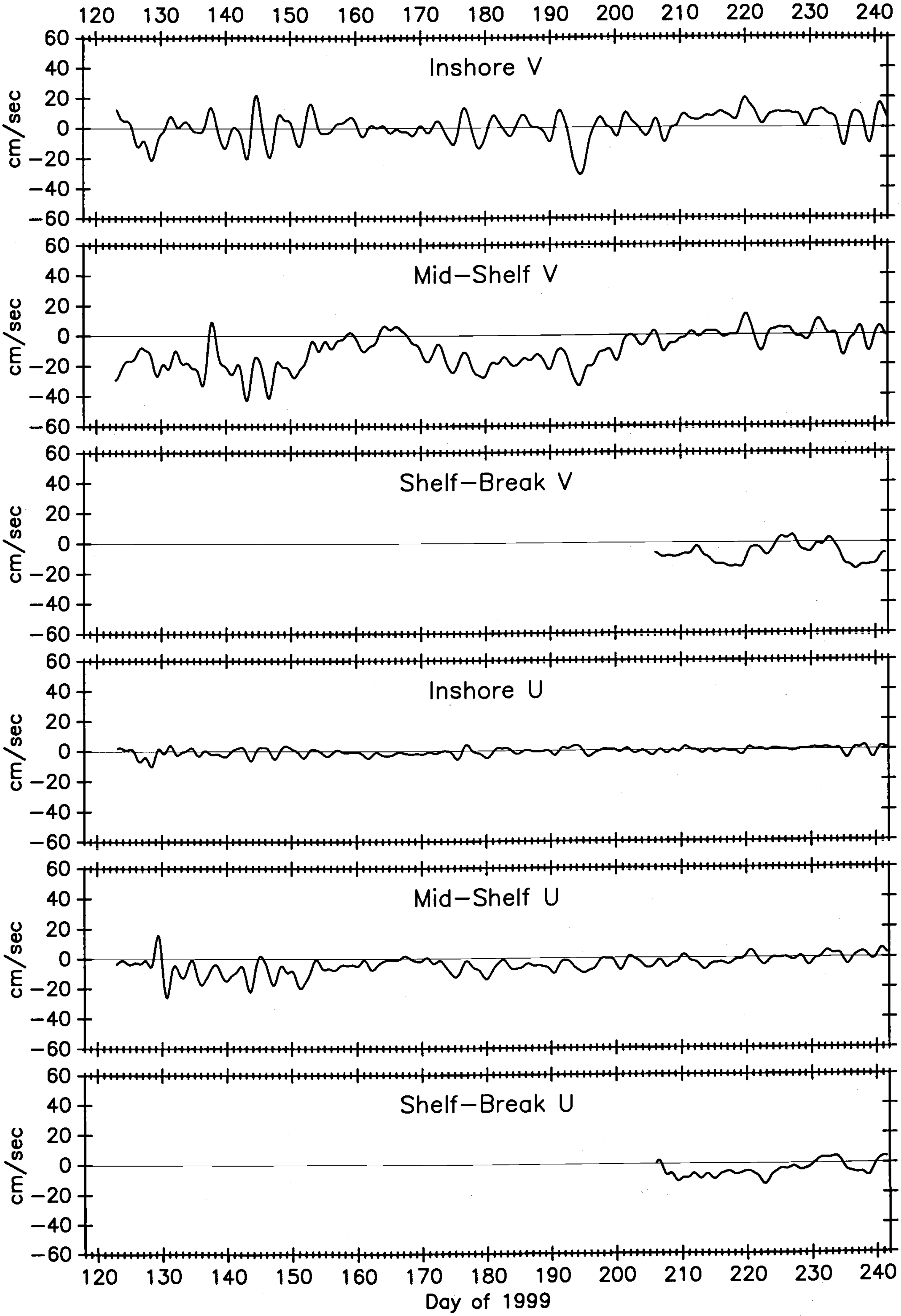
NOPP 40 Hour Filtered 20m Velocity



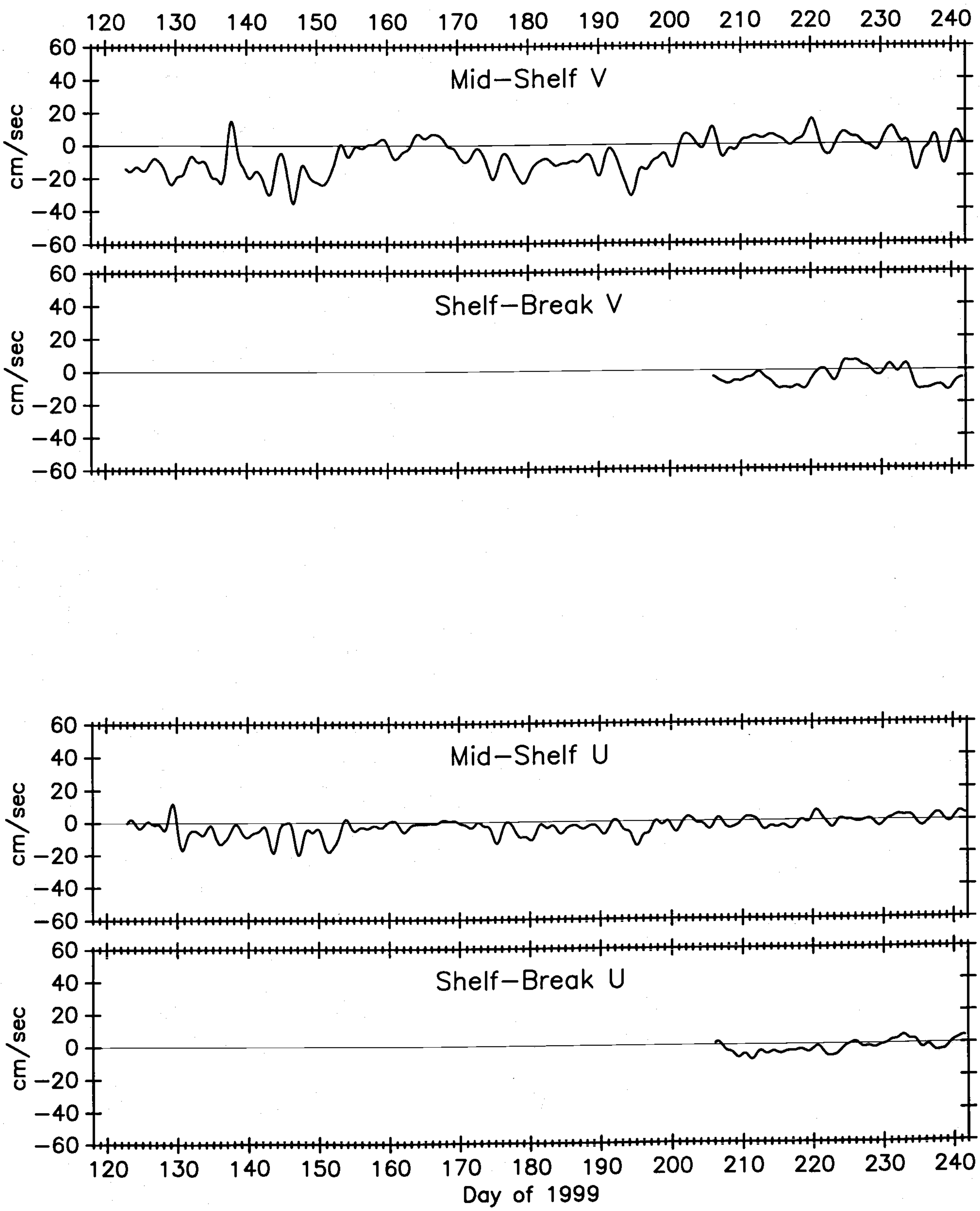
NOPP 40 Hour Filtered 30m Velocity

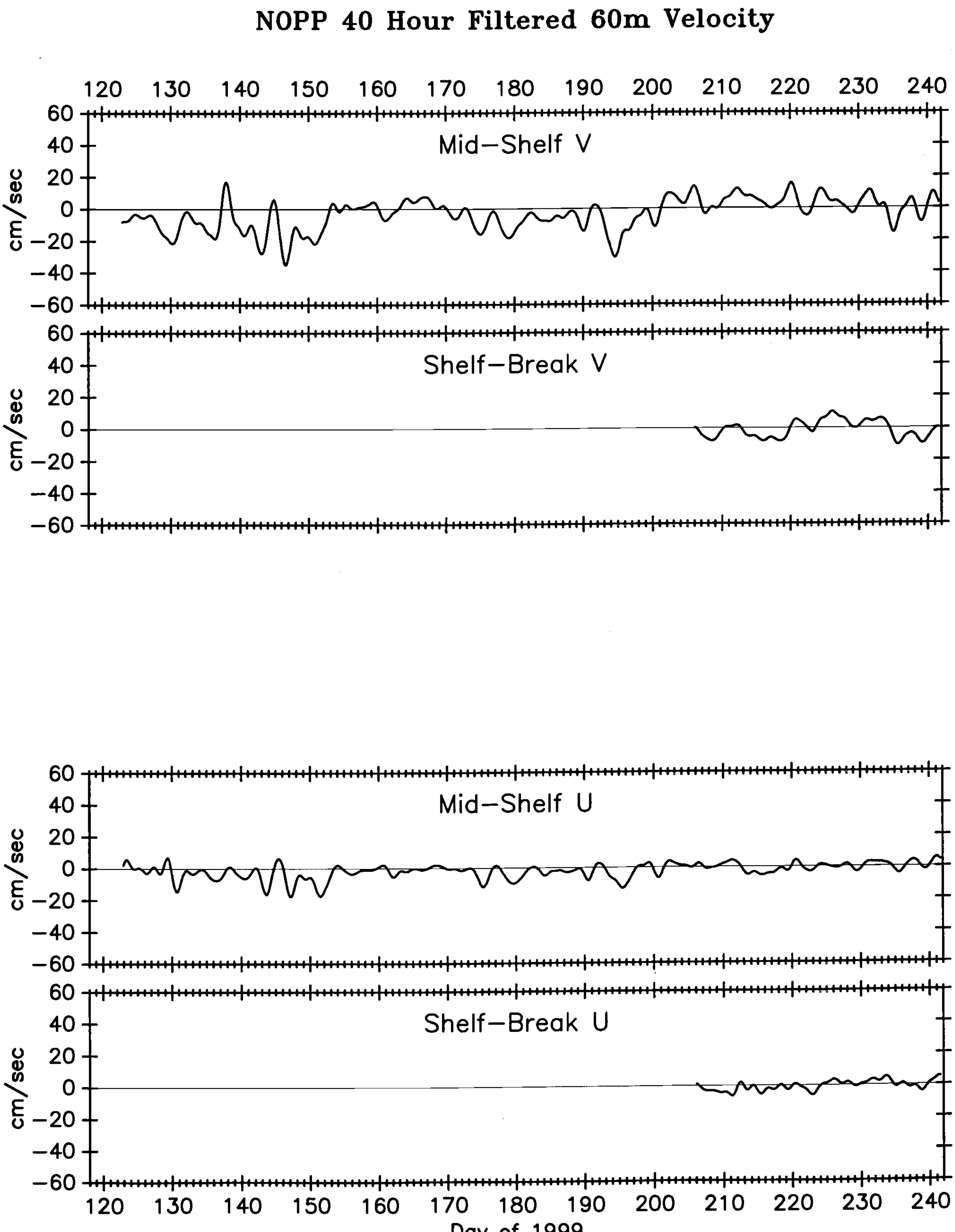


NOPP 40 Hour Filtered 40m Velocity

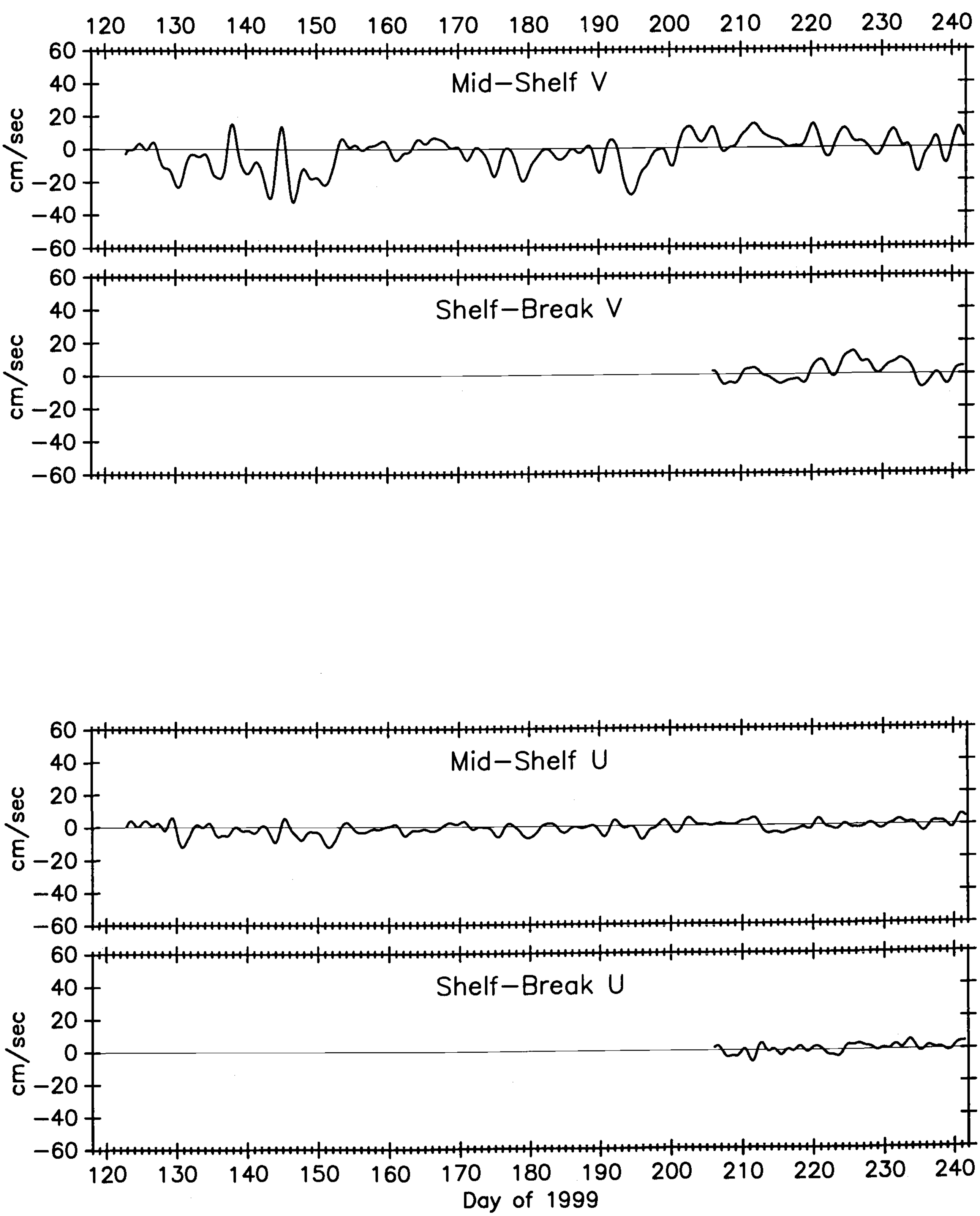


NOPP 40 Hour Filtered 50m Velocity




NOPP 40 Hour Filtered 60m Velocity
Mid−Shelf V
Shelf−Break V
Mid−Shelf U
Shelf−Break U
cm/sec
60
40
20
0
−20
−40
−60
120
130
140
150
160
170
180
190
200
210
220
230
240
Day of 1999

NOPP 40 Hour Filtered 70m Velocity

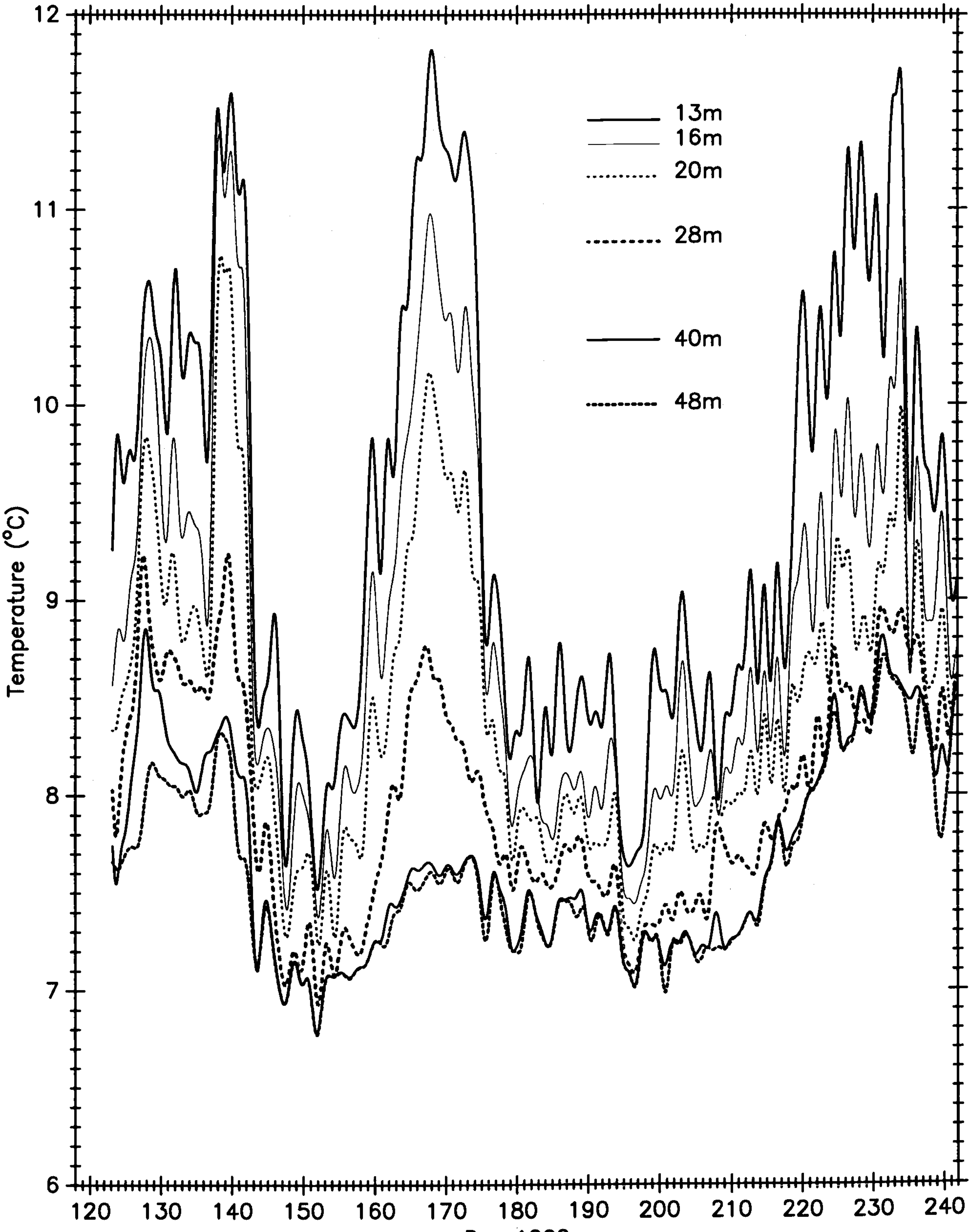


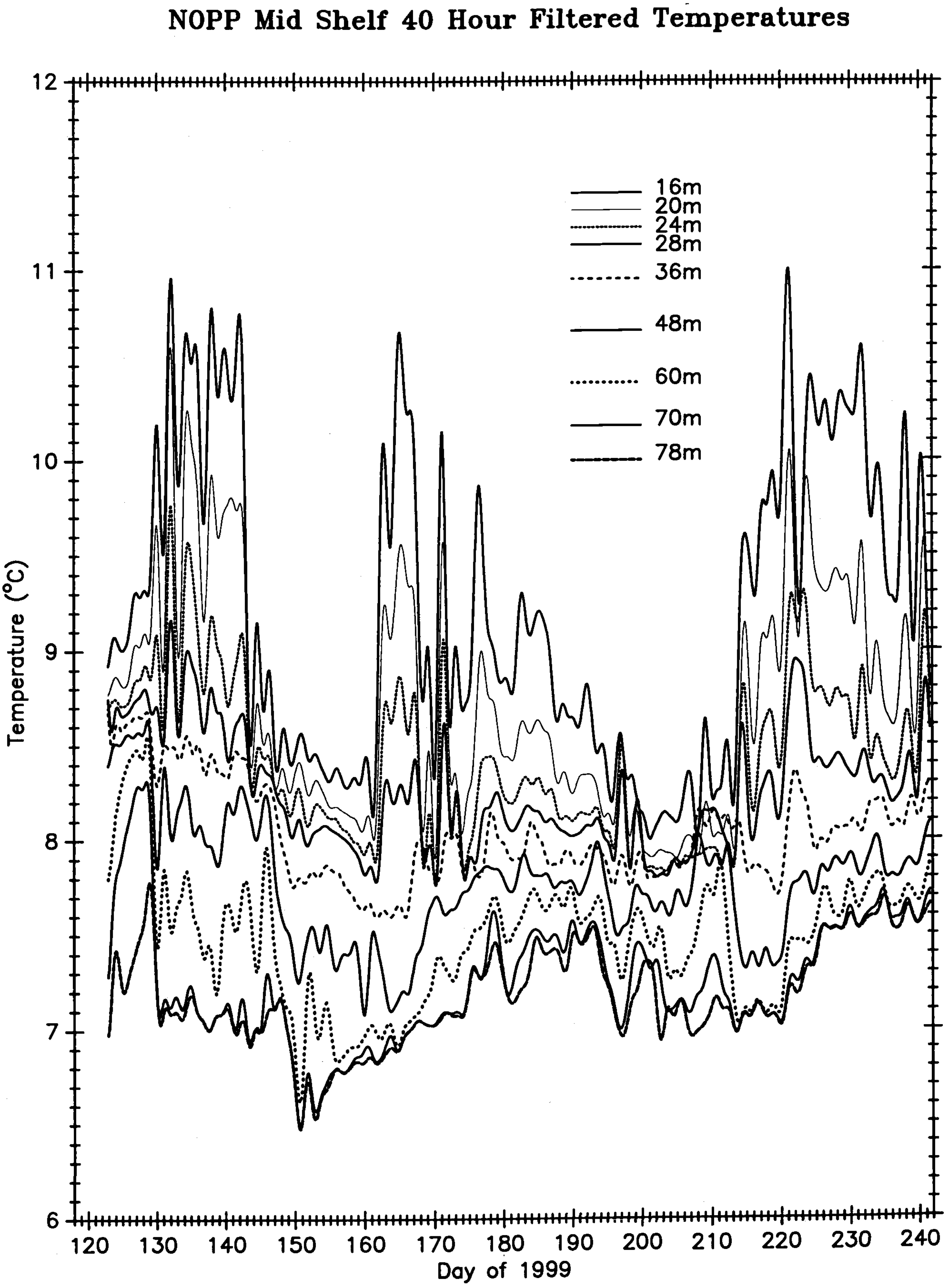
TEMPERATURE Time Series

40-hour Low-Pass Filtered

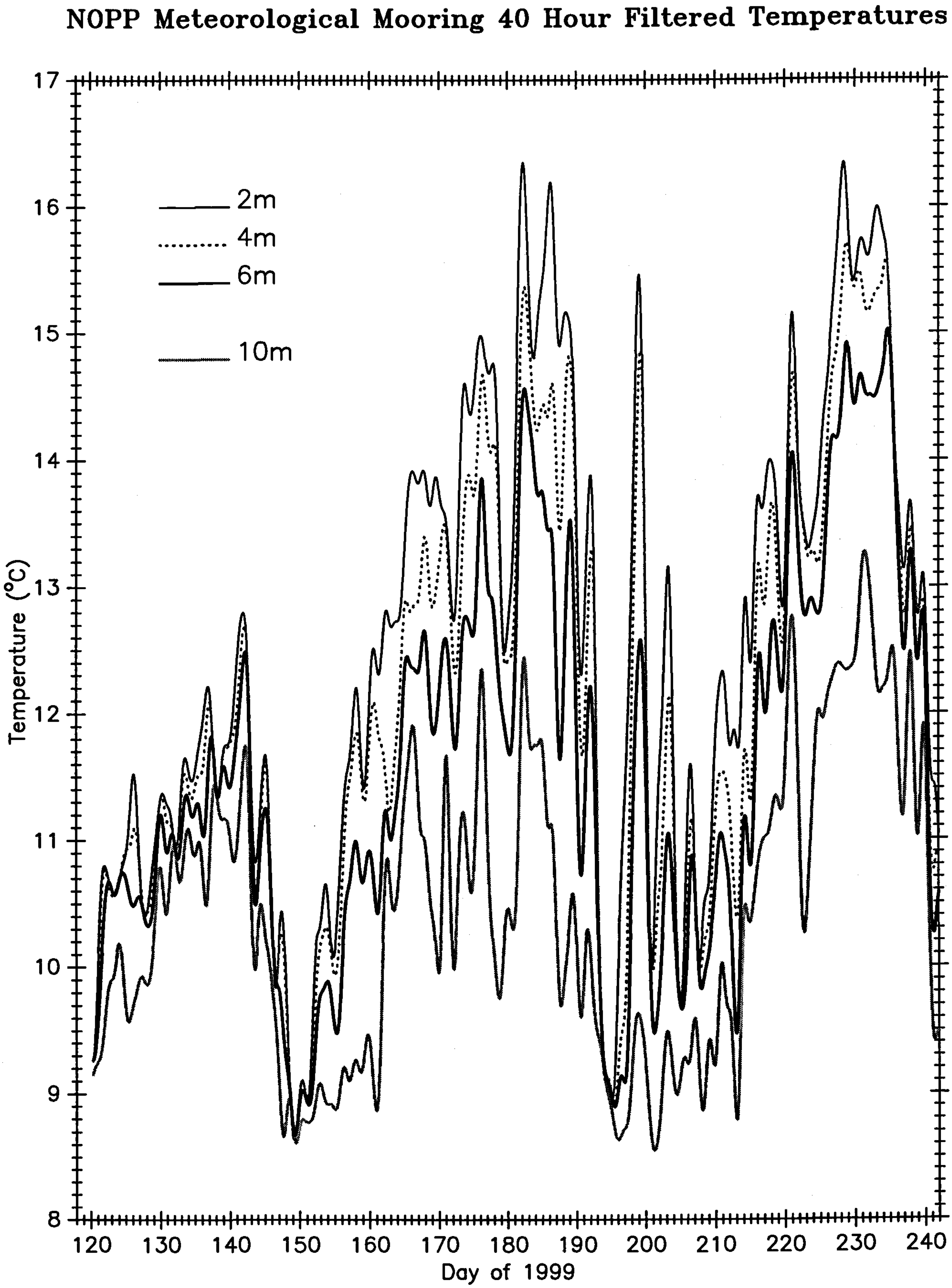
Plots of water temperature from the Inshore, Mid-Shelf, Met, and Shelf-Break moorings. Note that both the temperature scale and range are different for the Met mooring. Temperature is shown for every depth except from 2m on the Inshore and Shelf-Break moorings. Temperatures from each mooring are also shown separately for depths near 2, 16, 20, 28, 48, 60, 72, and 82 m, where available.

NOPP Inshore 40 Hour Filtered Temperatures



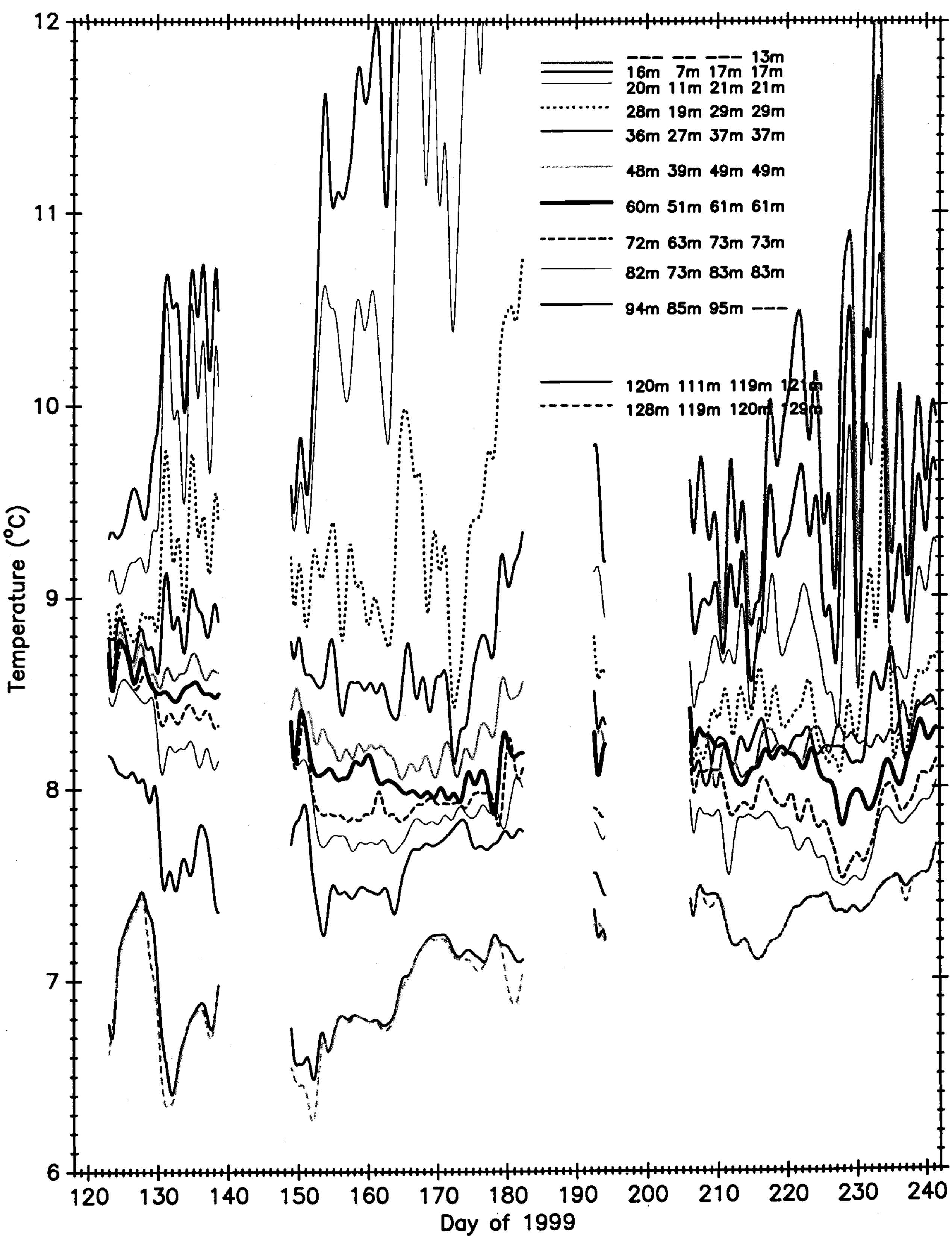


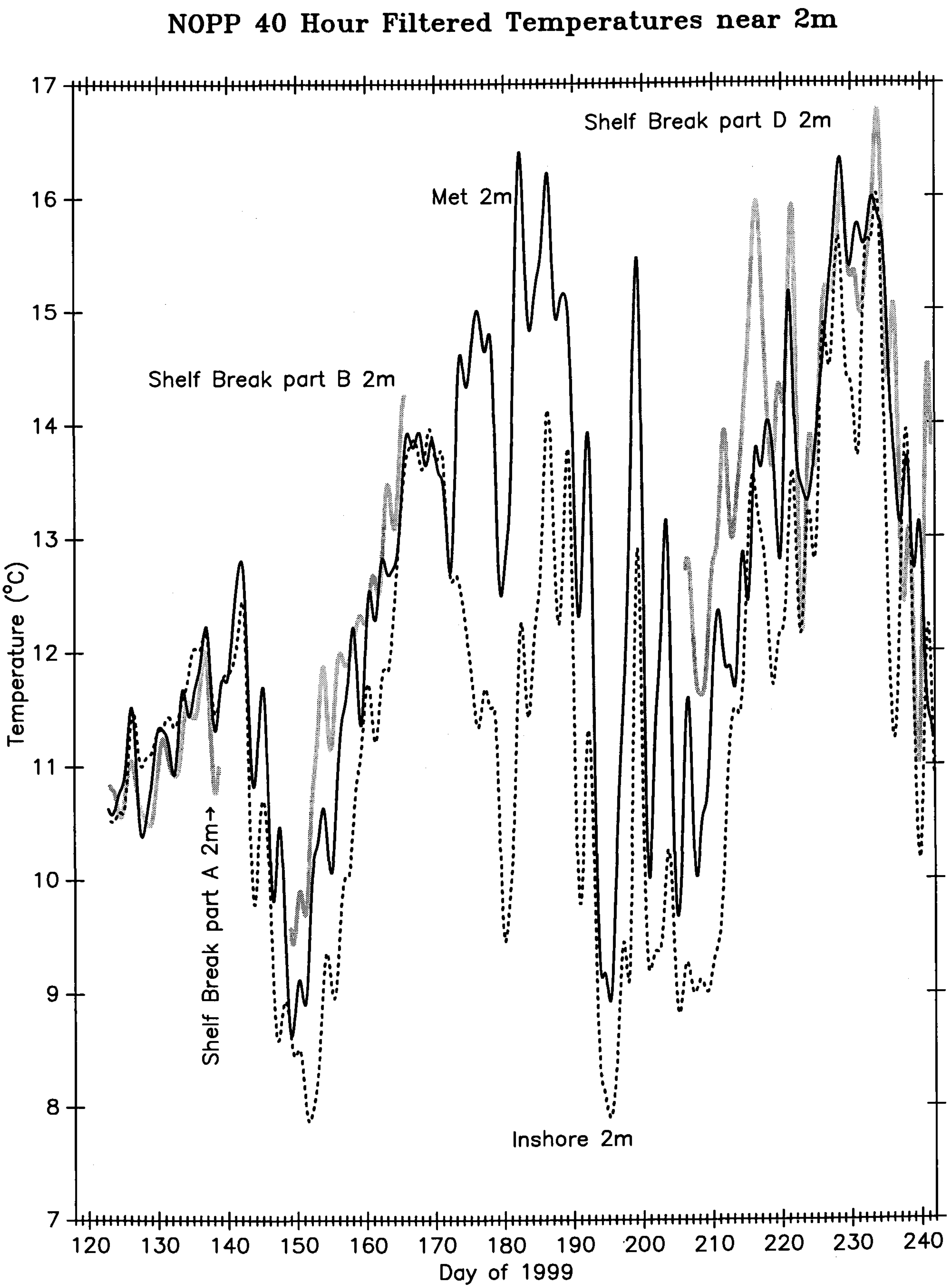
NOPP Mid Shelf 40 Hour Filtered Temperatures
16m
20m
24m
28m
36m
48m
60m
70m
78m
Temperature (°C)
Day of 1999
12
11
10
9
8
7
6
120
130
140
150
160
170
180
190
200
210
220
230
240

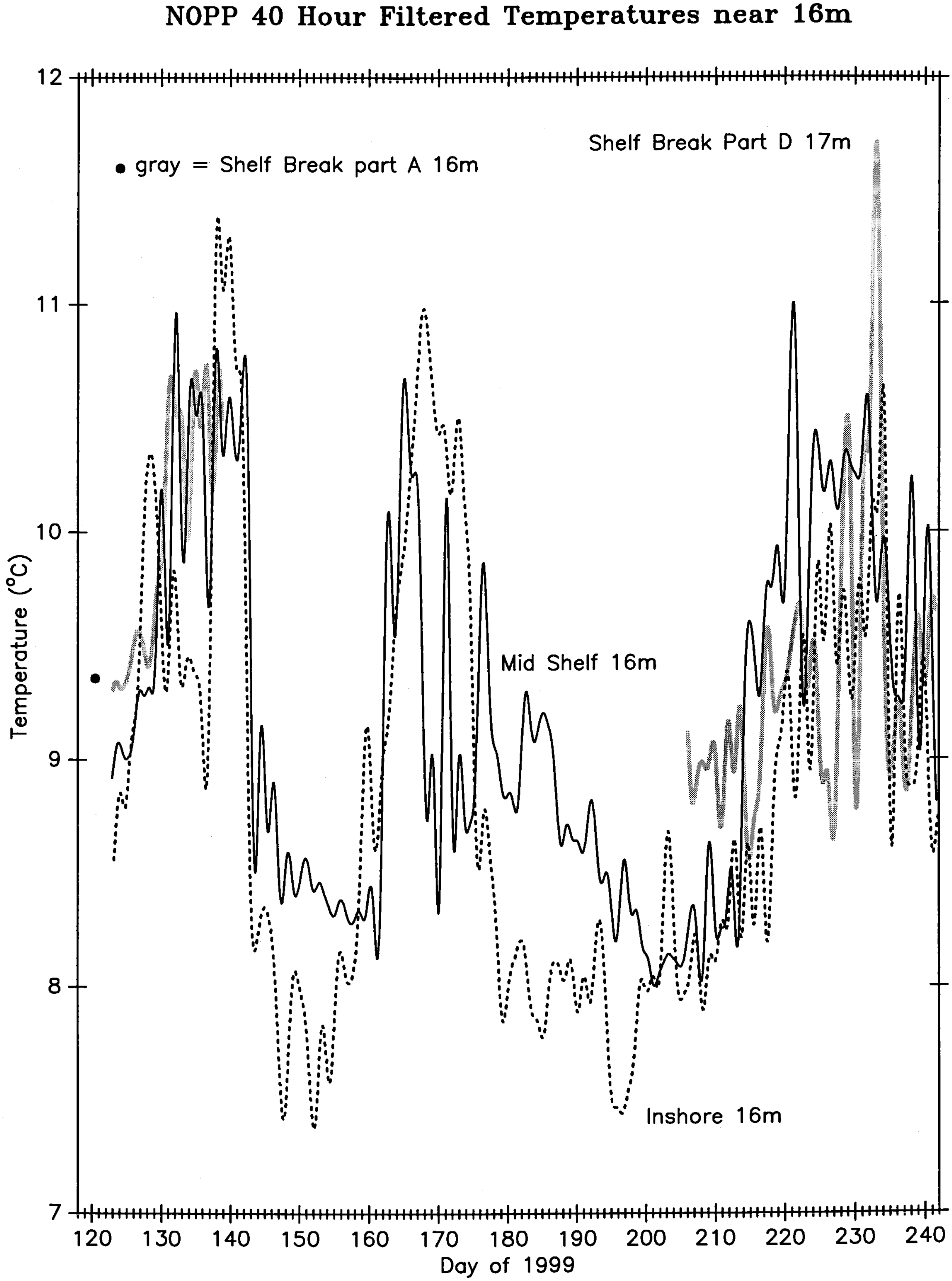


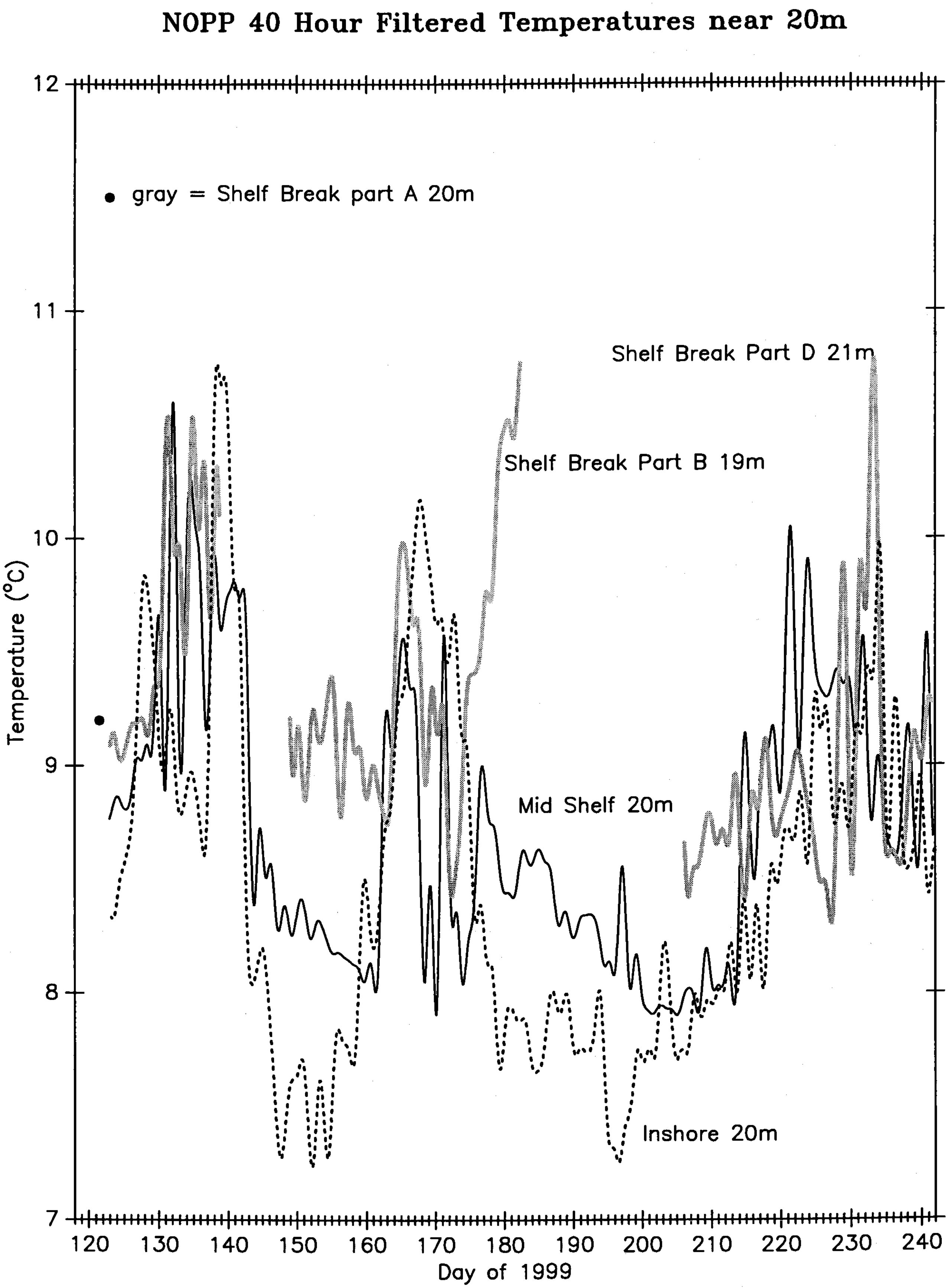
NOPP Meteorological Mooring 40 Hour Filtered Temperatures
2m
4m
6m
10m
Temperature (°C)
Day of 1999
8
9
10
11
12
13
14
15
16
17
120
130
140
150
160
170
180
190
200
210
220
230
240

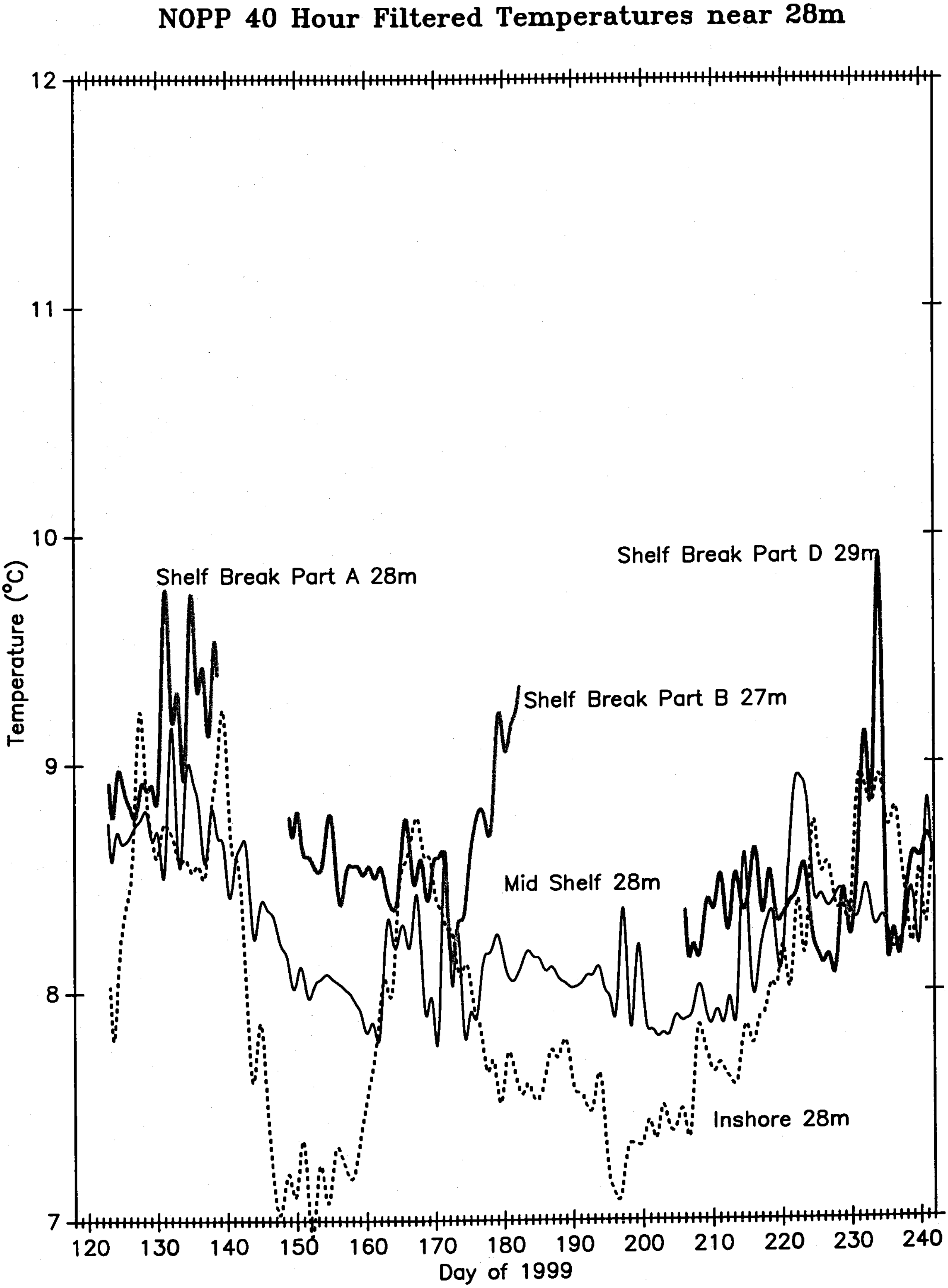
NOPP Shelf Break 40 Hour Filtered Temperatures

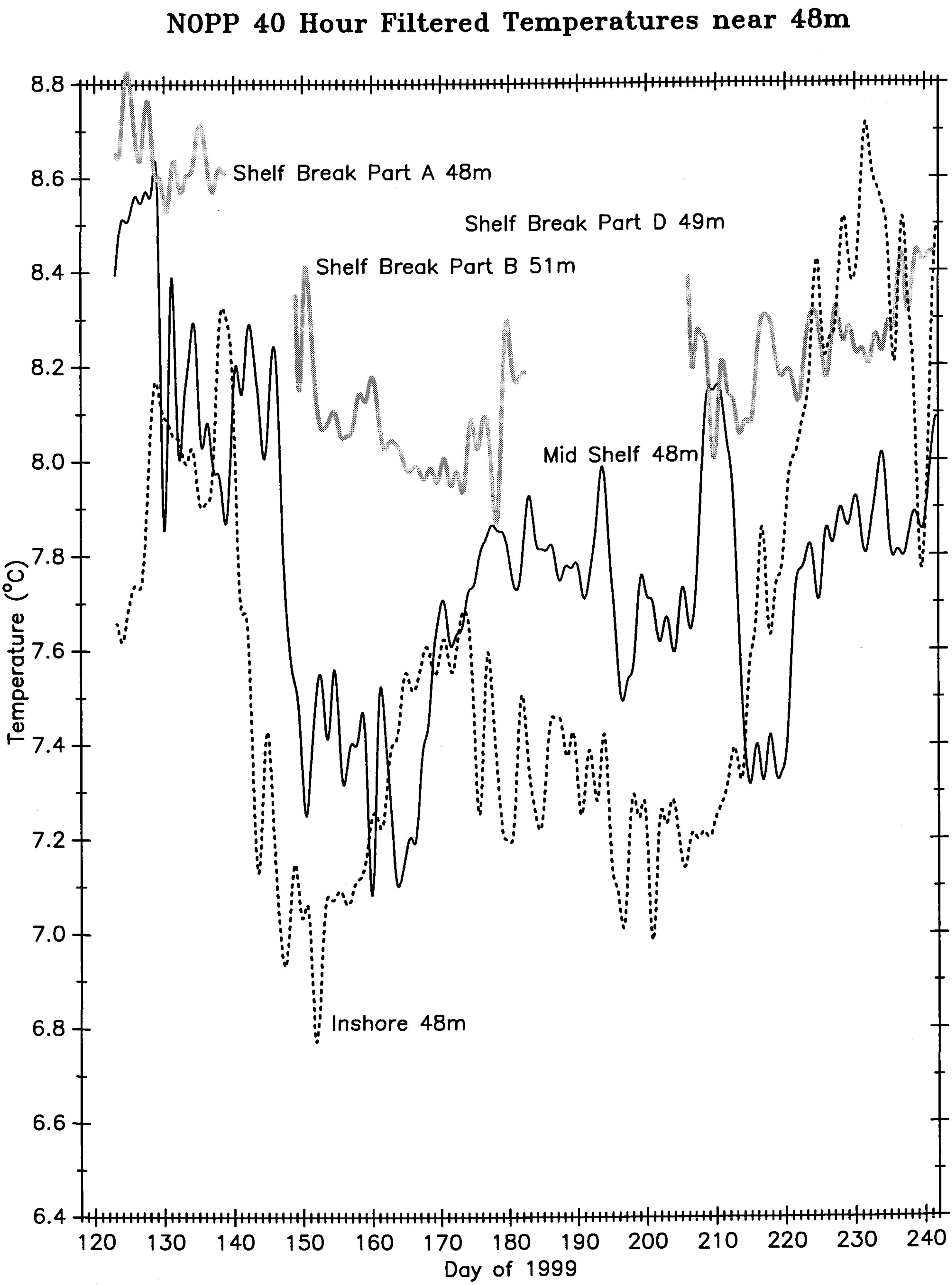


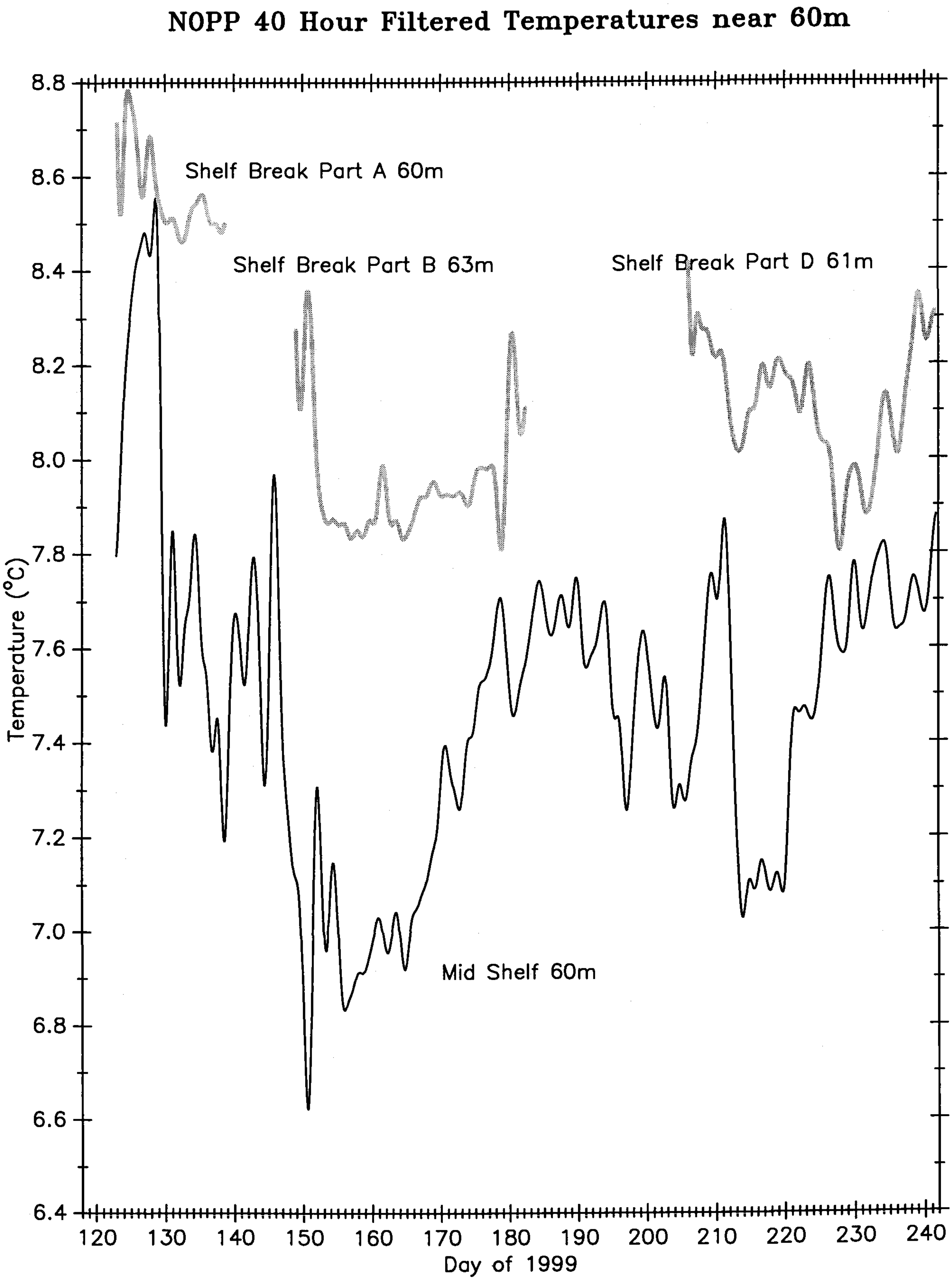

NOPP 40 Hour Filtered Temperatures near 2m
Shelf Break part D 2m
Met 2m
Shelf Break part B 2m
Shelf Break part A 2m→
Inshore 2m
Temperature (°C)
17
16
15
14
13
12
11
10
9
8
7
120
130
140
150
160
170
180
190
200
210
220
230
240
Day of 1999

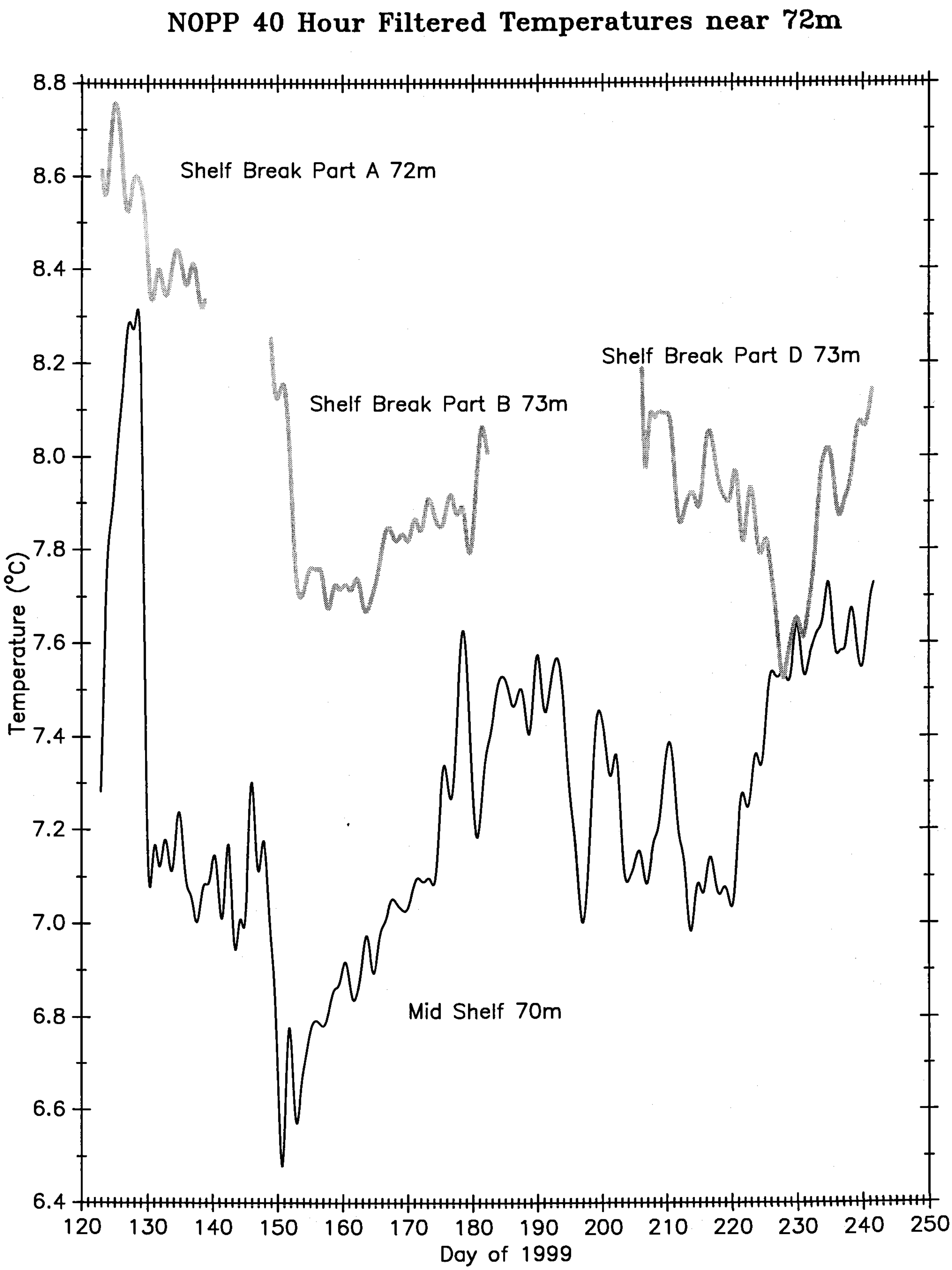

NOPP 40 Hour Filtered Temperatures near 16m
gray = Shelf Break part A 16m
Shelf Break Part D 17m
Mid Shelf 16m
Inshore 16m
Temperature (°C)
Day of 1999
12
11
10
9
8
7
120
130
140
150
160
170
180
190
200
210
220
230
240

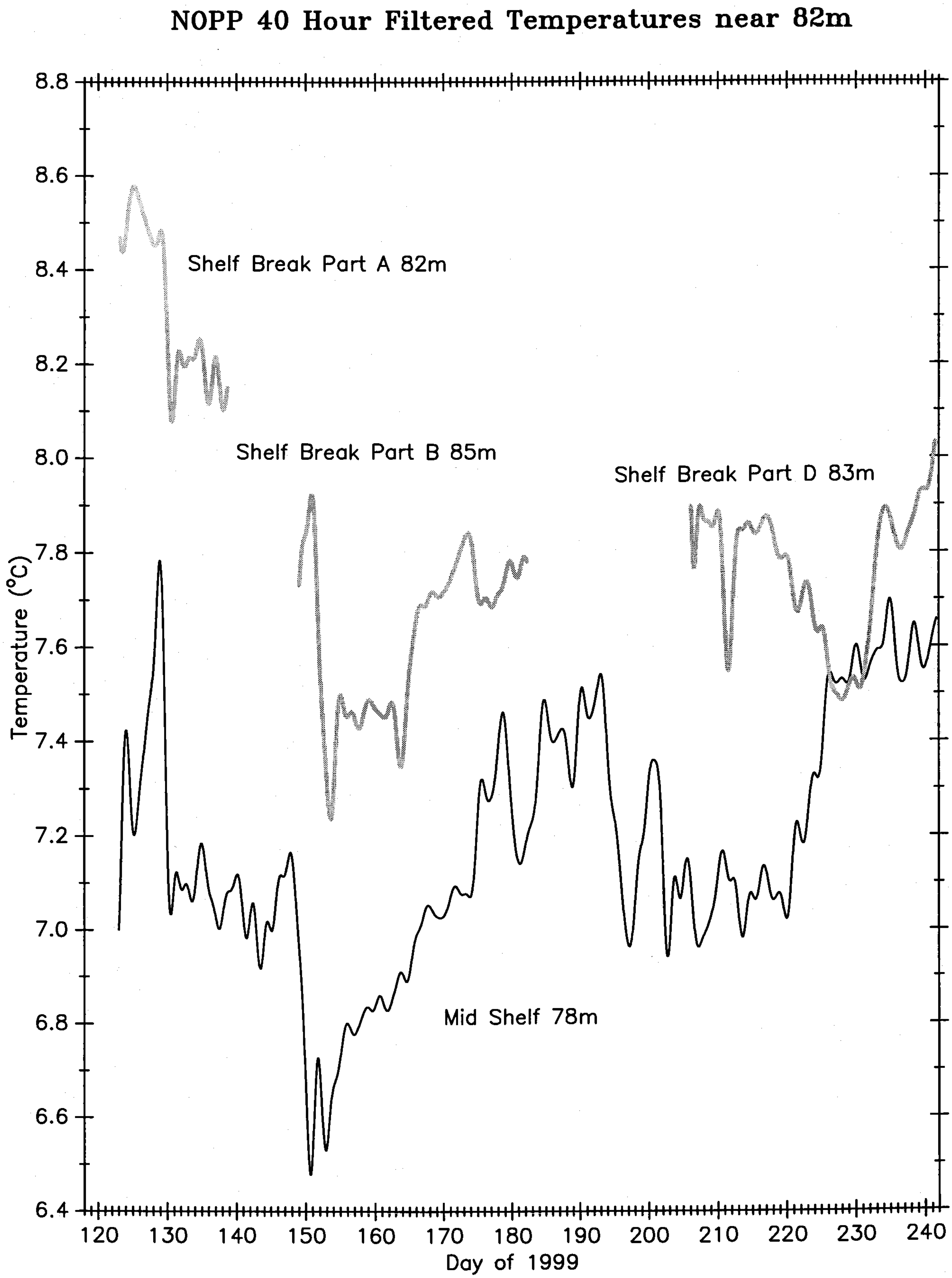

NOPP 40 Hour Filtered Temperatures near 20m
gray = Shelf Break part A 20m
Shelf Break Part D 21m
Shelf Break Part B 19m
Mid Shelf 20m
Inshore 20m
Temperature (°C)
Day of 1999
12
11
10
9
8
7
120
130
140
150
160
170
180
190
200
210
220
230
240


NOPP 40 Hour Filtered Temperatures near 28m
Temperature (°C)
Day of 1999
Shelf Break Part A 28m
Shelf Break Part B 27m
Shelf Break Part D 29m
Mid Shelf 28m
Inshore 28m
12
11
10
9
8
7
120
130
140
150
160
170
180
190
200
210
220
230
240


NOPP 40 Hour Filtered Temperatures near 48m
Shelf Break Part A 48m
Shelf Break Part D 49m
Shelf Break Part B 51m
Mid Shelf 48m
Inshore 48m
Temperature (°C)
Day of 1999
8.8
8.6
8.4
8.2
8.0
7.8
7.6
7.4
7.2
7.0
6.8
6.6
6.4
120
130
140
150
160
170
180
190
200
210
220
230
240


NOPP 40 Hour Filtered Temperatures near 60m
Shelf Break Part A 60m
Shelf Break Part B 63m
Shelf Break Part D 61m
Mid Shelf 60m
Temperature (°C)
8.8
8.6
8.4
8.2
8.0
7.8
7.6
7.4
7.2
7.0
6.8
6.6
6.4
120
130
140
150
160
170
180
190
200
210
220
230
240
Day of 1999


NOPP 40 Hour Filtered Temperatures near 72m
Shelf Break Part A 72m
Shelf Break Part B 73m
Shelf Break Part D 73m
Mid Shelf 70m
Temperature (°C)
Day of 1999
8.8
8.6
8.4
8.2
8.0
7.8
7.6
7.4
7.2
7.0
6.8
6.6
6.4
120
130
140
150
160
170
180
190
200
210
220
230
240
250



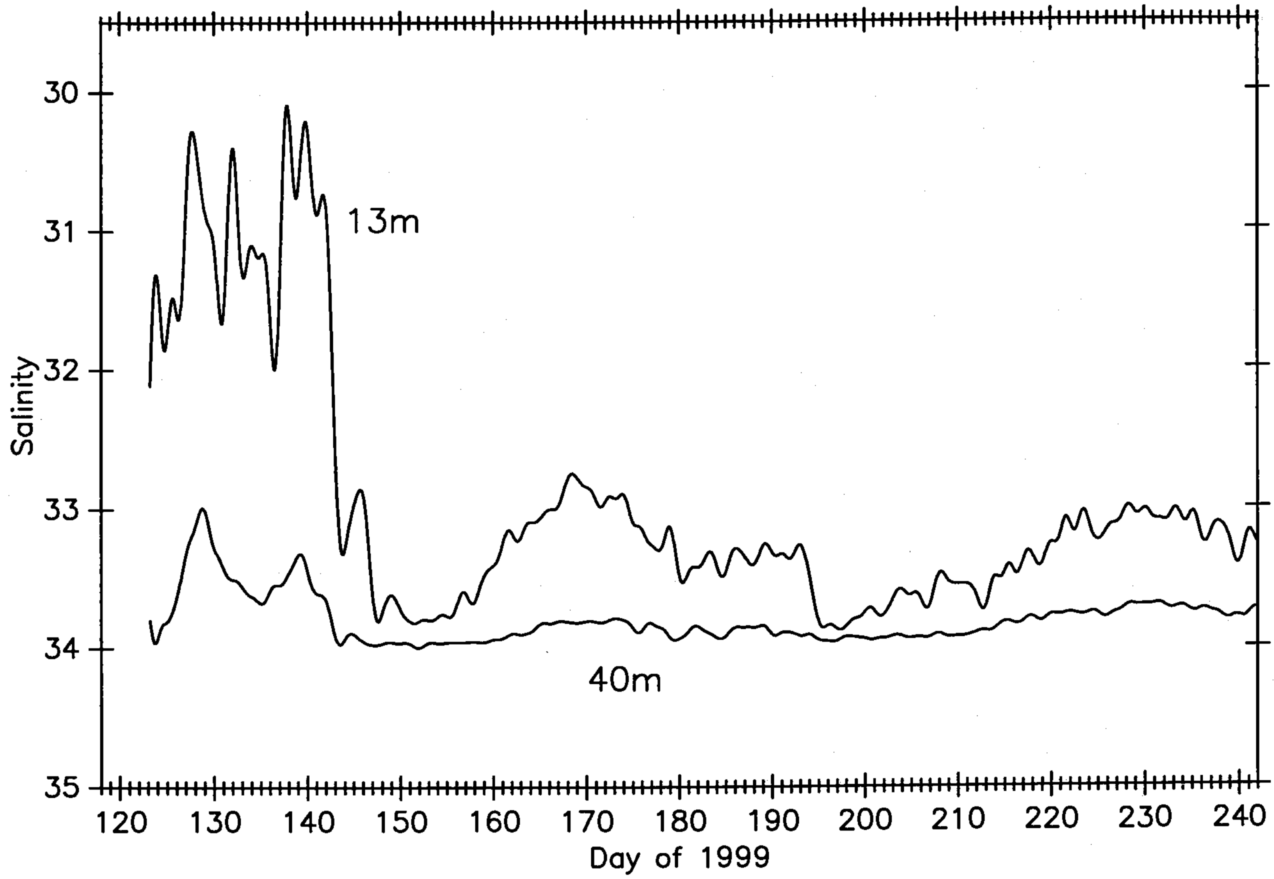
NOPP 40 Hour Filtered Temperatures near 82m
Shelf Break Part A 82m
Shelf Break Part B 85m
Shelf Break Part D 83m
Mid Shelf 78m
Temperature (°C)
Day of 1999
8.8
8.6
8.4
8.2
8.0
7.8
7.6
7.4
7.2
7.0
6.8
6.6
6.4
120
130
140
150
160
170
180
190
200
210
220
230
240

SALINITY Time Series

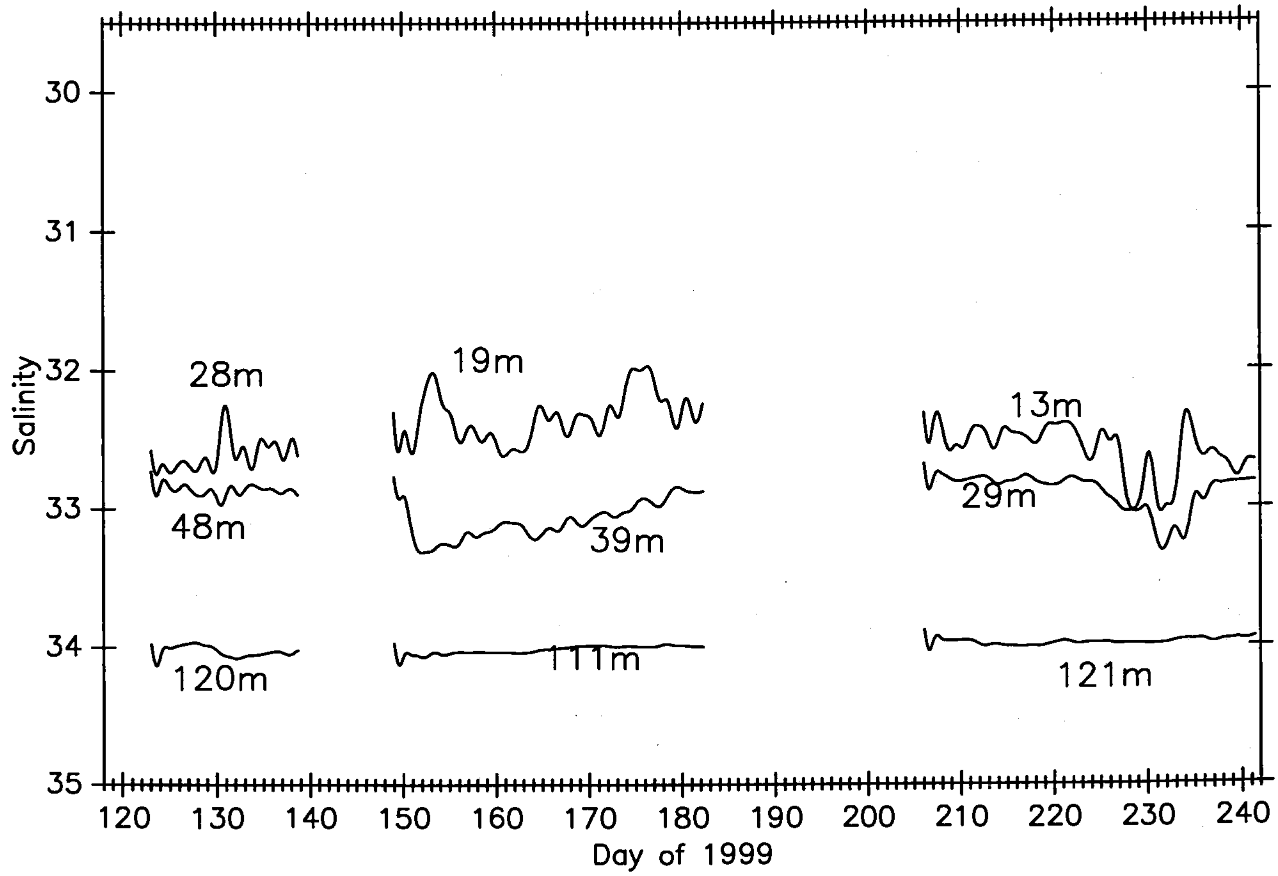
40-hour Low-Pass Filtered

Plots of salinity from the Inshore, Mid-Shelf, Met, and Shelf-Break moorings. Note that the salinity scale is the same on all plots, although the range is greater for the combined plot of Mid-Shelf & Met mooring salinities. Note the gap in Shelf-Break mooring salinity records after day 143, corresponding to the changes of depth associated with the mooring being hit by the trawler. Salinities are not presented for the entire duration of period C, following the loss of buoyancy from the Shelf-Break mooring on day 186.

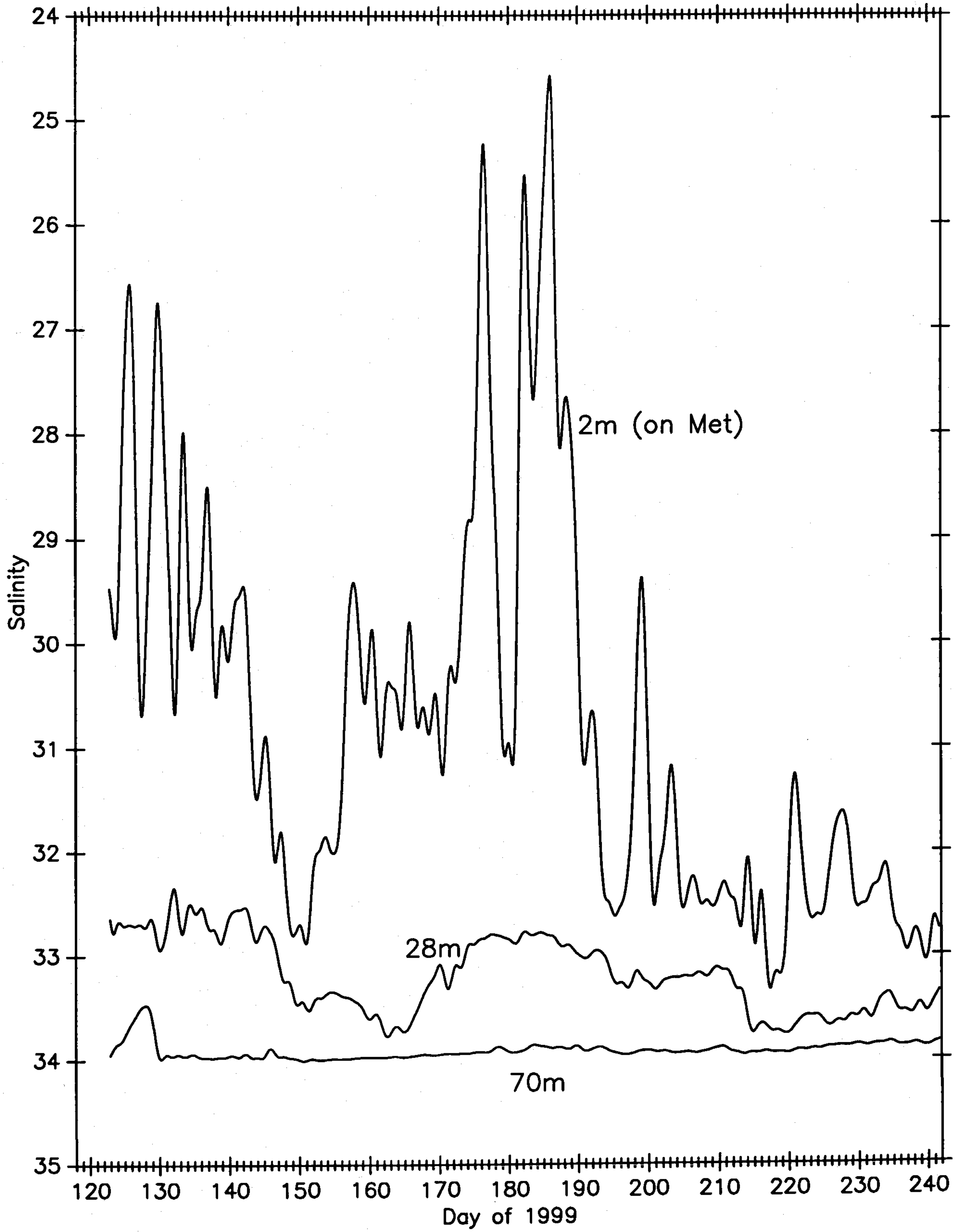
NOPP Inshore 40 Hour Filtered Salinities



NOPP Shelf Break 40 Hour Filtered Salinties



NOPP Mid Shelf 40 Hour Filtered Salinities

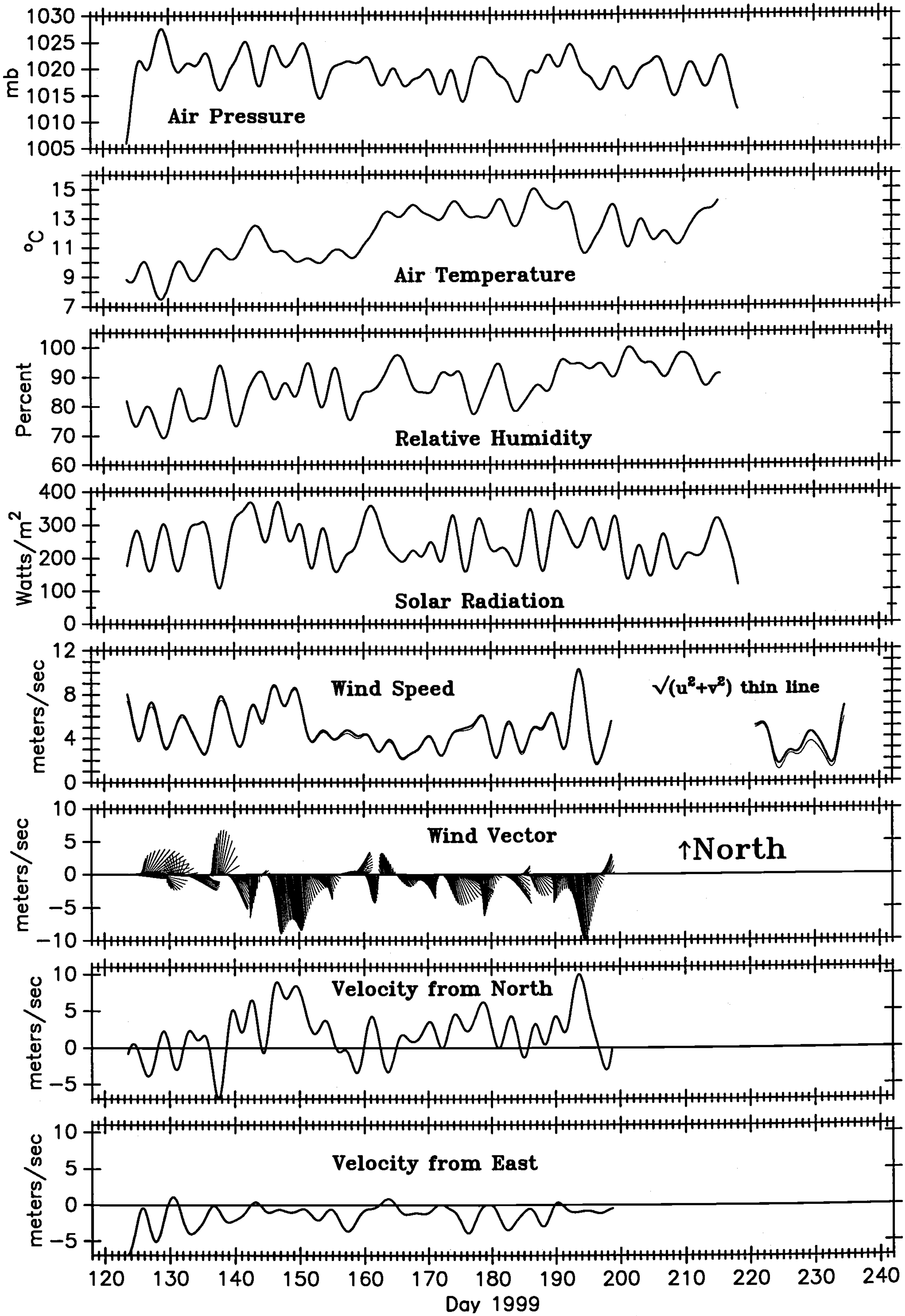


METEOROLOGICAL Time Series

40-hour Low-Pass Filtered

Plots of air pressure, air temperature, relative humidity, solar radiation, wind speed, wind vectors and velocity components. Wind velocity components are presented in the meteorological convention: velocity from north and from east. Wind velocity vectors are shown at 4-hourly intervals. Wind speed is plotted both as converted anemometer rotor counts (bold line) and as magnitude of the vector-averaged velocity (light line). No wind data is available for the period between loss of the anemometer on day 203 and replacement of the anemometer on day 215. Wind direction is not provided for the period following the anemometer replacement due to ambiguity in the orientation of the replacement anemometer.

NOPP Met Mooring 40 Hour Filtered Meteorological Data

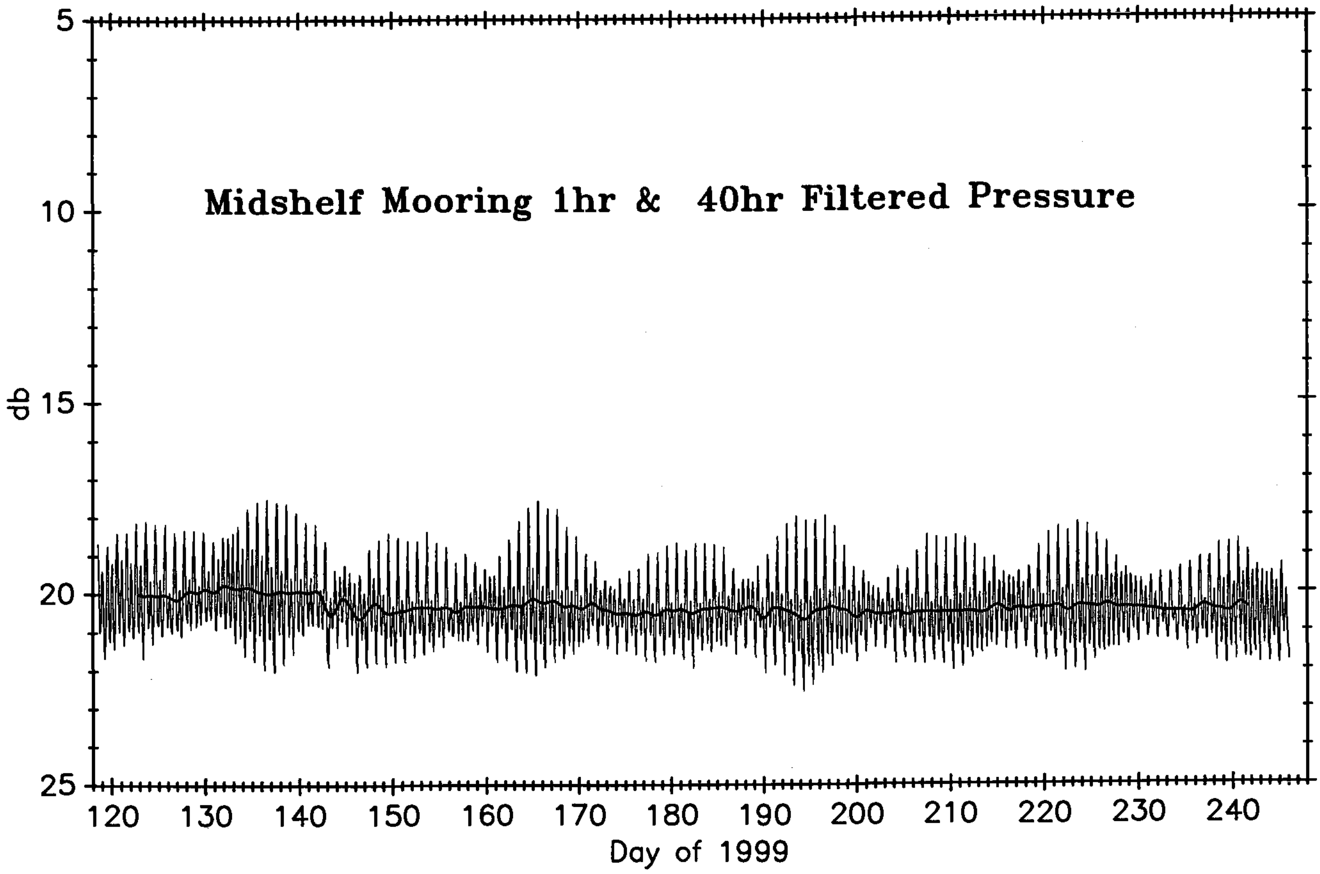


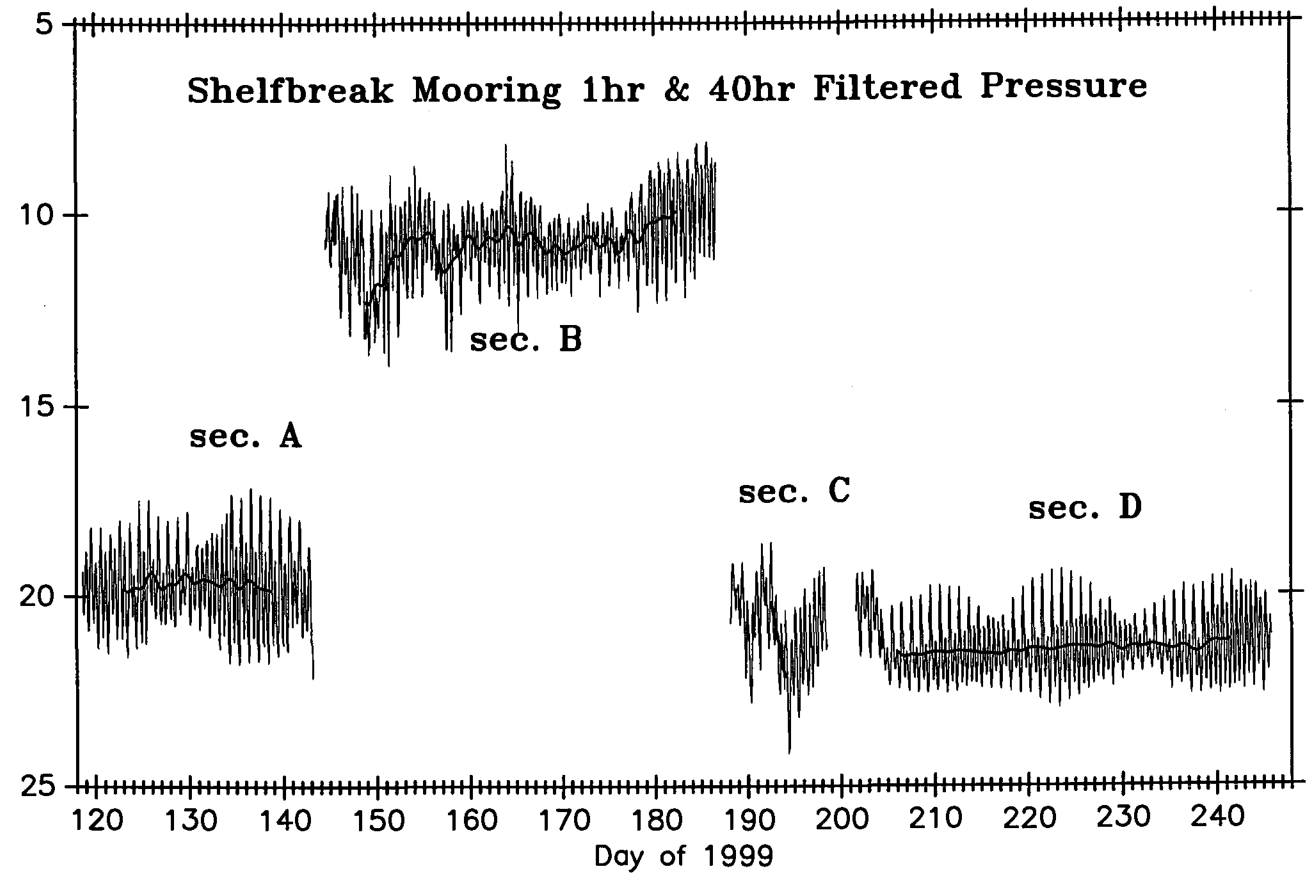
PRESSURE Time Series

40-hour & 1-hour Low-Pass Filtered

Plots of pressure from the Mid-Shelf and Shelf-Break moorings. The trawler impact of the Shelf-Break mooring on day 143 is evident in the pressure signal as a nearly 10 m upward displacement. Subsequent loss of buoyancy by the Shelf-Break mooring on day 186 is evident in the displacement down to about 21 m. The unfiltered pressure signal also suggests that the Shelf-Break mooring was hit again on day 191. The 1-hour filtered pressure signal from the Mid-Shelf mooring and parts of the Shelf-Break mooring (period A, prior to trawler impact, and period D, following redeployment), show clear semidiurnal signals.

NOPP Pressure Data



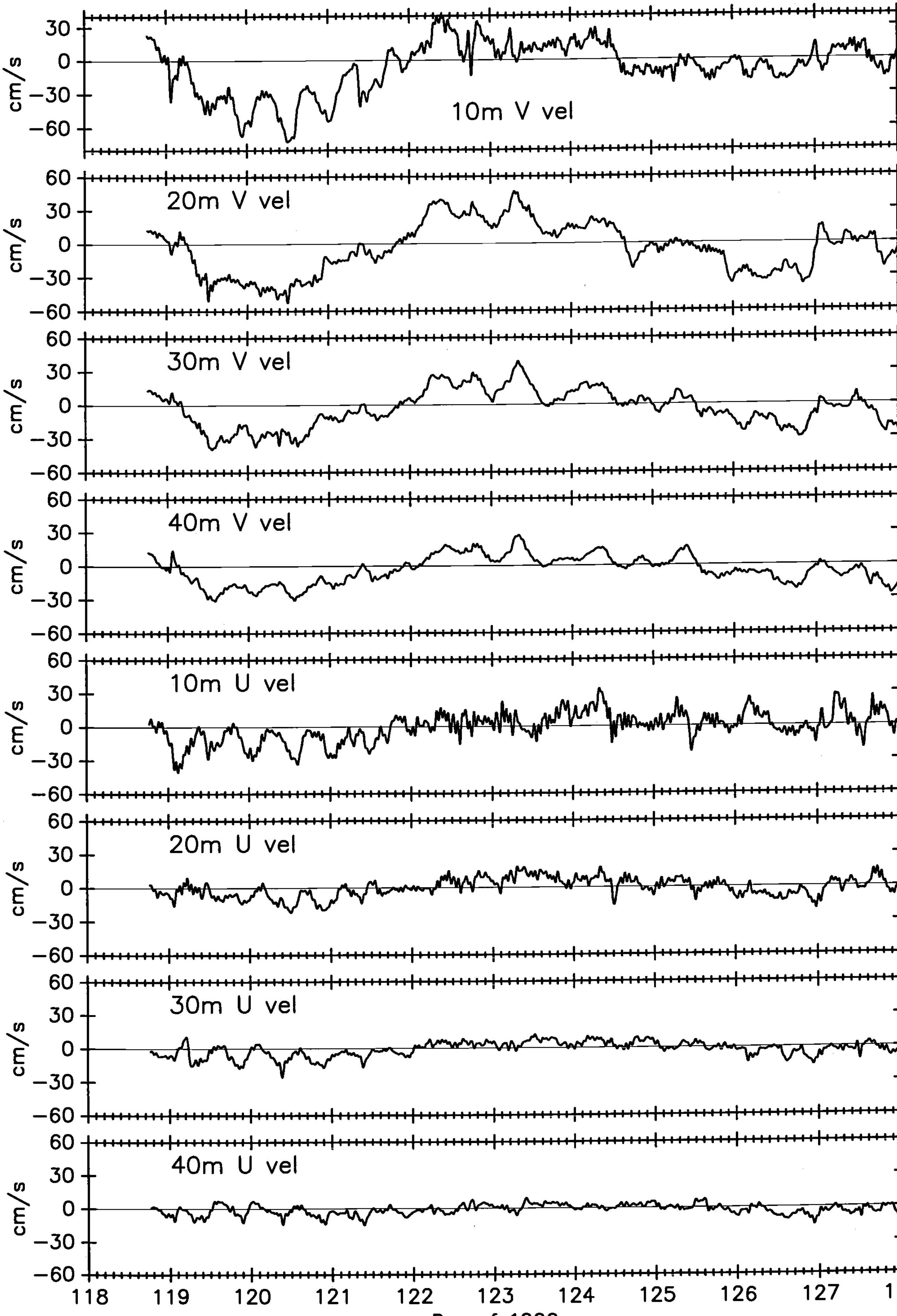


VELOCITY Time Series

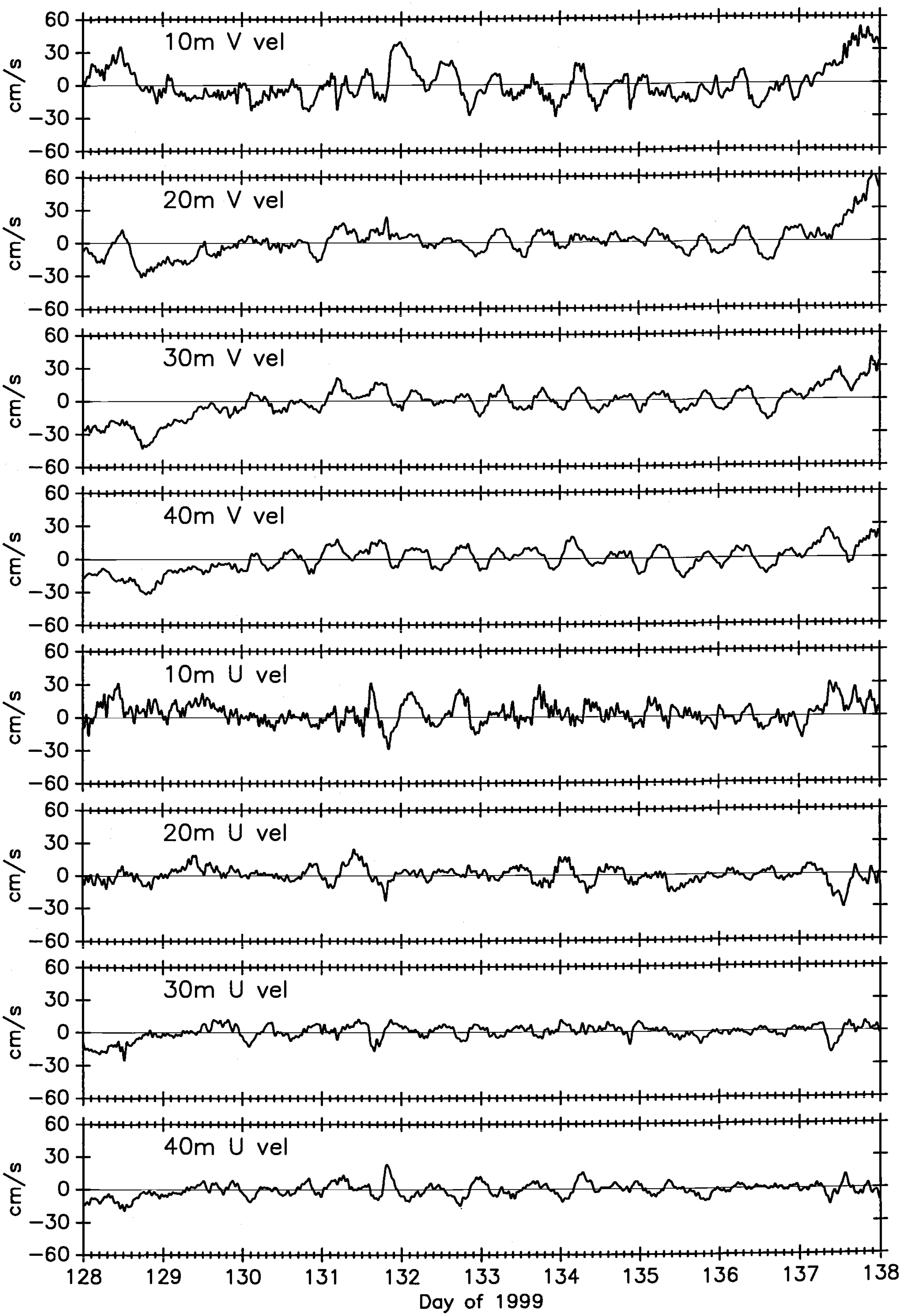
1-hour Low-pass Filtered

Plots of east and north components of velocity from the Inshore, Mid-Shelf, and Shelf-Break moorings. Velocity components from the Inshore mooring are shown for 10, 20, 30, and 40 m. Velocity components from the Mid-Shelf mooring are shown for 11, 31, 51, and 71 m. Velocity components from the first deployment (period A) of the Shelf-Break mooring are shown for 79, 91, 103, and 115 m. Velocity components from the second deployment (period D) of the Shelf-Break mooring are shown for 28, 48, 68, and 88 m.

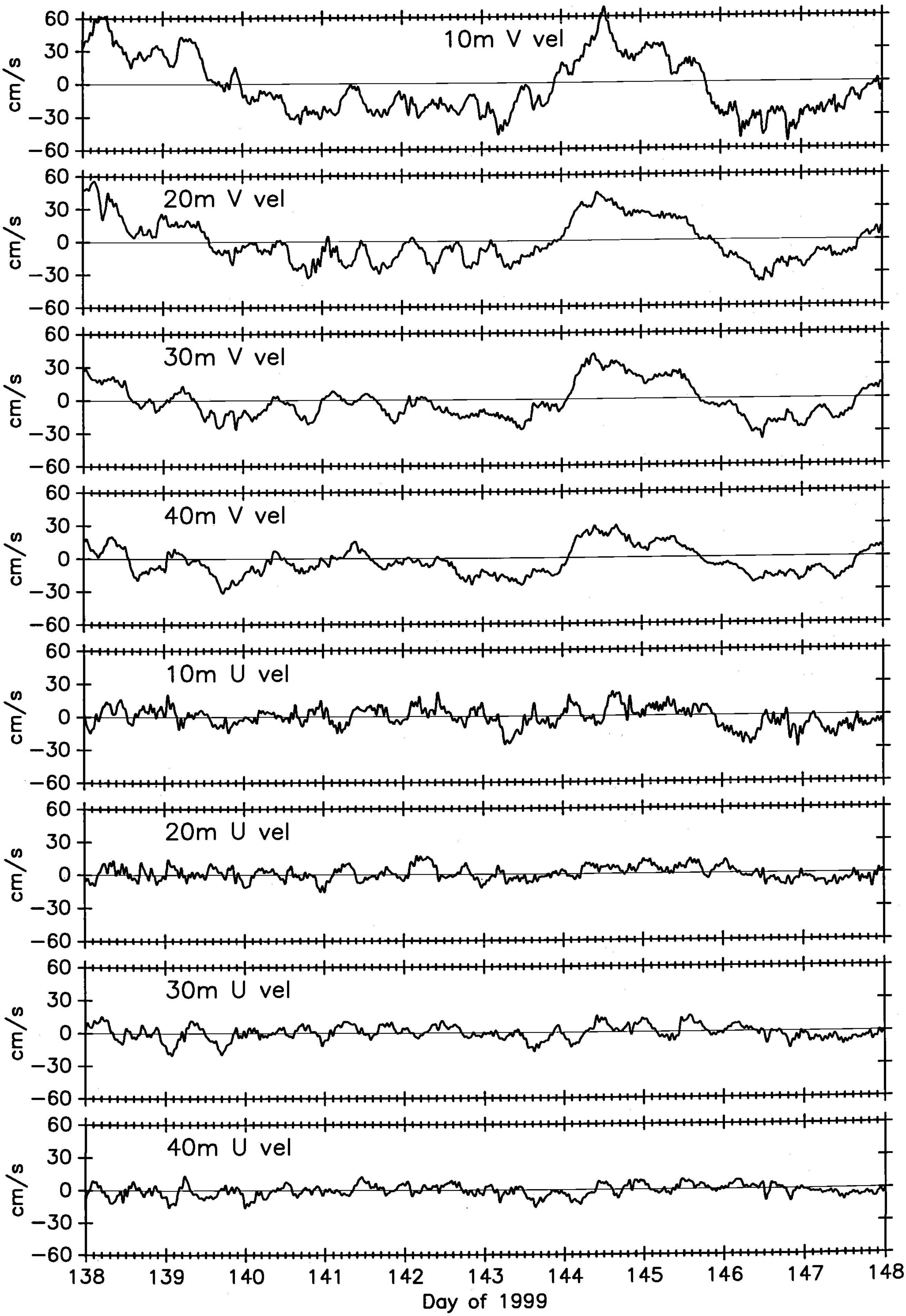
NOPP Inshore Mooring 1 hour Lowpass Filtered Velocities



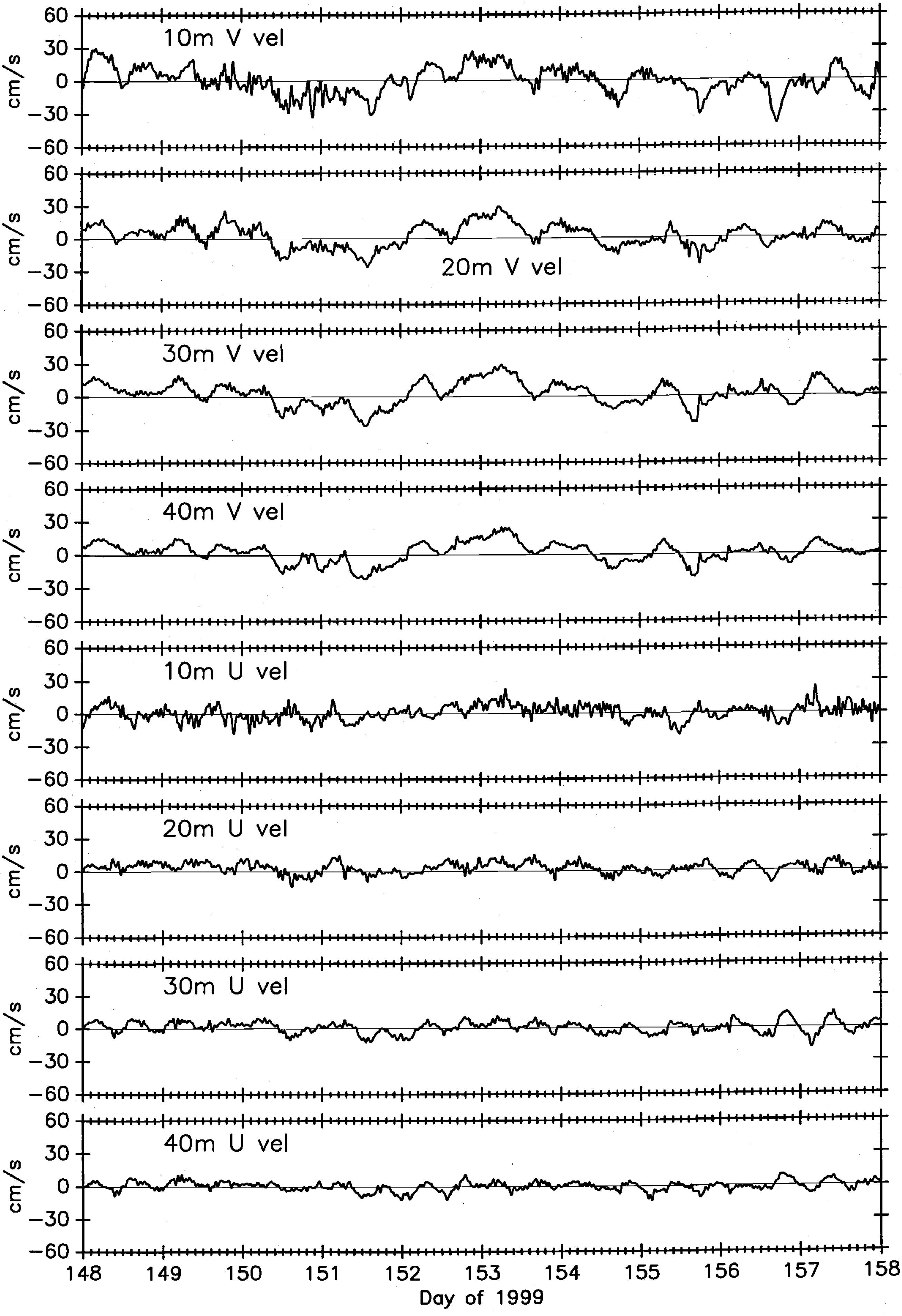
NOPP Inshore Mooring 1 hour Lowpass Filtered Velocities



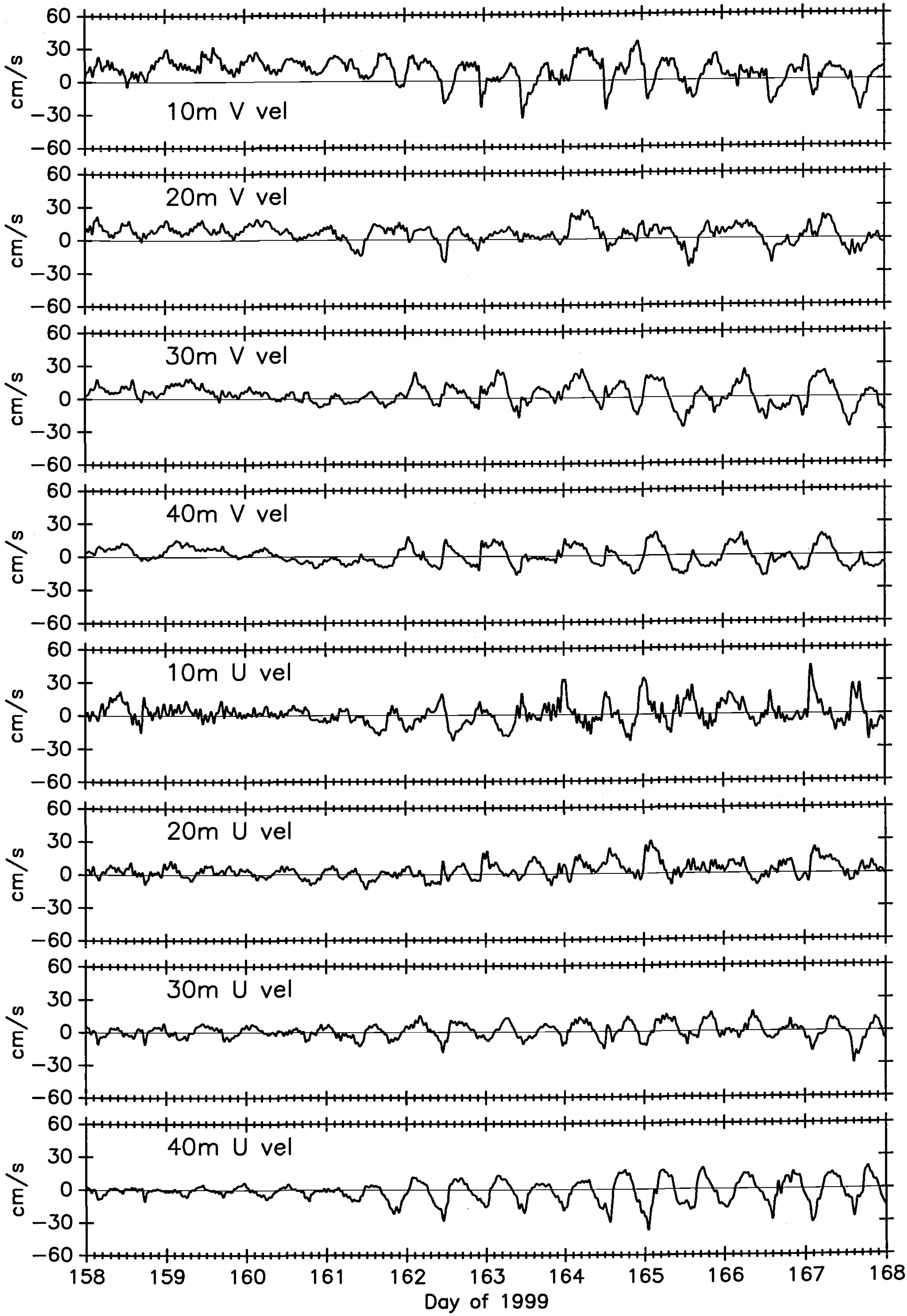
NOPP Inshore Mooring 1 hour Lowpass Filtered Velocities



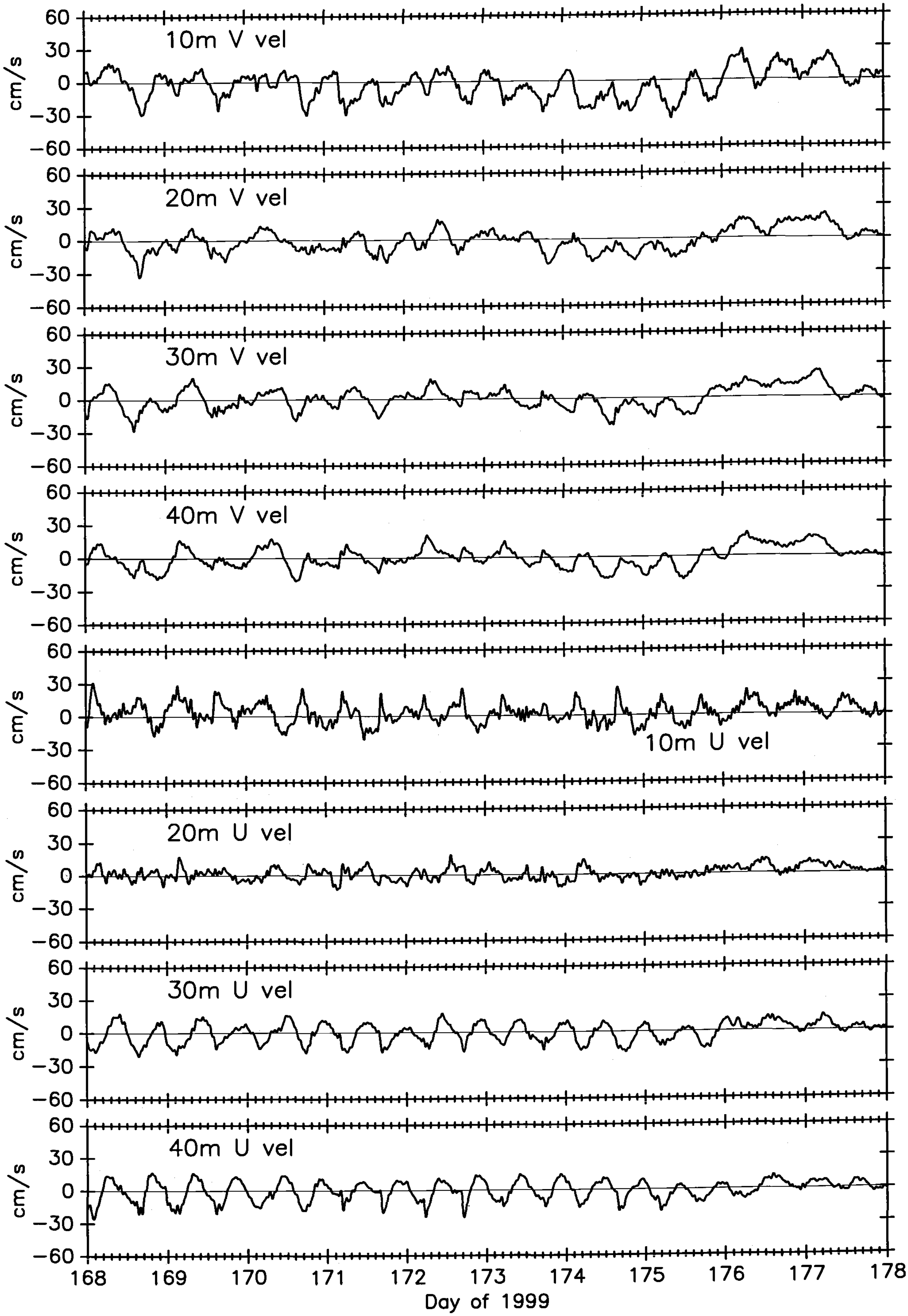
NOPP Inshore Mooring 1 hour Lowpass Filtered Velocities



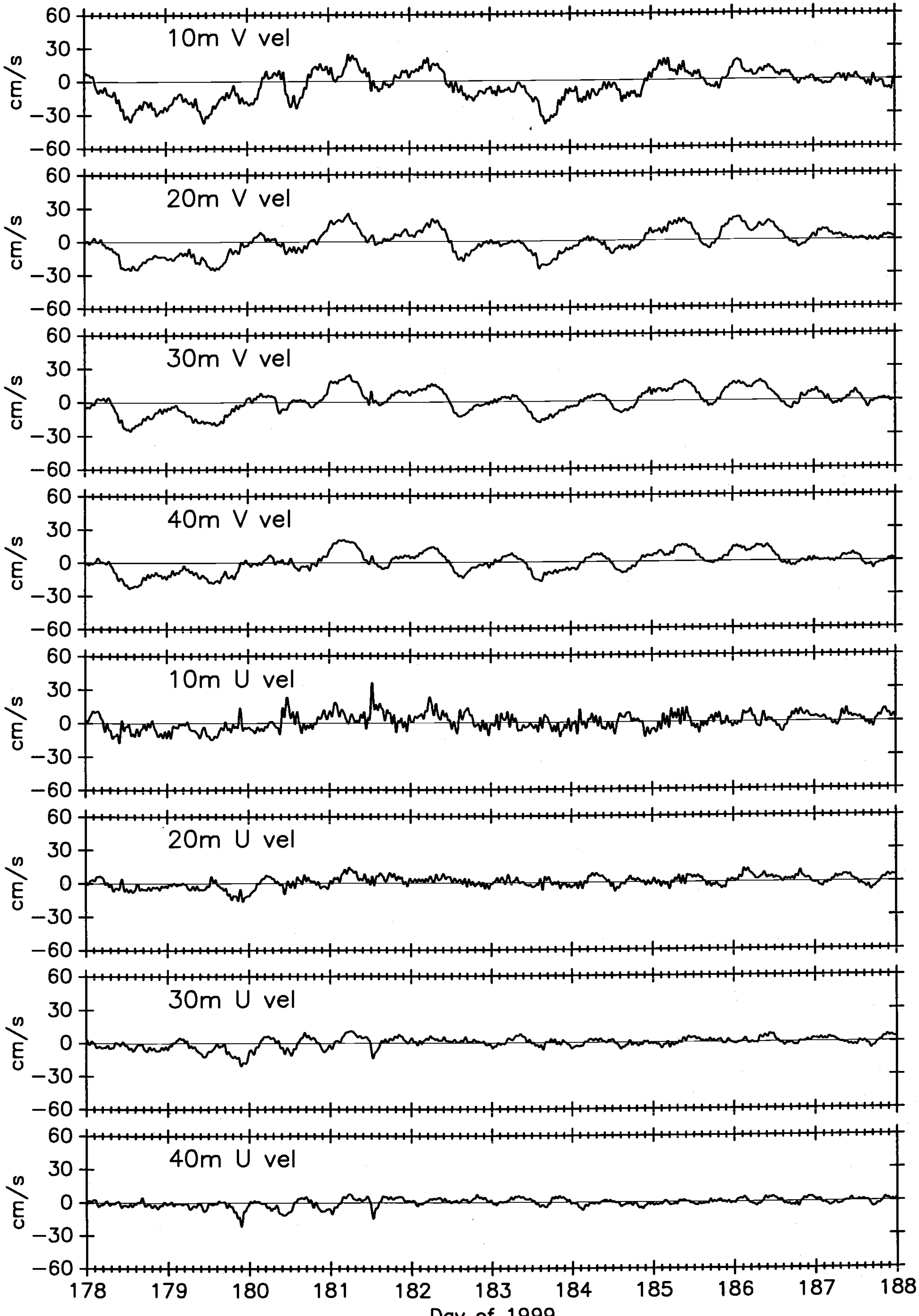
NOPP Inshore Mooring 1 hour Lowpass Filtered Velocities



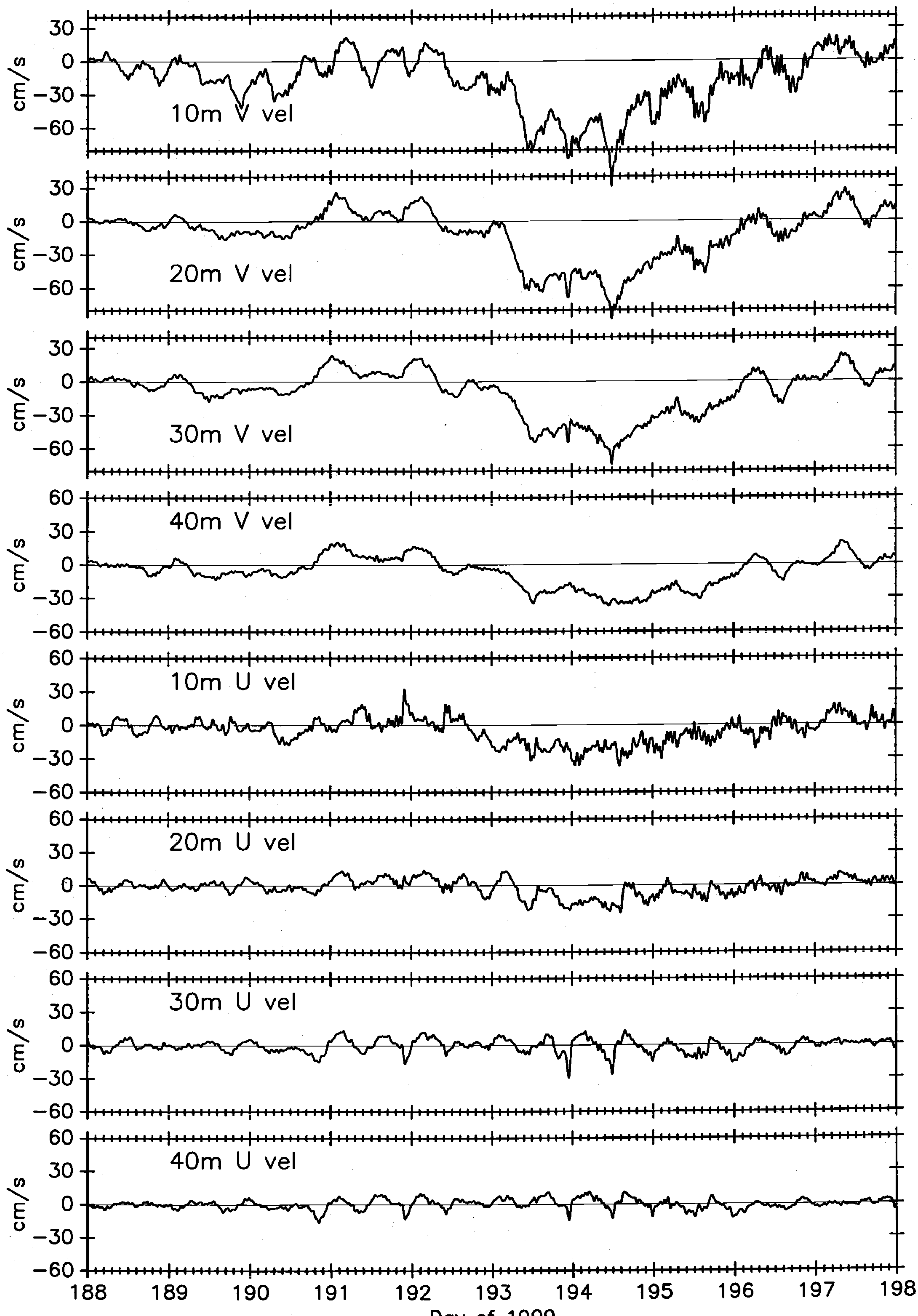
NOPP Inshore Mooring 1 hour Lowpass Filtered Velocities

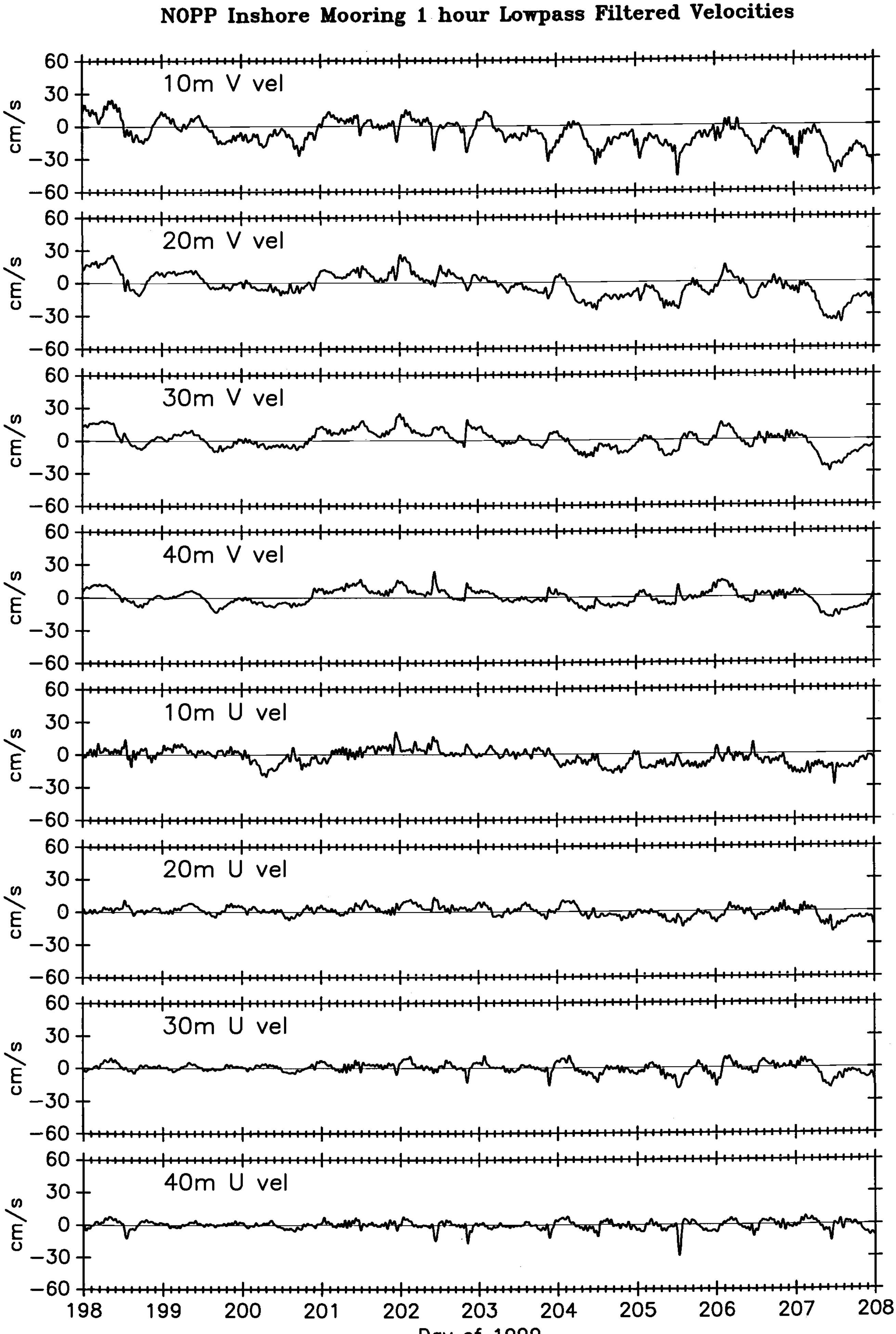


NOPP Inshore Mooring 1 hour Lowpass Filtered Velocities

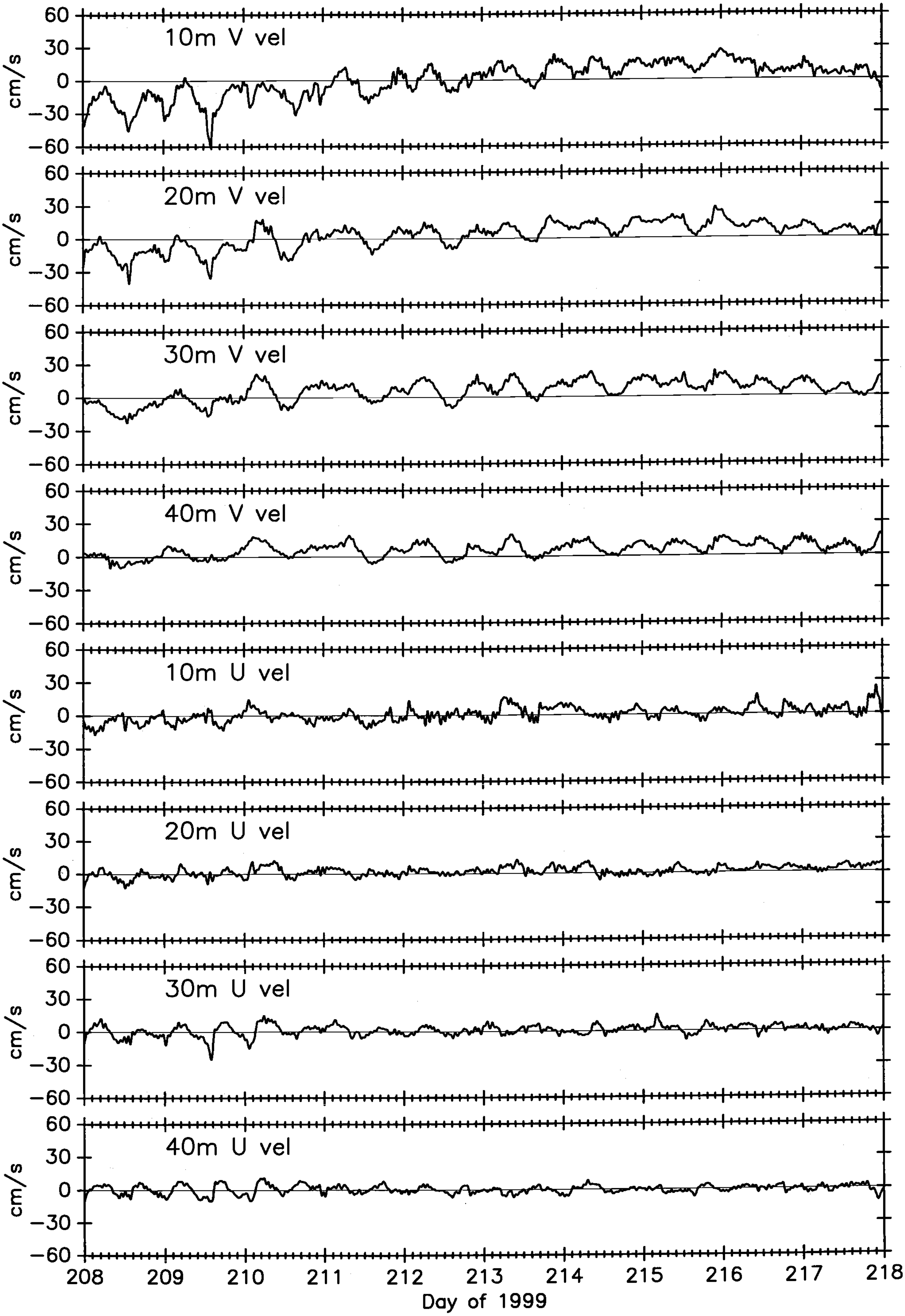


NOPP Inshore Mooring 1 hour Lowpass Filtered Velocities

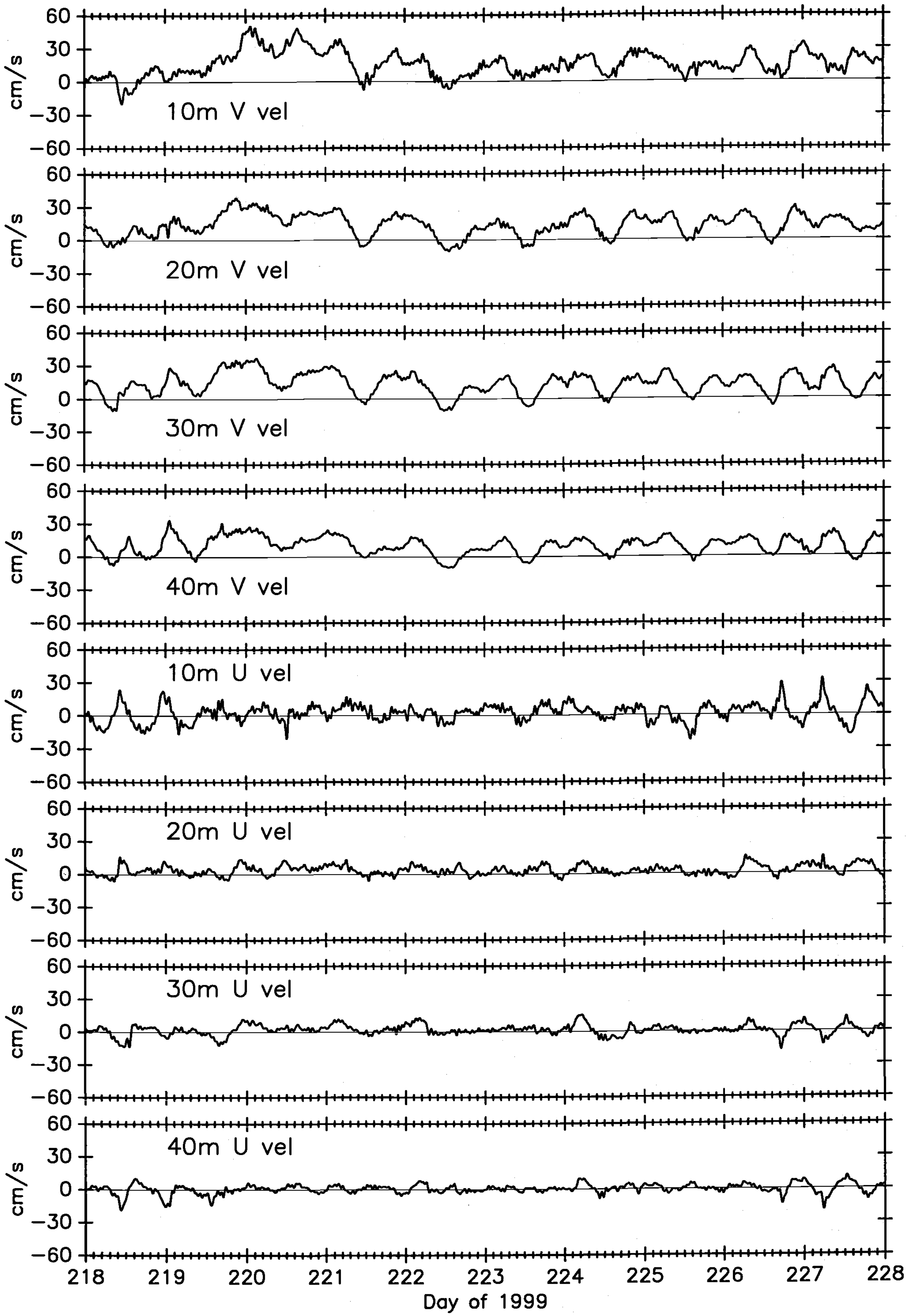



NOPP Inshore Mooring 1 hour Lowpass Filtered Velocities
10m V vel
20m V vel
30m V vel
40m V vel
10m U vel
20m U vel
30m U vel
40m U vel
cm/s
60
30
0
−30
−60
198
199
200
201
202
203
204
205
206
207
208
Day of 1999

NOPP Inshore Mooring 1 hour Lowpass Filtered Velocities



NOPP Inshore Mooring 1 hour Lowpass Filtered Velocities



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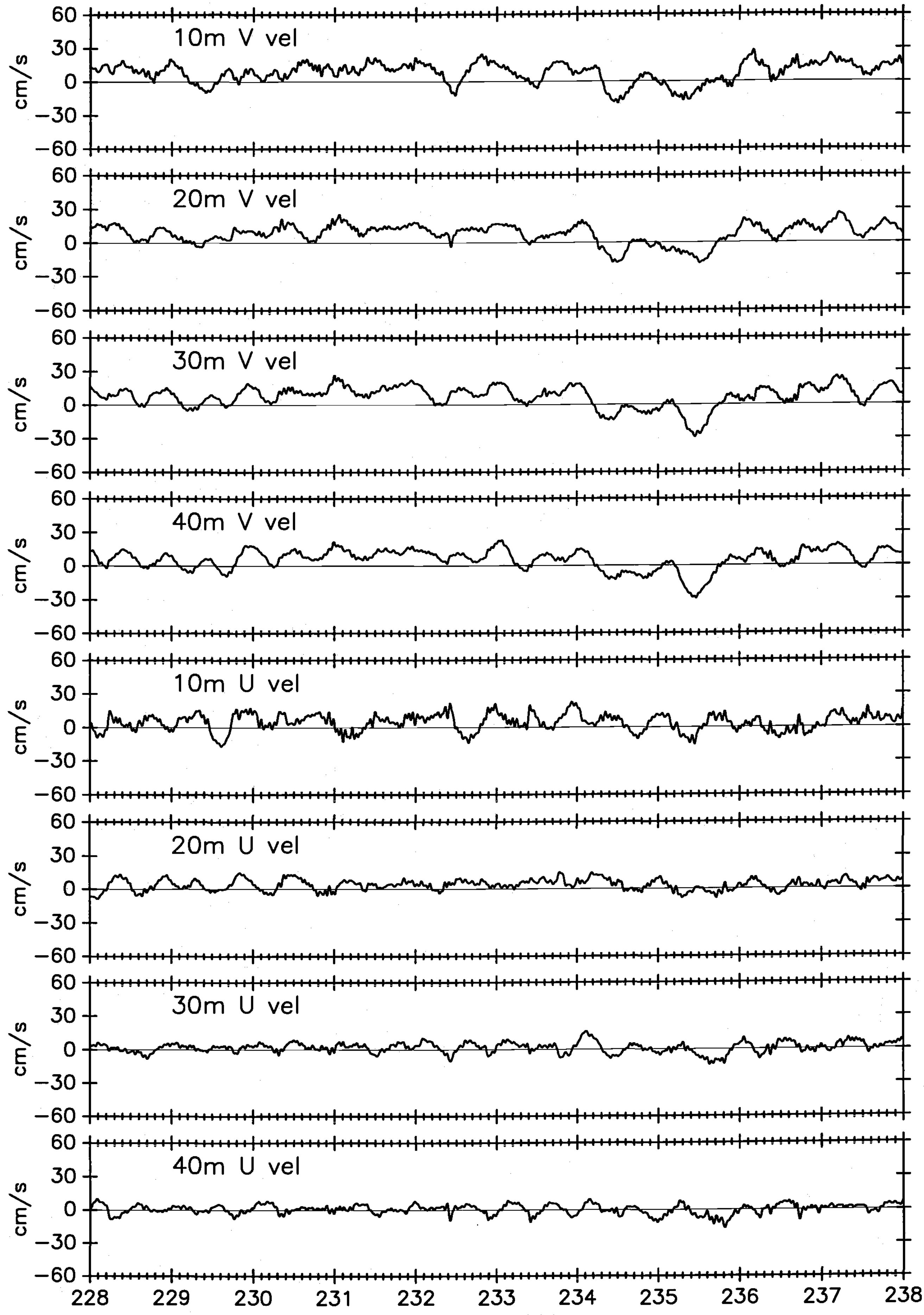
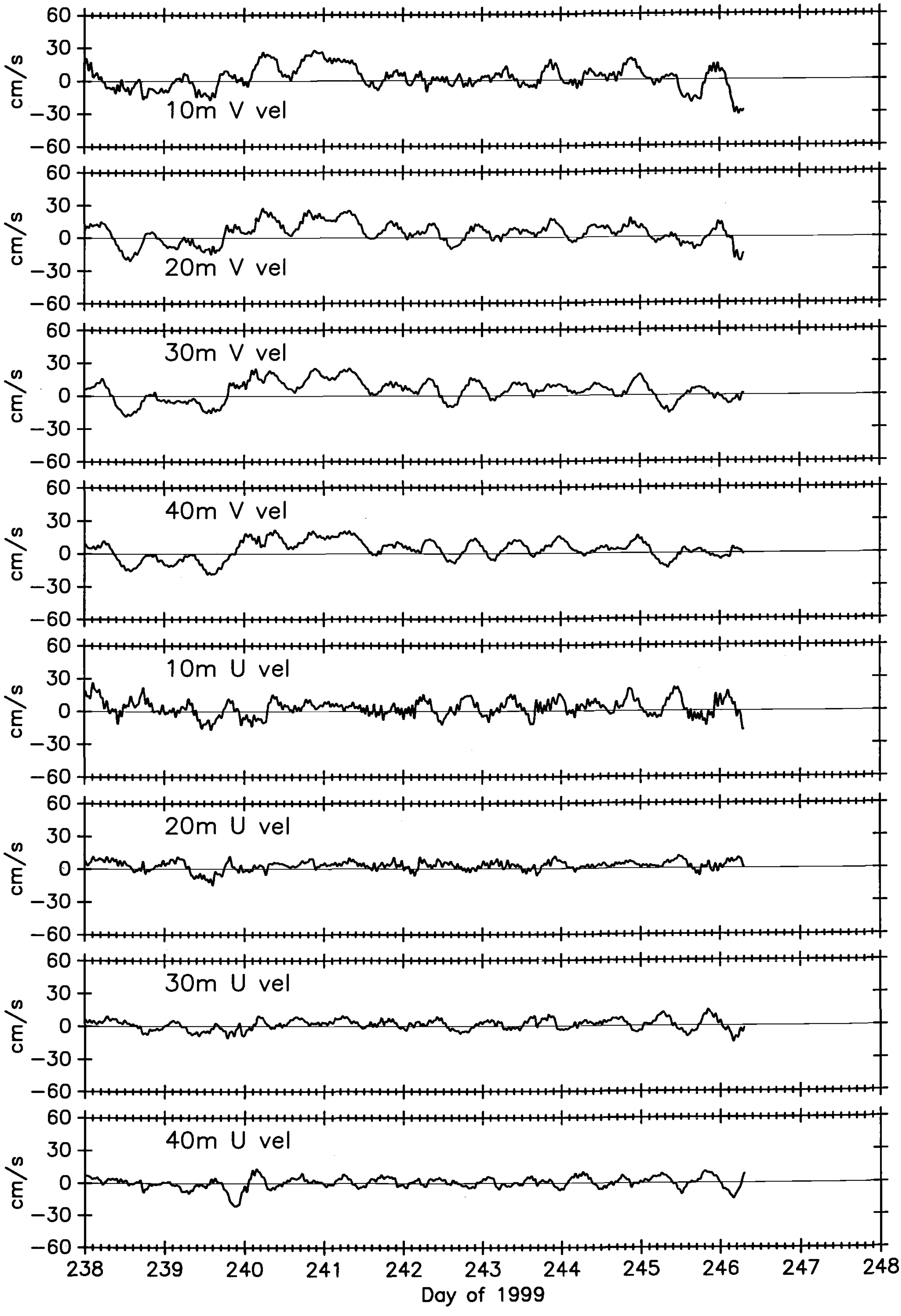
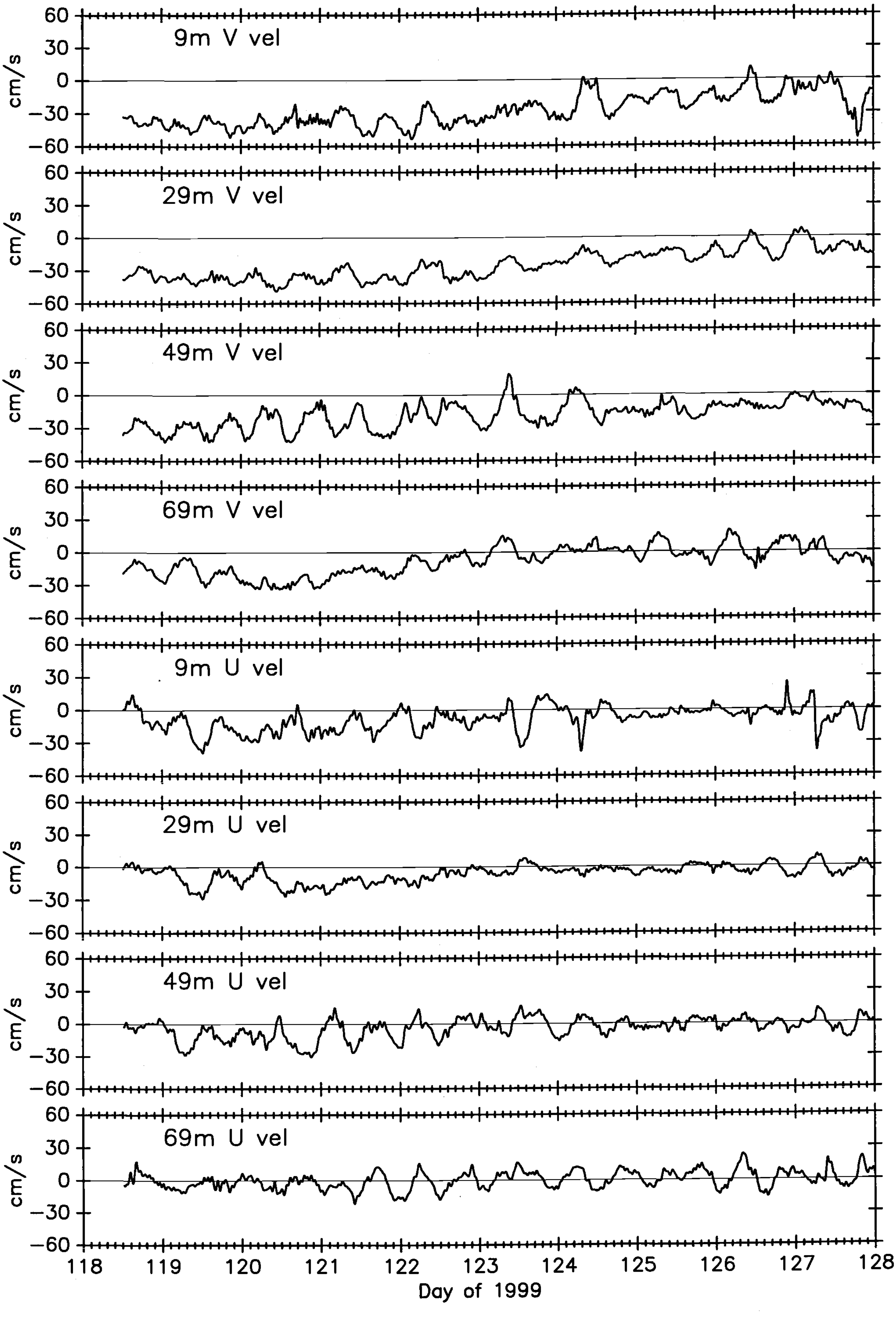


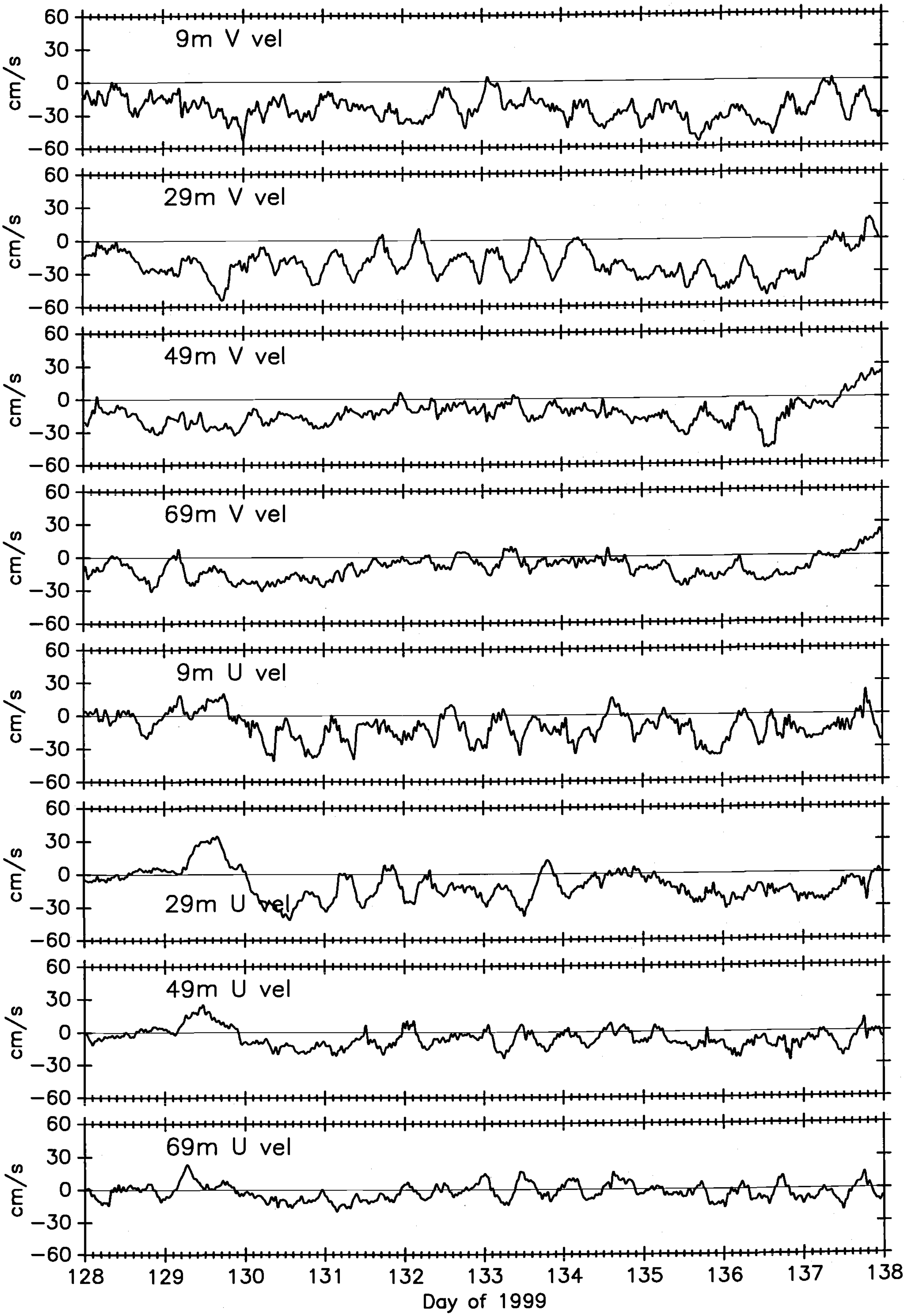
NOPP Inshore Mooring 1 hour Lowpass Filtered Velocities



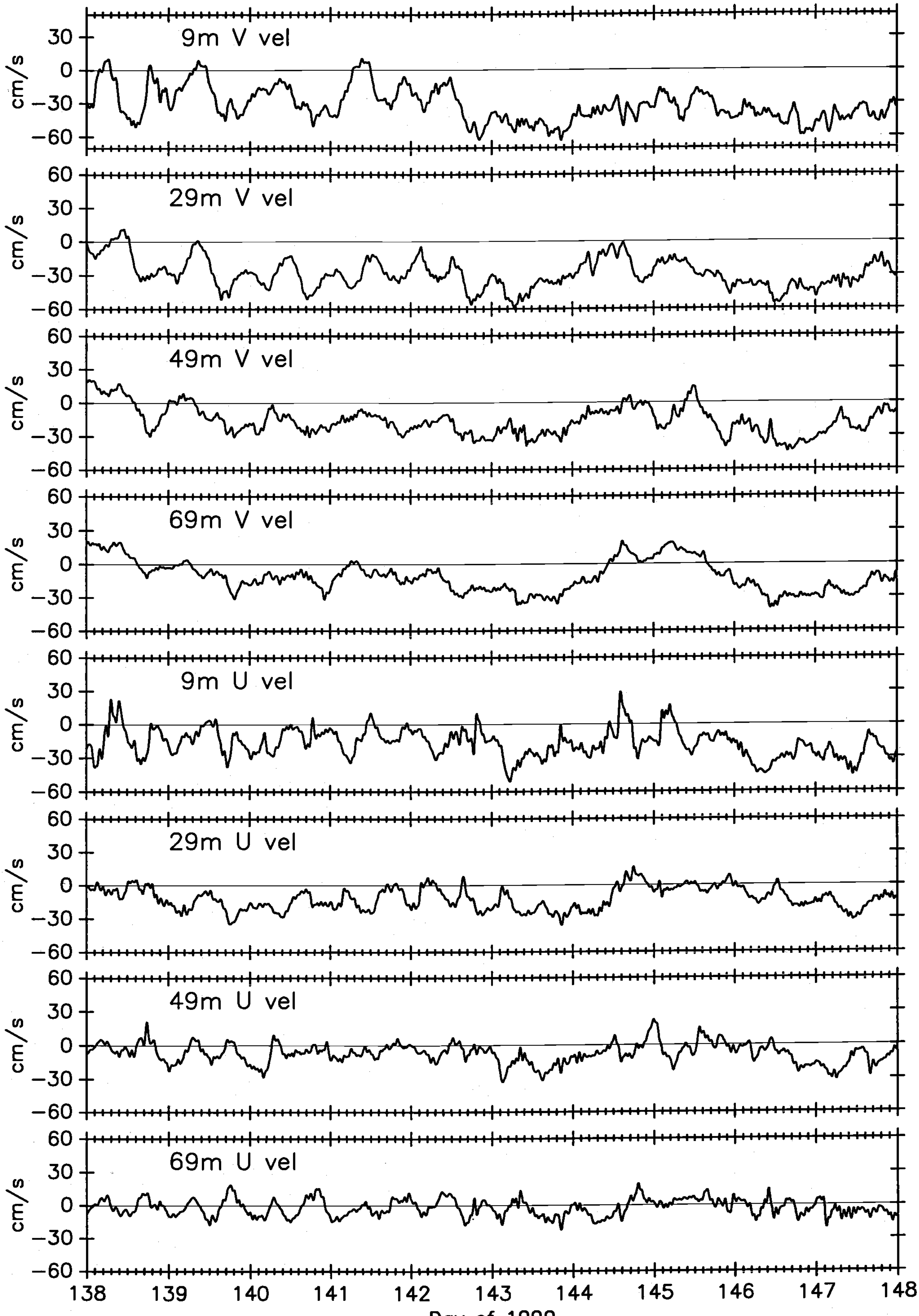
NOPP Mid-Shelf Mooring 1 hour Lowpass Filtered Velocities



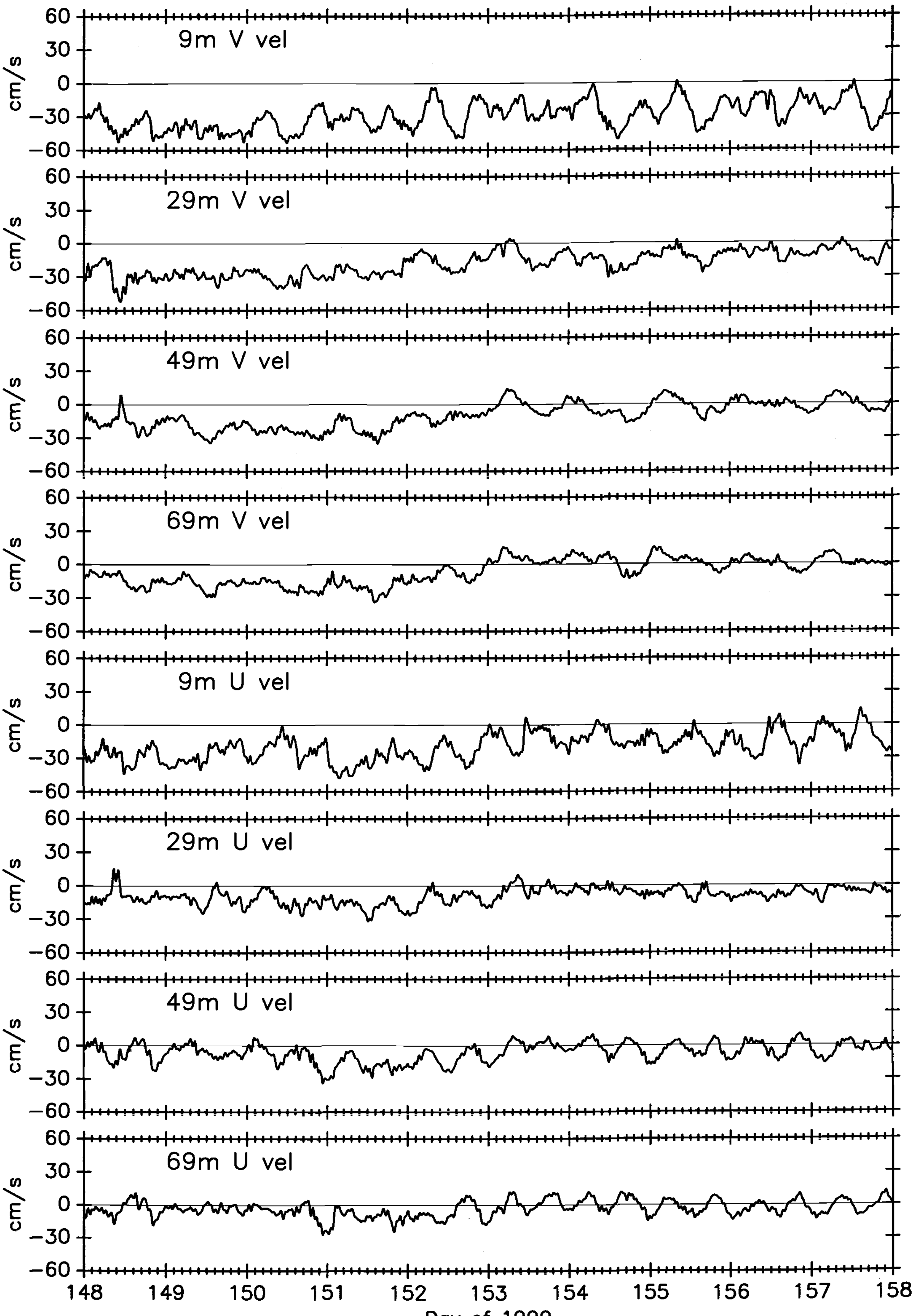
NOPP Mid–Shelf Mooring 1 hour Lowpass Filtered Velocities

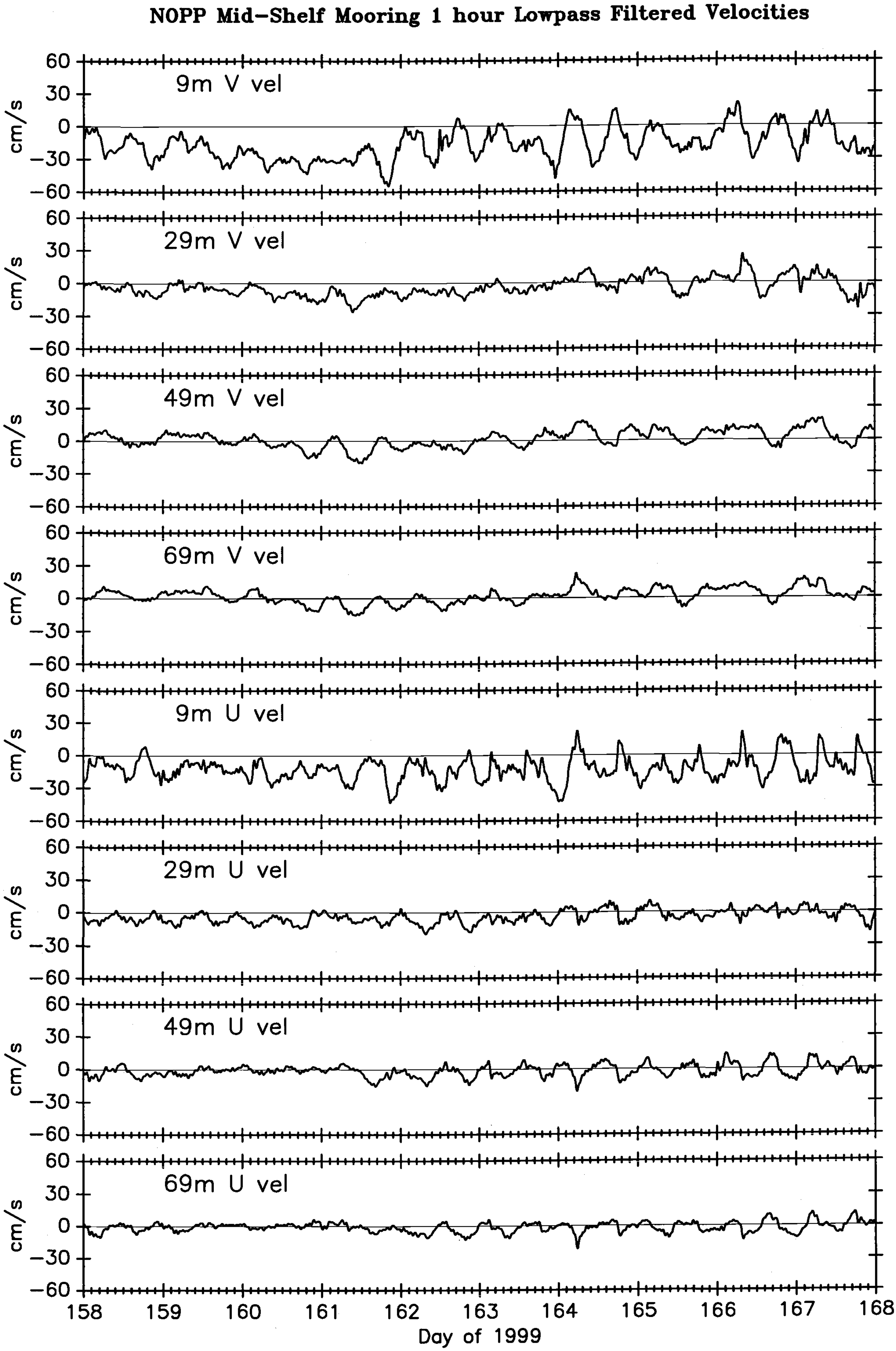


NOPP Mid–Shelf Mooring 1 hour Lowpass Filtered Velocities



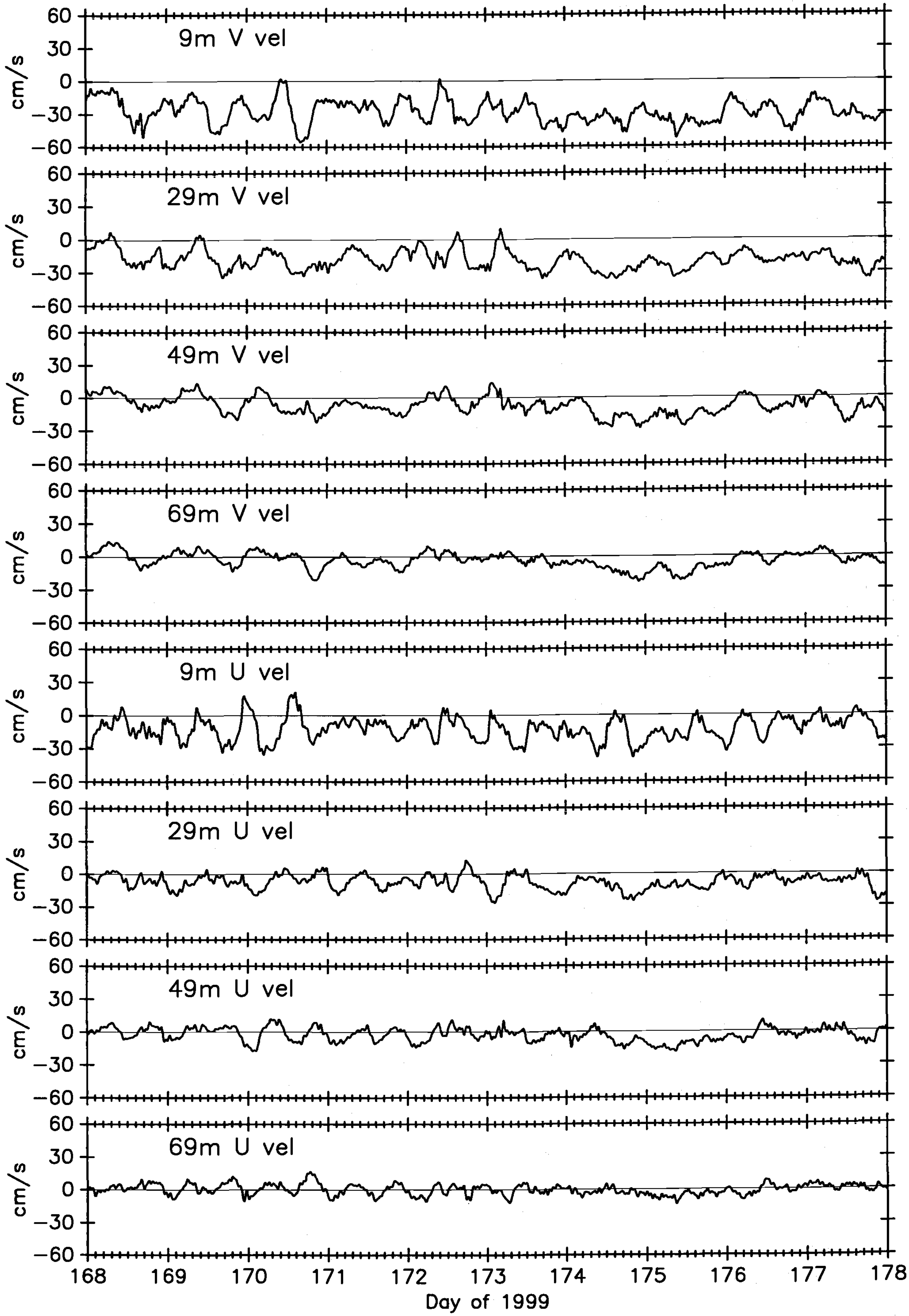
NOPP Mid–Shelf Mooring 1 hour Lowpass Filtered Velocities



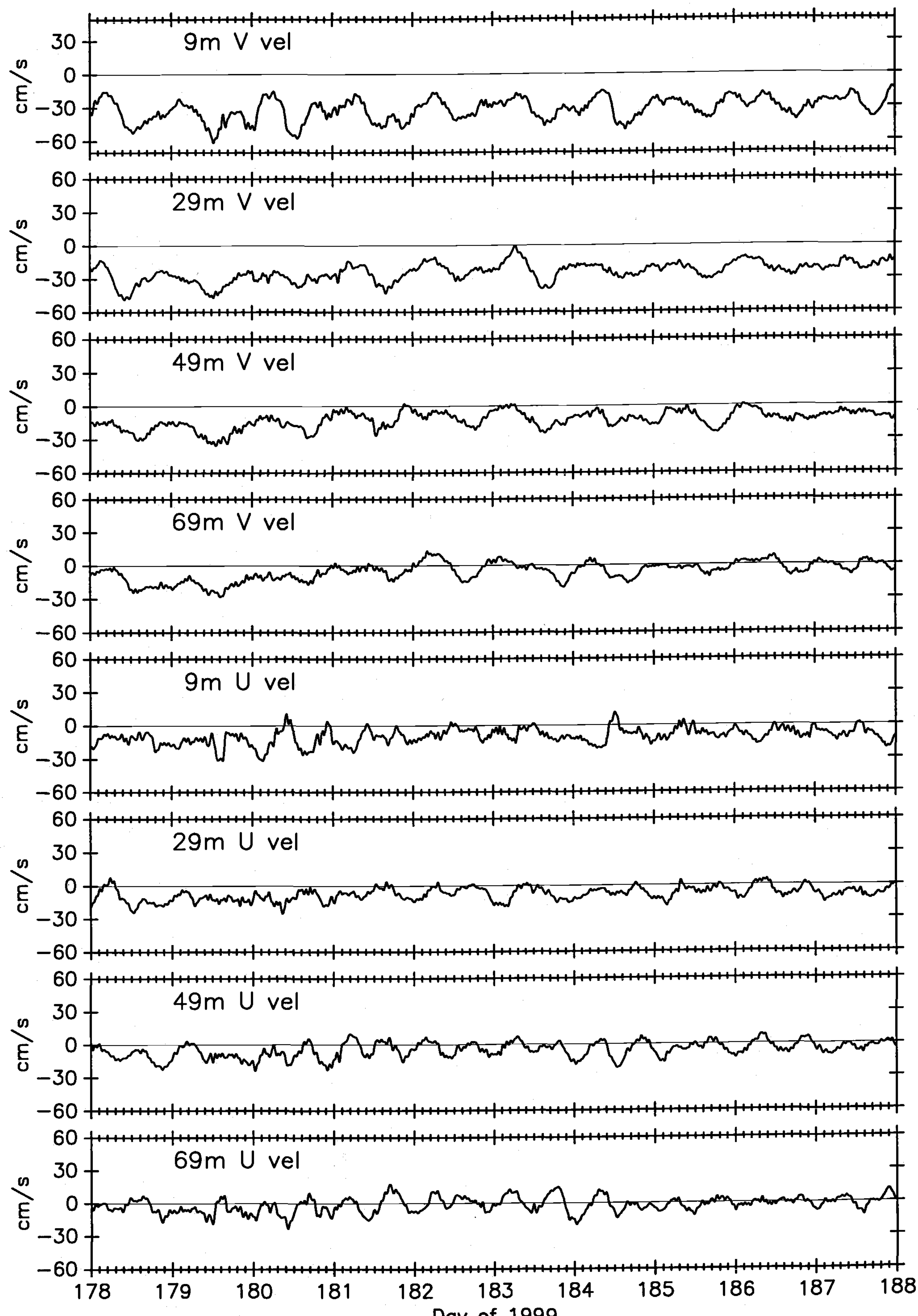


NOPP Mid-Shelf Mooring 1 hour Lowpass Filtered Velocities
9m V vel
29m V vel
49m V vel
69m V vel
9m U vel
29m U vel
49m U vel
69m U vel
cm/s
60
30
0
-30
-60
158
159
160
161
162
163
164
165
166
167
168
Day of 1999

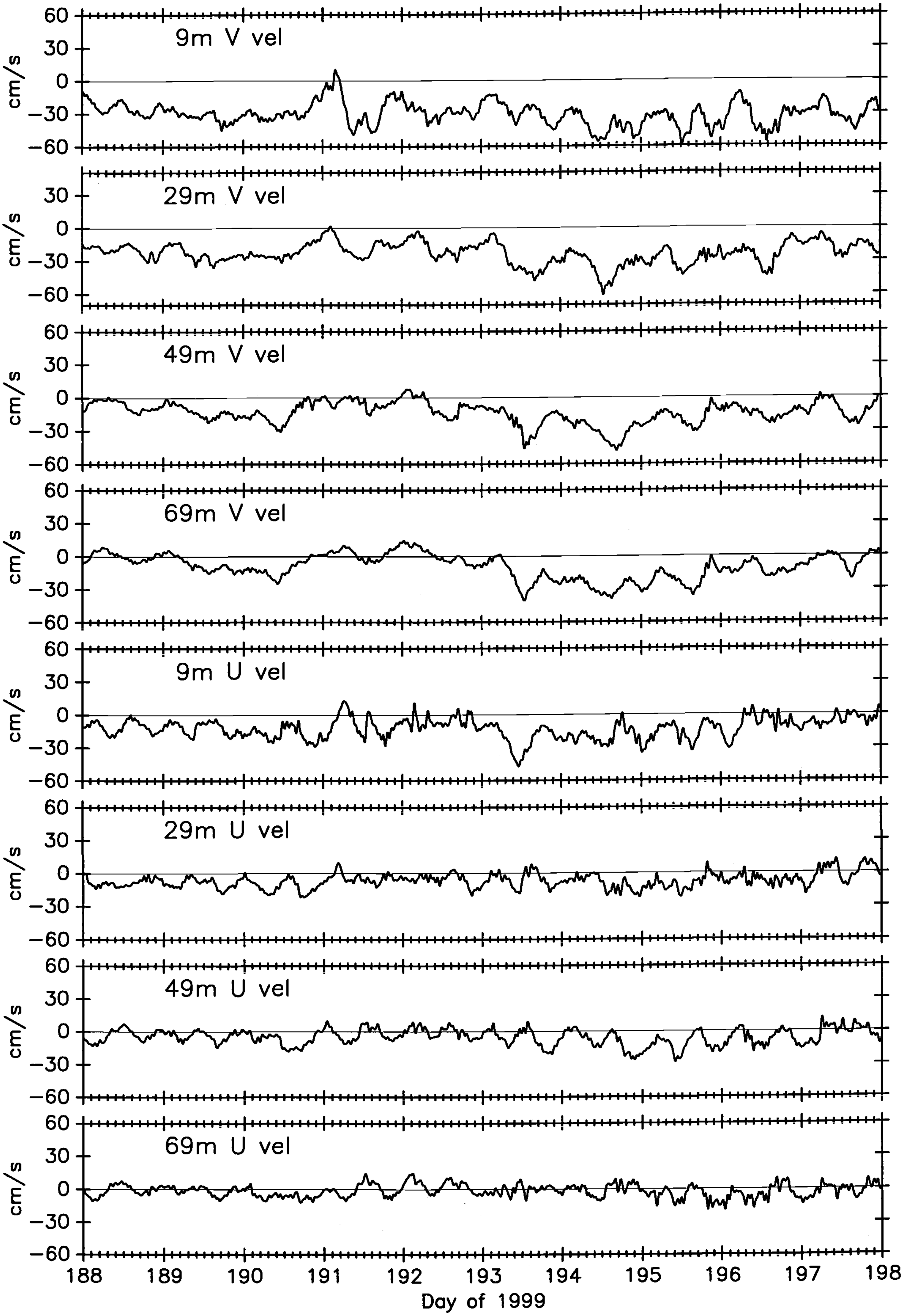
NOPP Mid-Shelf Mooring 1 hour Lowpass Filtered Velocities



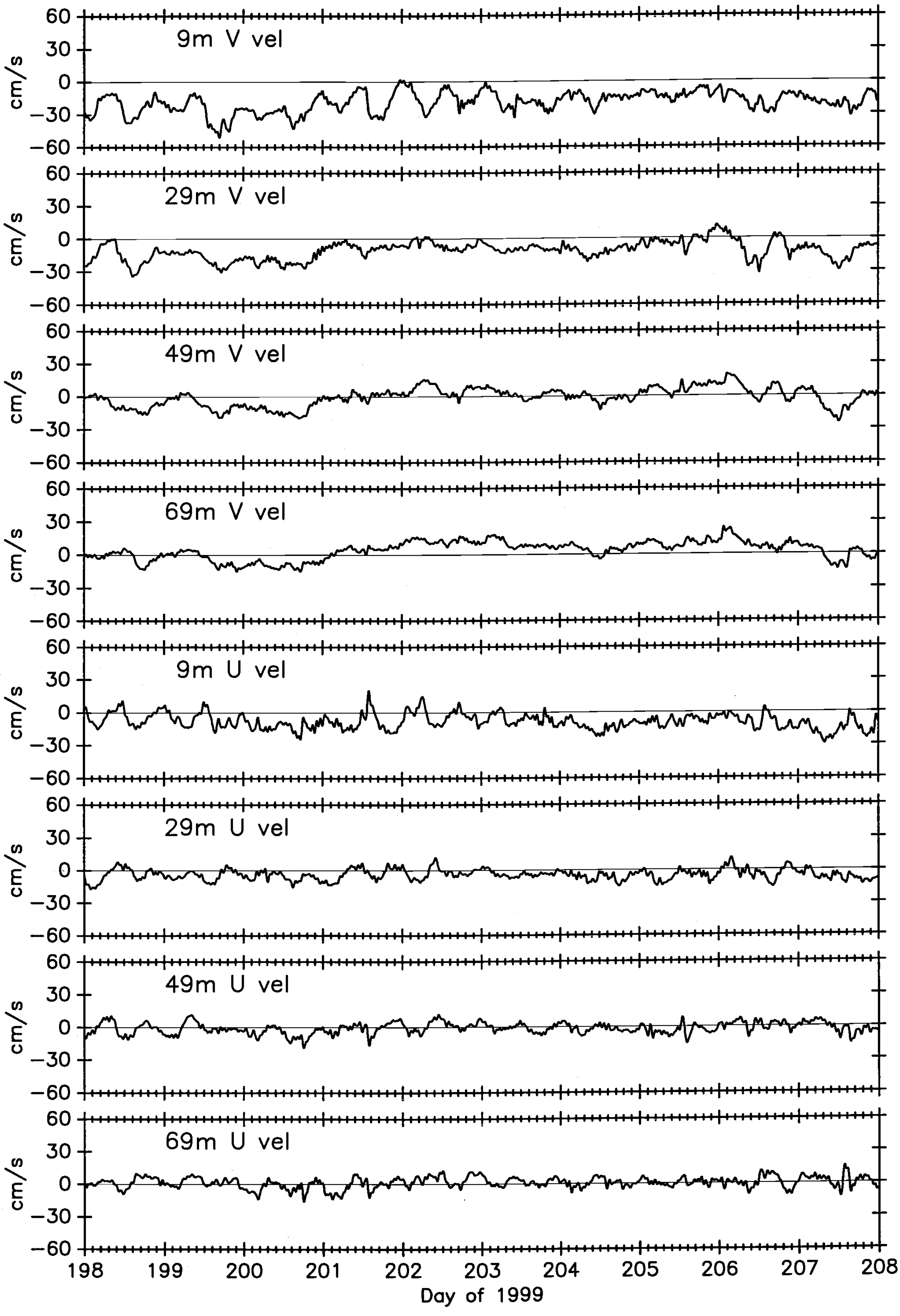
NOPP Mid-Shelf Mooring 1 hour Lowpass Filtered Velocities



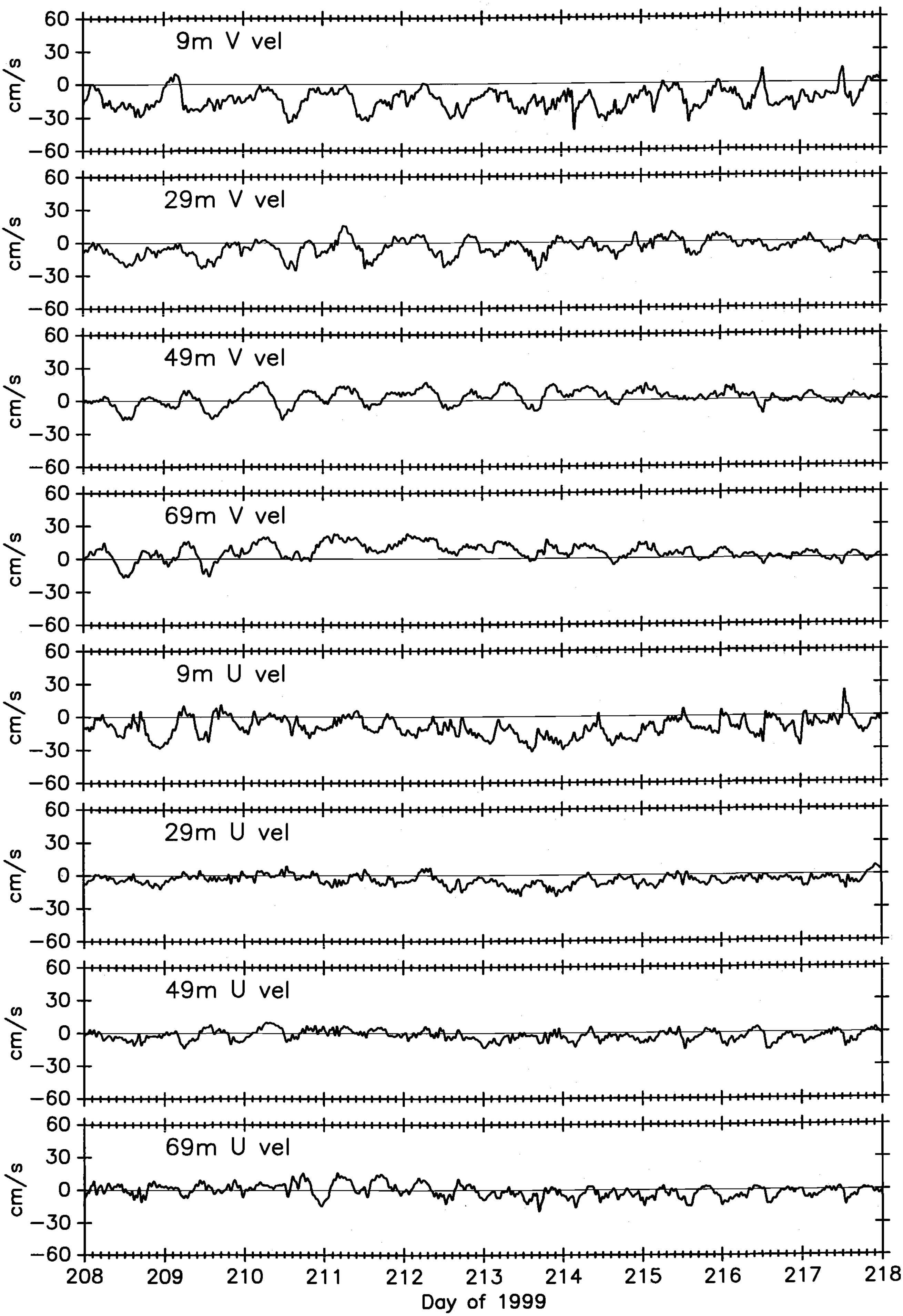
NOPP Mid-Shelf Mooring 1 hour Lowpass Filtered Velocities



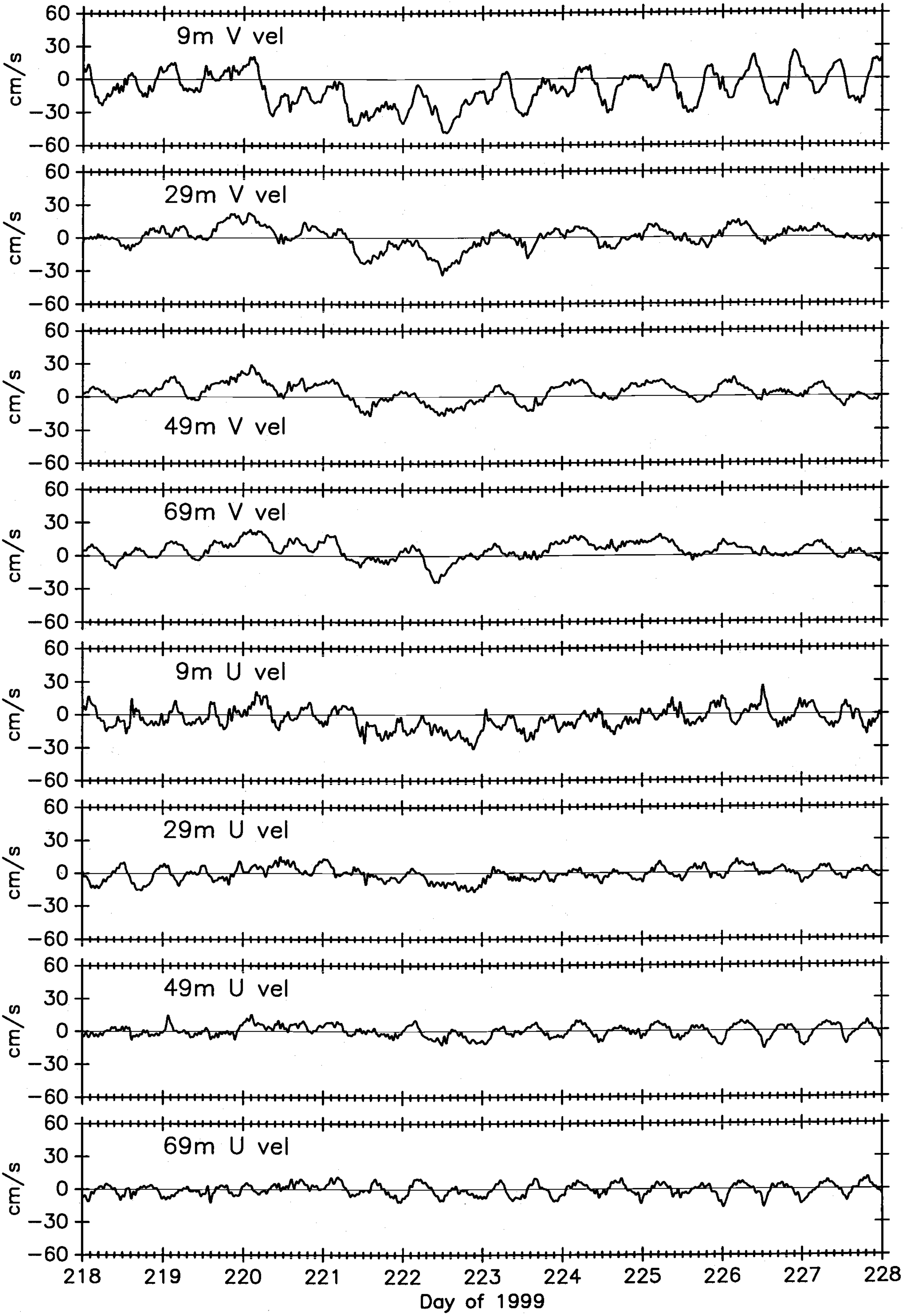
NOPP Mid-Shelf Mooring 1 hour Lowpass Filtered Velocities



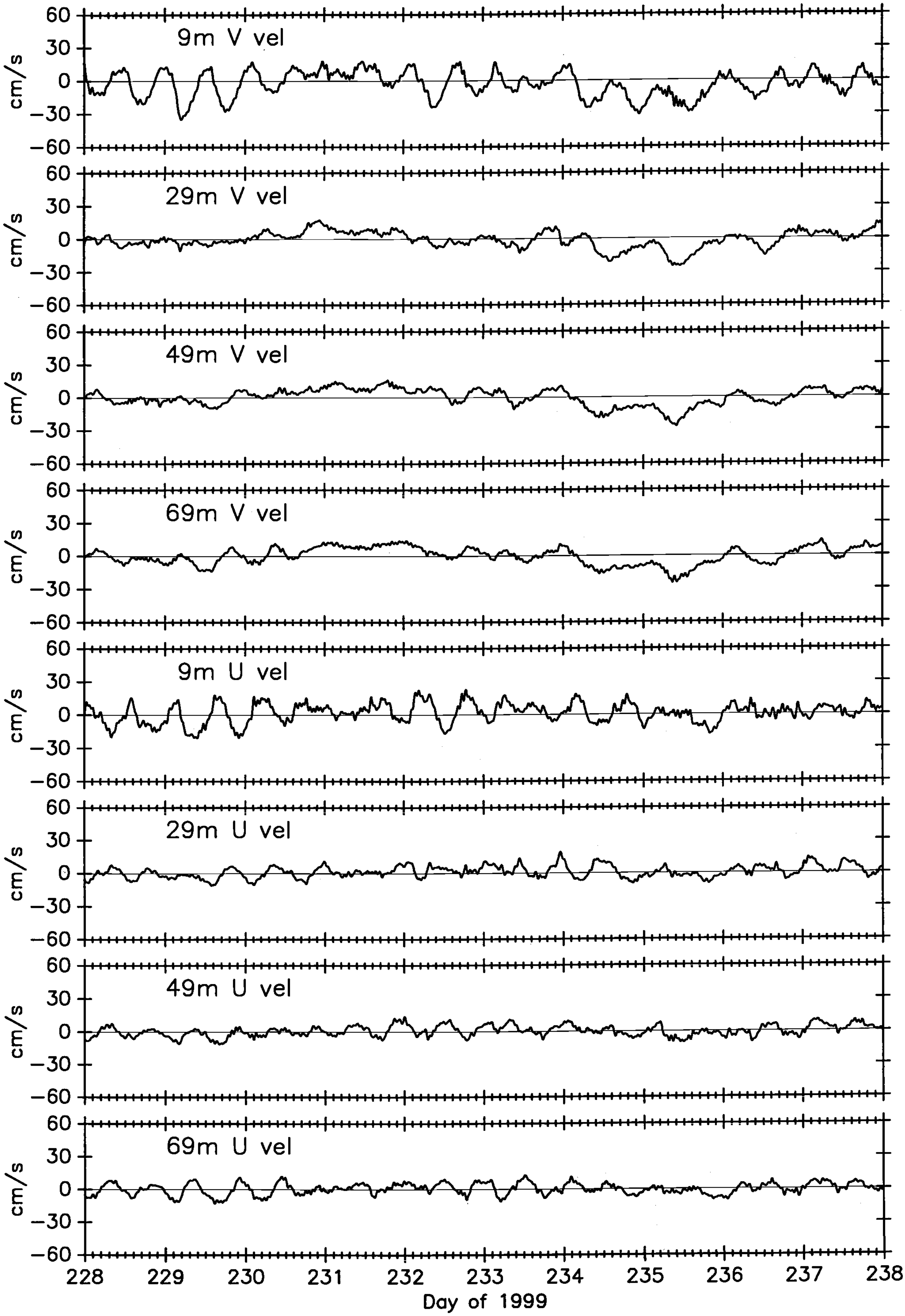
NOPP Mid-Shelf Mooring 1 hour Lowpass Filtered Velocities



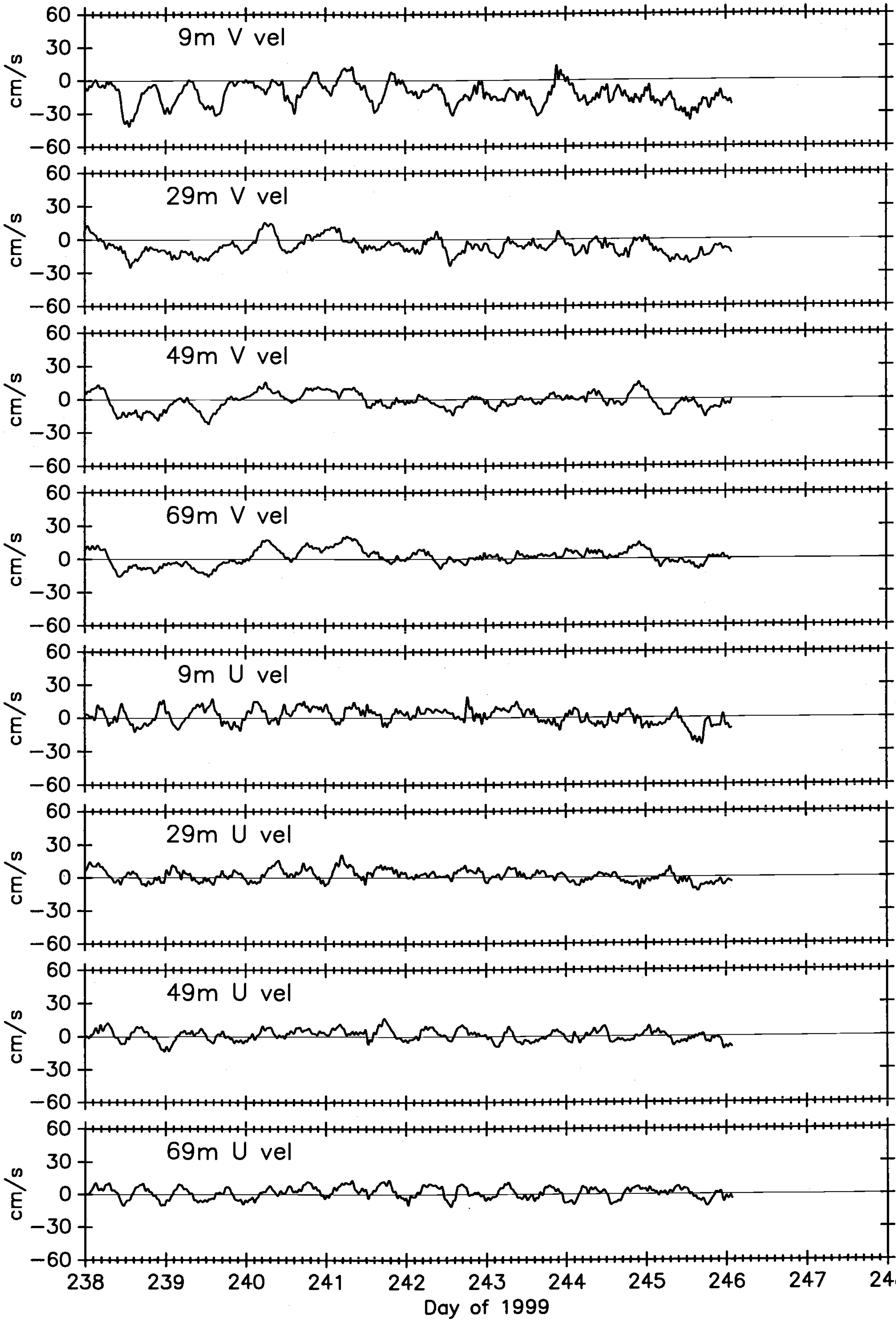
NOPP Mid-Shelf Mooring 1 hour Lowpass Filtered Velocities



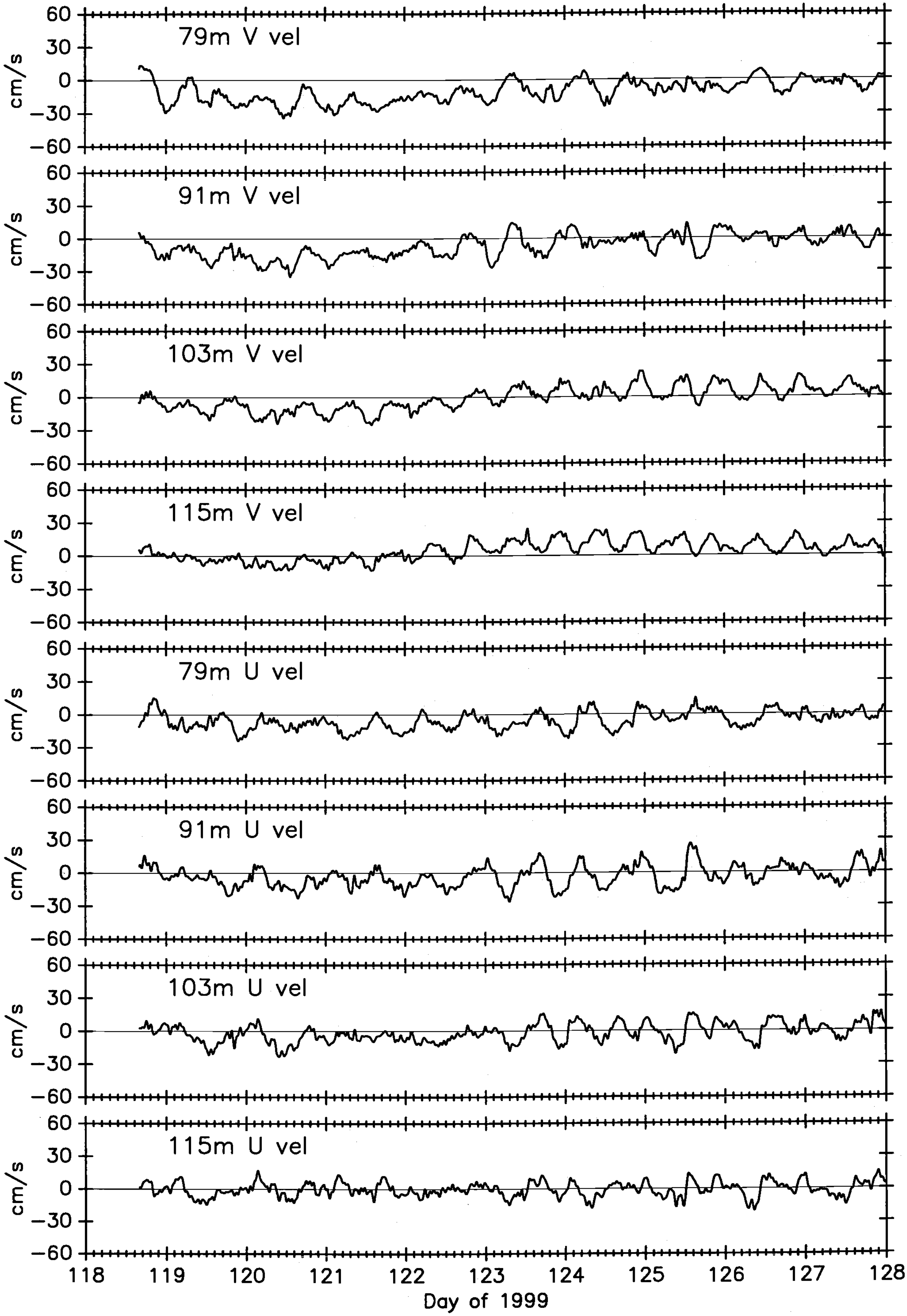
NOPP Mid-Shelf Mooring 1 hour Lowpass Filtered Velocities



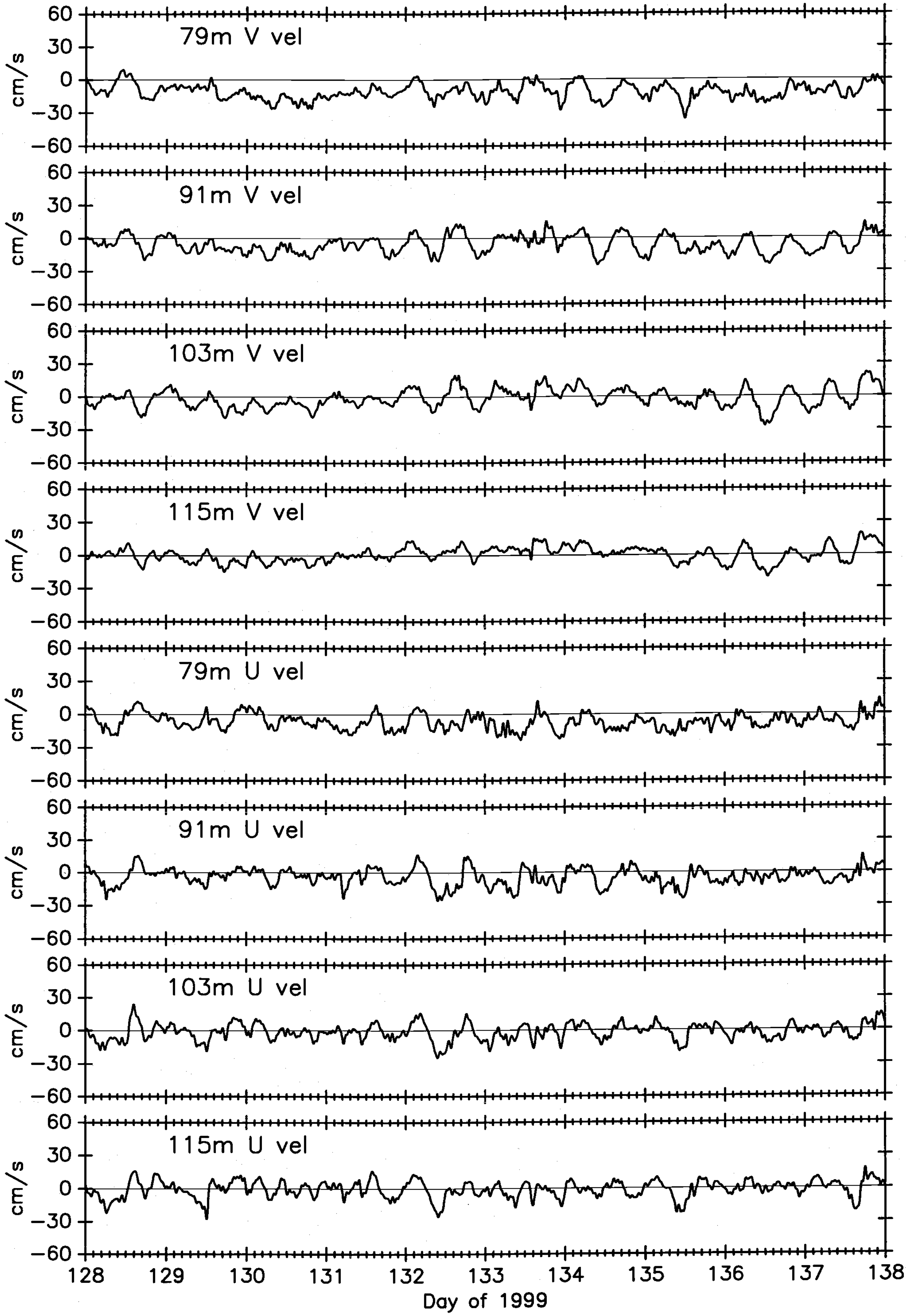
NOPP Mid-Shelf Mooring 1 hour Lowpass Filtered Velocities



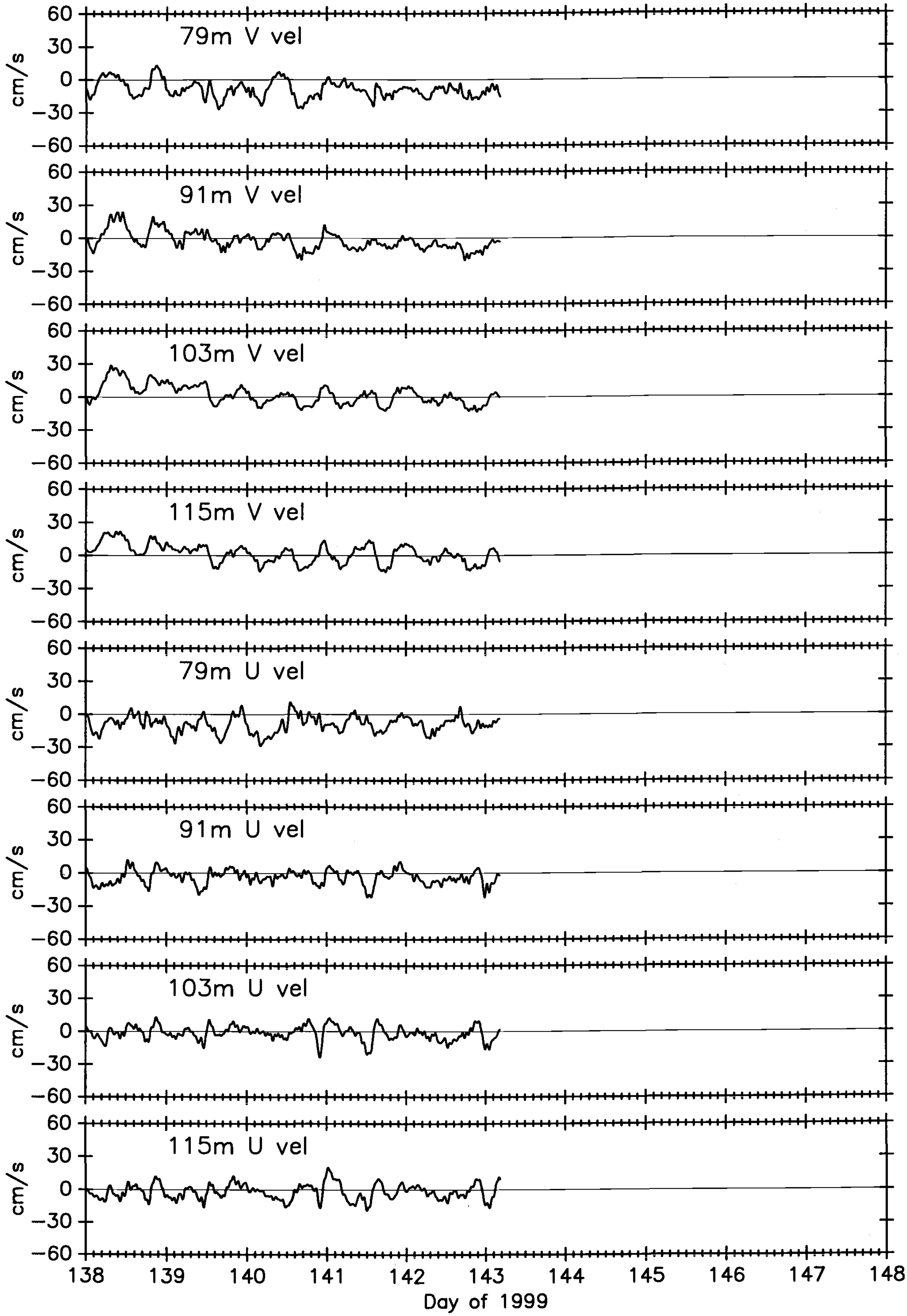
NOPP Shelf-Break Mooring period A 1 hour Lowpass Filtered Velocities



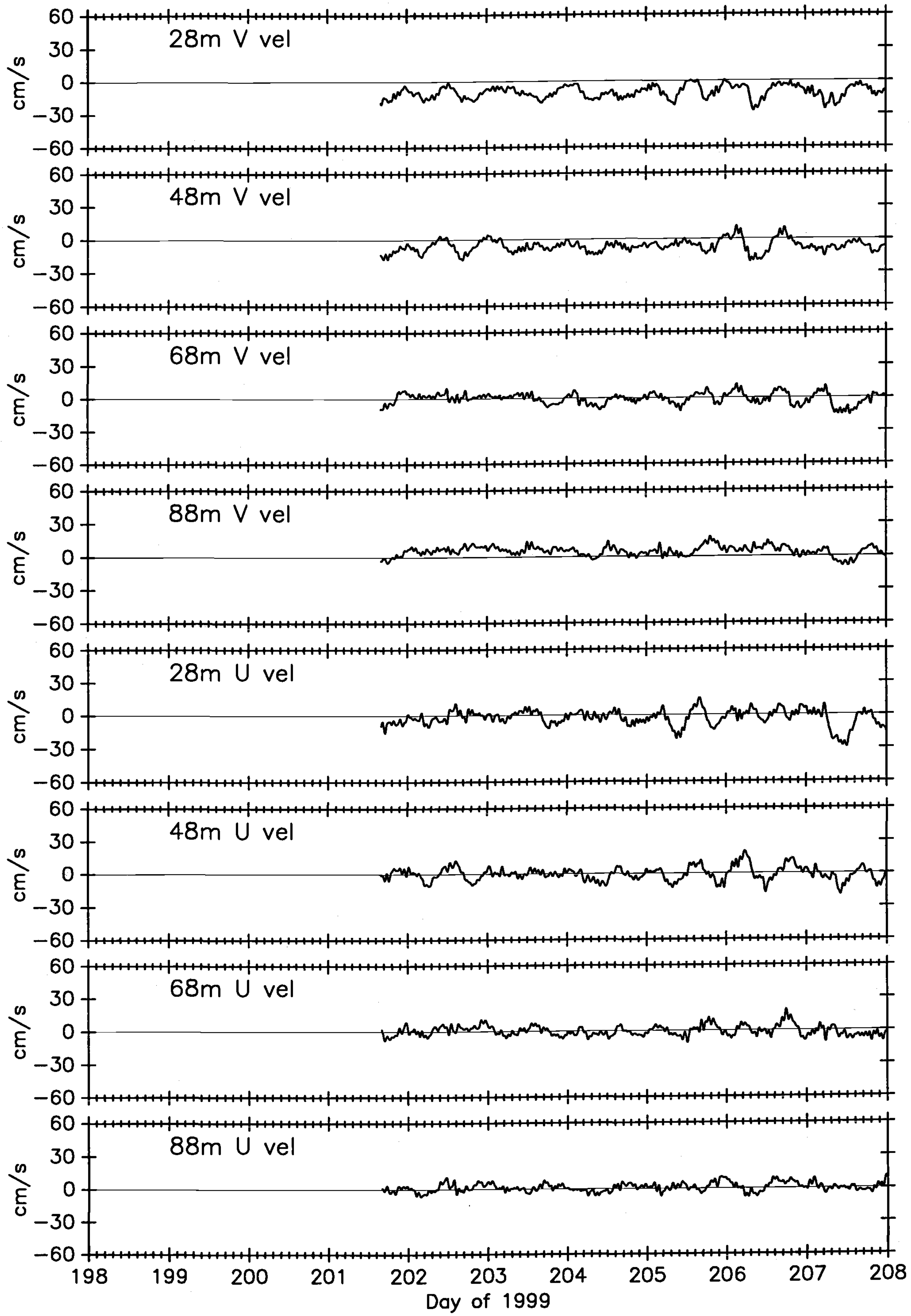
NOPP Shelf-Break Mooring period A 1 hour Lowpass Filtered Velocities



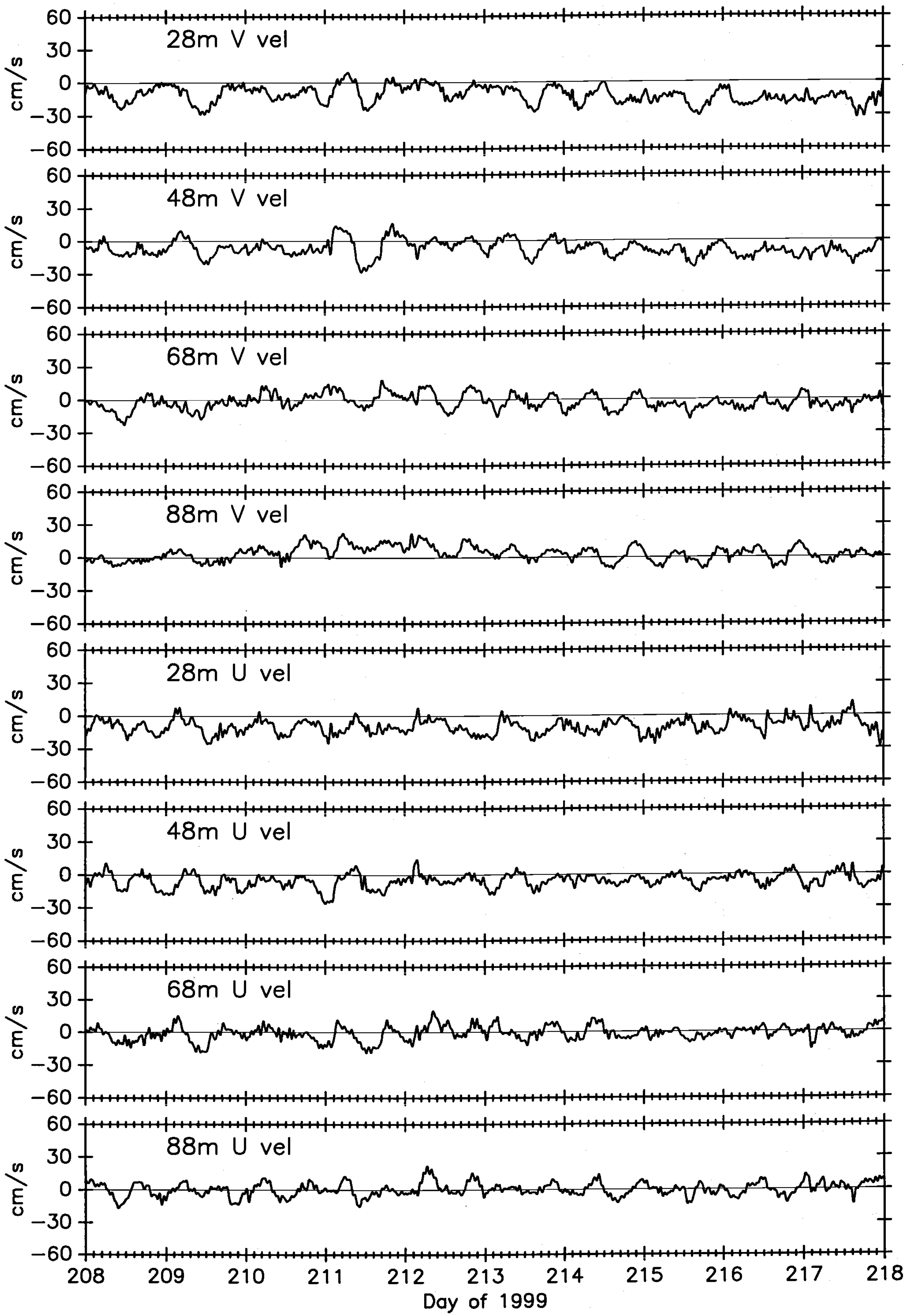
NOPP Shelf-Break Mooring period A 1 hour Lowpass Filtered Velocities



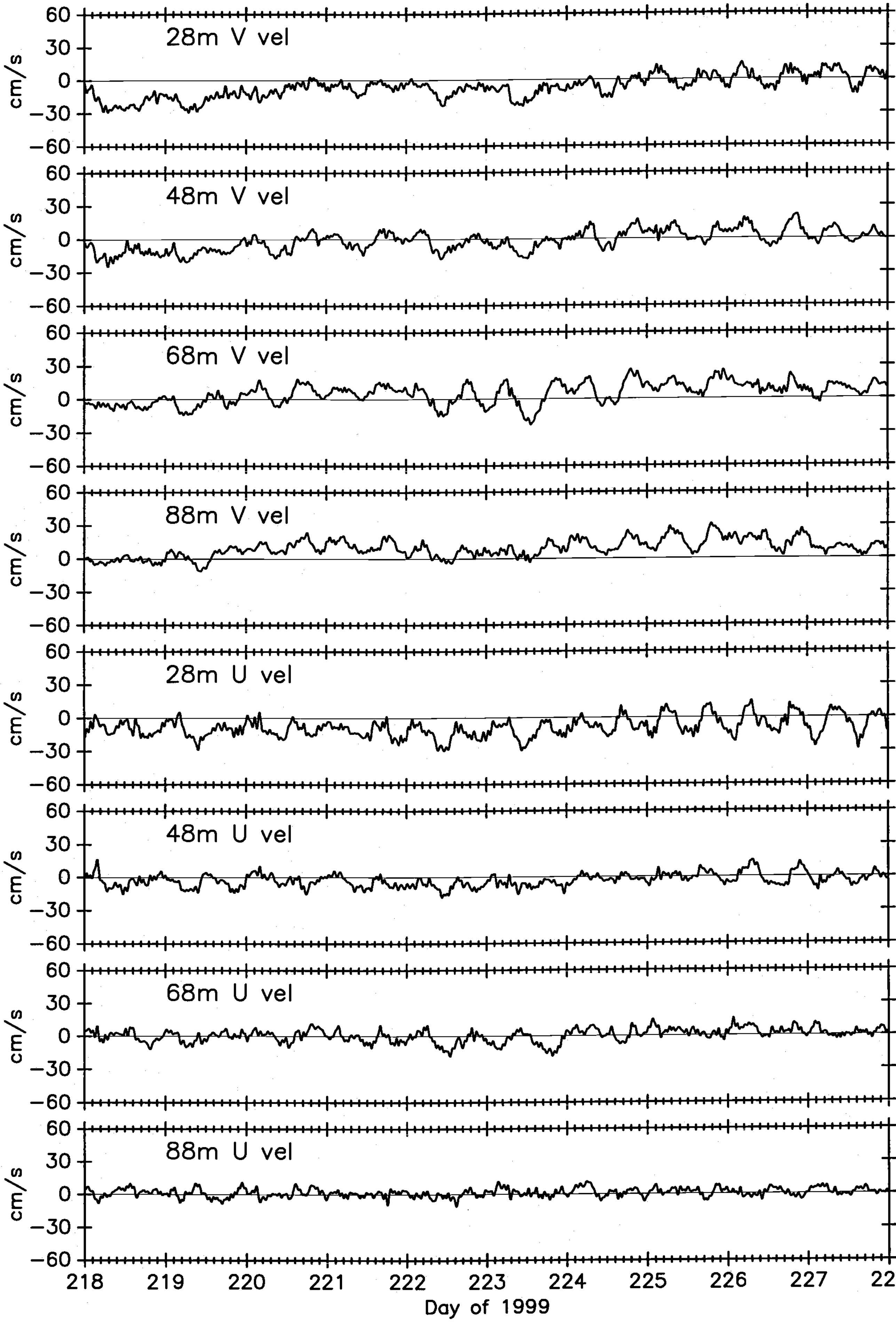
NOPP Shelf-Break Mooring period D 1 hour Lowpass Filtered Velocities



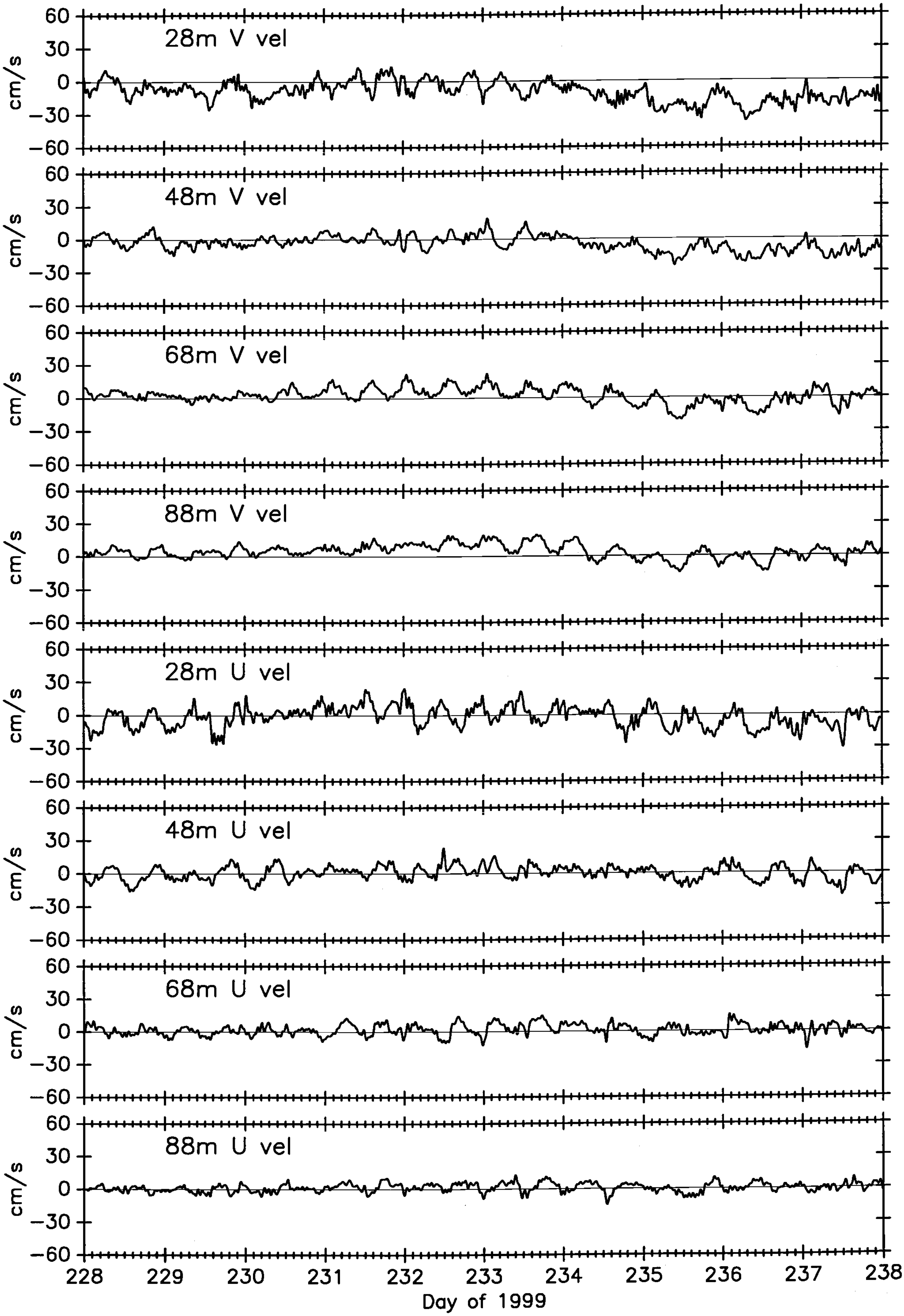
NOPP Shelf-Break Mooring period D 1 hour Lowpass Filtered Velocities

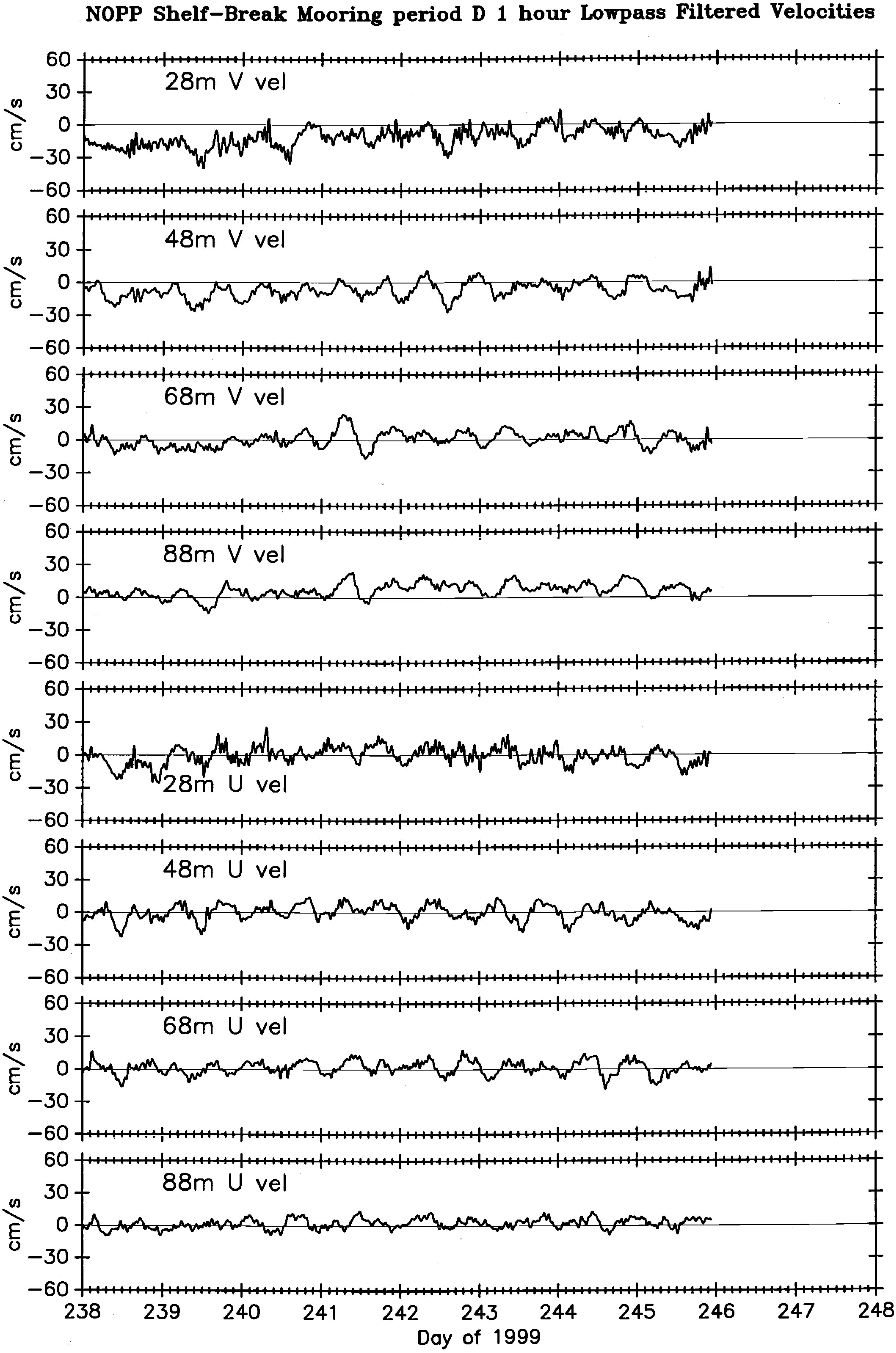


NOPP Shelf-Break Mooring period D 1 hour Lowpass Filtered Velocities



NOPP Shelf-Break Mooring period D 1 hour Lowpass Filtered Velocities

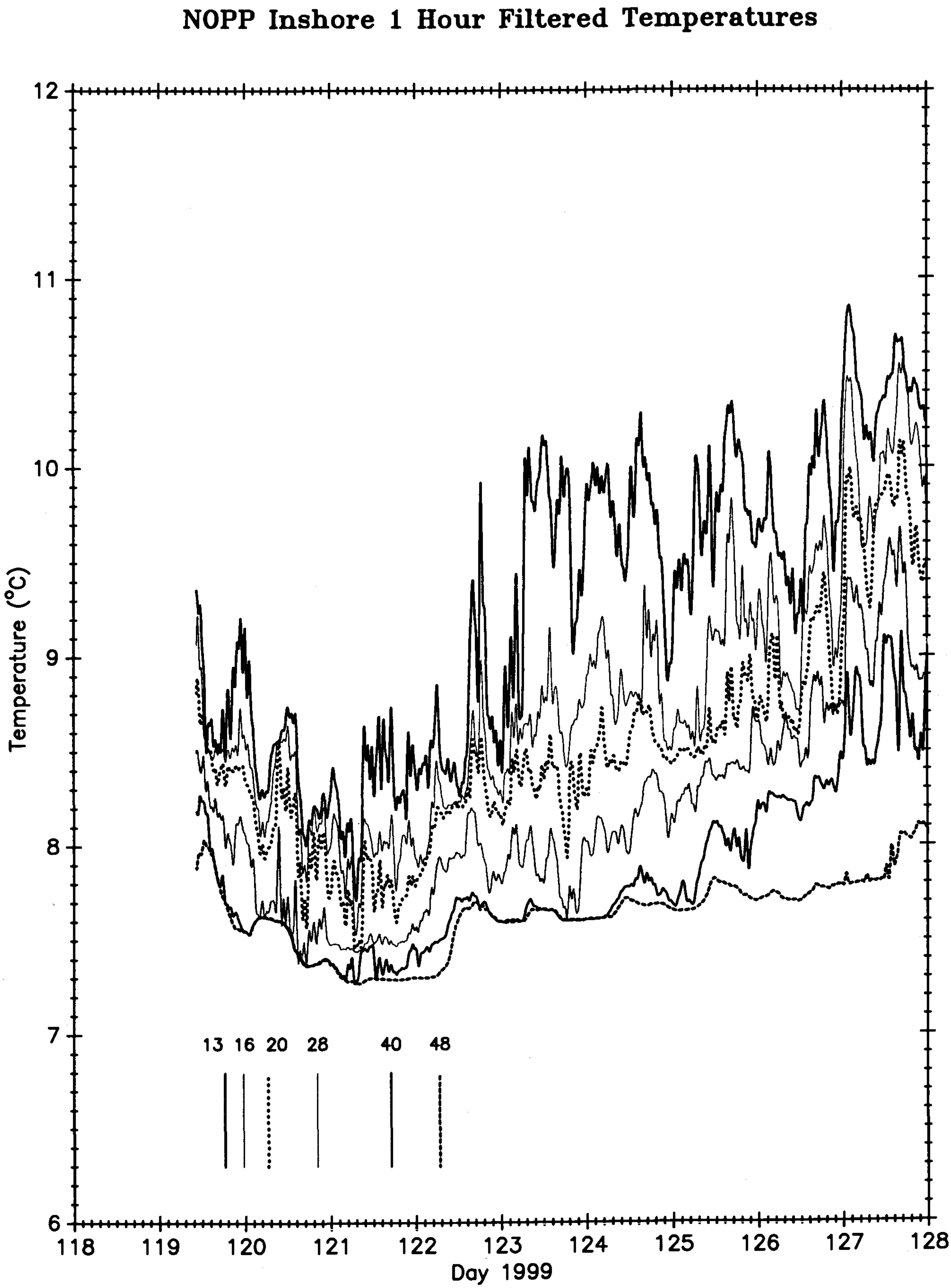


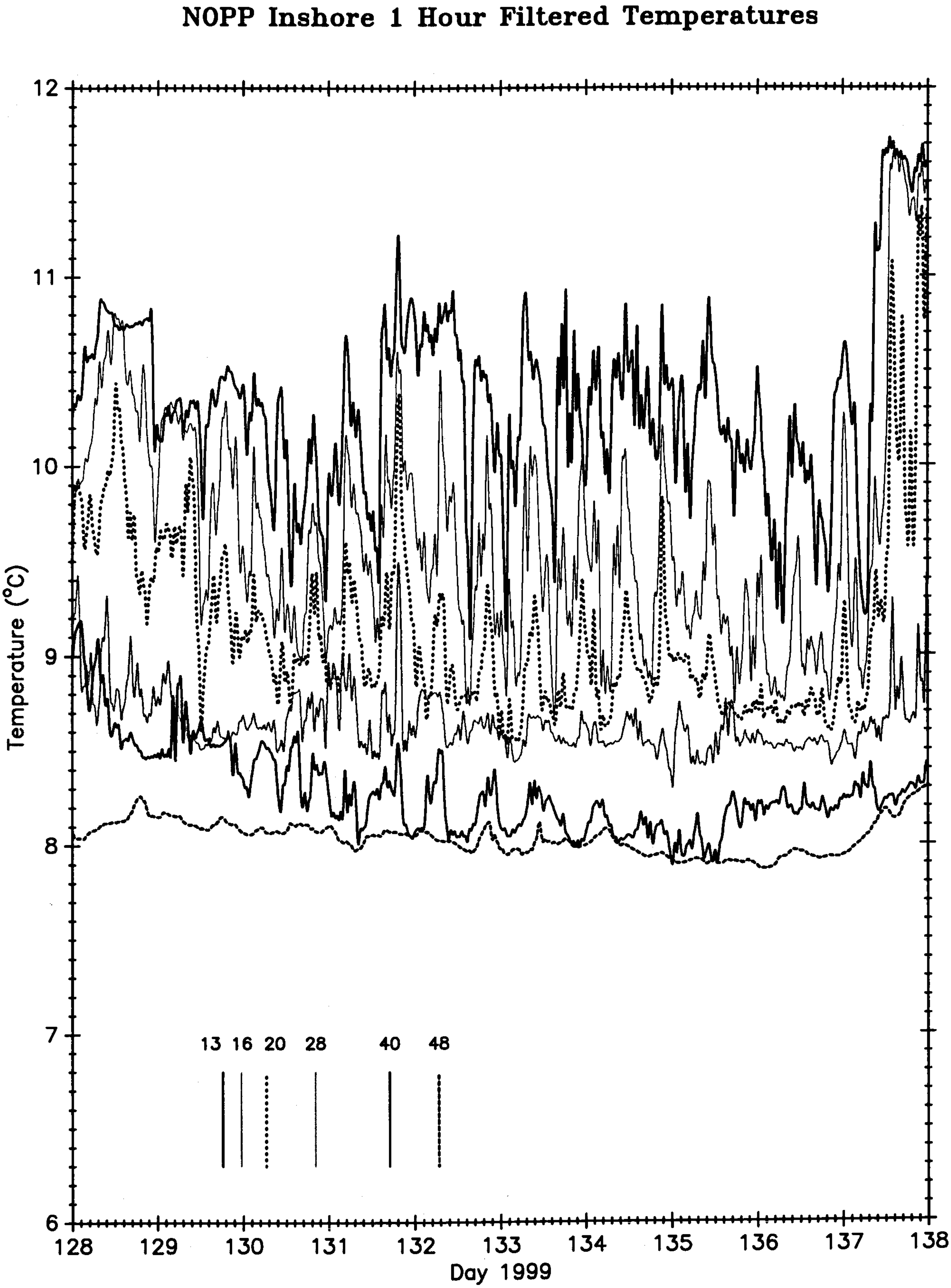

NOPP Shelf-Break Mooring period D 1 hour Lowpass Filtered Velocities
28m V vel
48m V vel
68m V vel
88m V vel
28m U vel
48m U vel
68m U vel
88m U vel
cm/s
60
30
0
−30
−60
238
239
240
241
242
243
244
245
246
247
248
Day of 1999

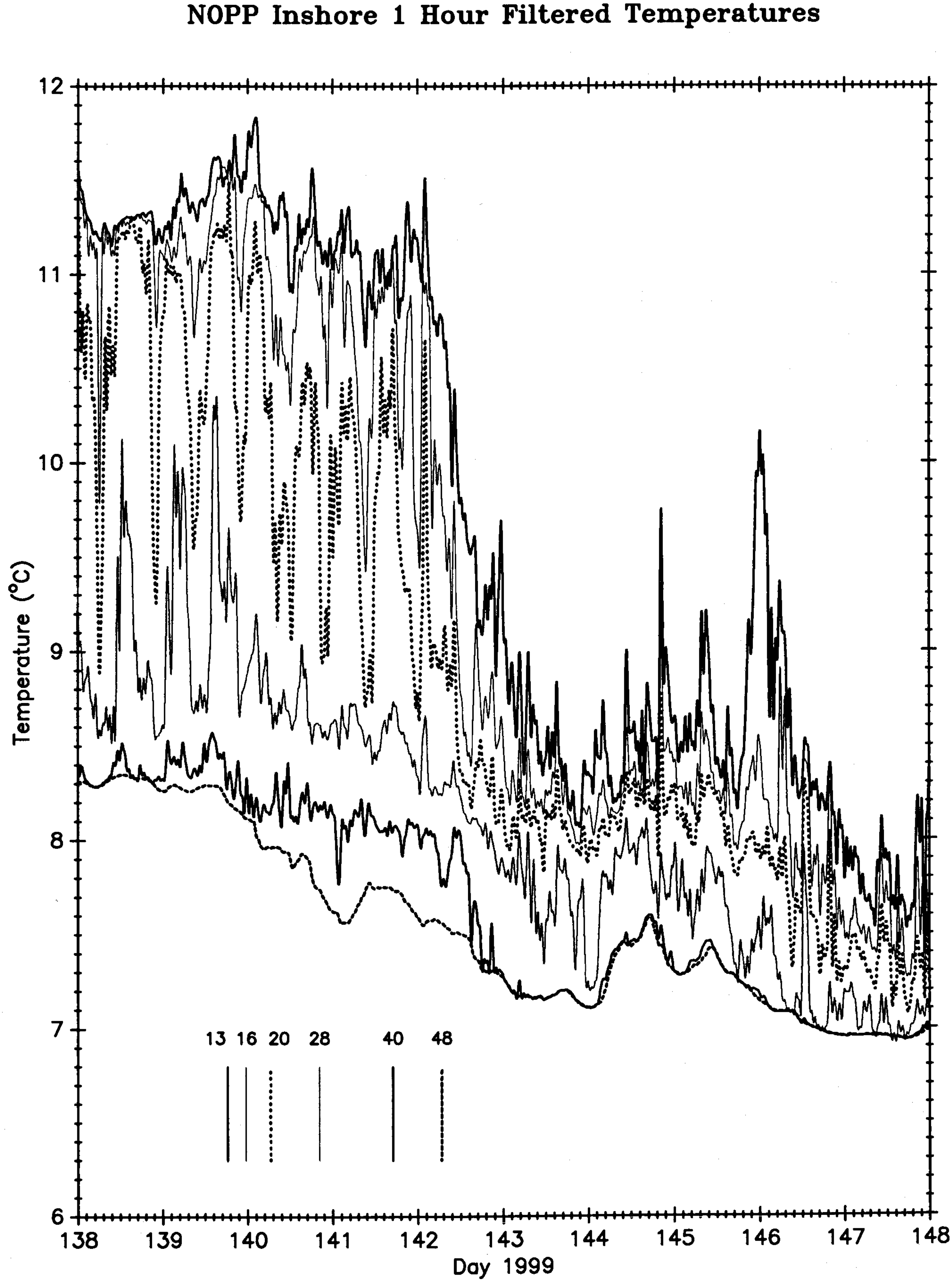
TEMPERATURE Time Series

1-hour Low-Pass Filtered

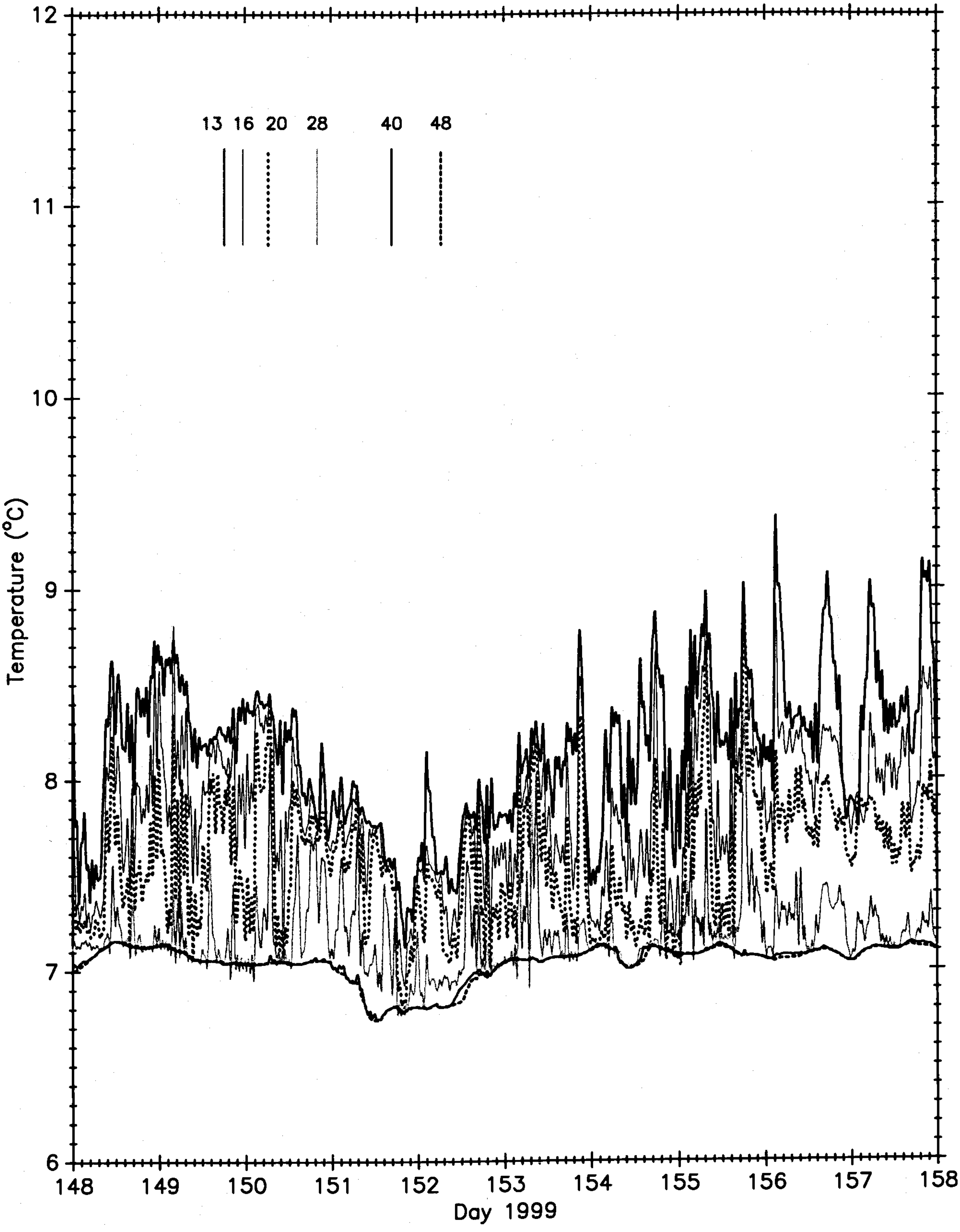
Plots of water temperature from the Inshore, Mid-Shelf, Met, and Shelf-Break moorings. Note that both the temperature scale and range are different for the Met mooring than the Inshore, Mid-Shelf, and Shelf-Break moorings. Temperature is shown for every depth except 2m on the Inshore and Shelf-Break moorings.


NOPP Inshore 1 Hour Filtered Temperatures
12
11
10
9
8
7
6
Temperature (°C)
13 16 20 28 40 48
118 119 120 121 122 123 124 125 126 127 128
Day 1999

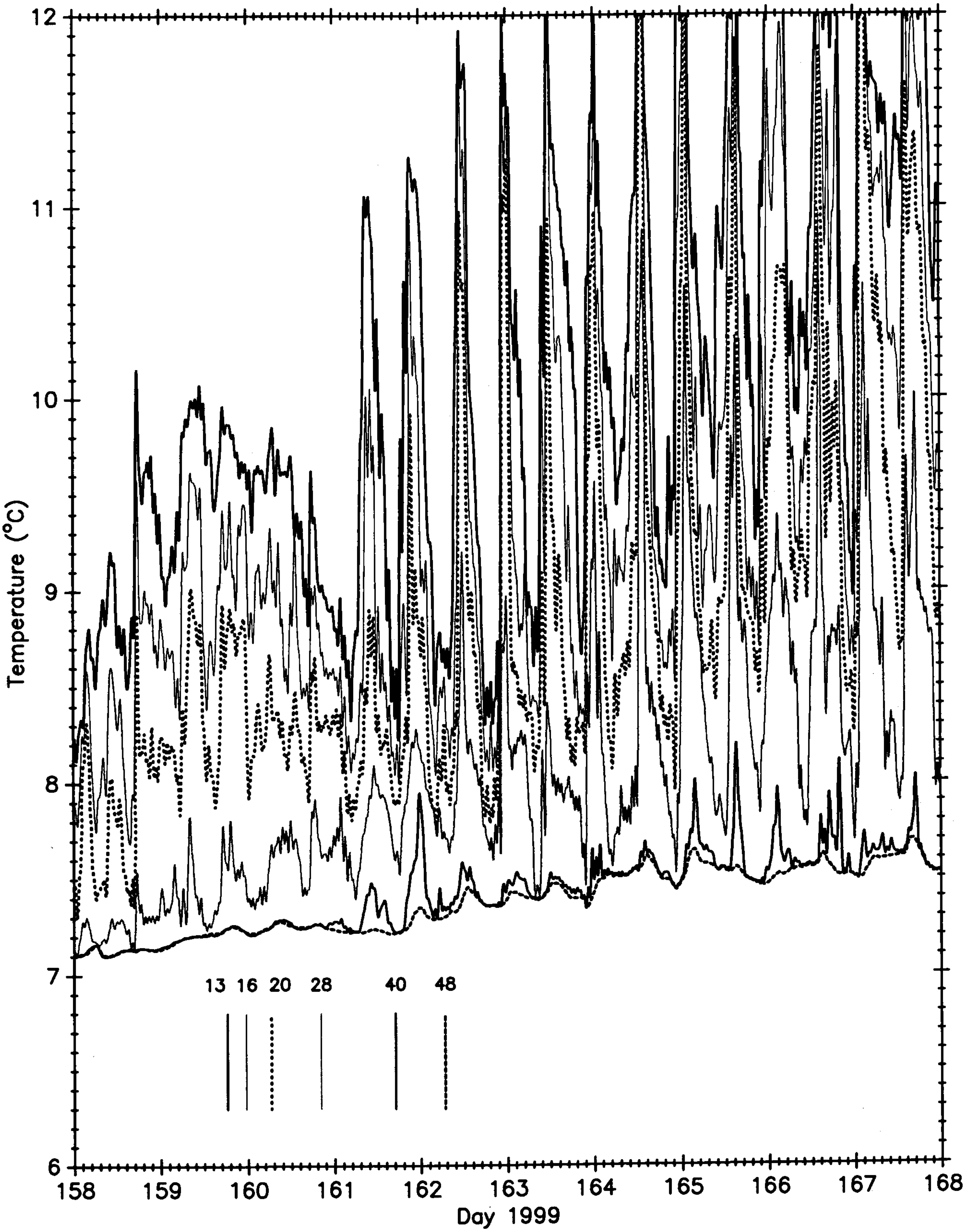

NOPP Inshore 1 Hour Filtered Temperatures
Temperature (°C)
12
11
10
9
8
7
6
13 16 20 28 40 48
128 129 130 131 132 133 134 135 136 137 138
Day 1999

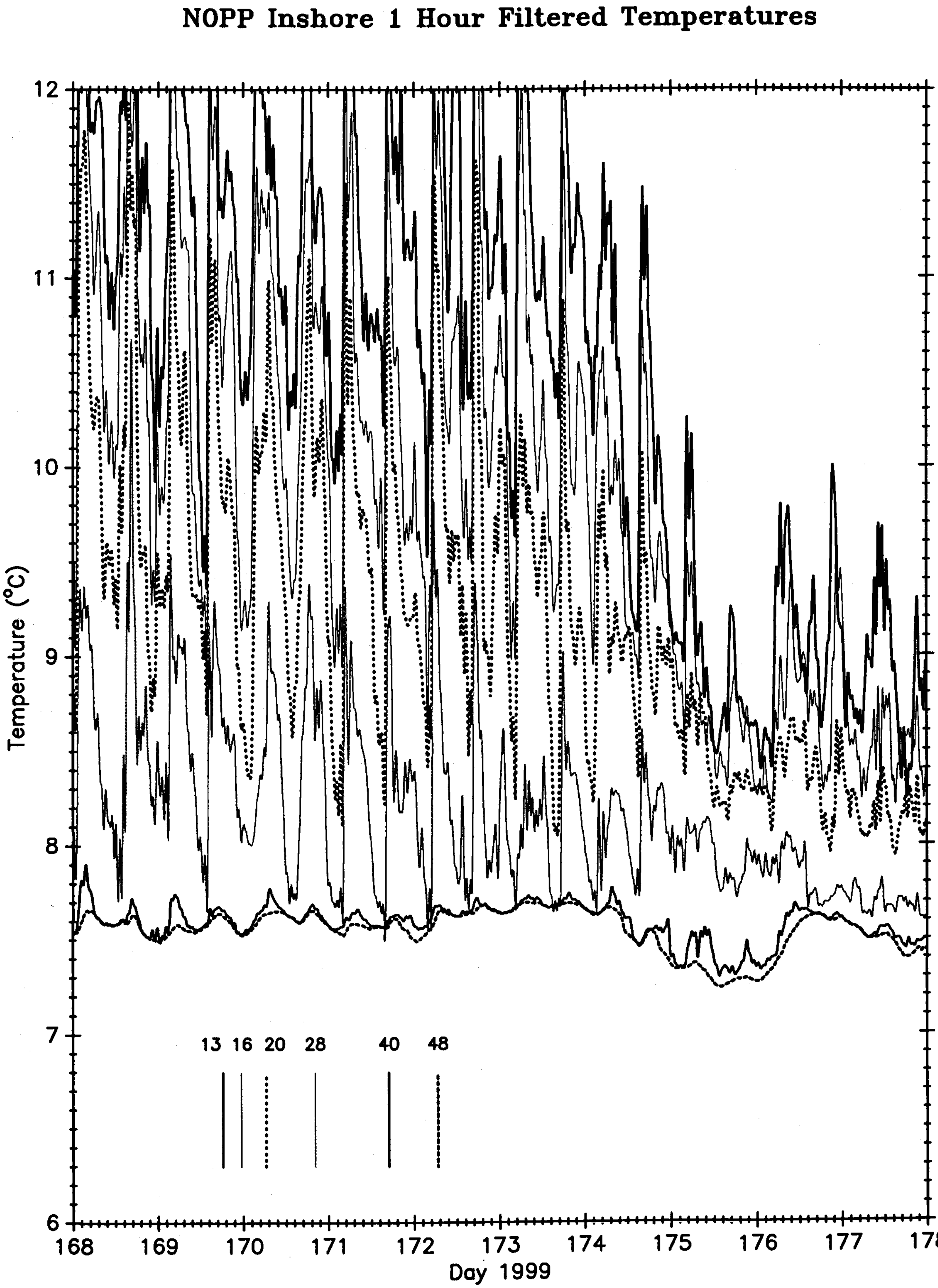

NOPP Inshore 1 Hour Filtered Temperatures
Temperature (°C)
12
11
10
9
8
7
6
13 16 20 28 40 48
138 139 140 141 142 143 144 145 146 147 148
Day 1999

NOPP Inshore 1 Hour Filtered Temperatures

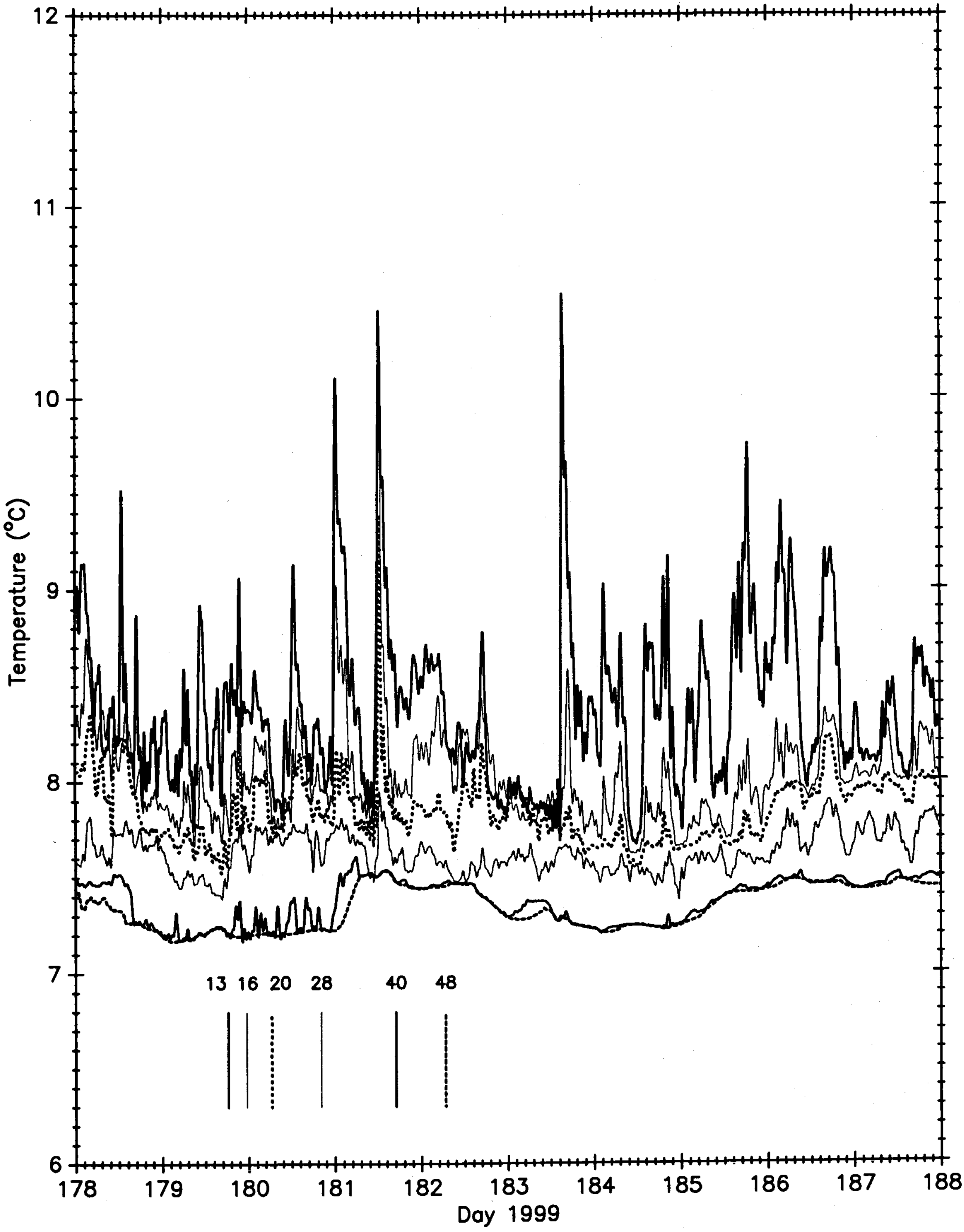


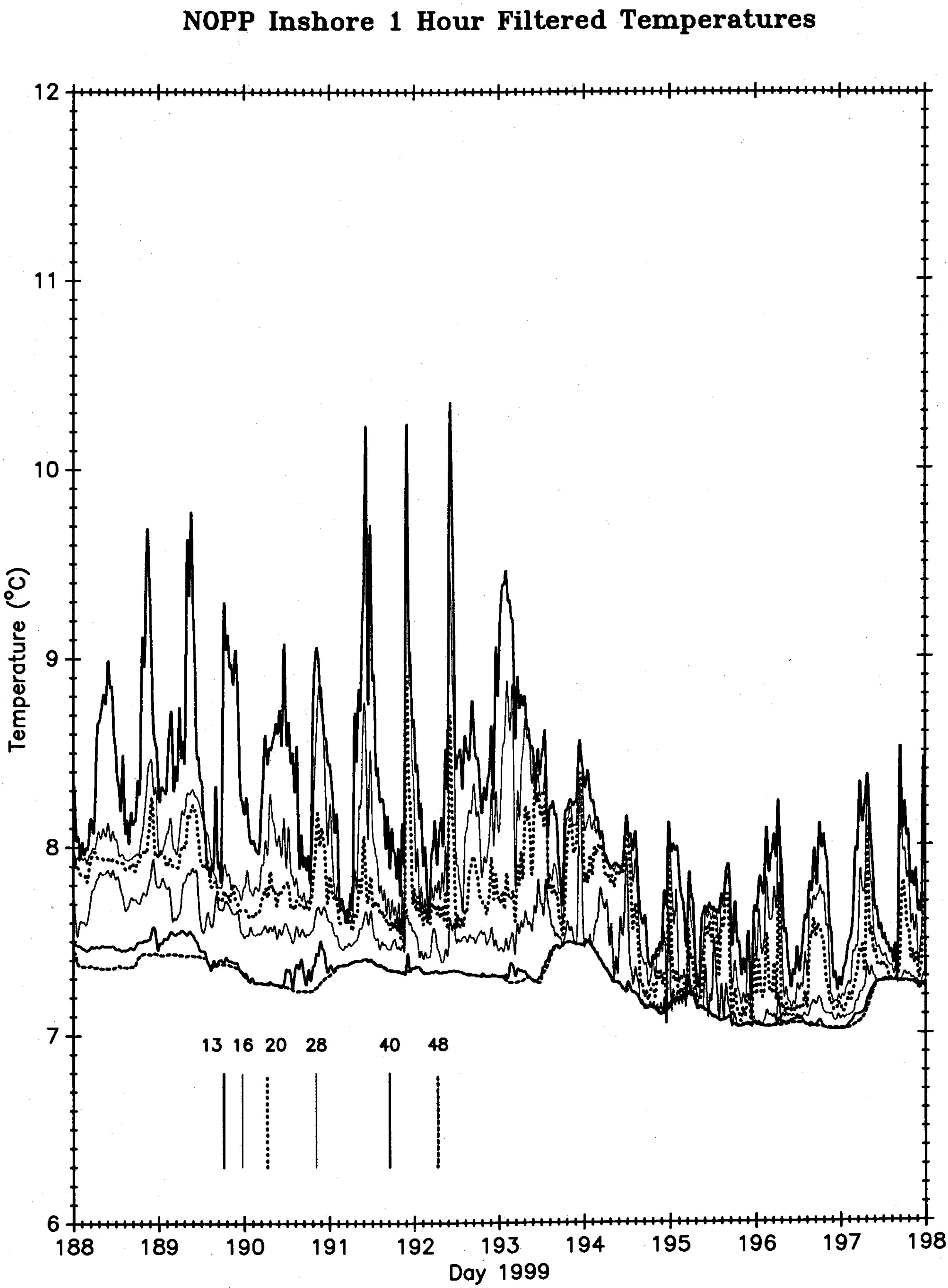
NOPP Inshore 1 Hour Filtered Temperatures

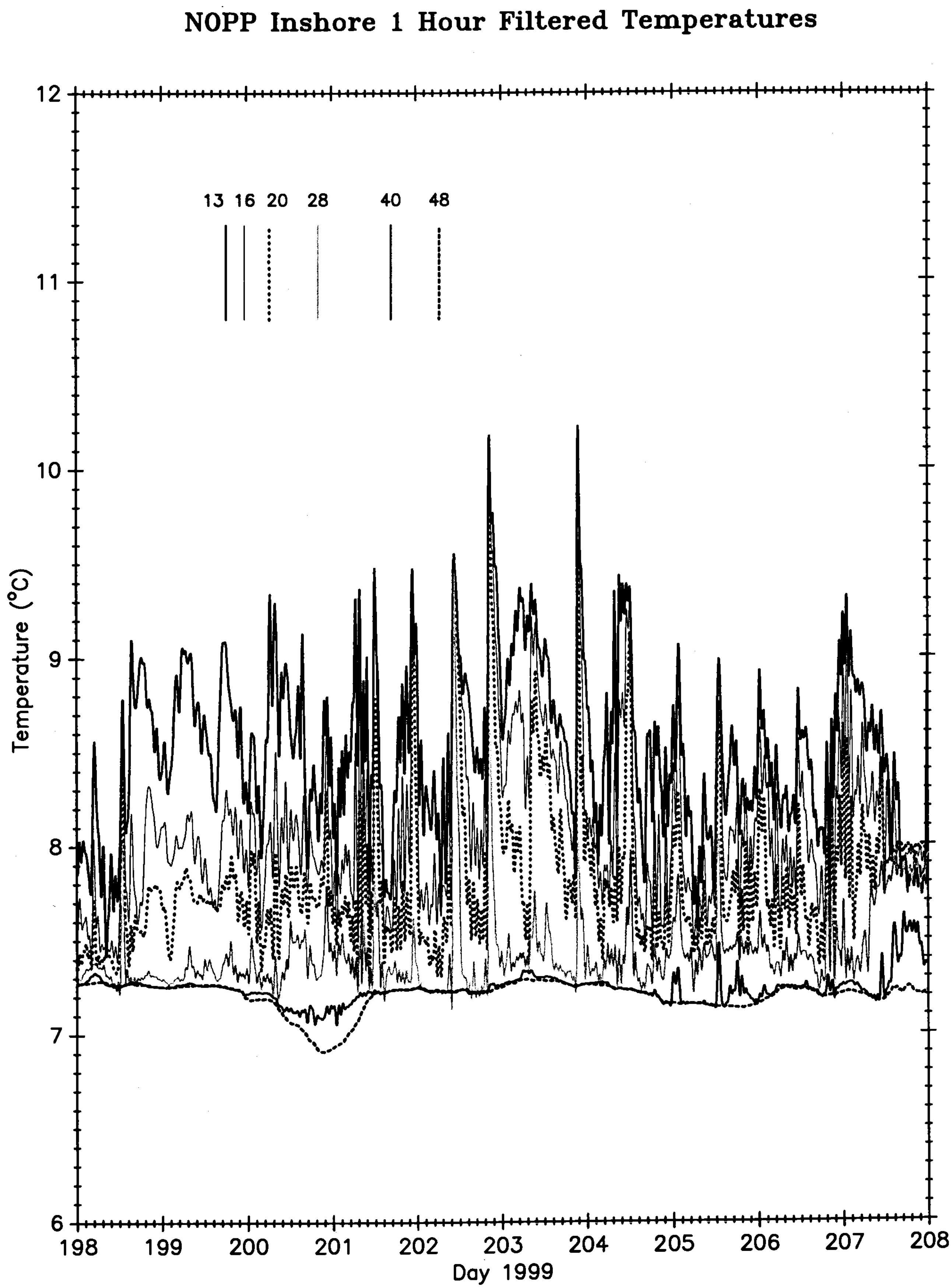



NOPP Inshore 1 Hour Filtered Temperatures
Temperature (°C)
12
11
10
9
8
7
6
13
16
20
28
40
48
168
169
170
171
172
173
174
175
176
177
178
Day 1999

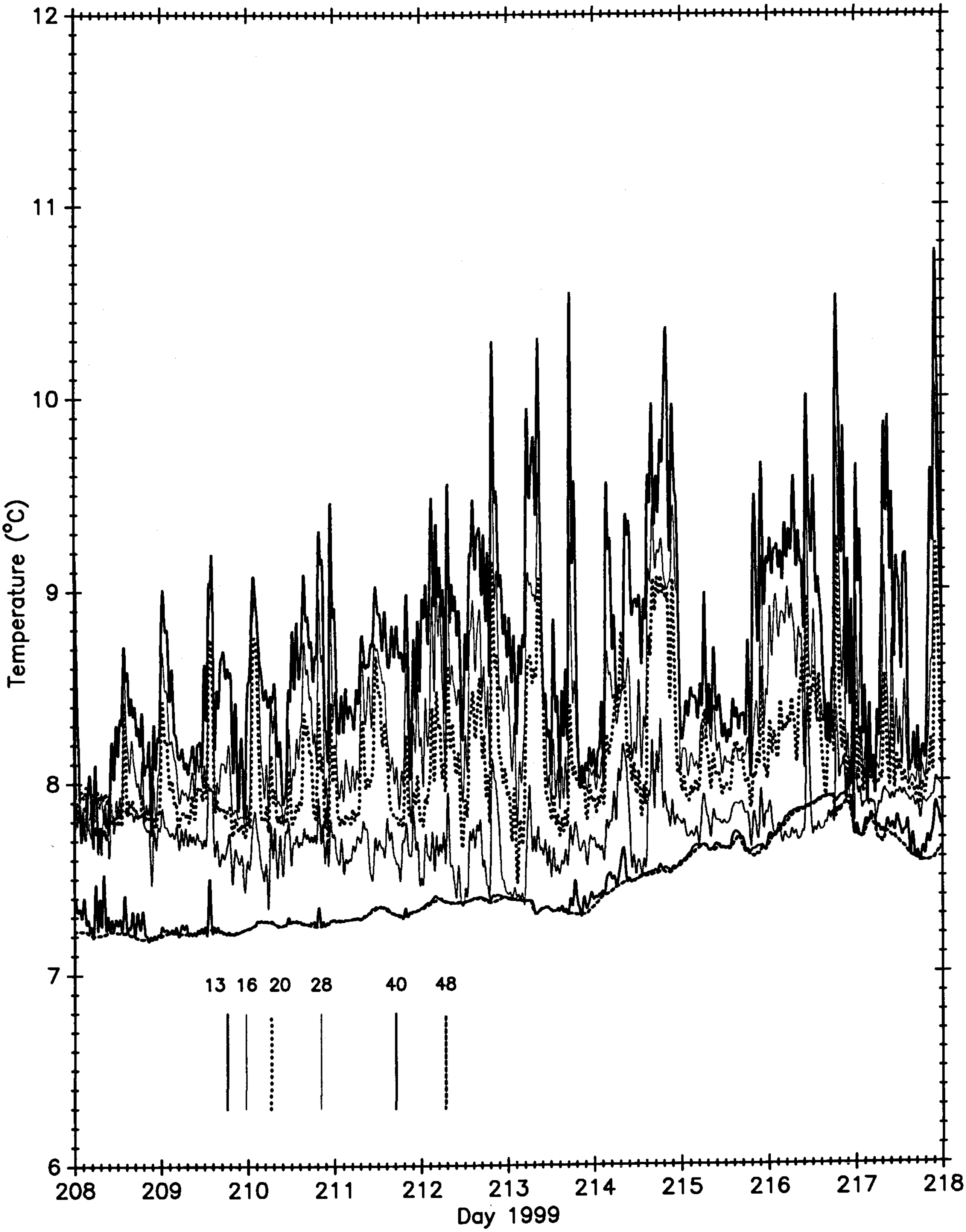
NOPP Inshore 1 Hour Filtered Temperatures



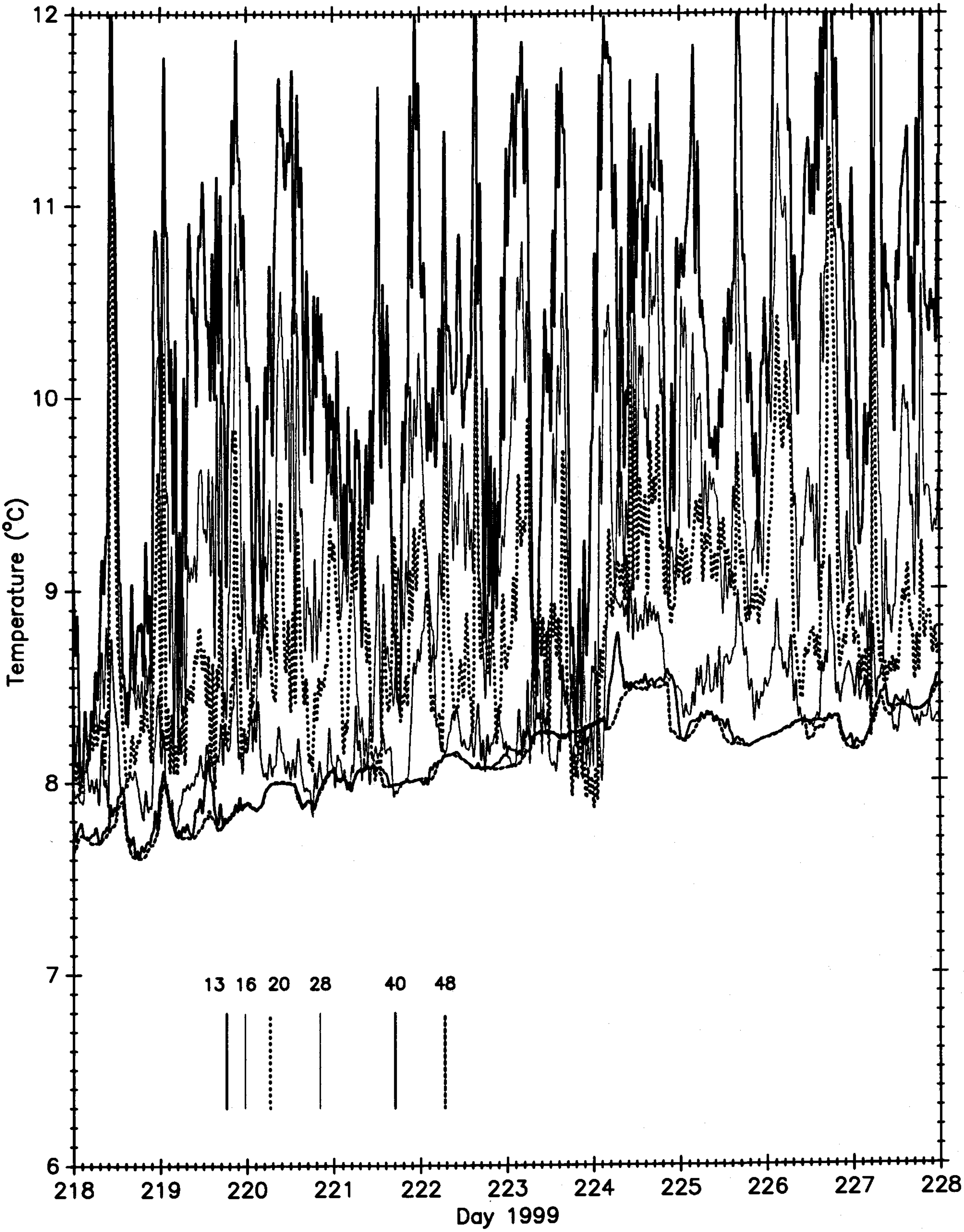

NOPP Inshore 1 Hour Filtered Temperatures
12
11
10
9
8
7
6
Temperature (°C)
13
16
20
28
40
48
188
189
190
191
192
193
194
195
196
197
198
Day 1999

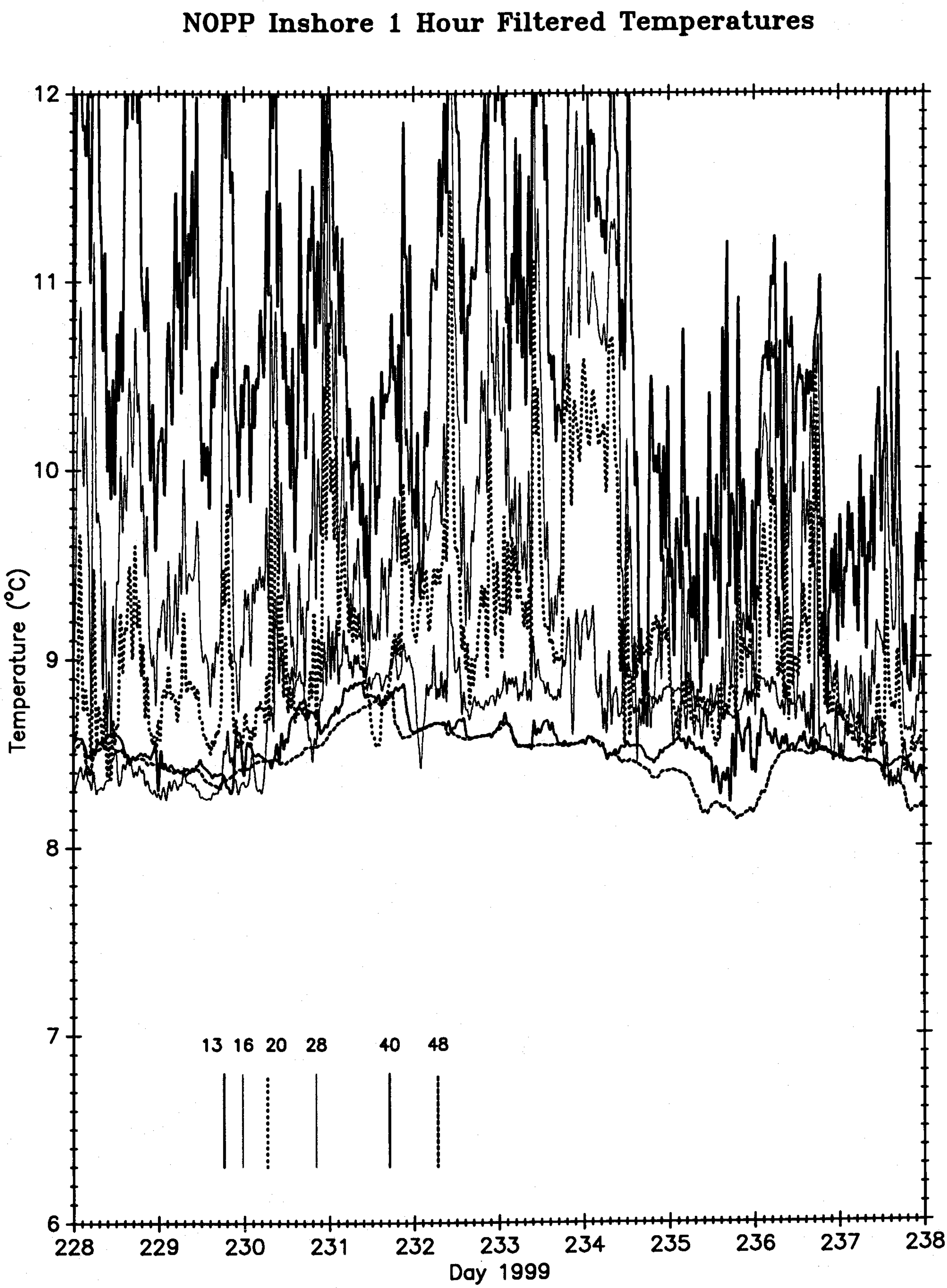

NOPP Inshore 1 Hour Filtered Temperatures
13
16
20
28
40
48
12
11
10
9
8
7
6
Temperature (°C)
198
199
200
201
202
203
204
205
206
207
208
Day 1999

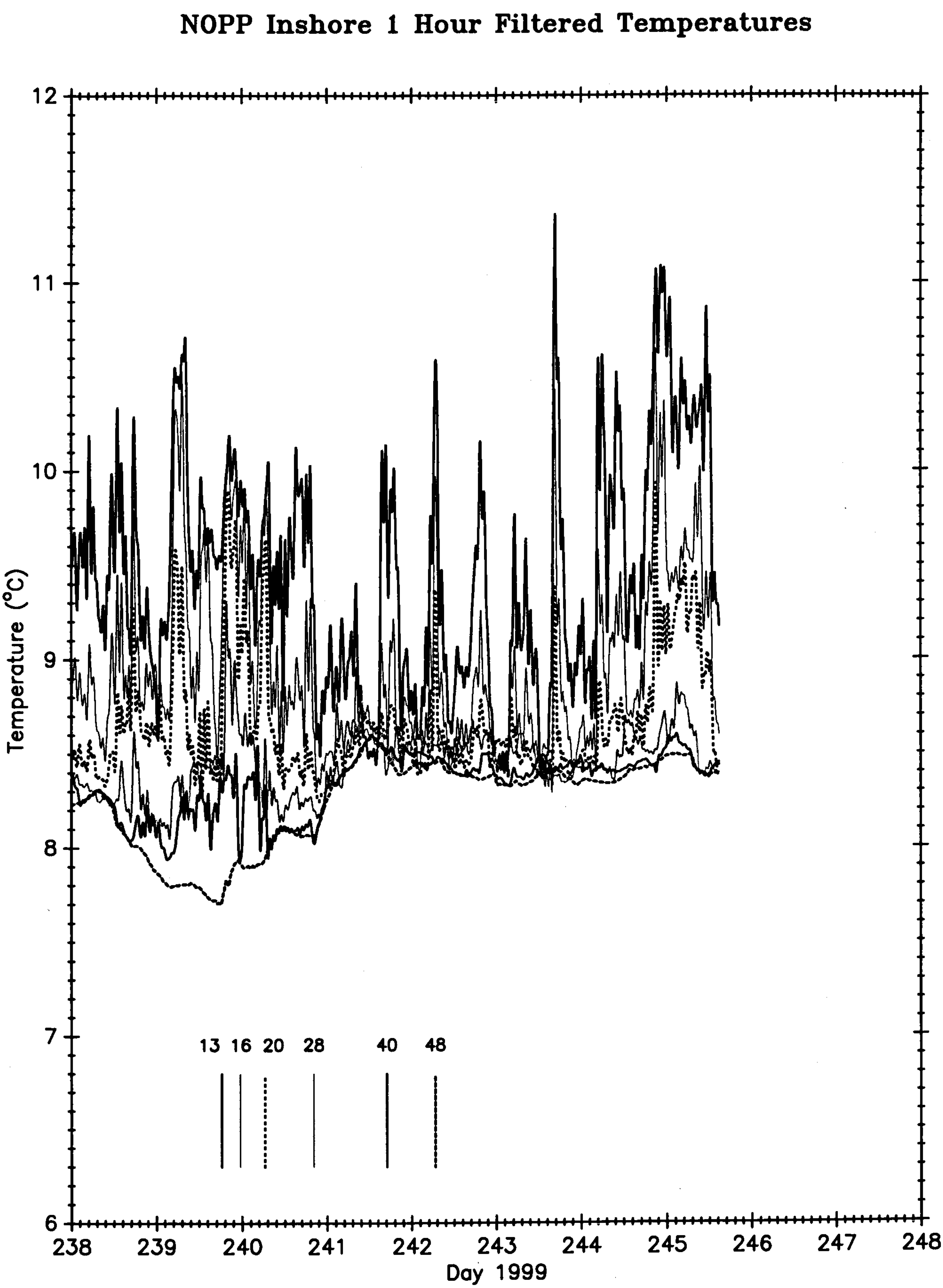
NOPP Inshore 1 Hour Filtered Temperatures

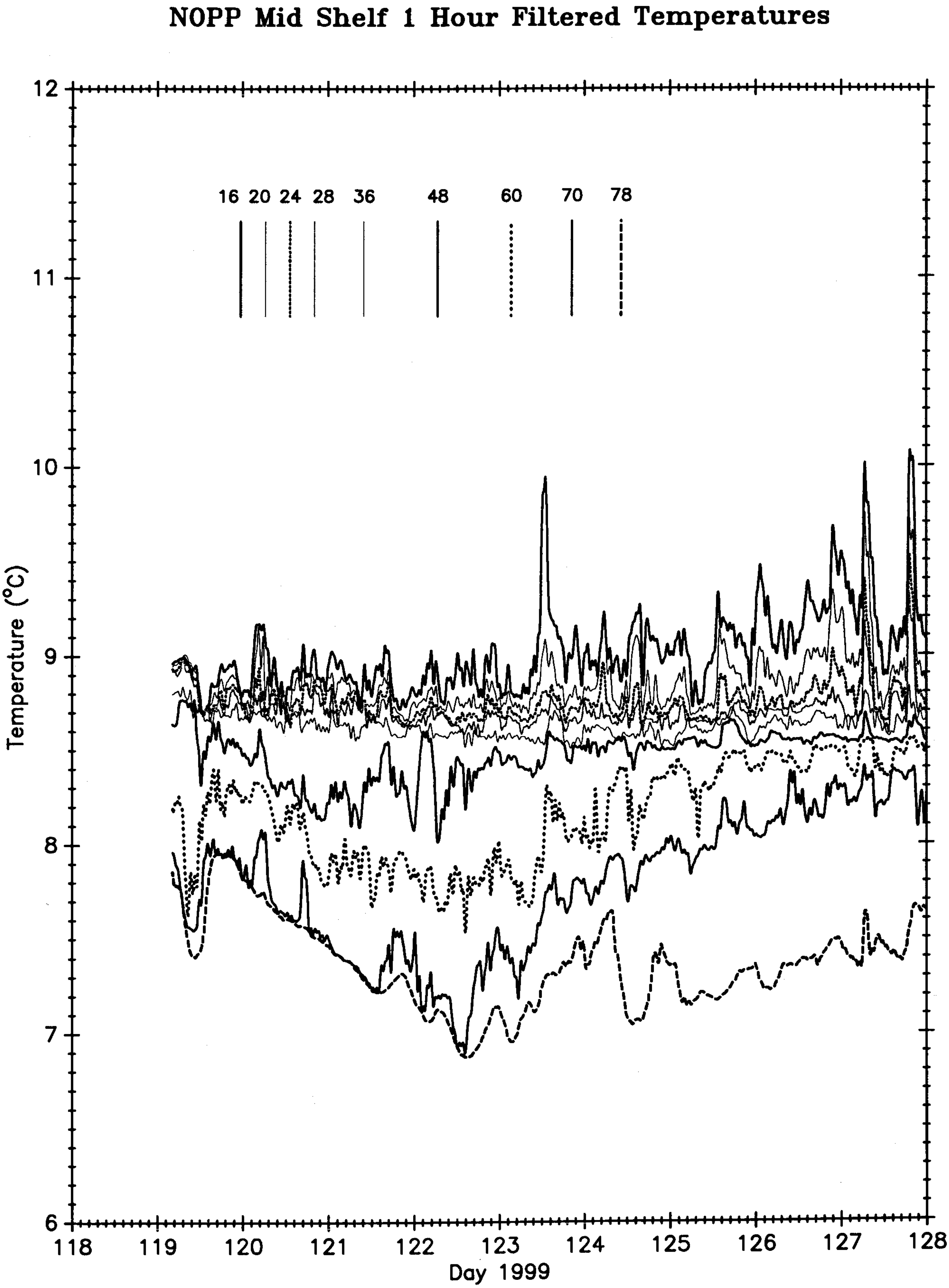


NOPP Inshore 1 Hour Filtered Temperatures

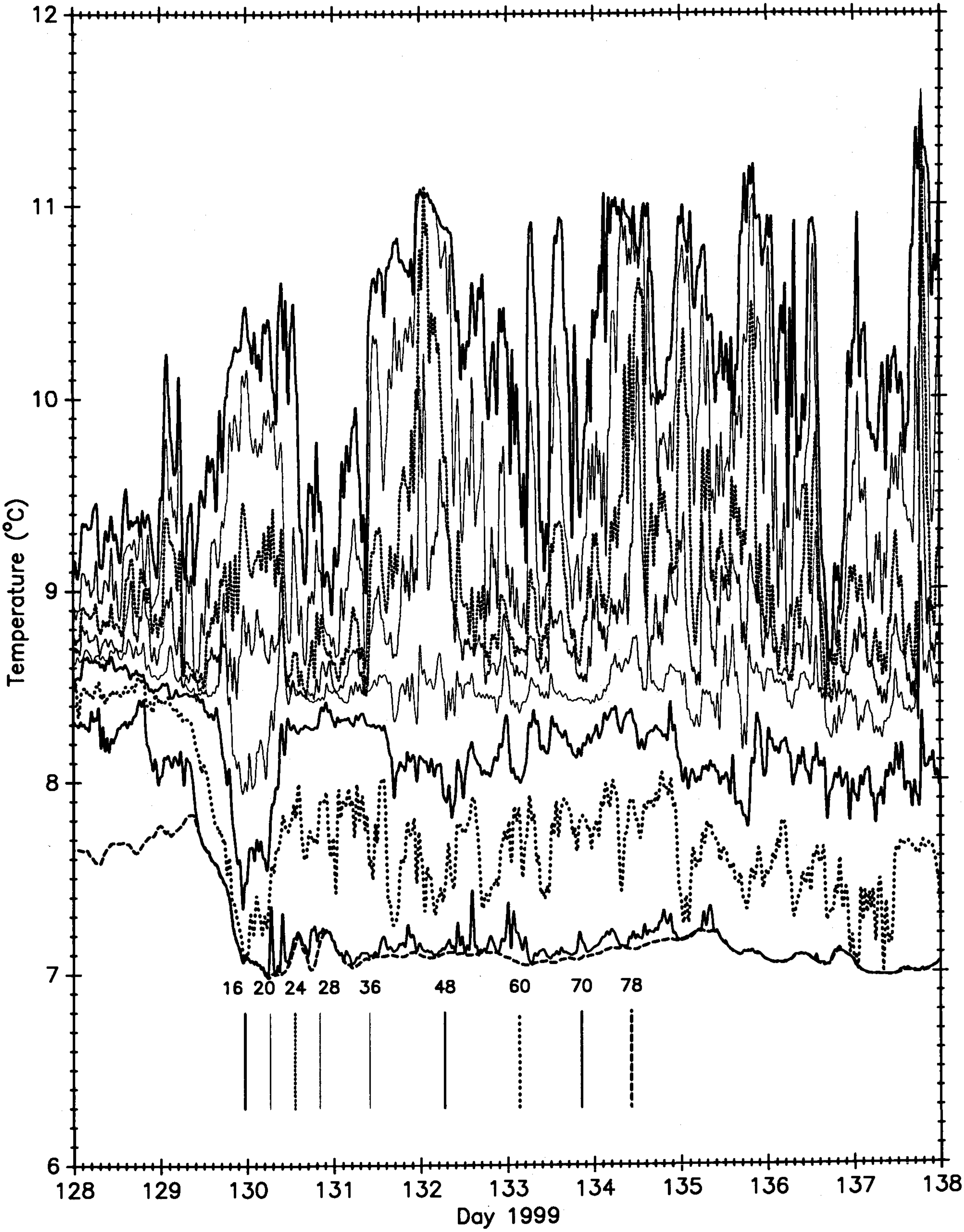


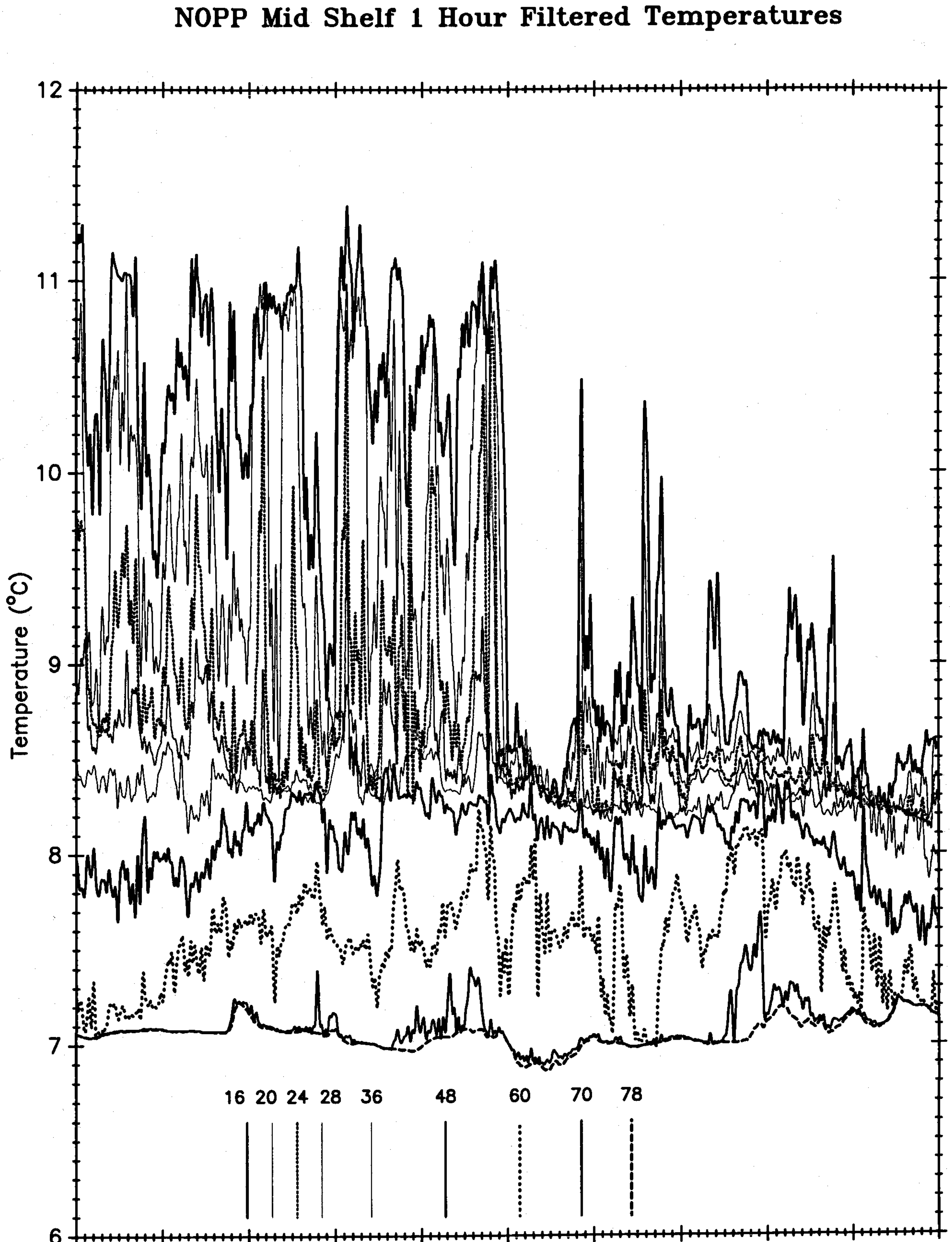

NOPP Inshore 1 Hour Filtered Temperatures
Temperature (°C)
12
11
10
9
8
7
6
13
16
20
28
40
48
228
229
230
231
232
233
234
235
236
237
238
Day 1999


NOPP Inshore 1 Hour Filtered Temperatures
Temperature (°C)
12
11
10
9
8
7
6
238
239
240
241
242
243
244
245
246
247
248
Day 1999
13 16 20 28 40 48

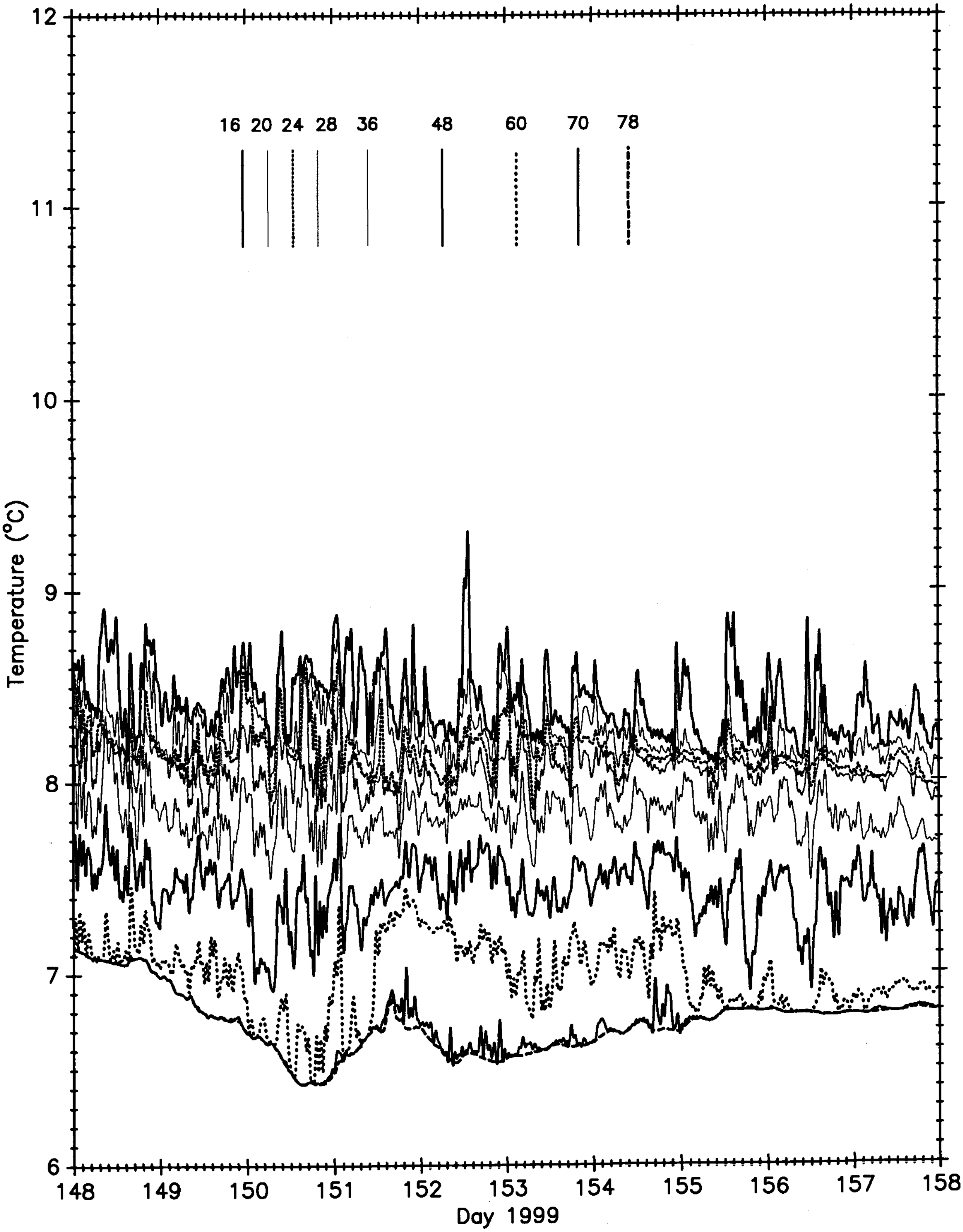

NOPP Mid Shelf 1 Hour Filtered Temperatures
16 20 24 28 36 48 60 70 78
Temperature (°C)
12
11
10
9
8
7
6
118 119 120 121 122 123 124 125 126 127 128
Day 1999

NOPP Mid Shelf 1 Hour Filtered Temperatures

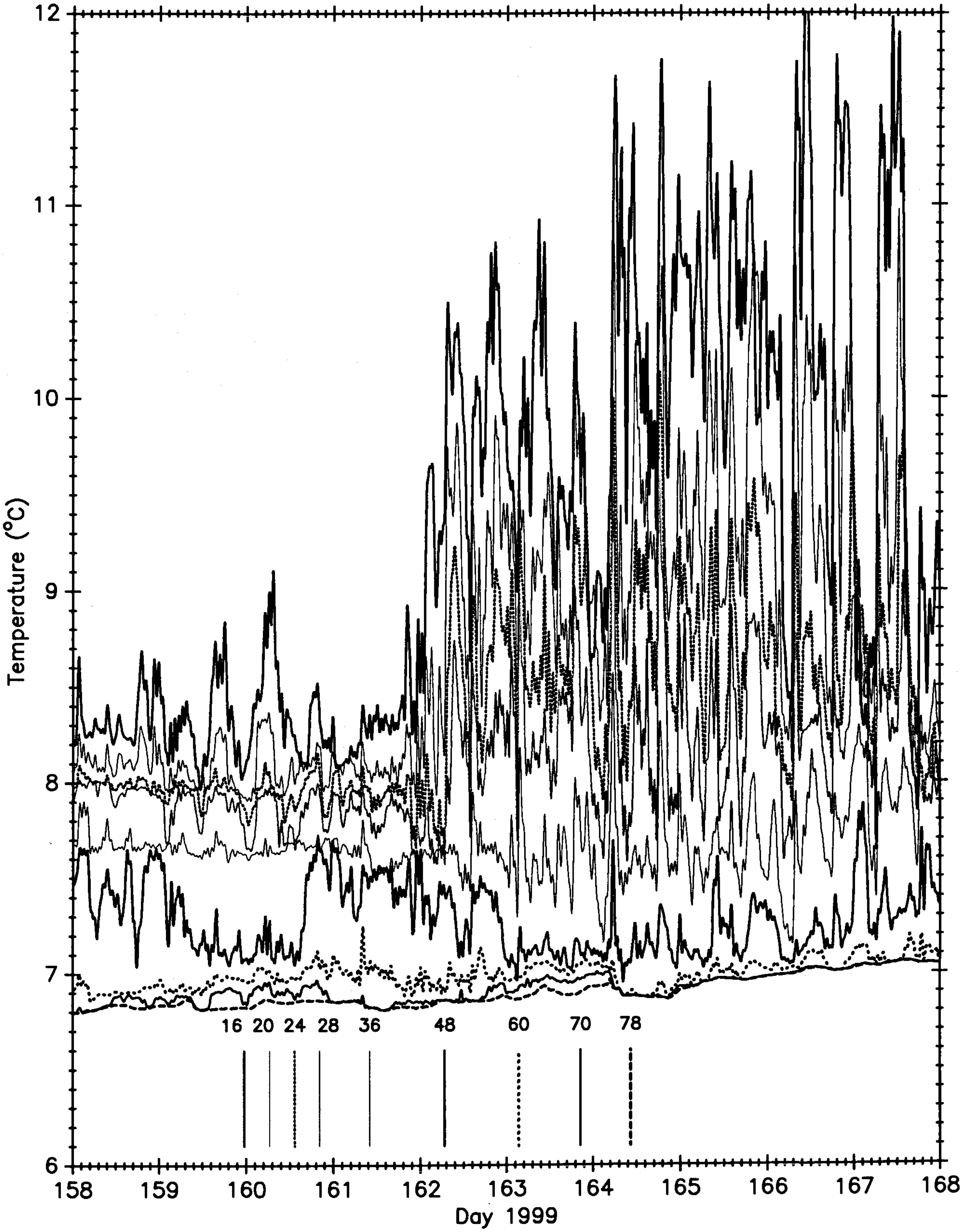


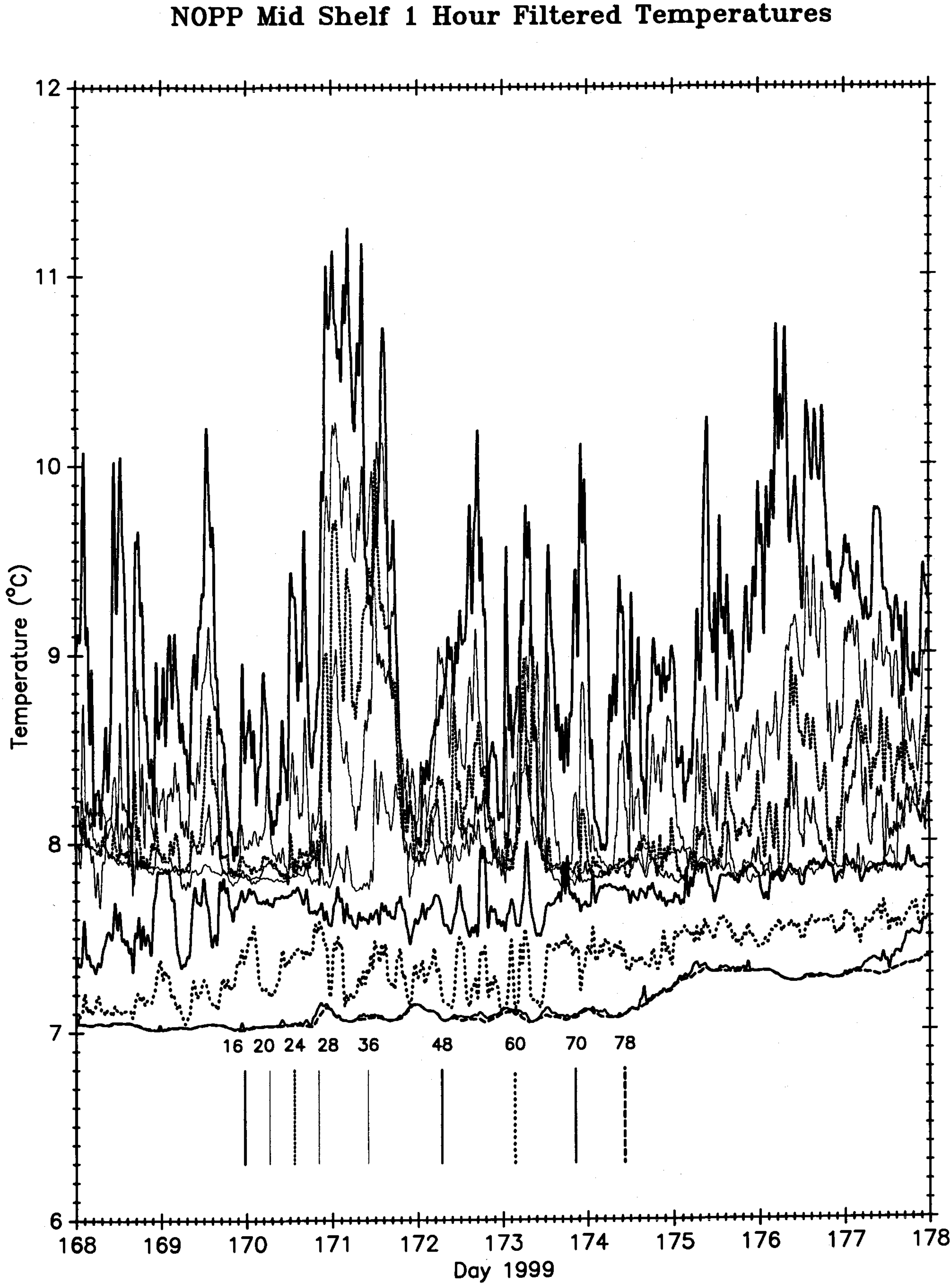

NOPP Mid Shelf 1 Hour Filtered Temperatures
Temperature (°C)
12
11
10
9
8
7
6
16
20
24
28
36
48
60
70
78
138
139
140
141
142
143
144
145
146
147
148
Day 1999

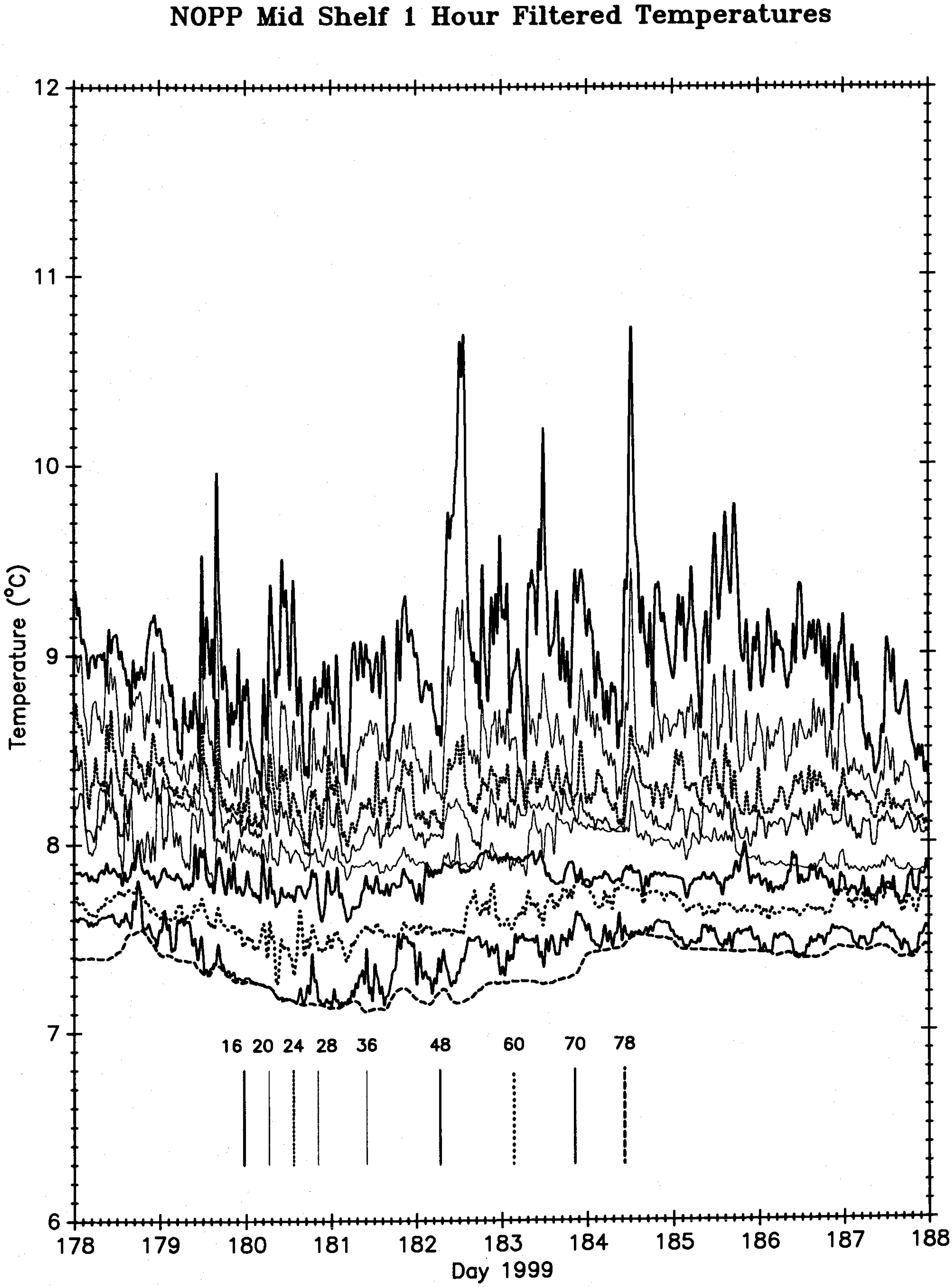
NOPP Mid Shelf 1 Hour Filtered Temperatures



NOPP Mid Shelf 1 Hour Filtered Temperatures

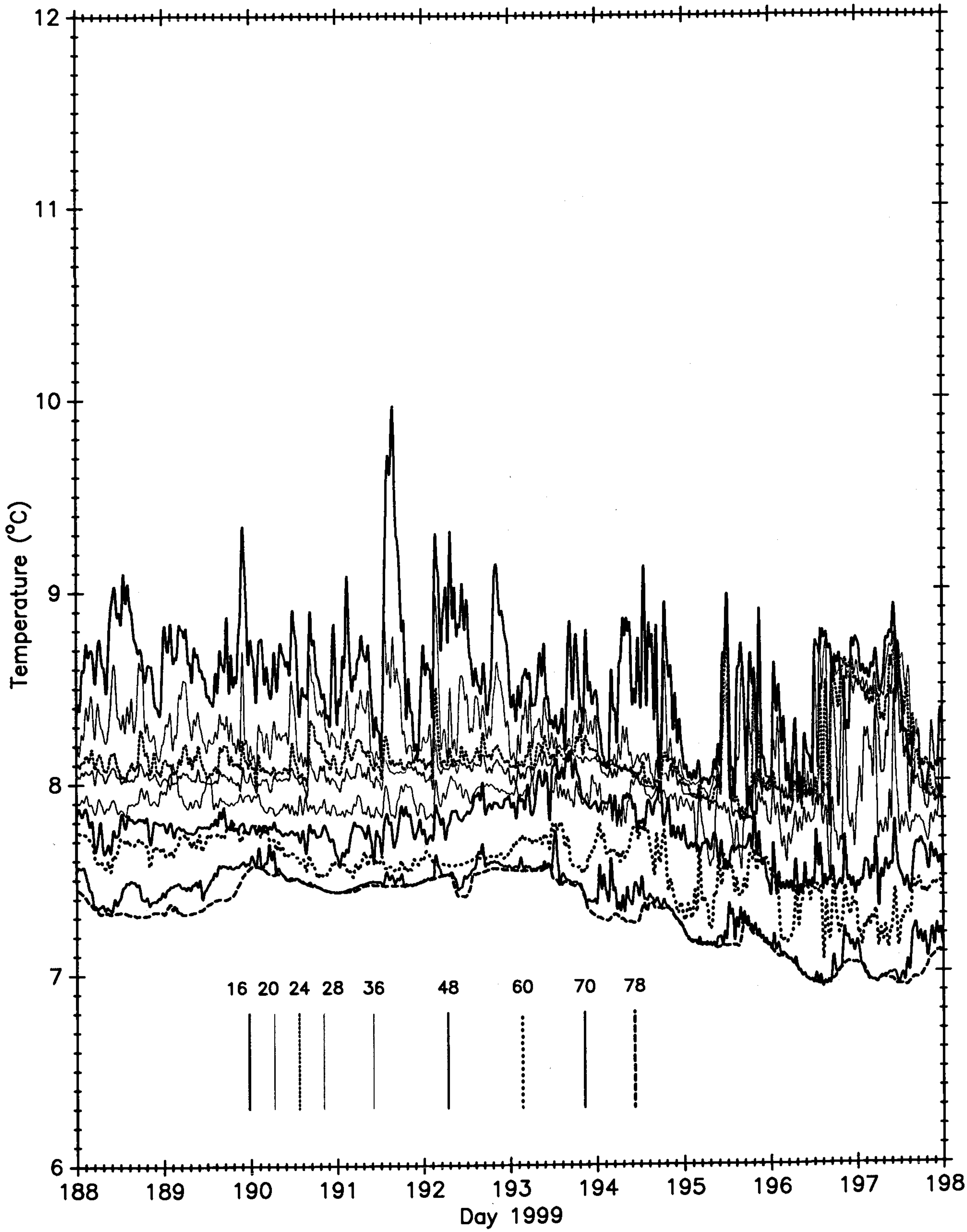


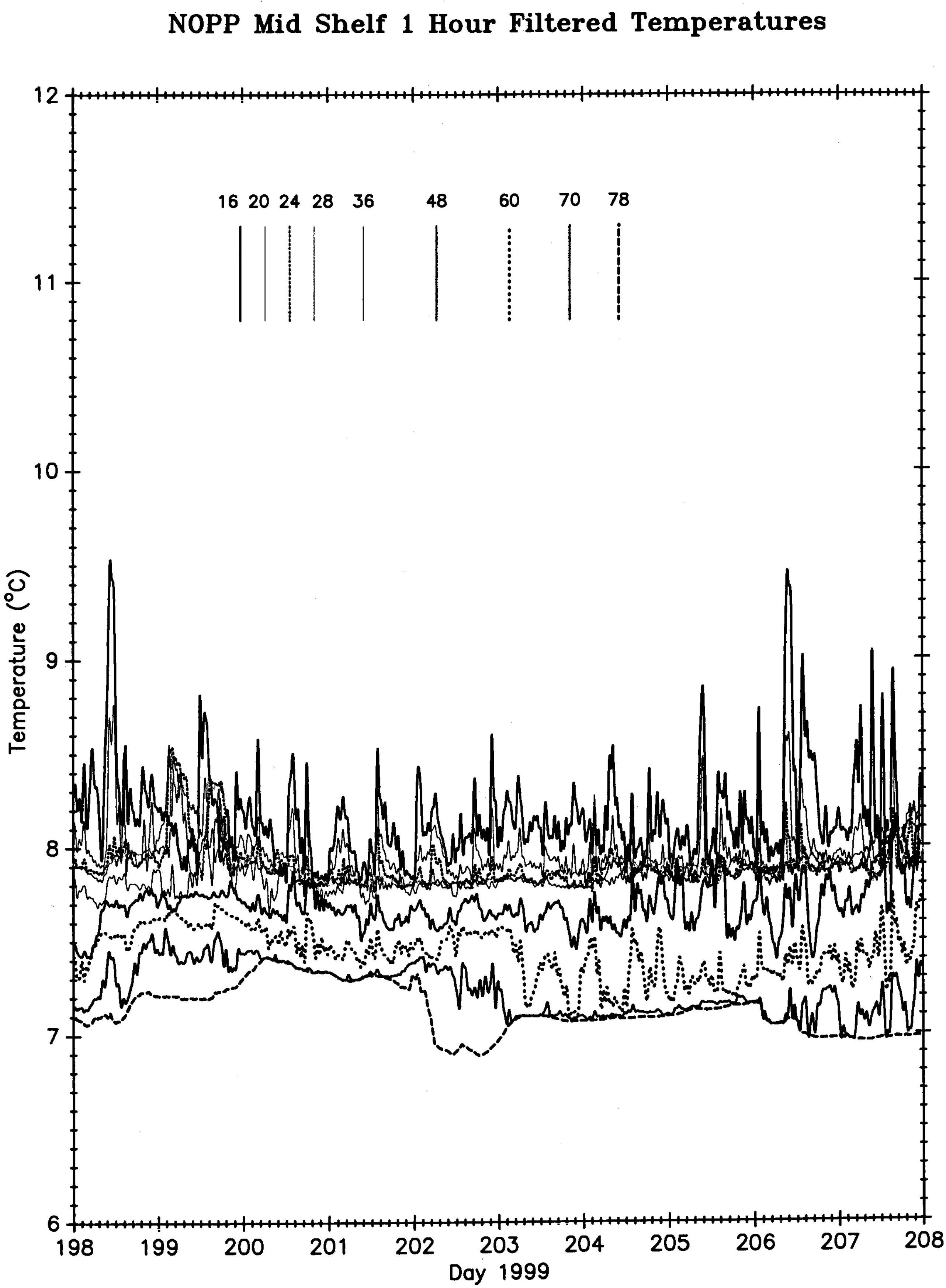

NOPP Mid Shelf 1 Hour Filtered Temperatures
Temperature (°C)
12
11
10
9
8
7
6
16 20 24 28 36 48 60 70 78
168 169 170 171 172 173 174 175 176 177 178
Day 1999



NOPP Mid Shelf 1 Hour Filtered Temperatures
Temperature (°C)
12
11
10
9
8
7
6
16 20 24 28 36 48 60 70 78
178 179 180 181 182 183 184 185 186 187 188
Day 1999

NOPP Mid Shelf 1 Hour Filtered Temperatures




NOPP Mid Shelf 1 Hour Filtered Temperatures
16
20
24
28
36
48
60
70
78
Temperature (°C)
12
11
10
9
8
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198
199
200
201
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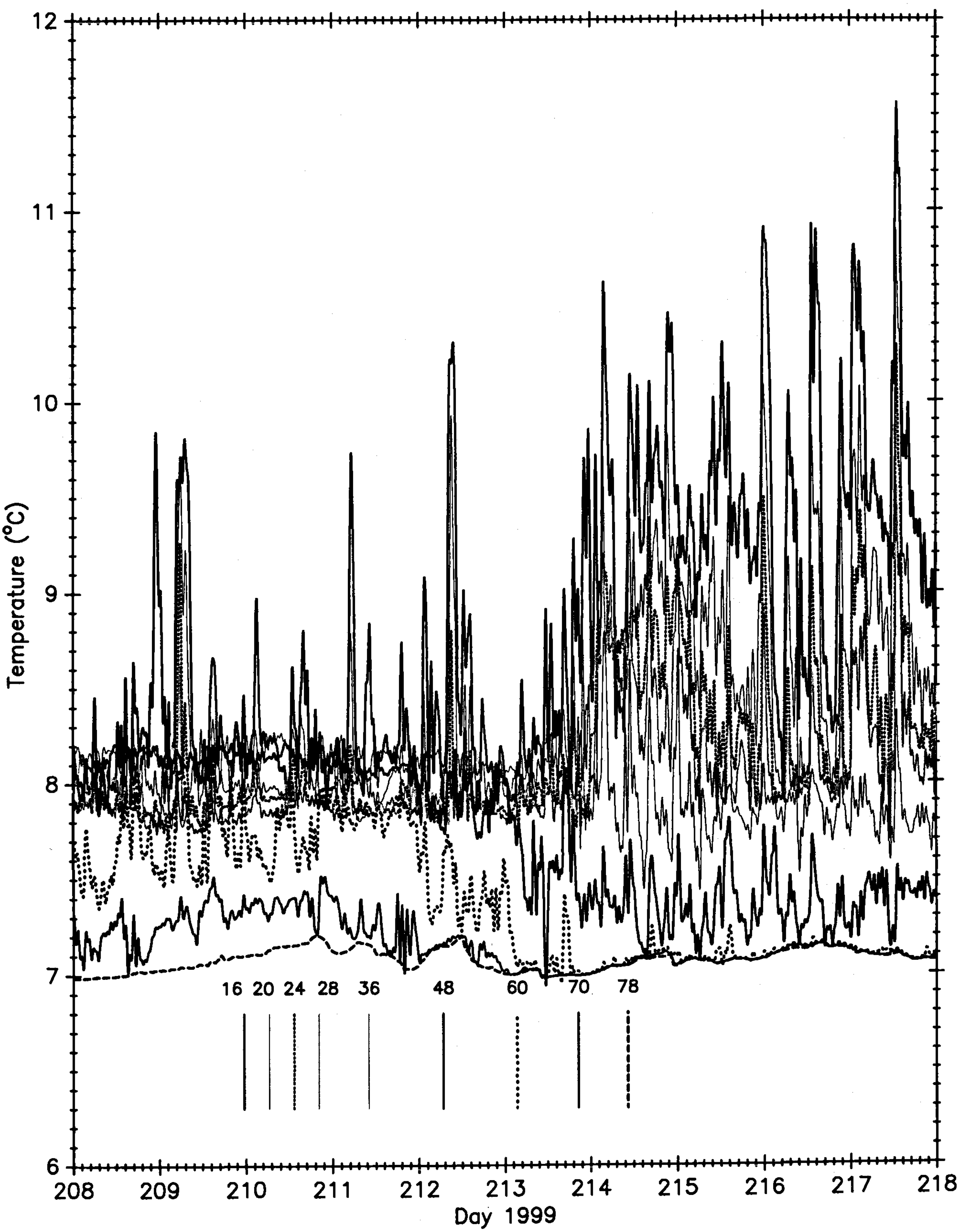
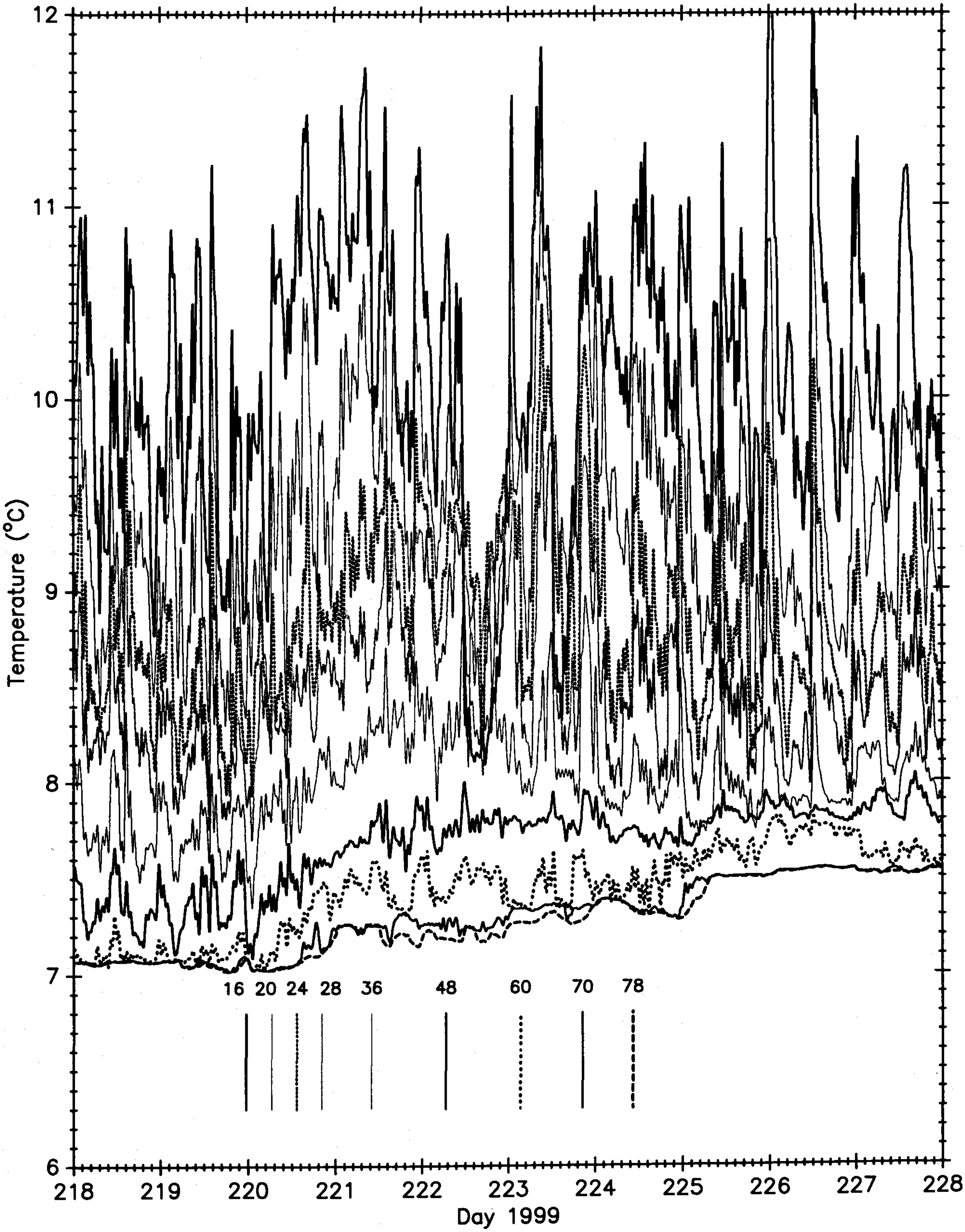
203
204
205
206
207
208
Day 1999

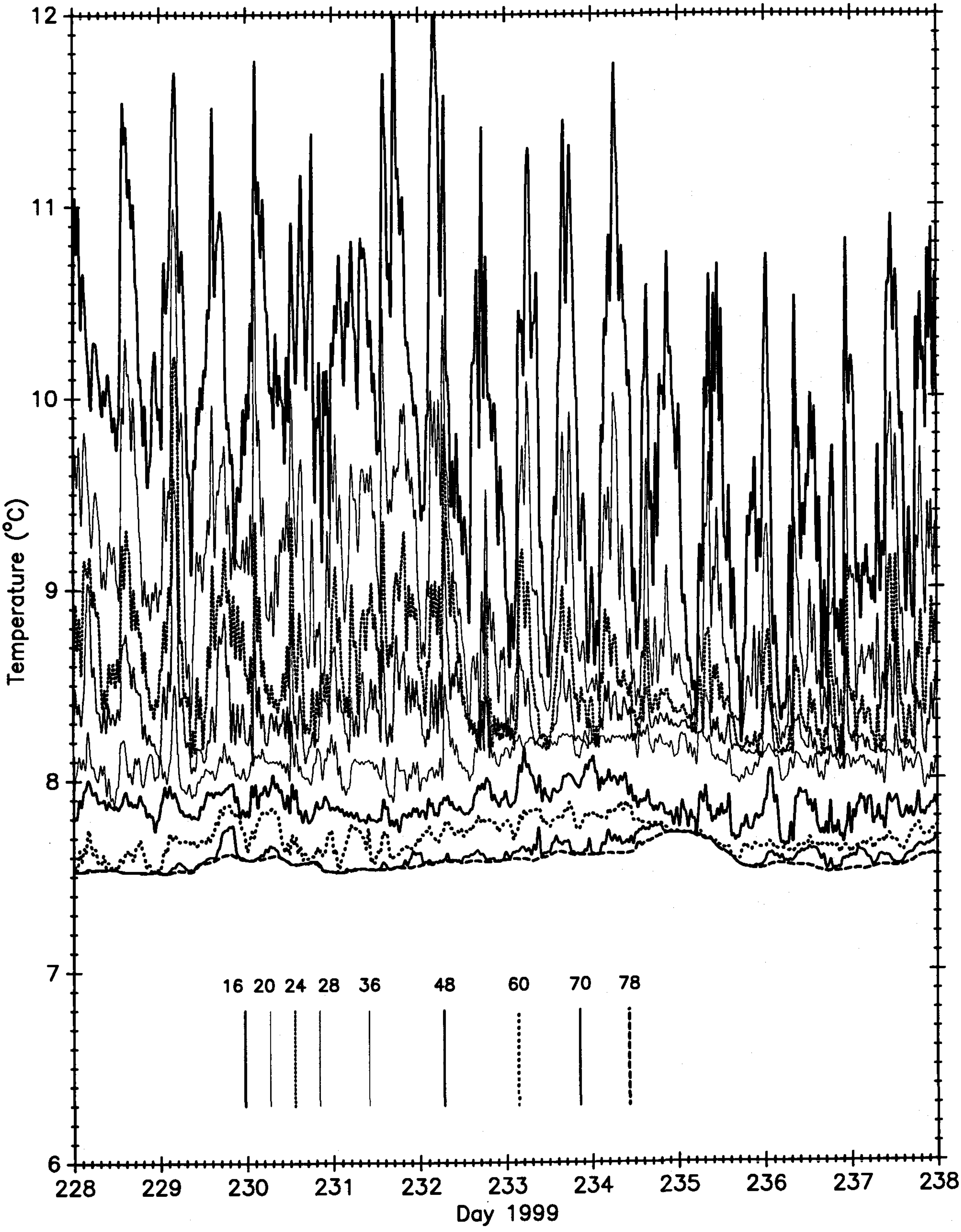
NOPP Mid Shelf 1 Hour Filtered Temperatures

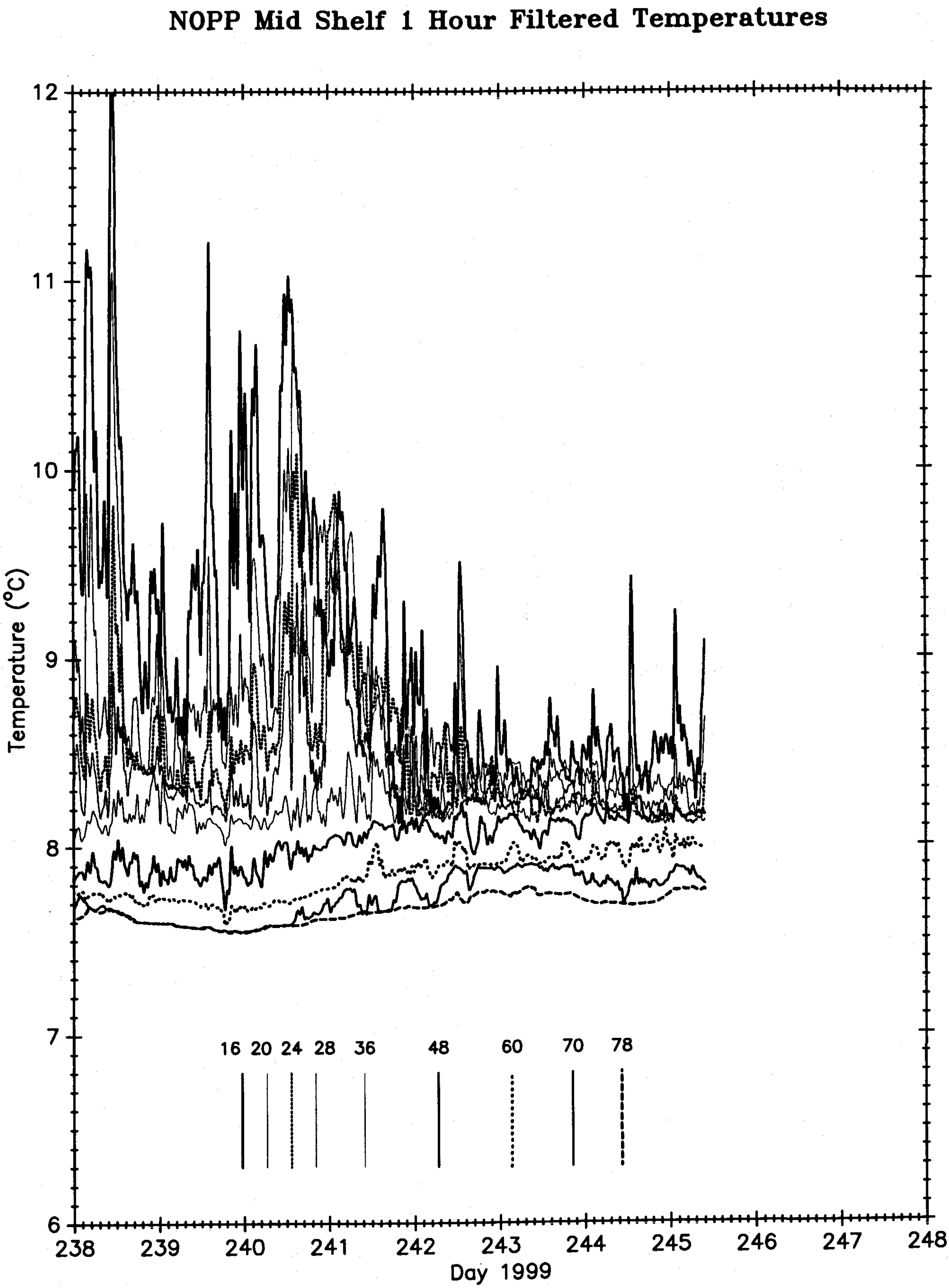


NOPP Mid Shelf 1 Hour Filtered Temperatures

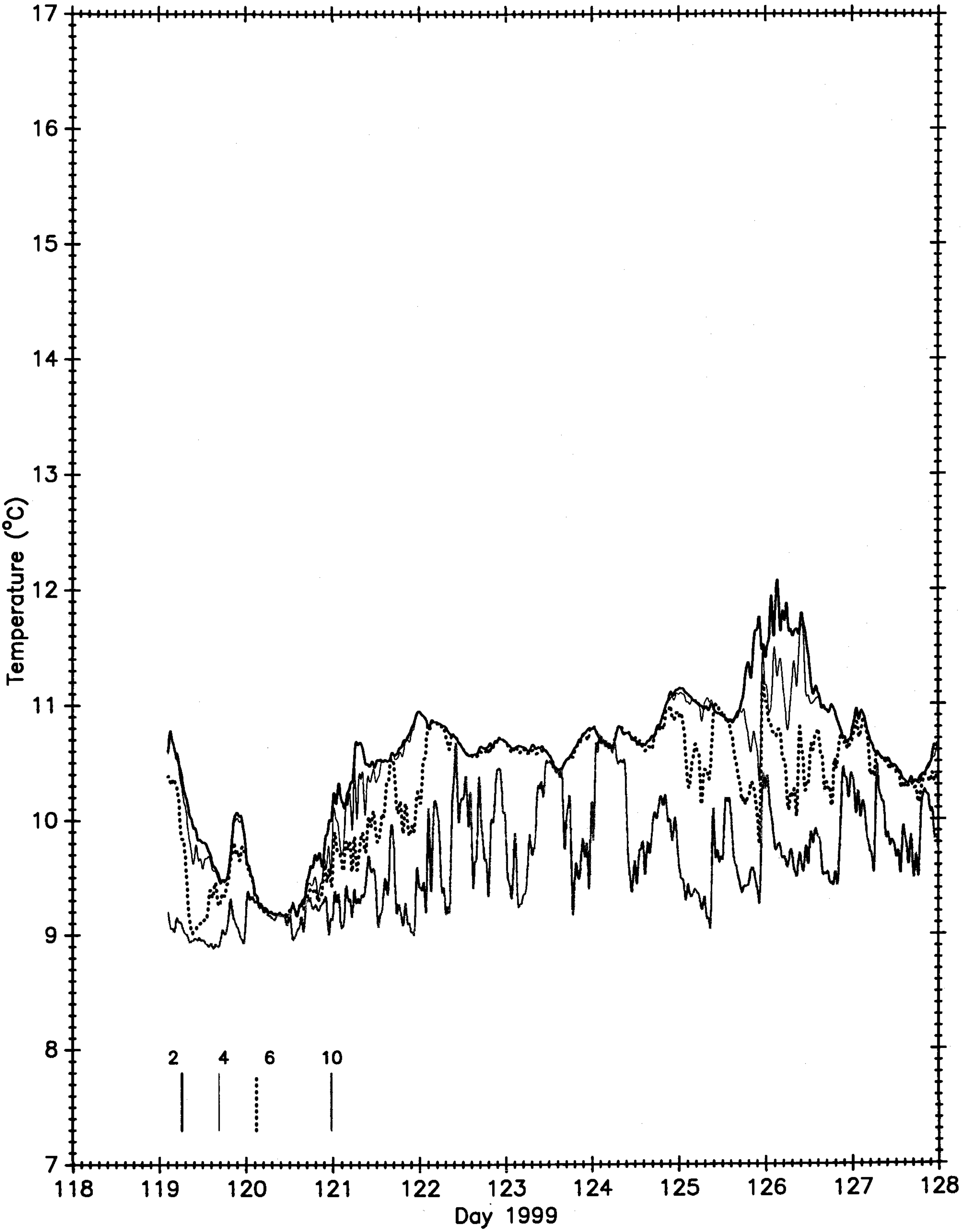


NOPP Mid Shelf 1 Hour Filtered Temperatures

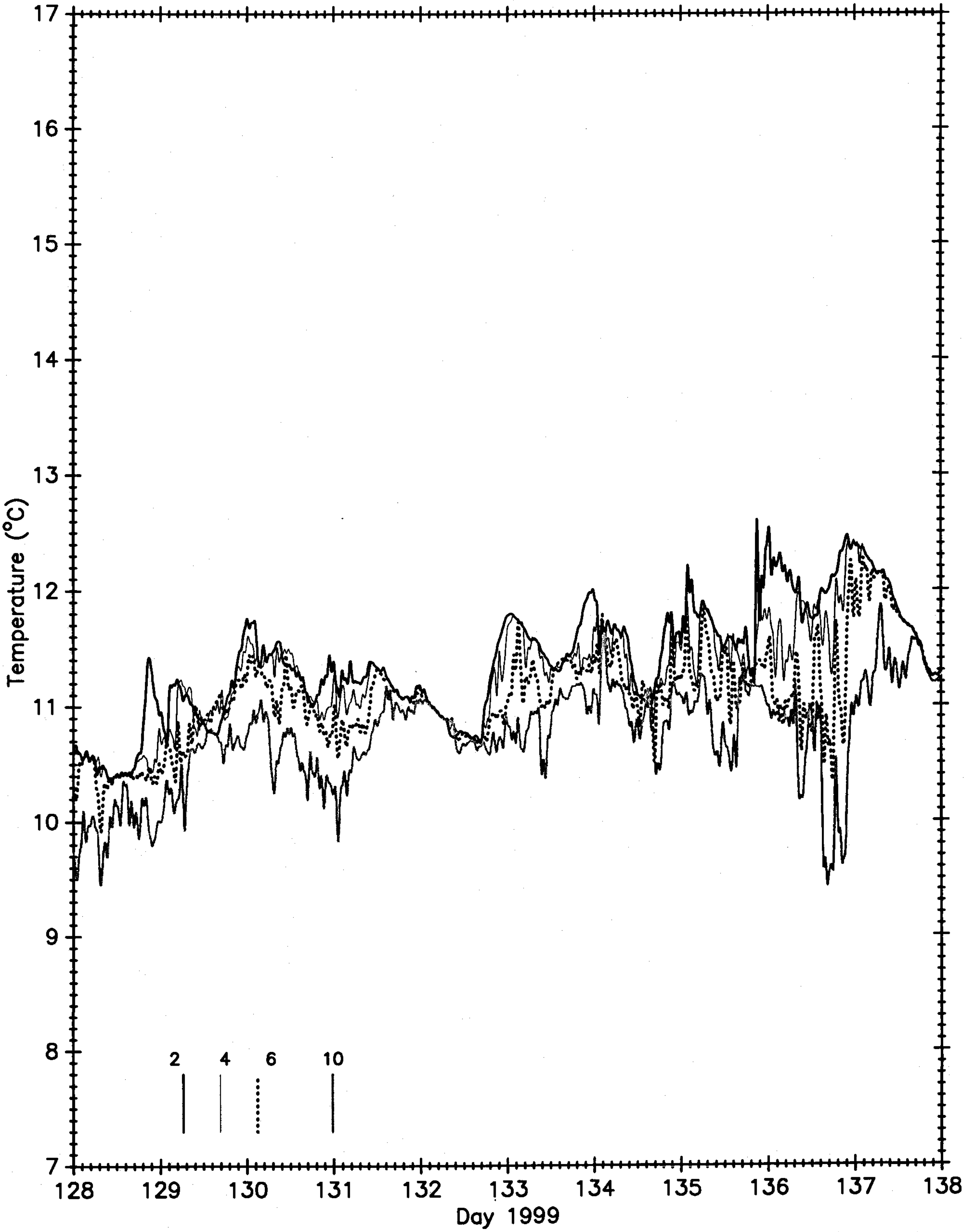



NOPP Mid Shelf 1 Hour Filtered Temperatures
Temperature (°C)
Day 1999
12
11
10
9
8
7
6
238
239
240
241
242
243
244
245
246
247
248
16
20
24
28
36
48
60
70
78

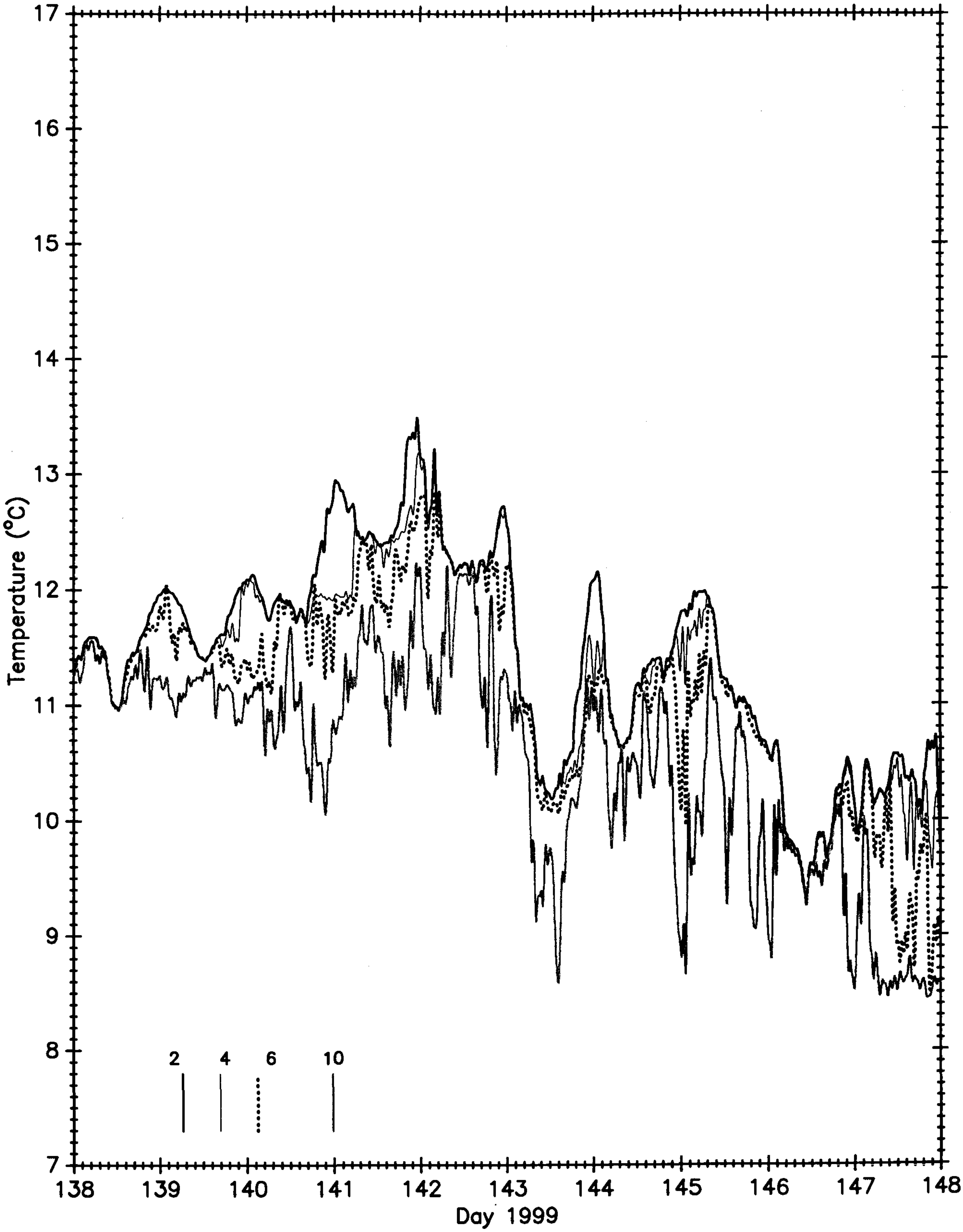
NOPP Meteorological Mooring 1 Hour Filtered Temperature

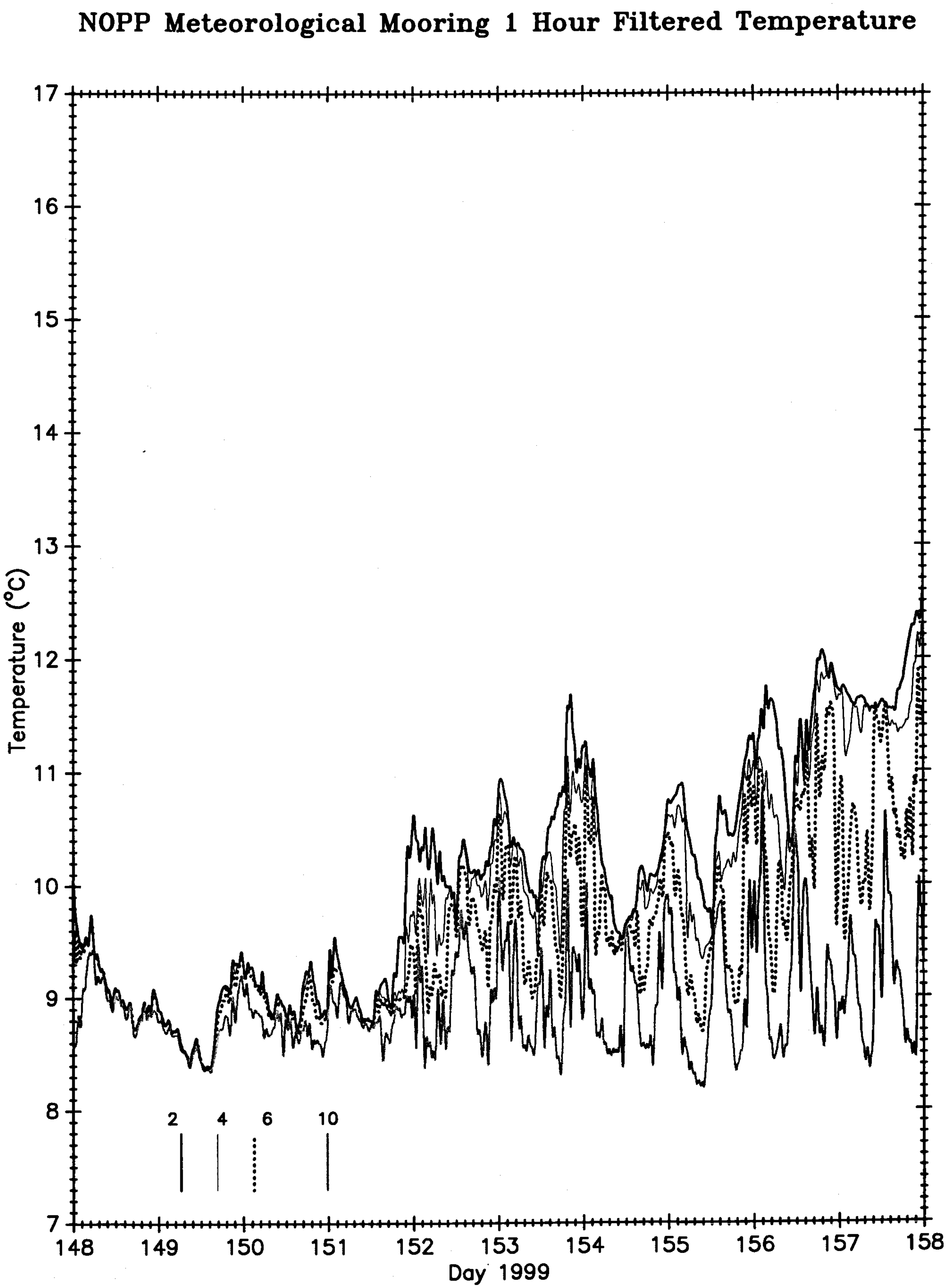


NOPP Meteorological Mooring 1 Hour Filtered Temperature



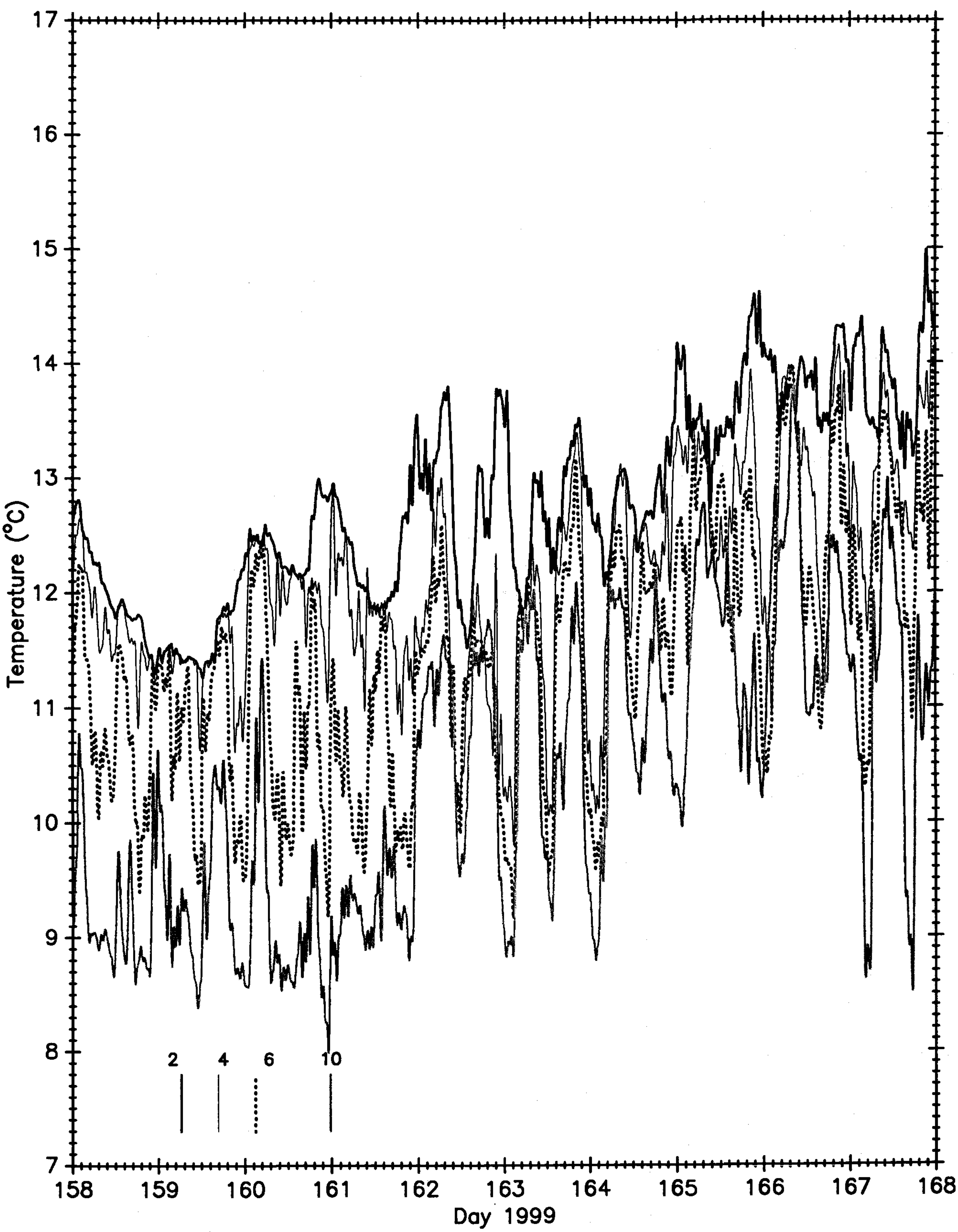
NOPP Meteorological Mooring 1 Hour Filtered Temperature

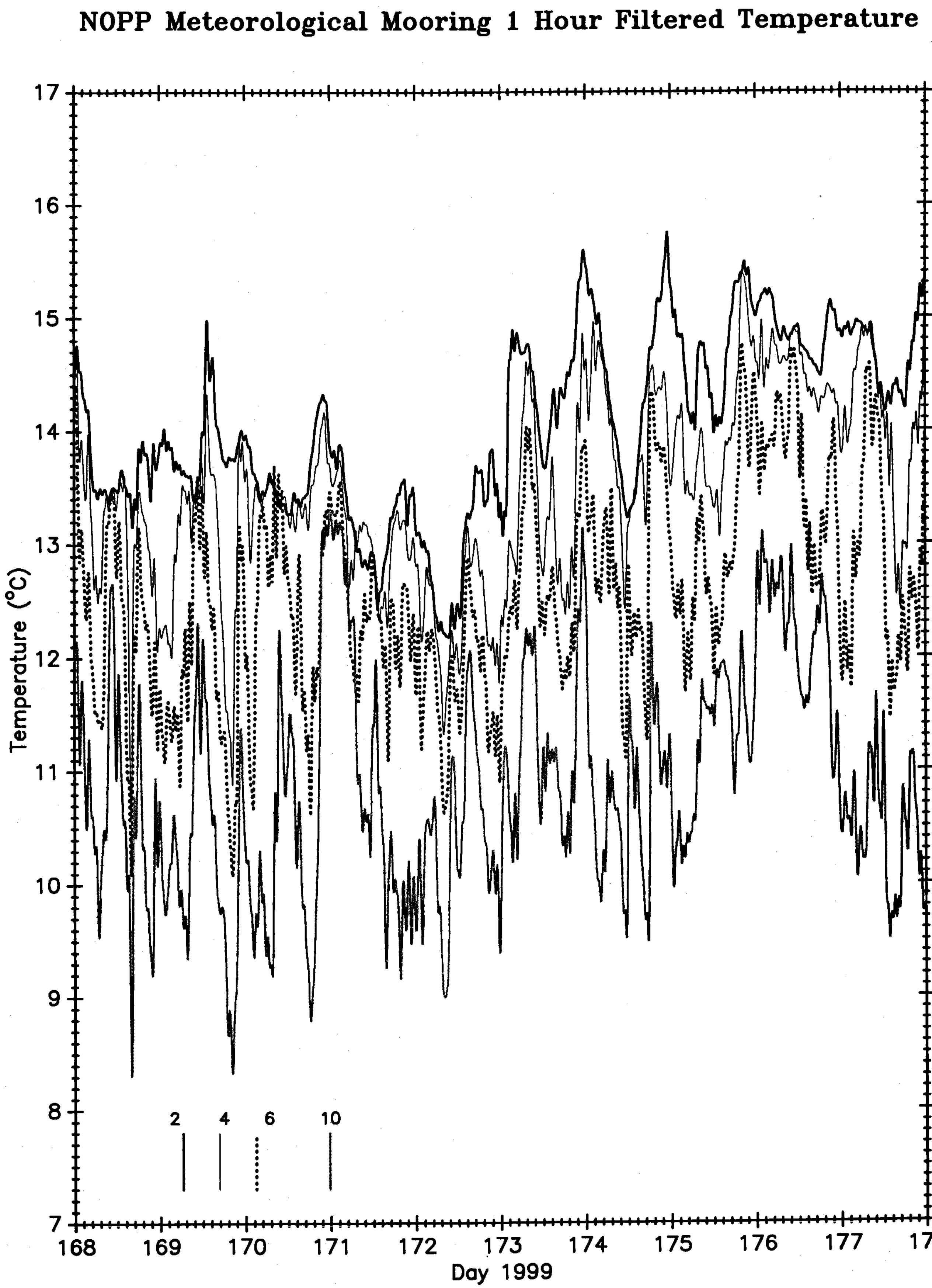




NOPP Meteorological Mooring 1 Hour Filtered Temperature
Temperature (°C)
17
16
15
14
13
12
11
10
9
8
7
2
4
6
10
148
149
150
151
152
153
154
155
156
157
158
Day 1999

NOPP Meteorological Mooring 1 Hour Filtered Temperature




NOPP Meteorological Mooring 1 Hour Filtered Temperature
Temperature (°C)
17
16
15
14
13
12
11
10
9
8
7
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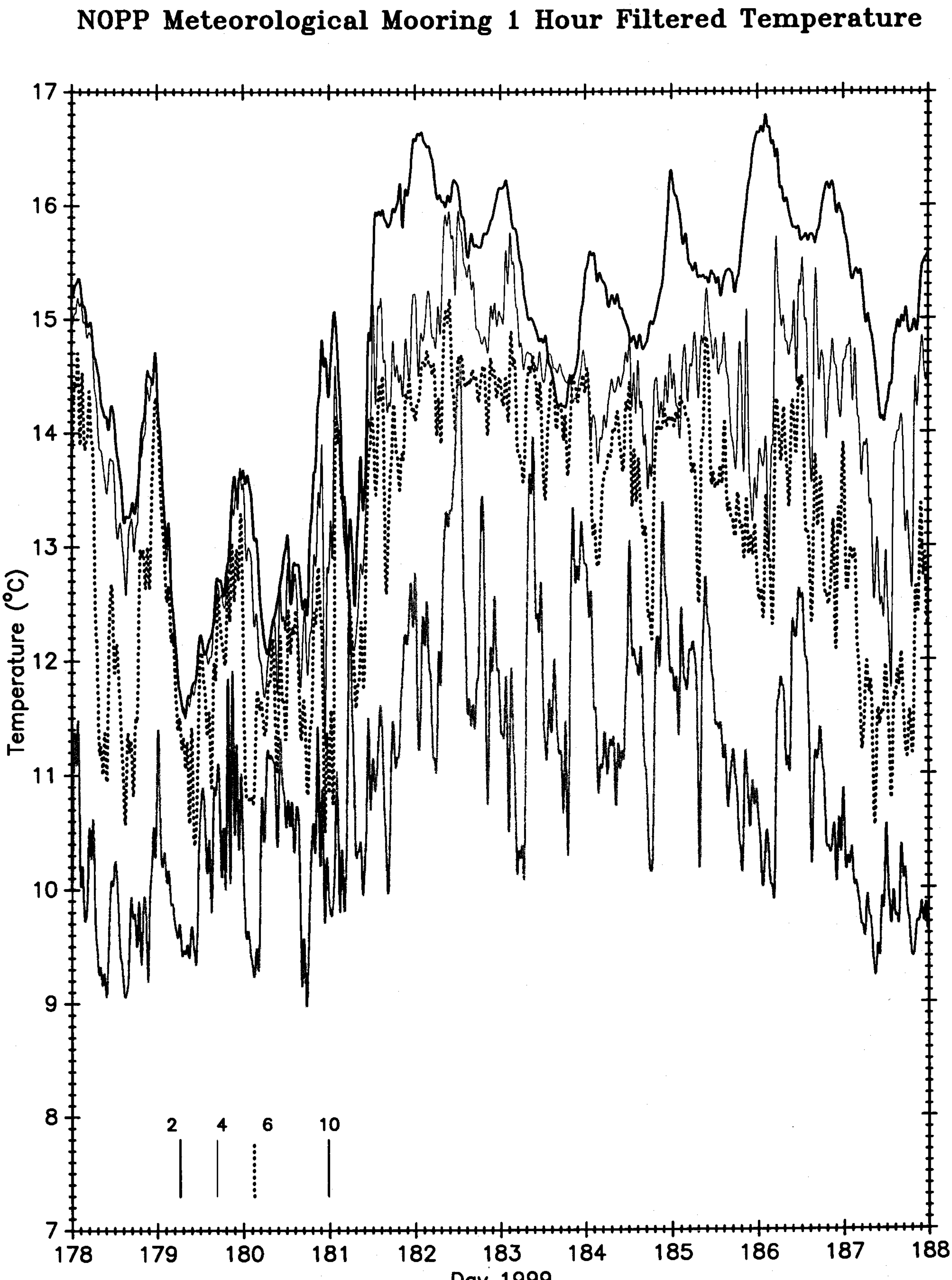
4
6
10
168
169
170
171
172
173
174
175
176
177
178
Day 1999


NOPP Meteorological Mooring 1 Hour Filtered Temperature
Temperature (°C)
17
16
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14
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12
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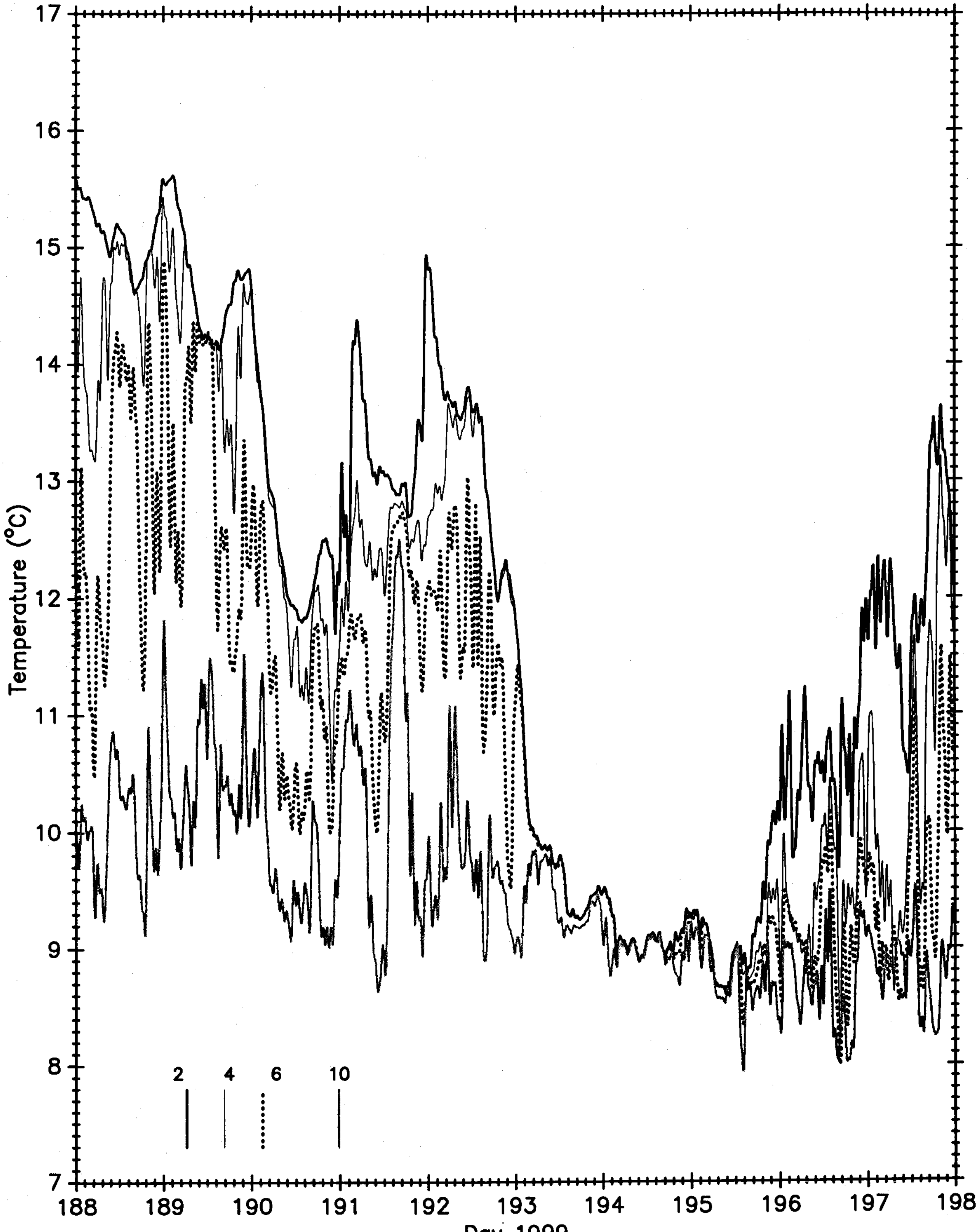
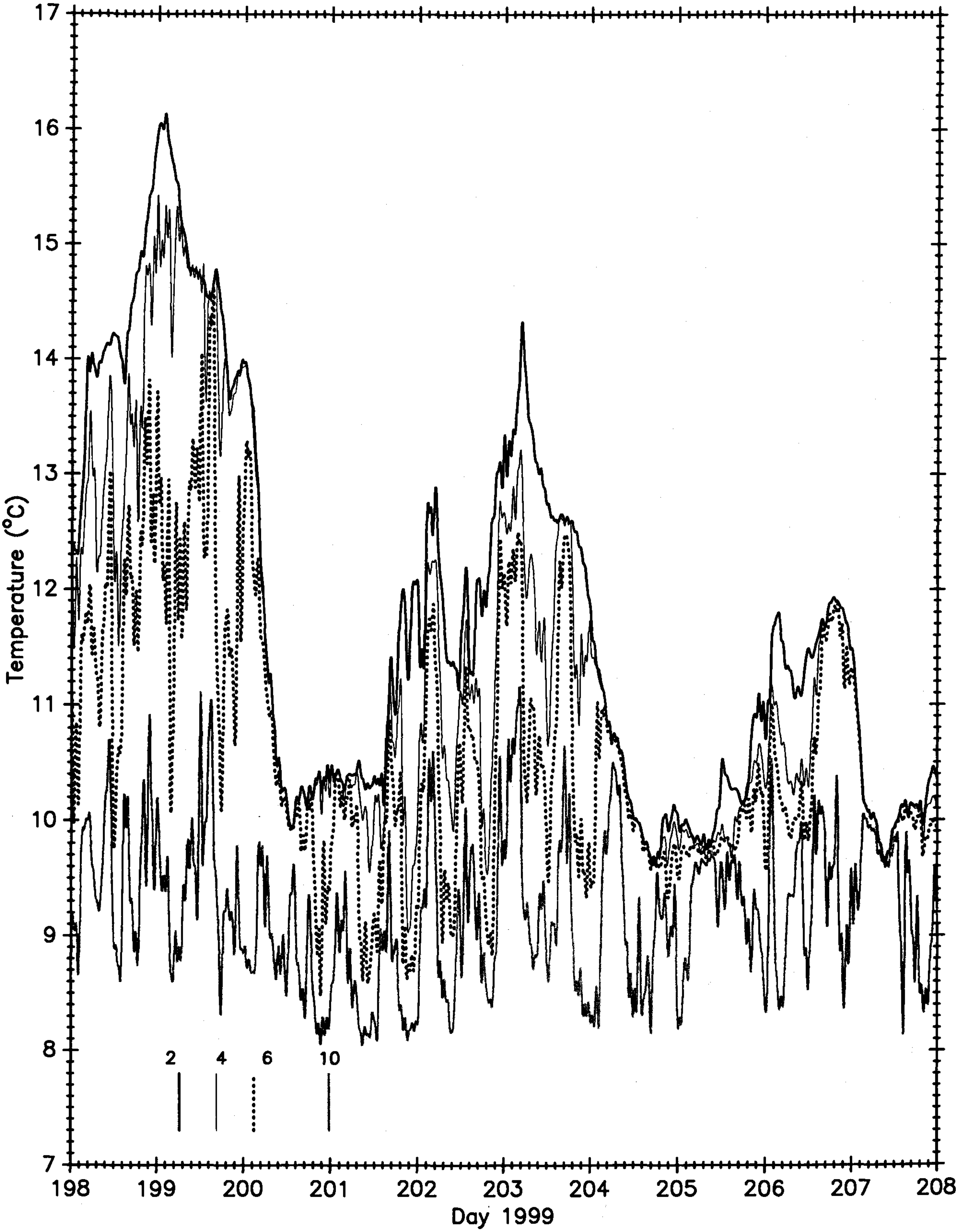
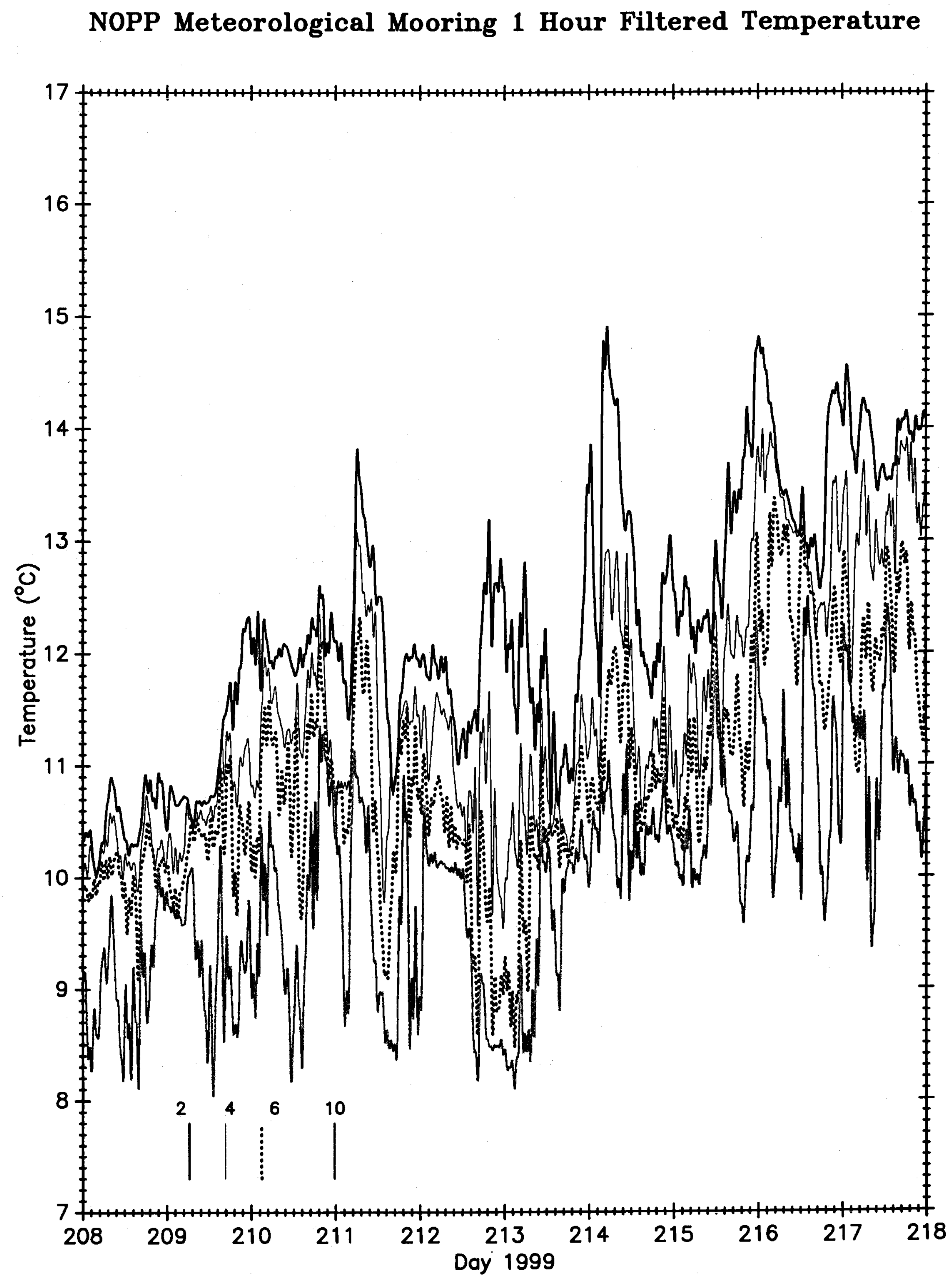
8
7
2
4
6
10
178
179
180
181
182
183
184
185
186
187
188
Day 1999

NOPP Meteorological Mooring 1 Hour Filtered Temperature

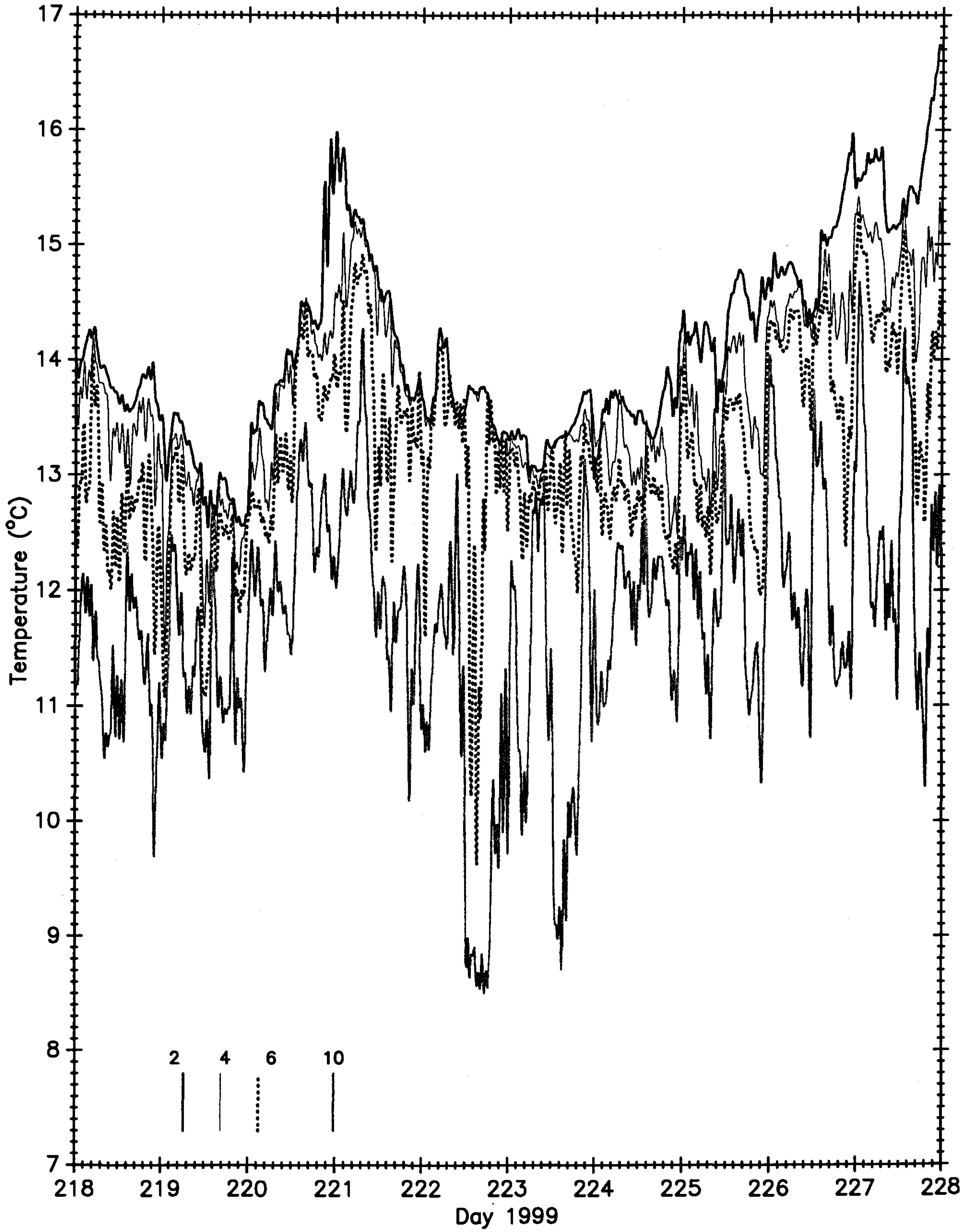


NOPP Meteorological Mooring 1 Hour Filtered Temperature

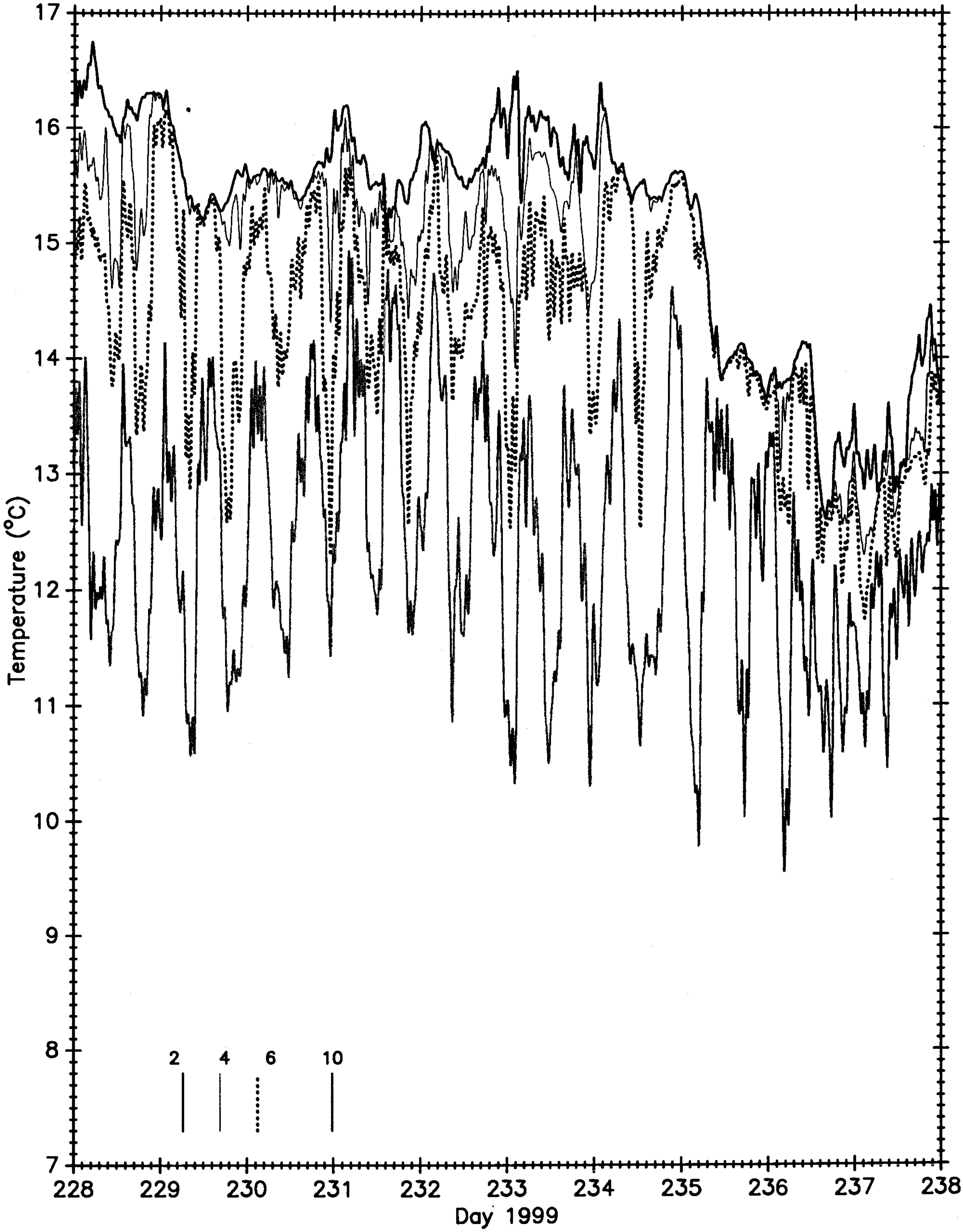



NOPP Meteorological Mooring 1 Hour Filtered Temperature
Temperature (°C)
Day 1999
17
16
15
14
13
12
11
10
9
8
7
208
209
210
211
212
213
214
215
216
217
218
2
4
6
10

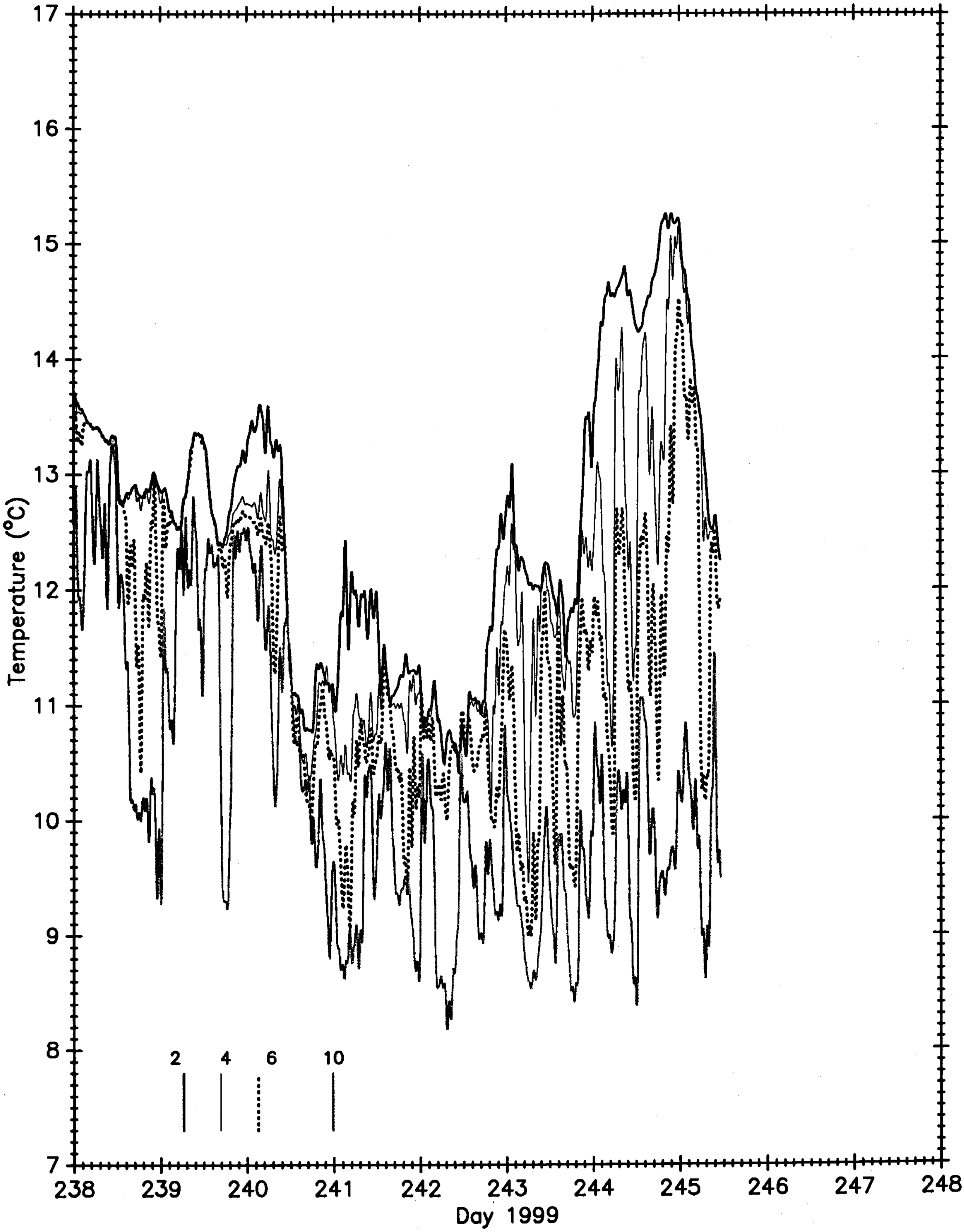
NOPP Meteorological Mooring 1 Hour Filtered Temperature



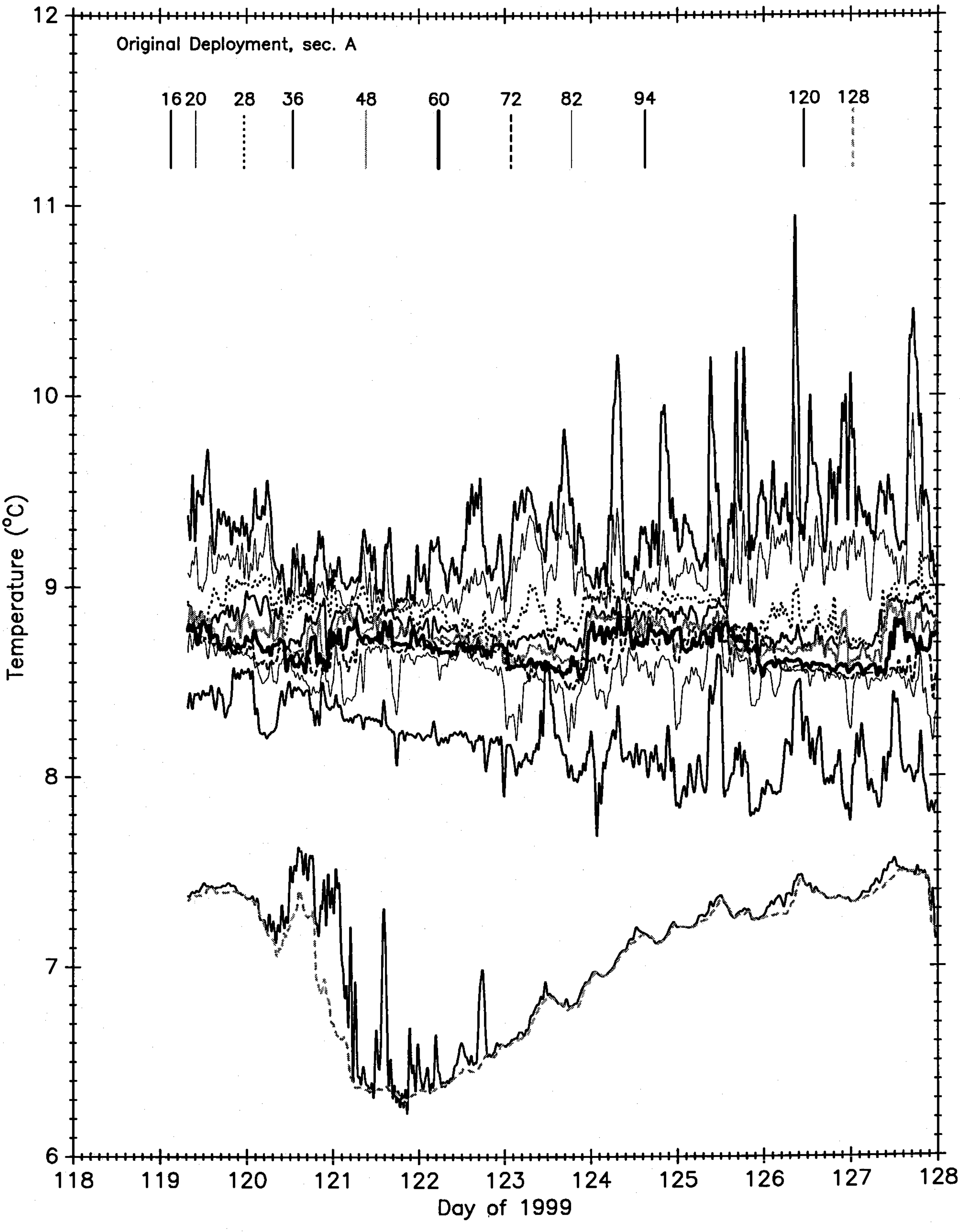
NOPP Meteorological Mooring 1 Hour Filtered Temperature



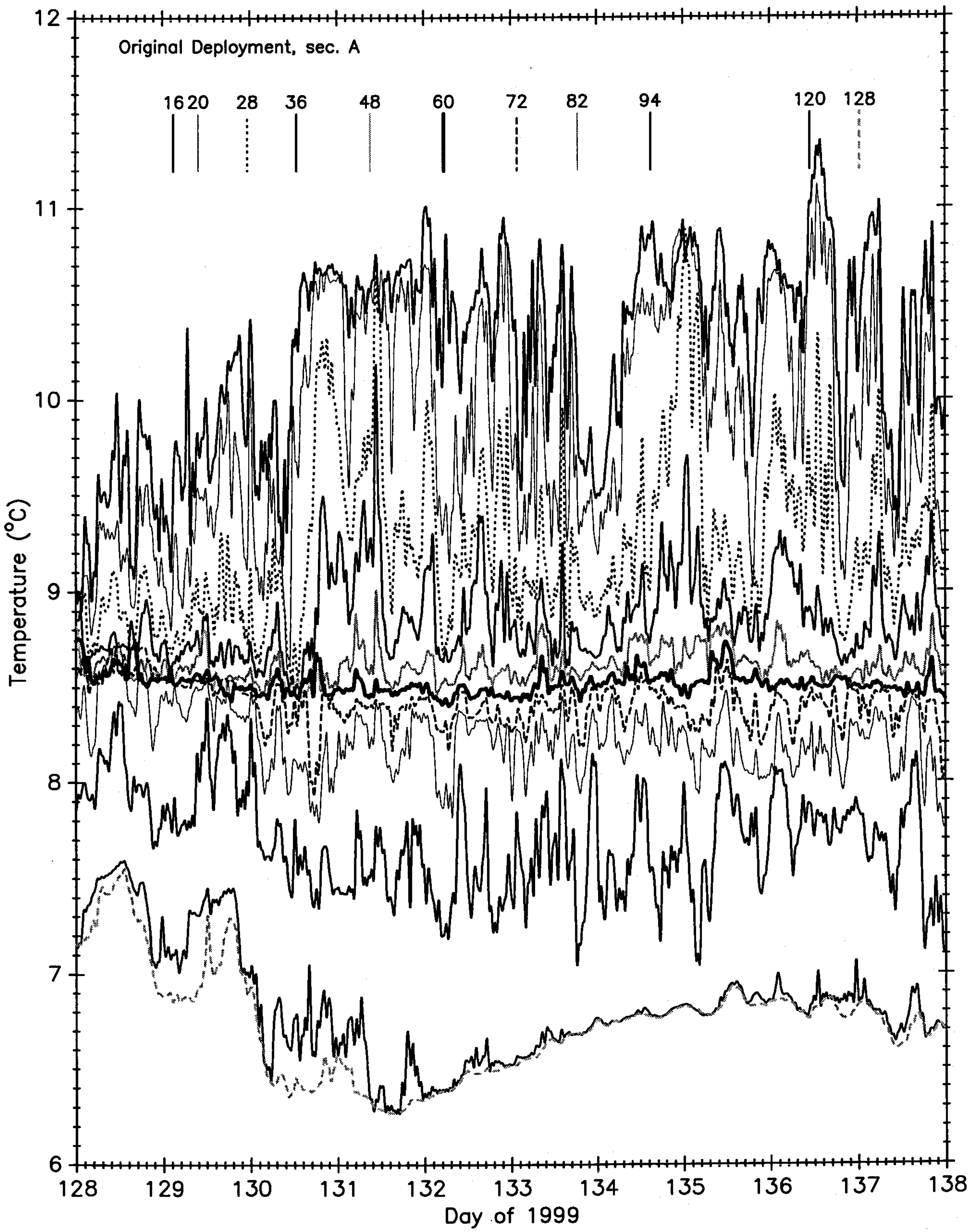
NOPP Meteorological Mooring 1 Hour Filtered Temperature



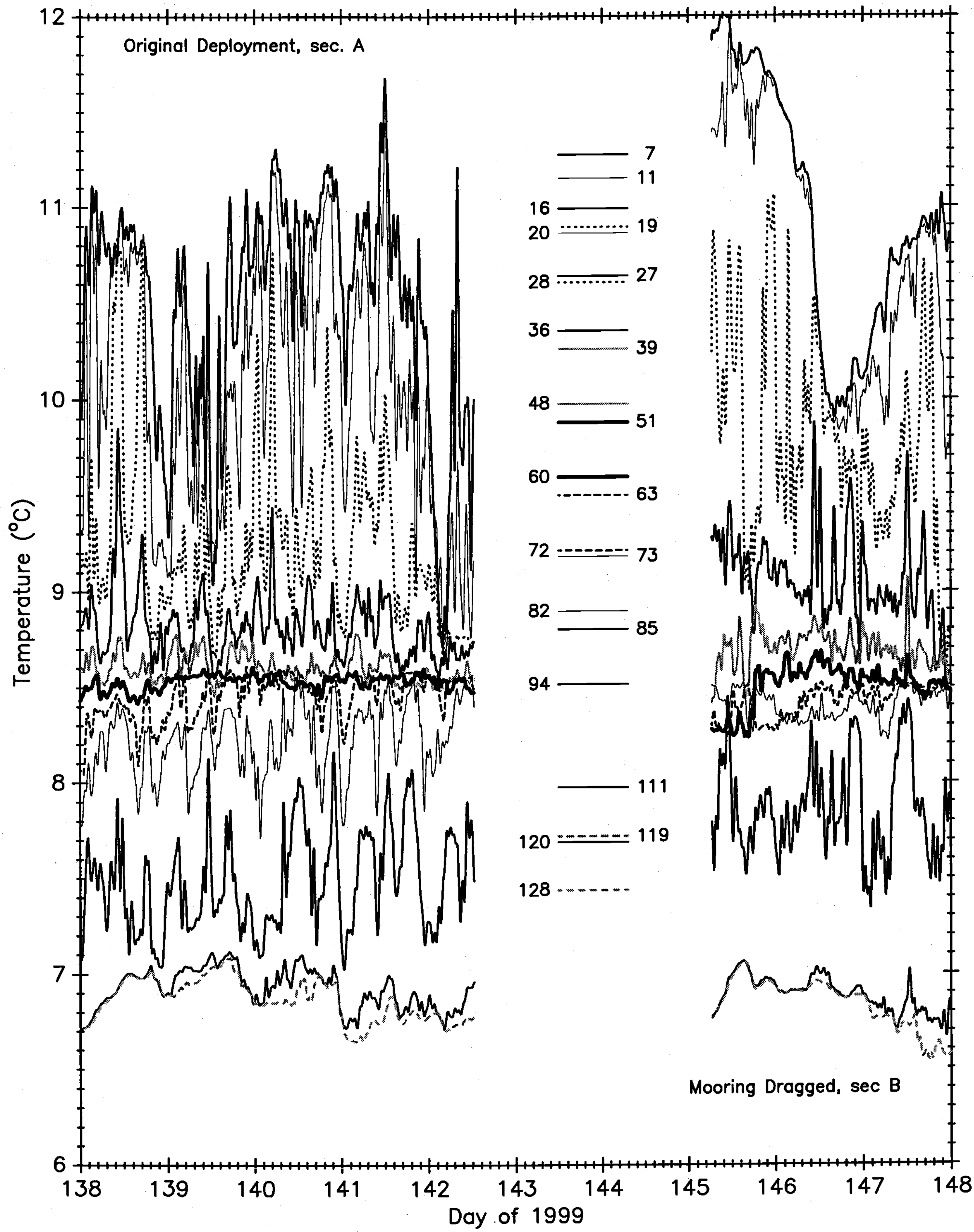
NOPP Shelf Break 1 Hour Filtered Temperatures



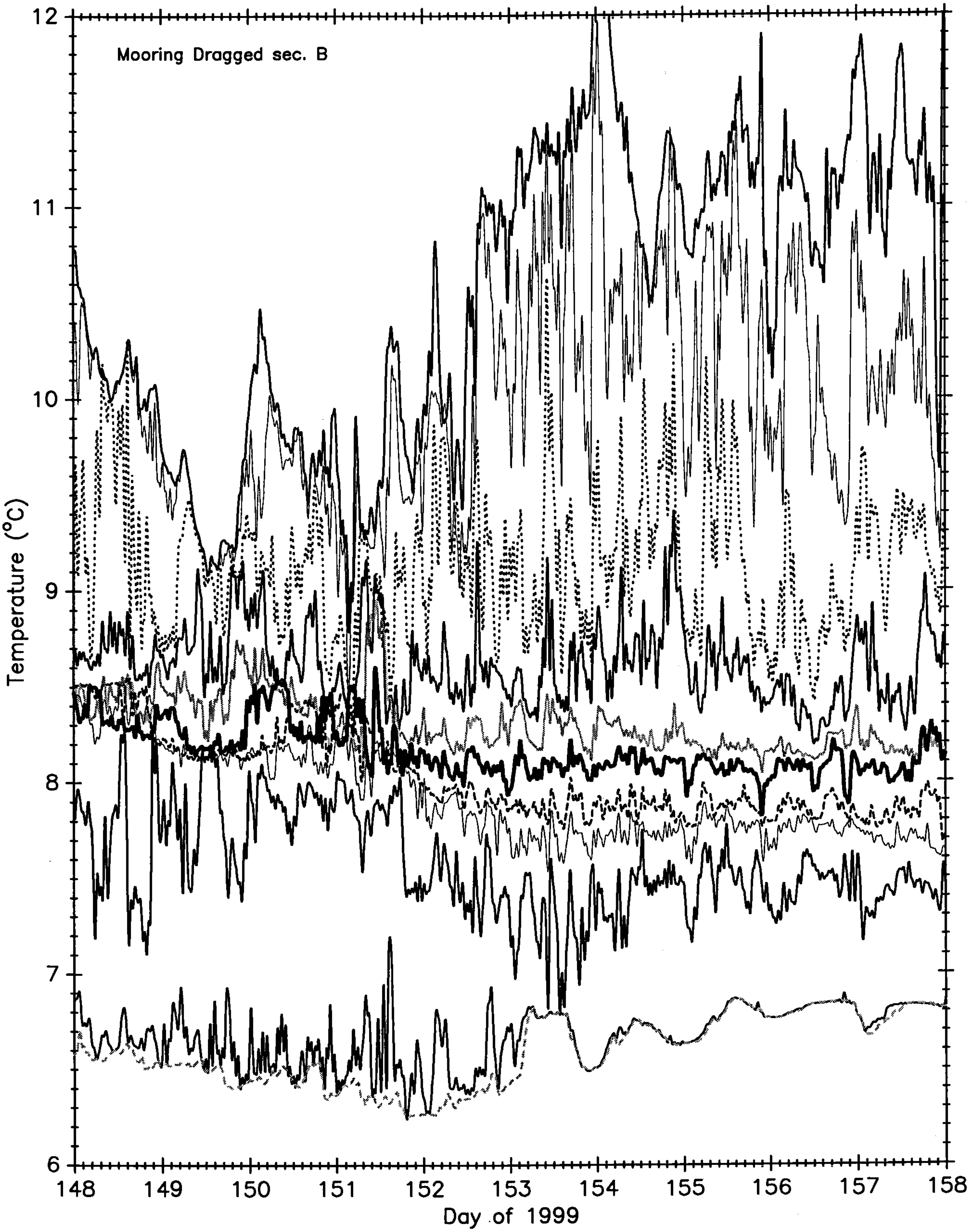
NOPP Shelf Break 1 Hour Filtered Temperatures



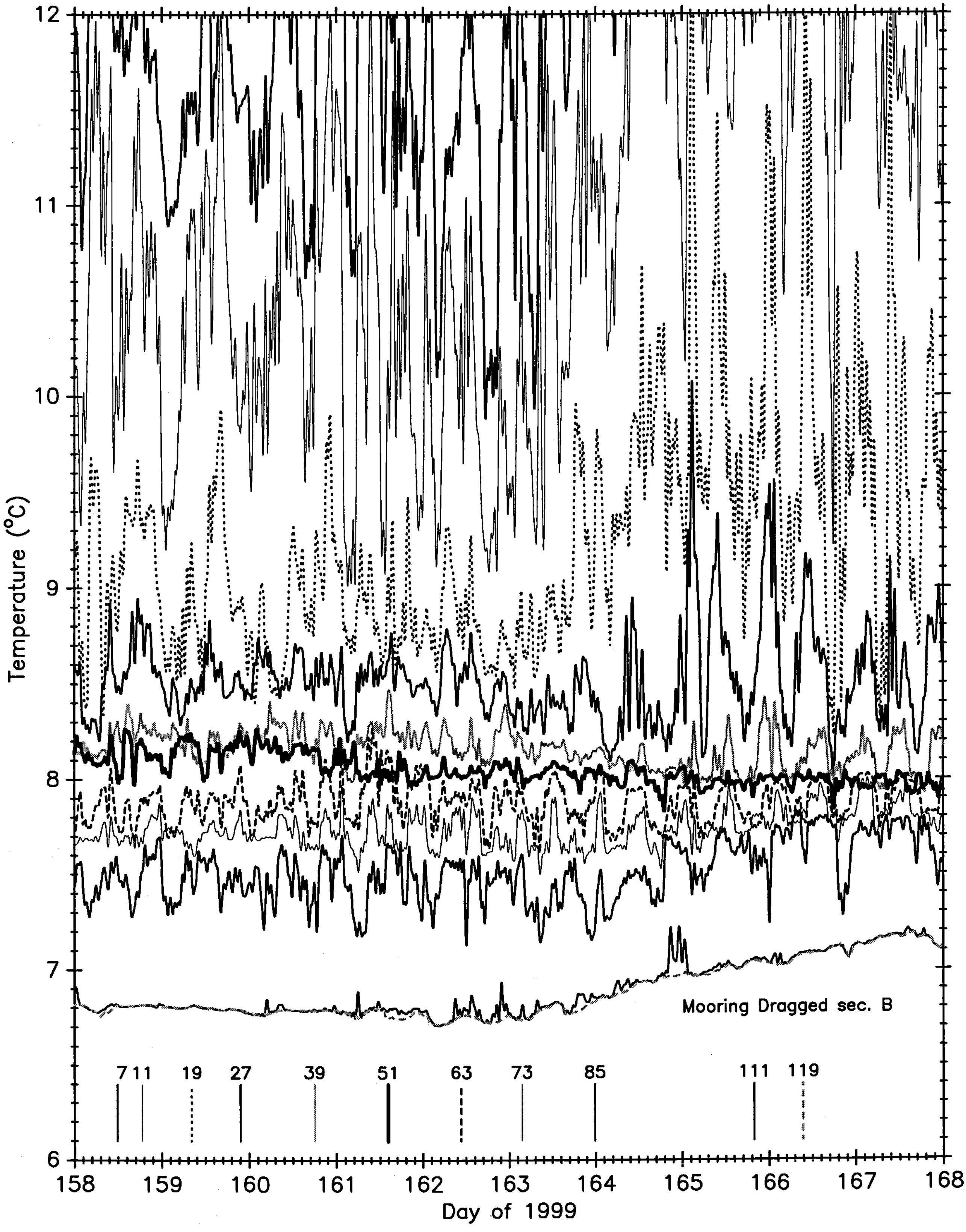
NOPP Shelf Break 1 Hour Filtered Temperatures



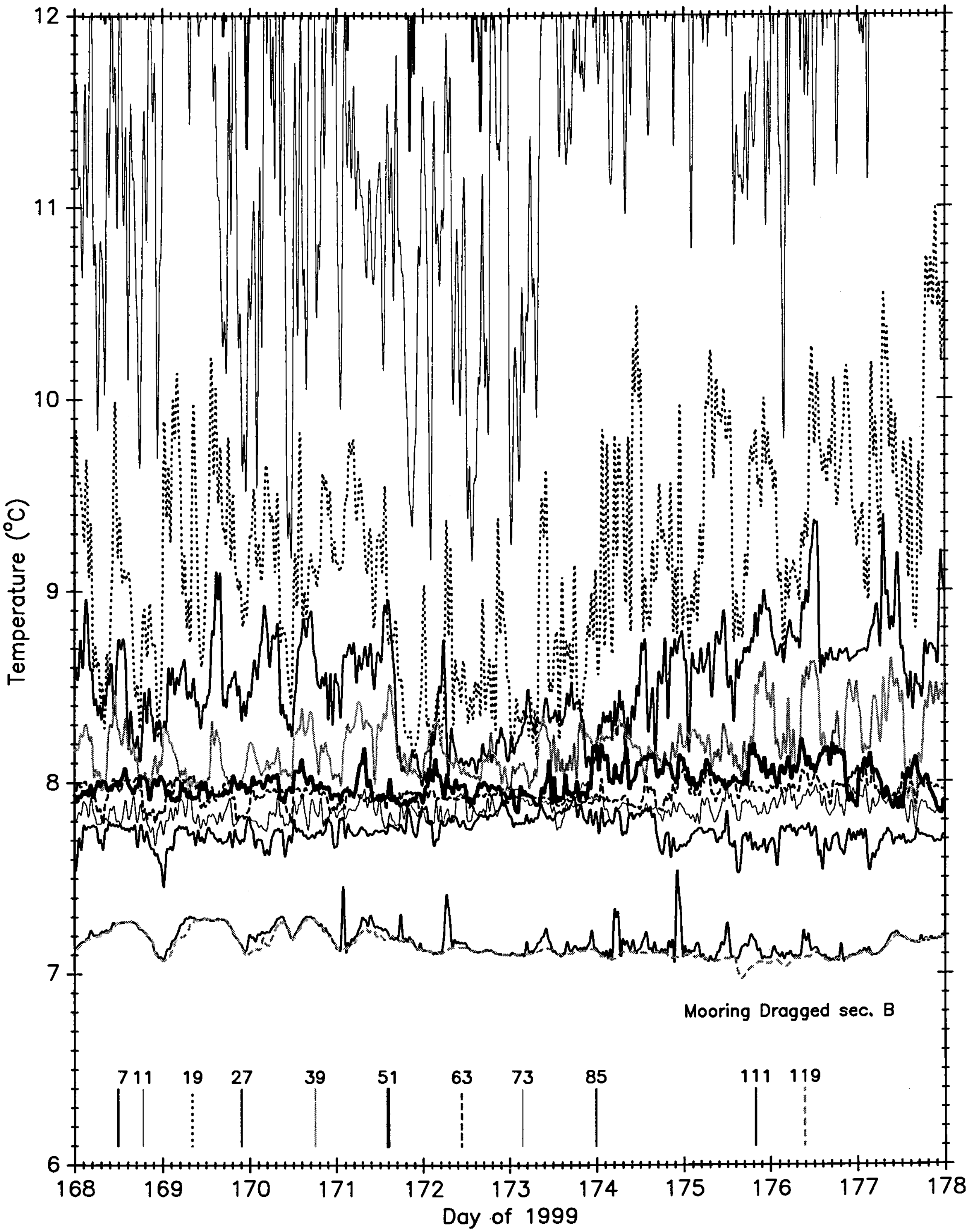
NOPP Shelf Break 1 Hour Filtered Temperatures



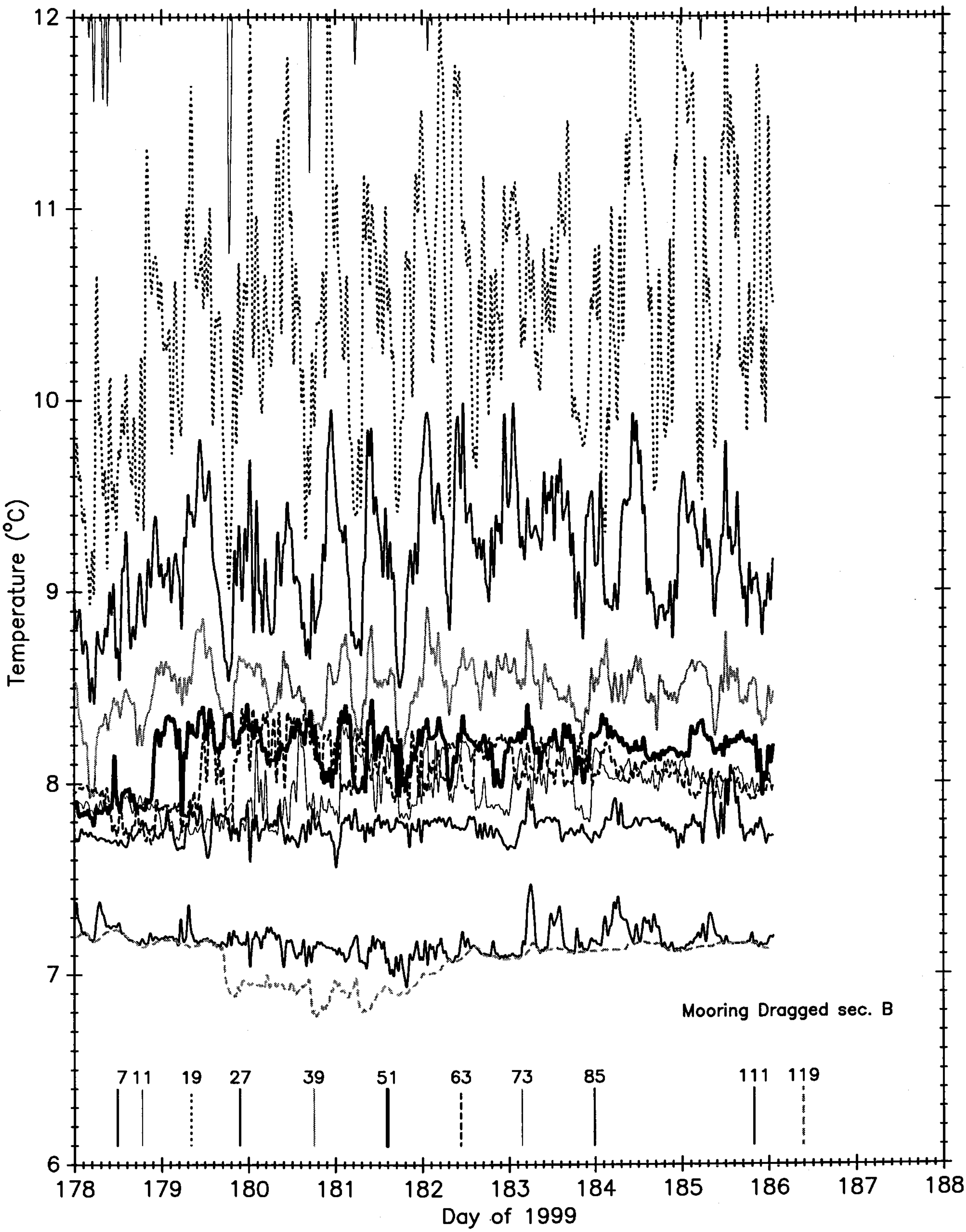
NOPP Shelf Break 1 Hour Filtered Temperatures



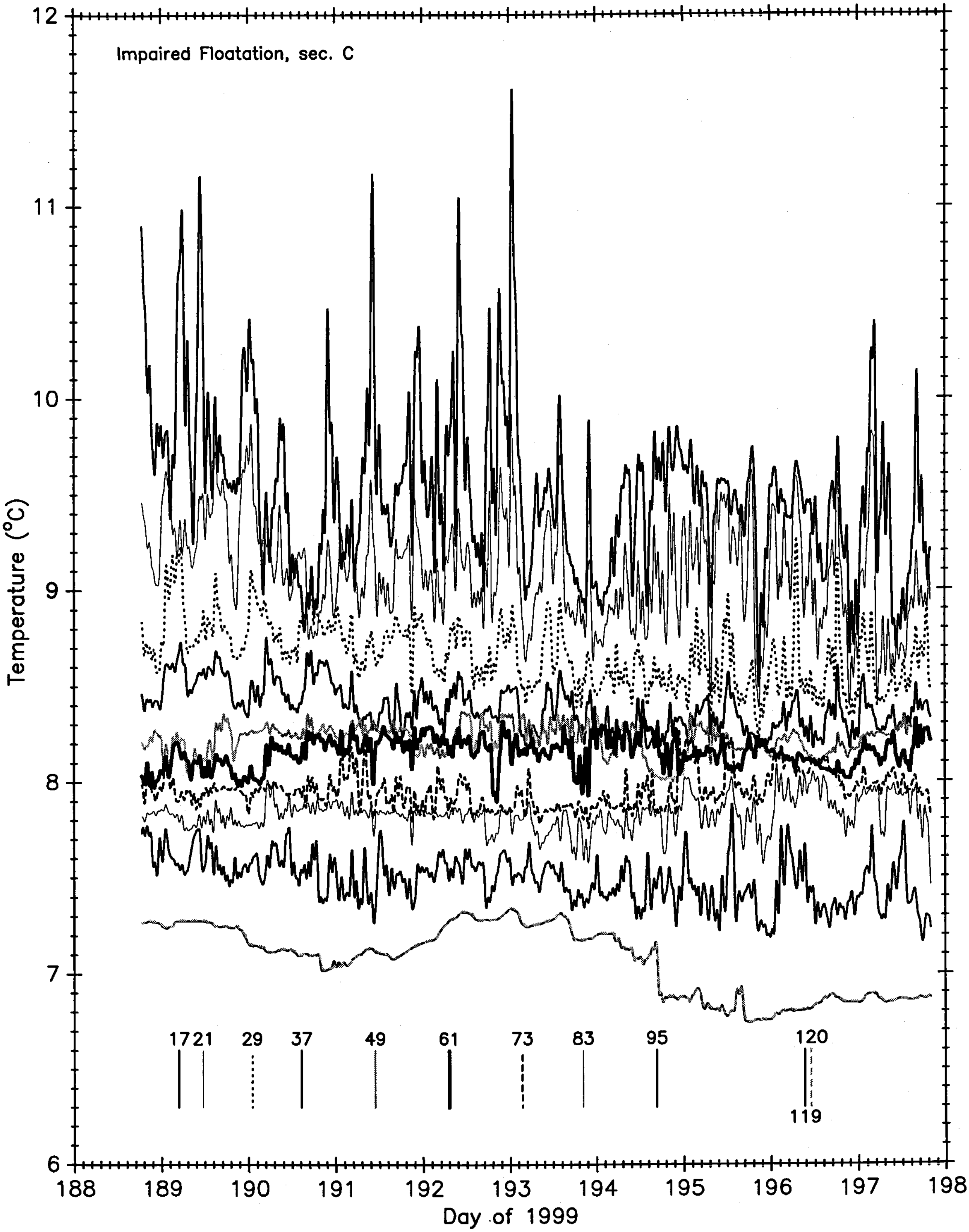
NOPP Shelf Break 1 Hour Filtered Temperatures



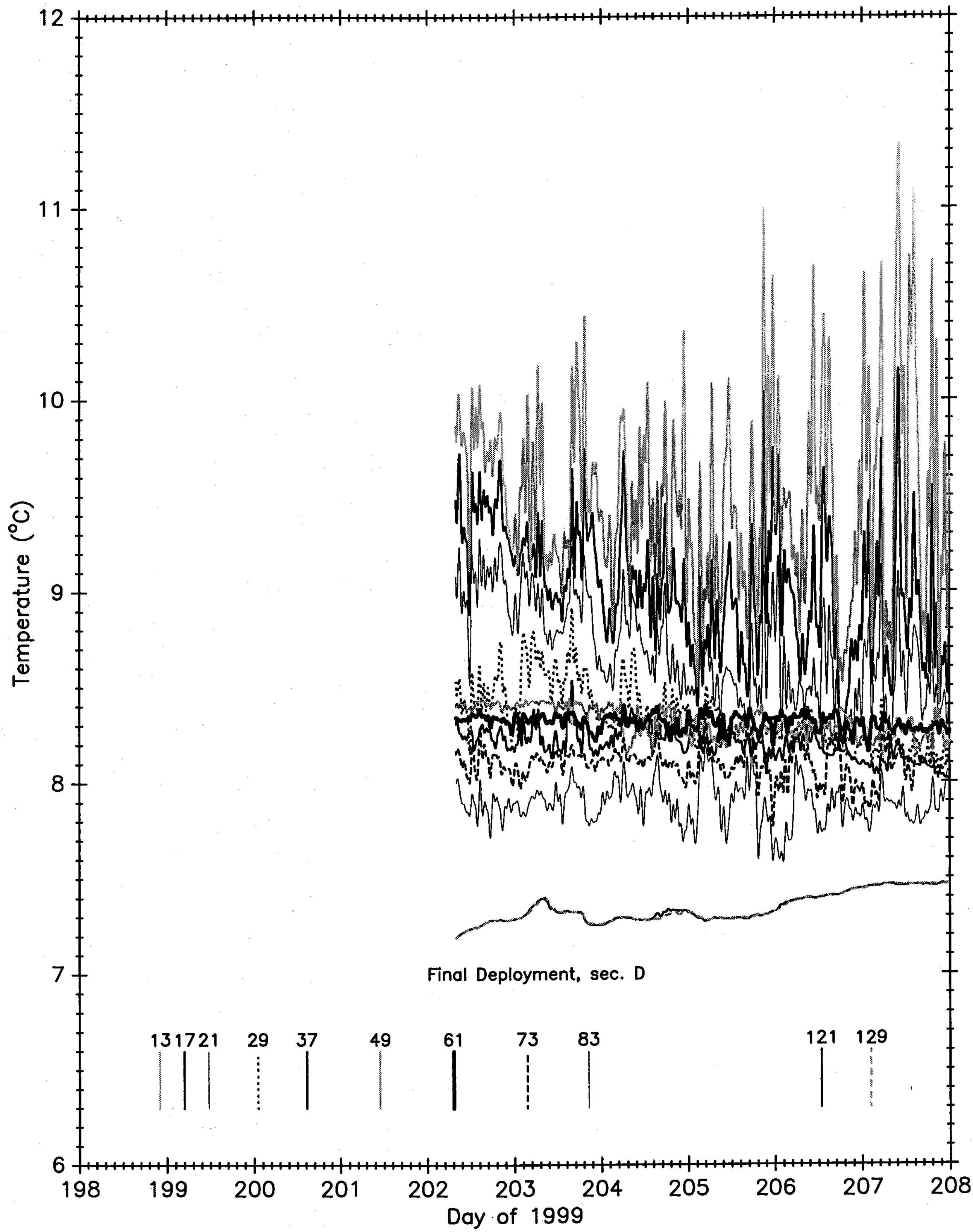
NOPP Shelf Break 1 Hour Filtered Temperatures



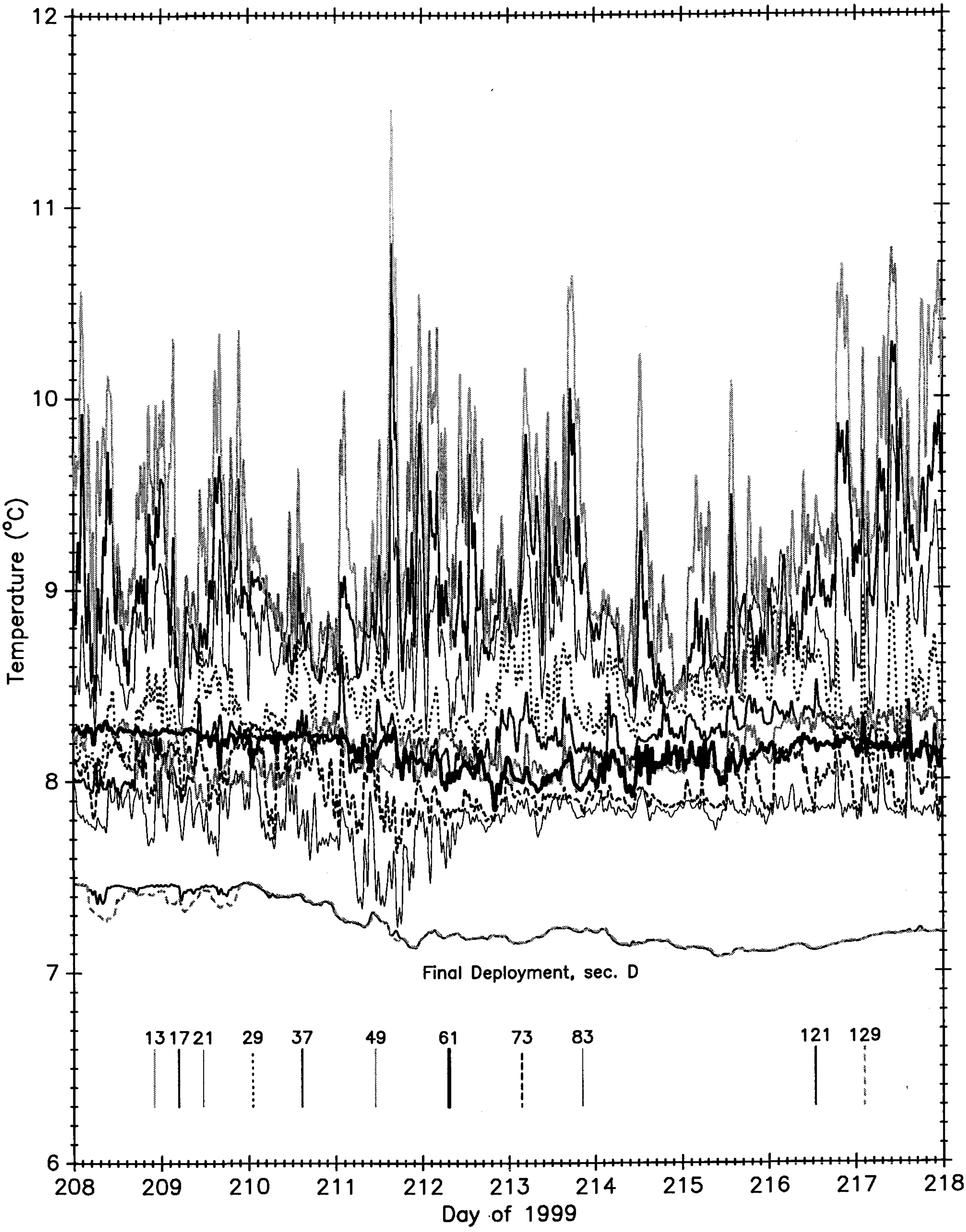
NOPP Shelf Break 1 Hour Filtered Temperatures



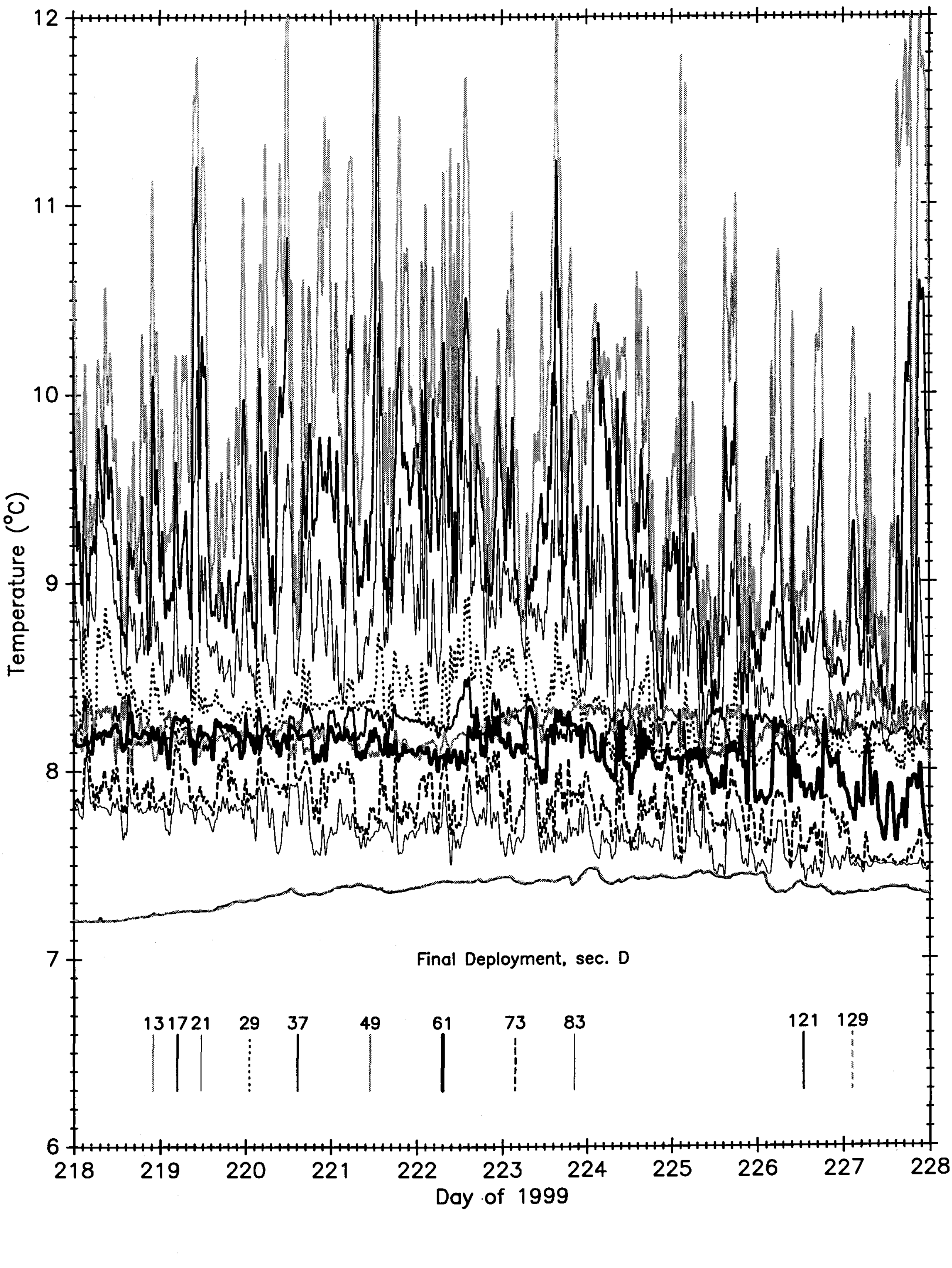
NOPP Shelf Break 1 Hour Filtered Temperatures



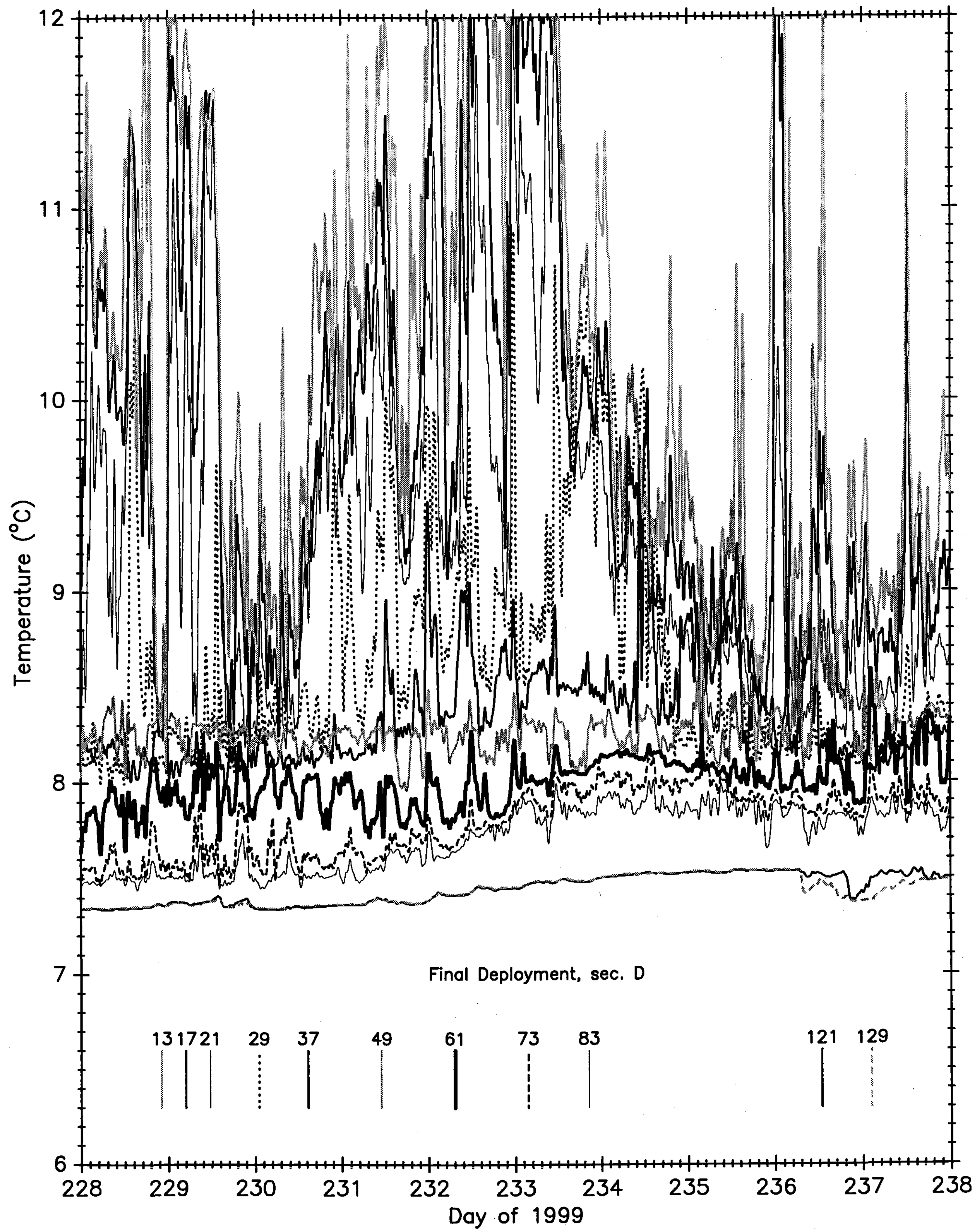
NOPP Shelf Break 1 Hour Filtered Temperatures



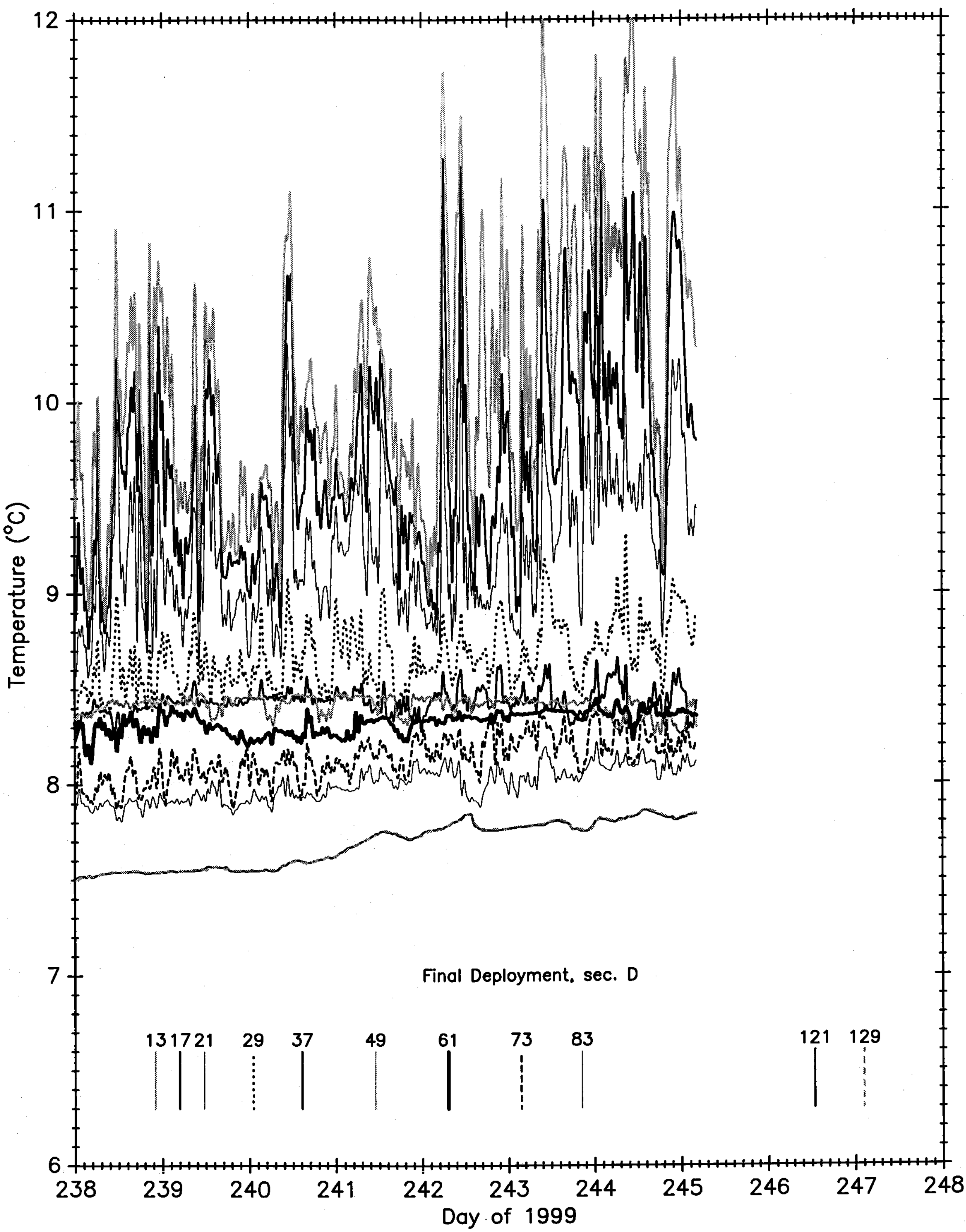
NOPP Shelf Break 1 Hour Filtered Temperatures



NOPP Shelf Break 1 Hour Filtered Temperatures



NOPP Shelf Break 1 Hour Filtered Temperatures

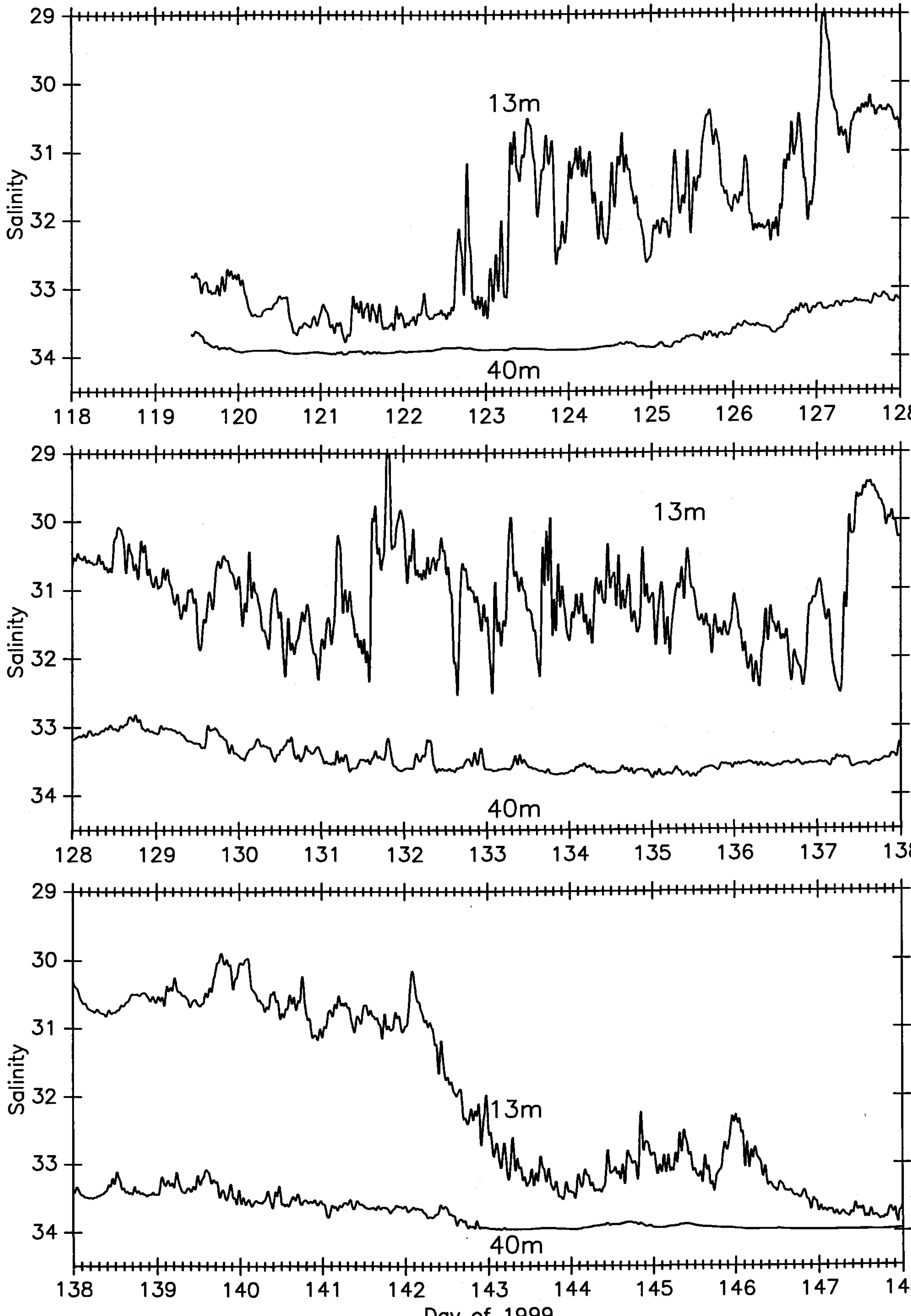


SALINITY Time Series

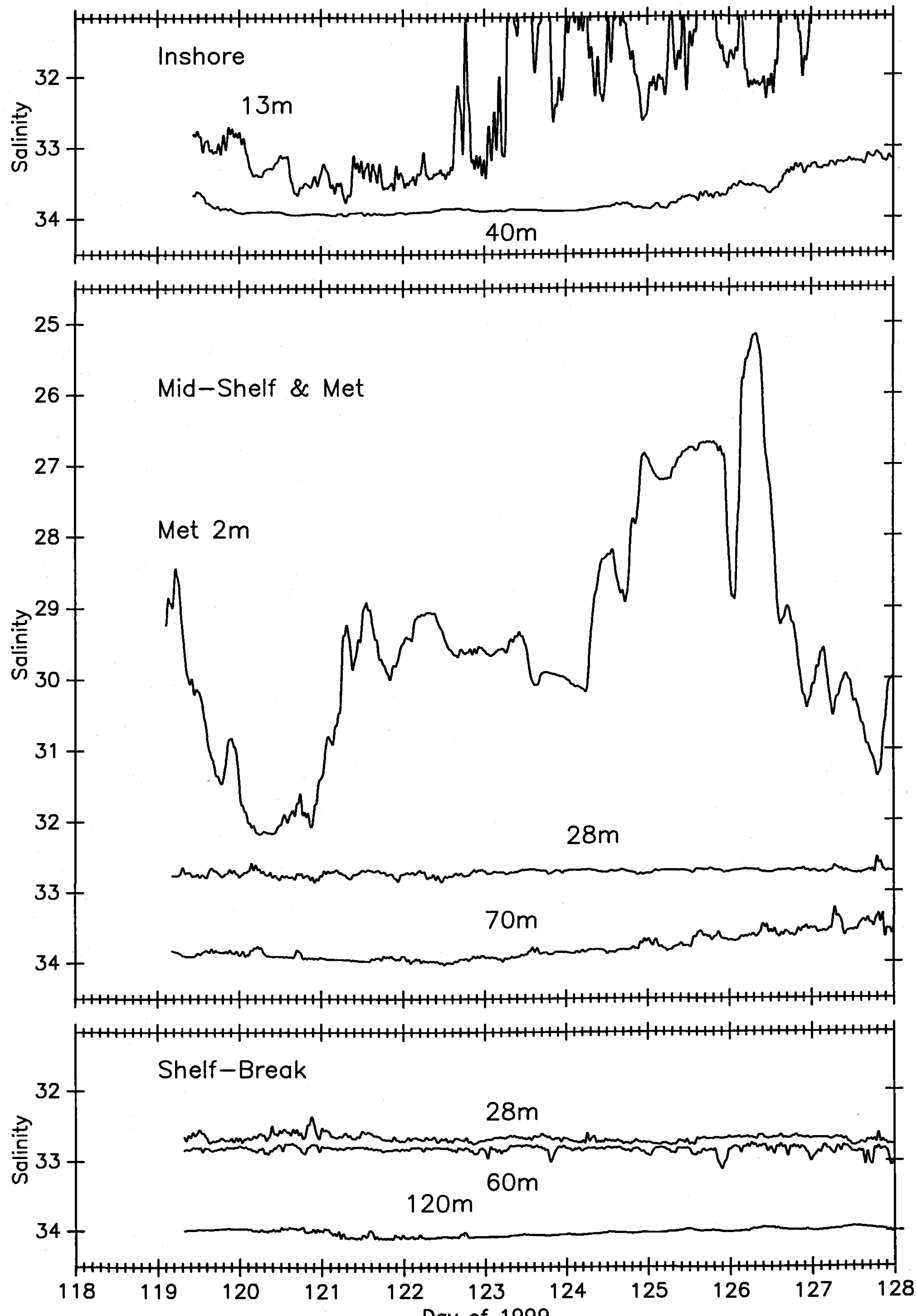
1-hour Low-Pass Filtered

Plots of salinity from the Inshore, Mid-Shelf, Met, and Shelf-Break. Note that the salinity scale is the same on all plots, although the range is greater for the combined plot of combined Mid-Shelf & Met mooring salinities. Note the gap in Shelf-Break mooring salinity records after day 143, corresponding to the changes of depth associated with the mooring being hit by the trawler. Plots of salinity from 29 m and 61 m are presented for the duration of period C, following the loss of buoyancy from the Shelf-Break mooring on day 186. Salinity from 119 m during this period is omitted as unreliable. Inshore mooring salinity is also plotted separately for the period prior to day 148, to accommodate the low near-surface values near the beginning of the record.

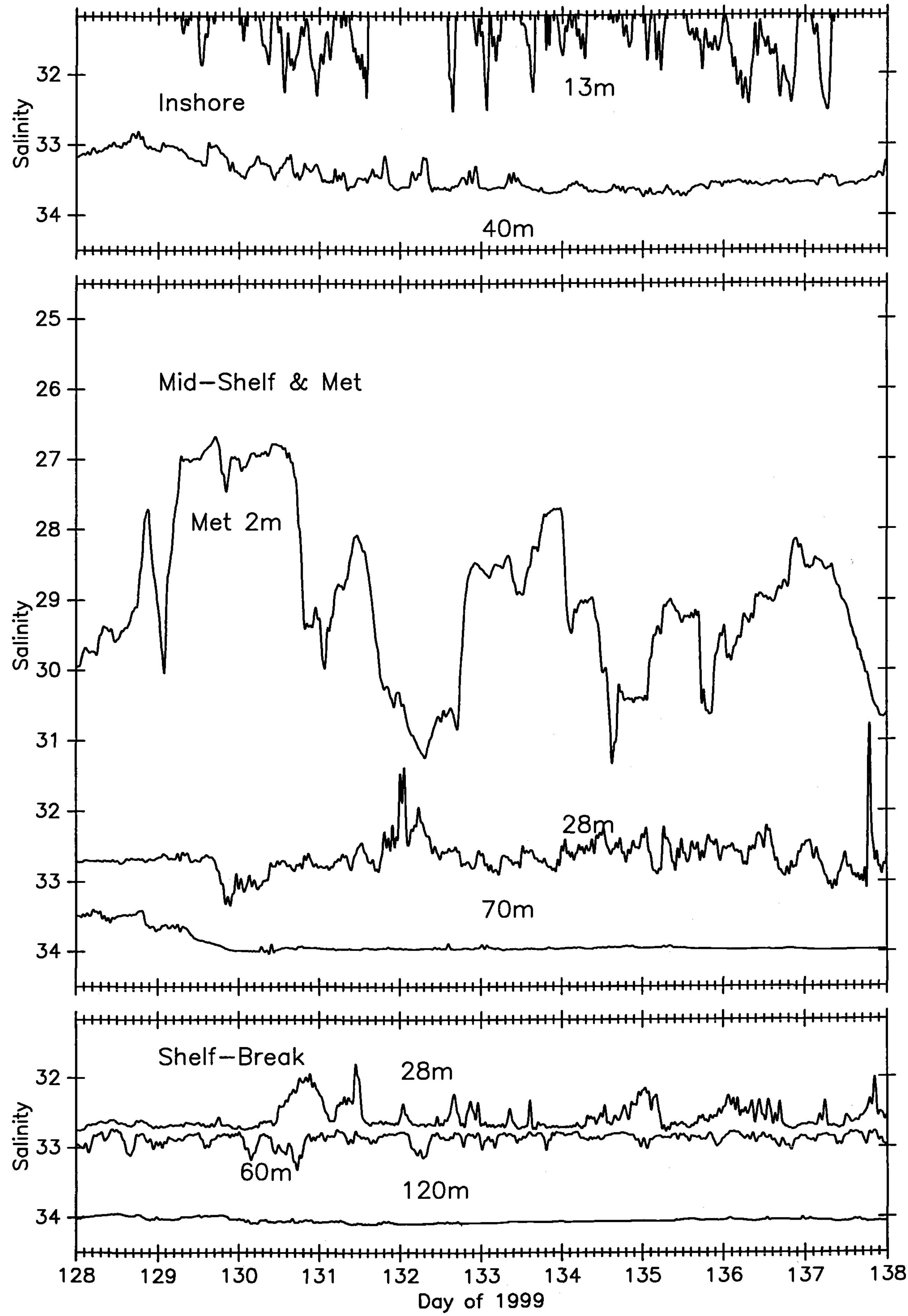
NOPP Inshore Mooring 1 Hour Filtered Salinities



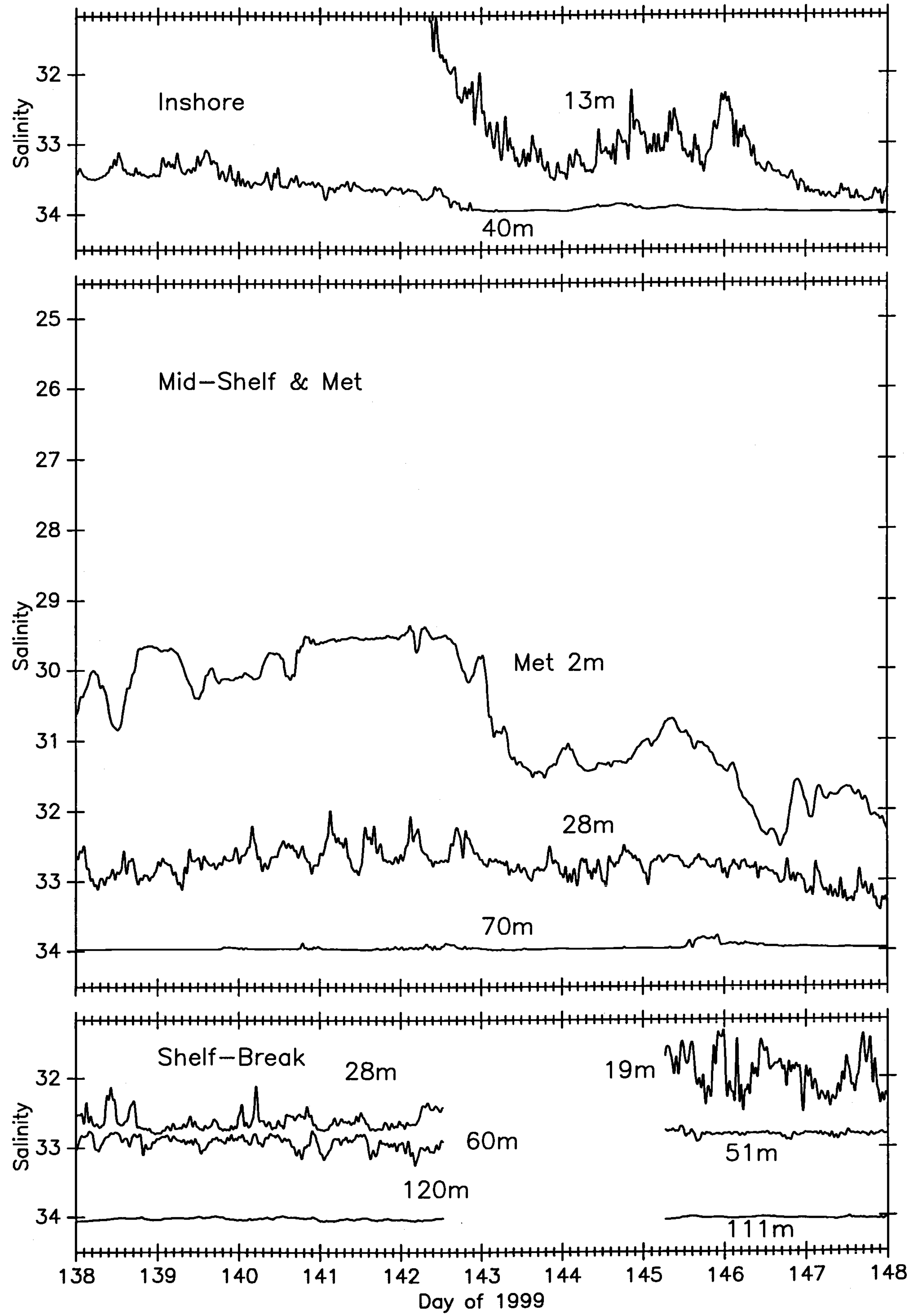
NOPP 1 Hour Filtered Salinities



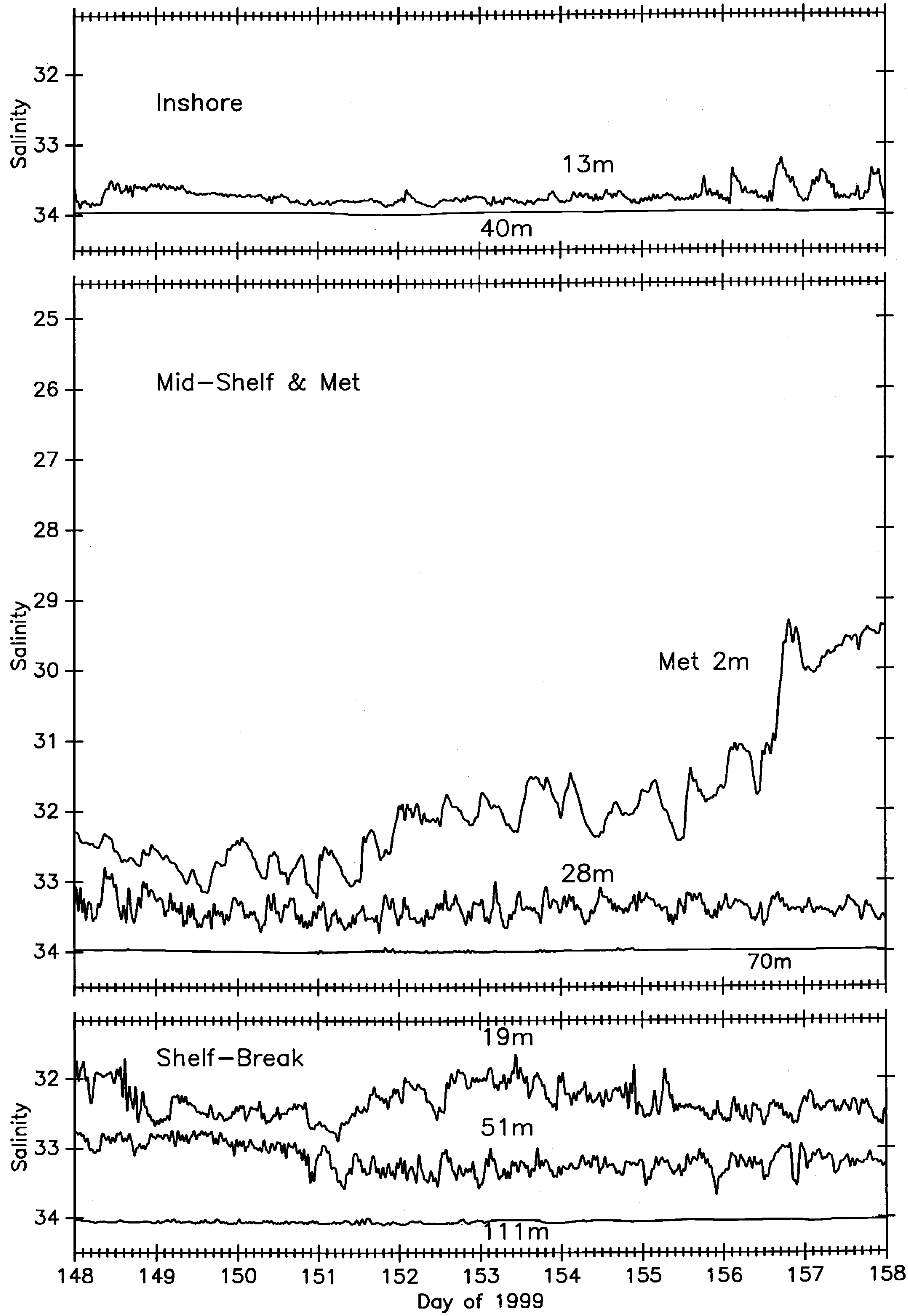
NOPP 1 Hour Filtered Salinities



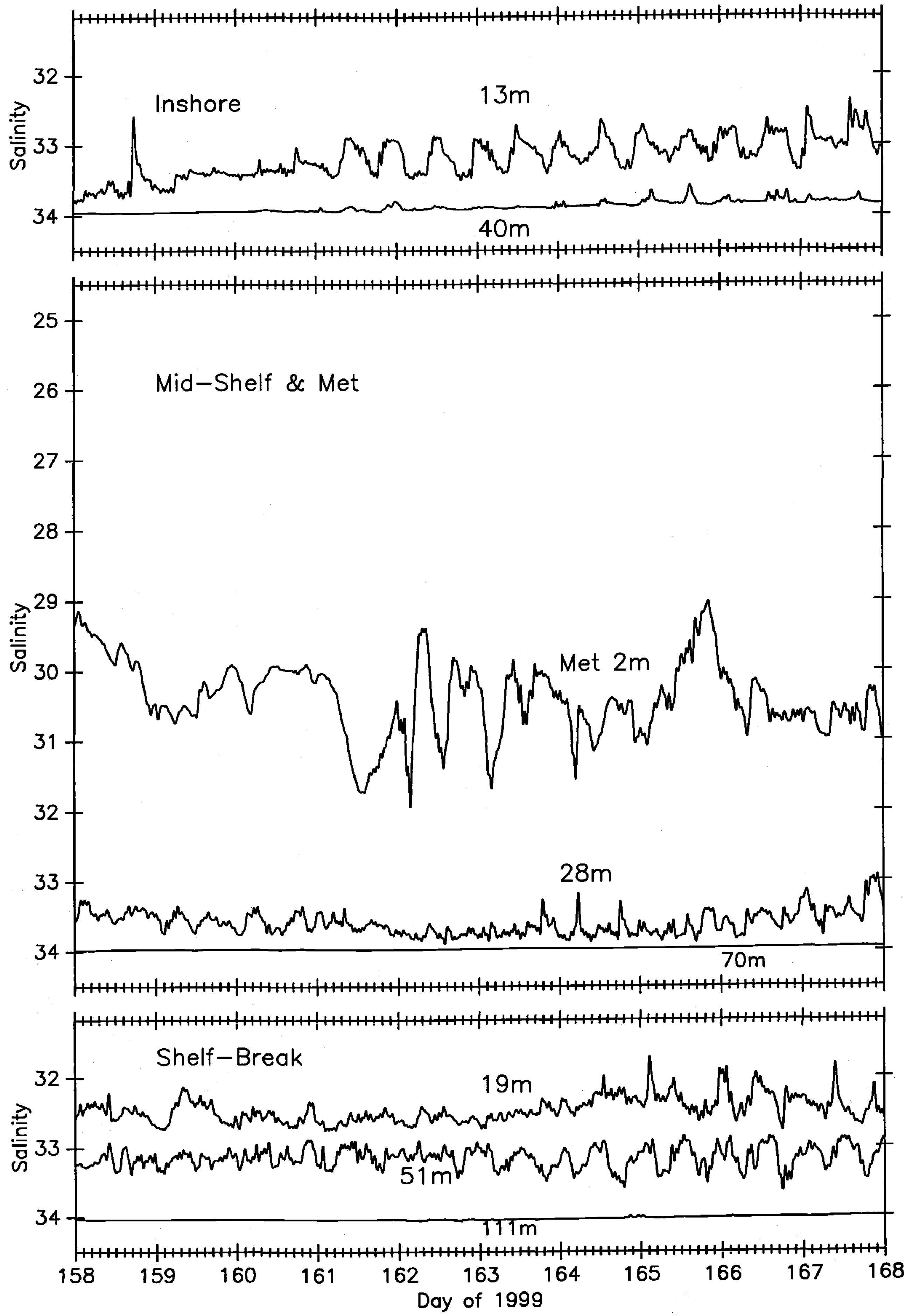
NOPP 1 Hour Filtered Salinities



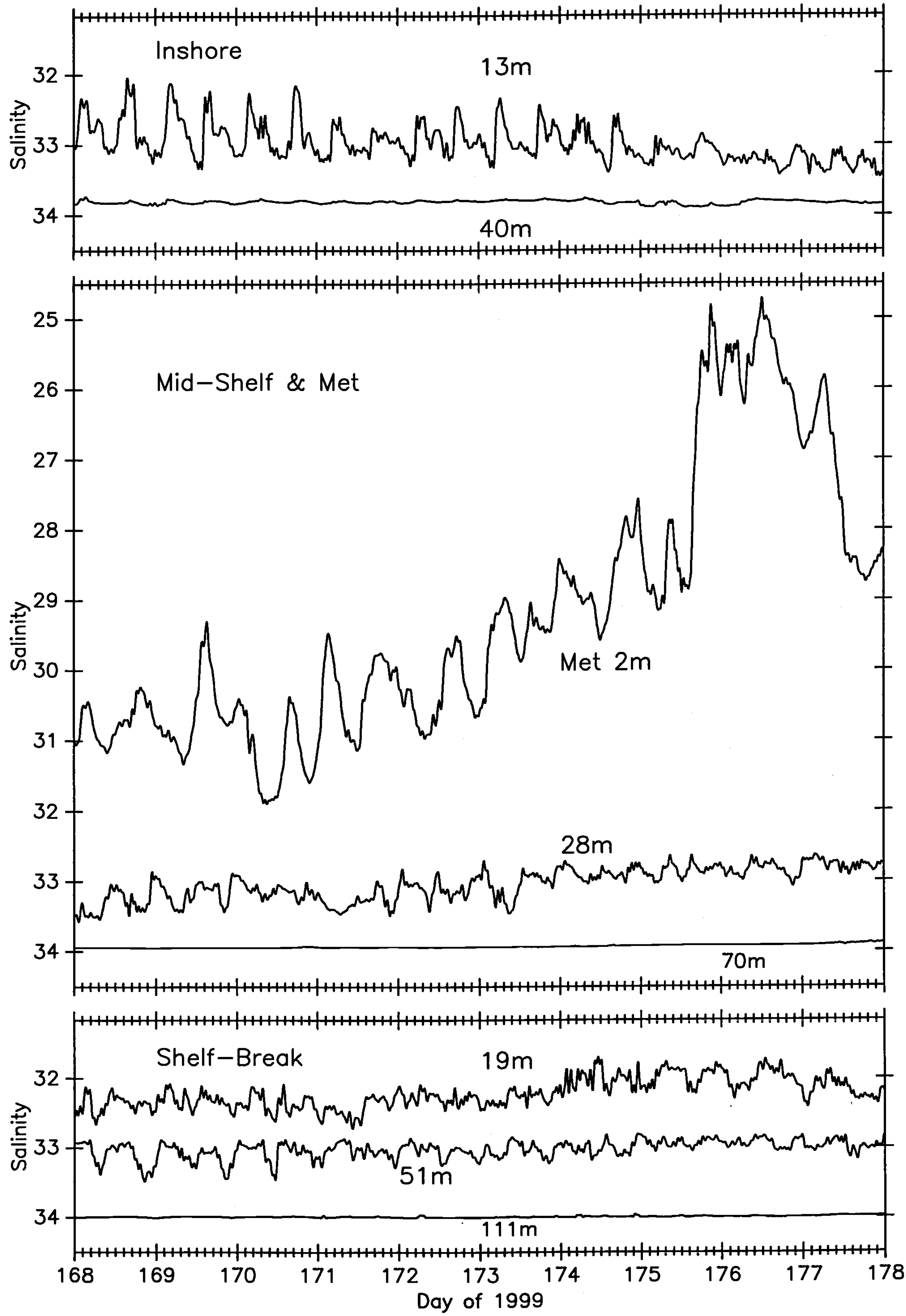
NOPP 1 Hour Filtered Salinities



NOPP 1 Hour Filtered Salinities



NOPP 1 Hour Filtered Salinities



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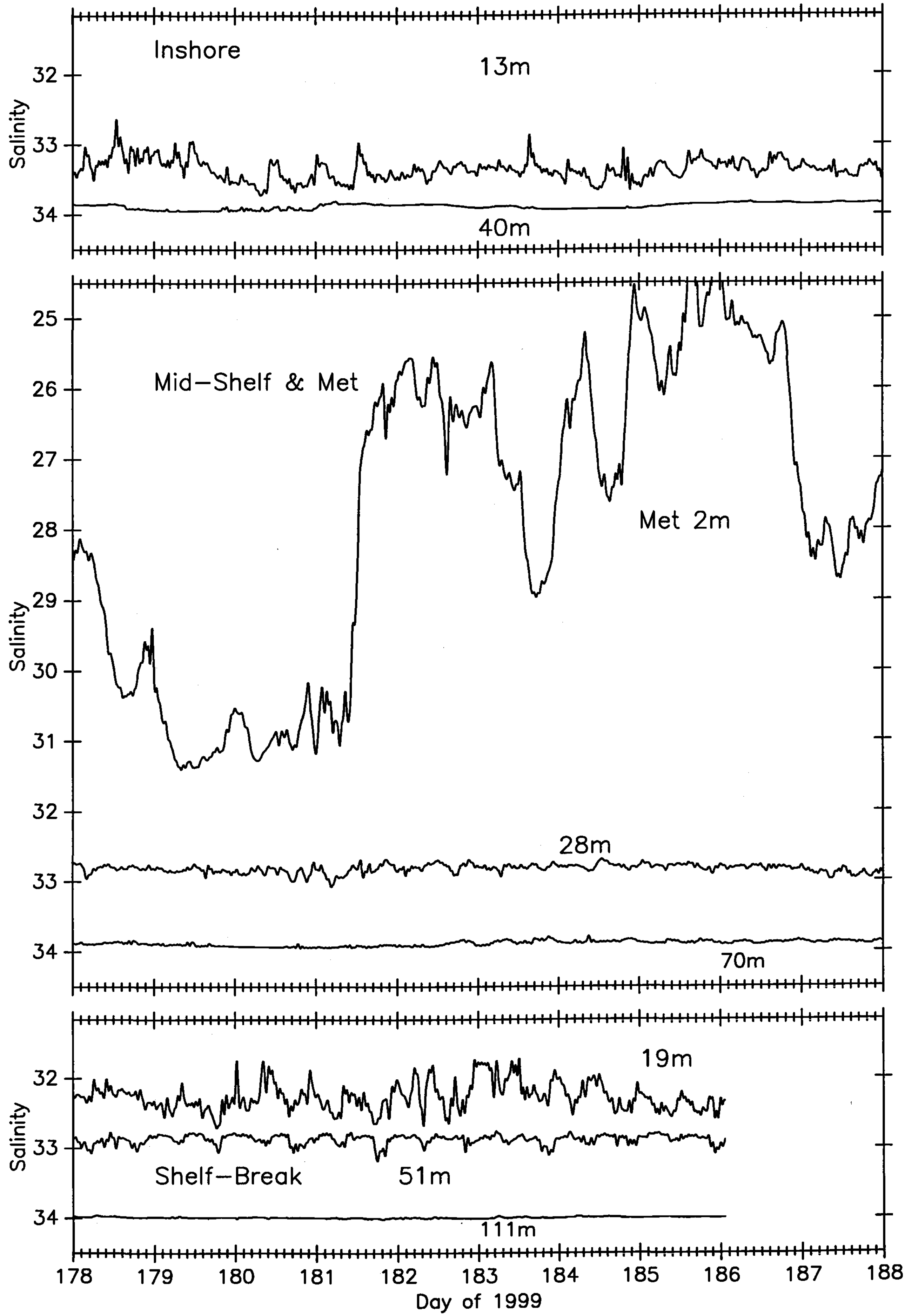
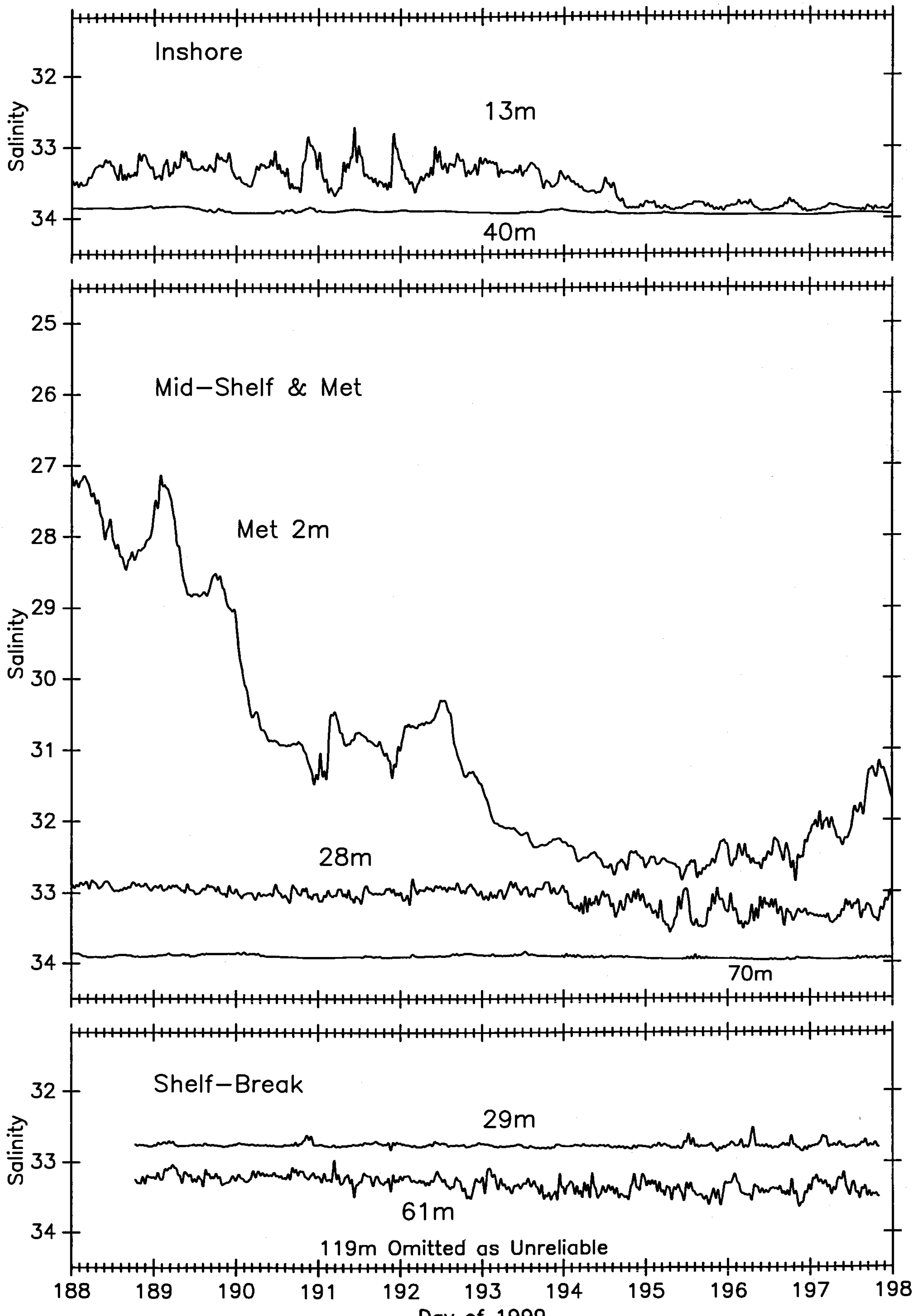
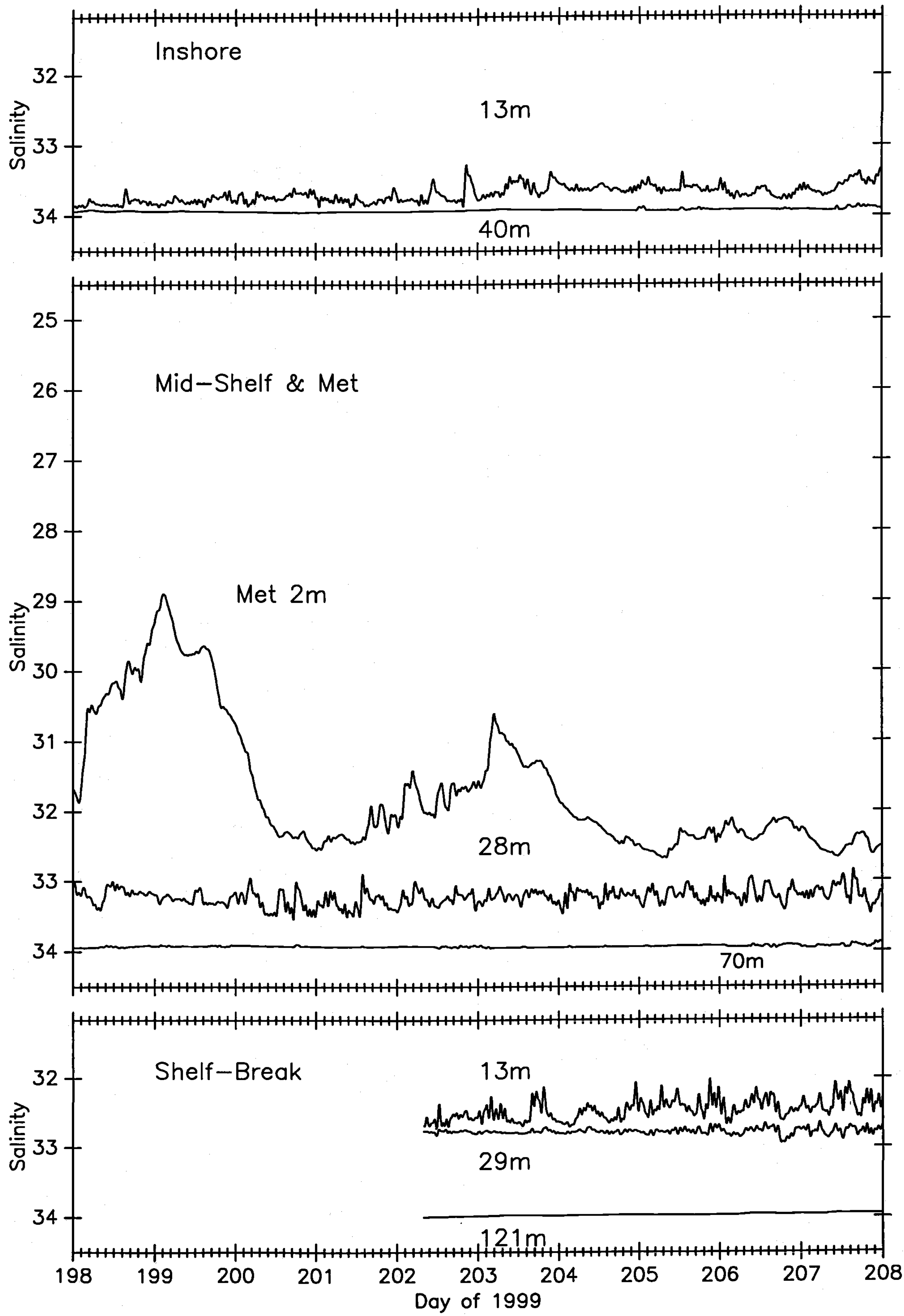


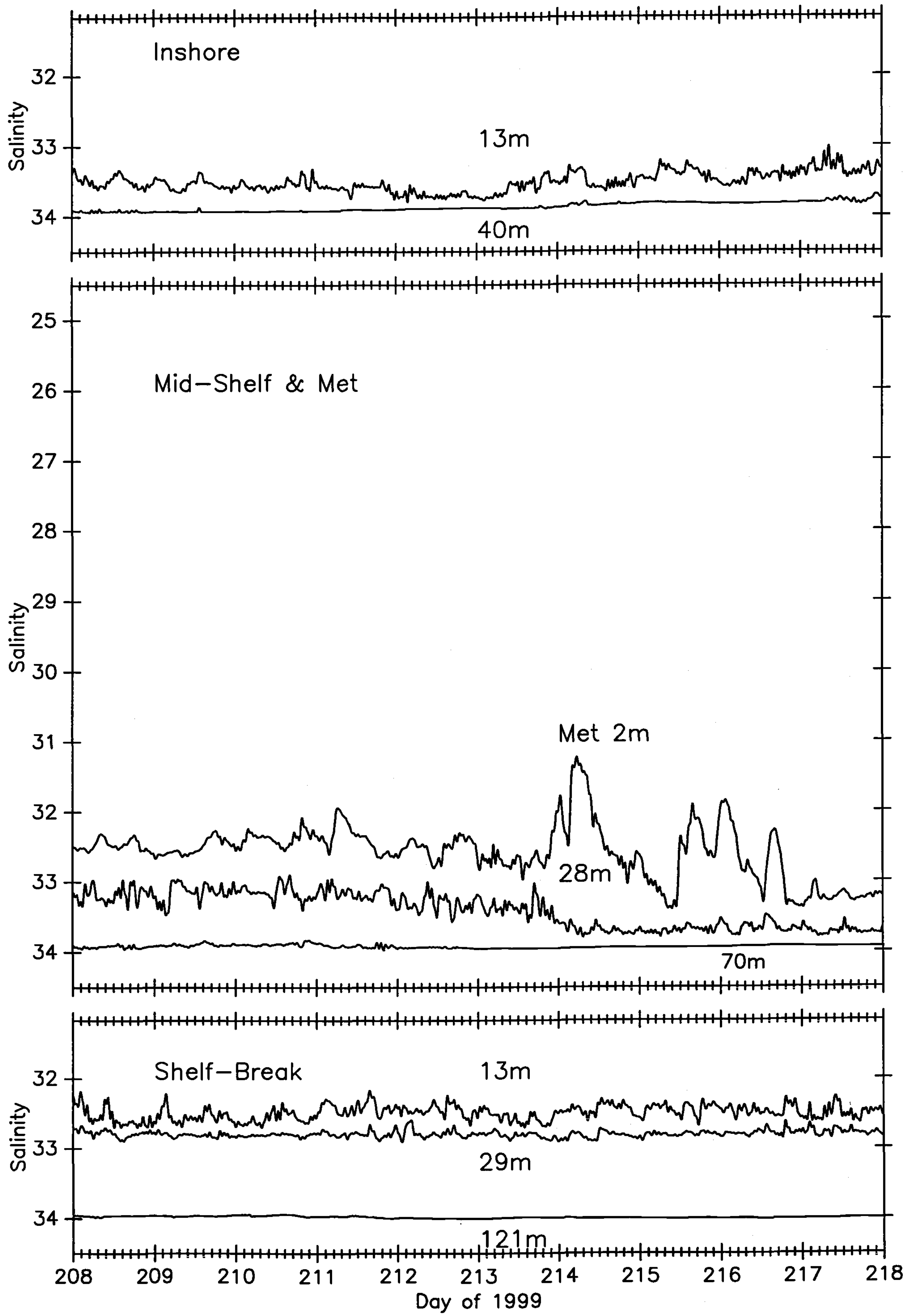
NOPP 1 Hour Filtered Salinities



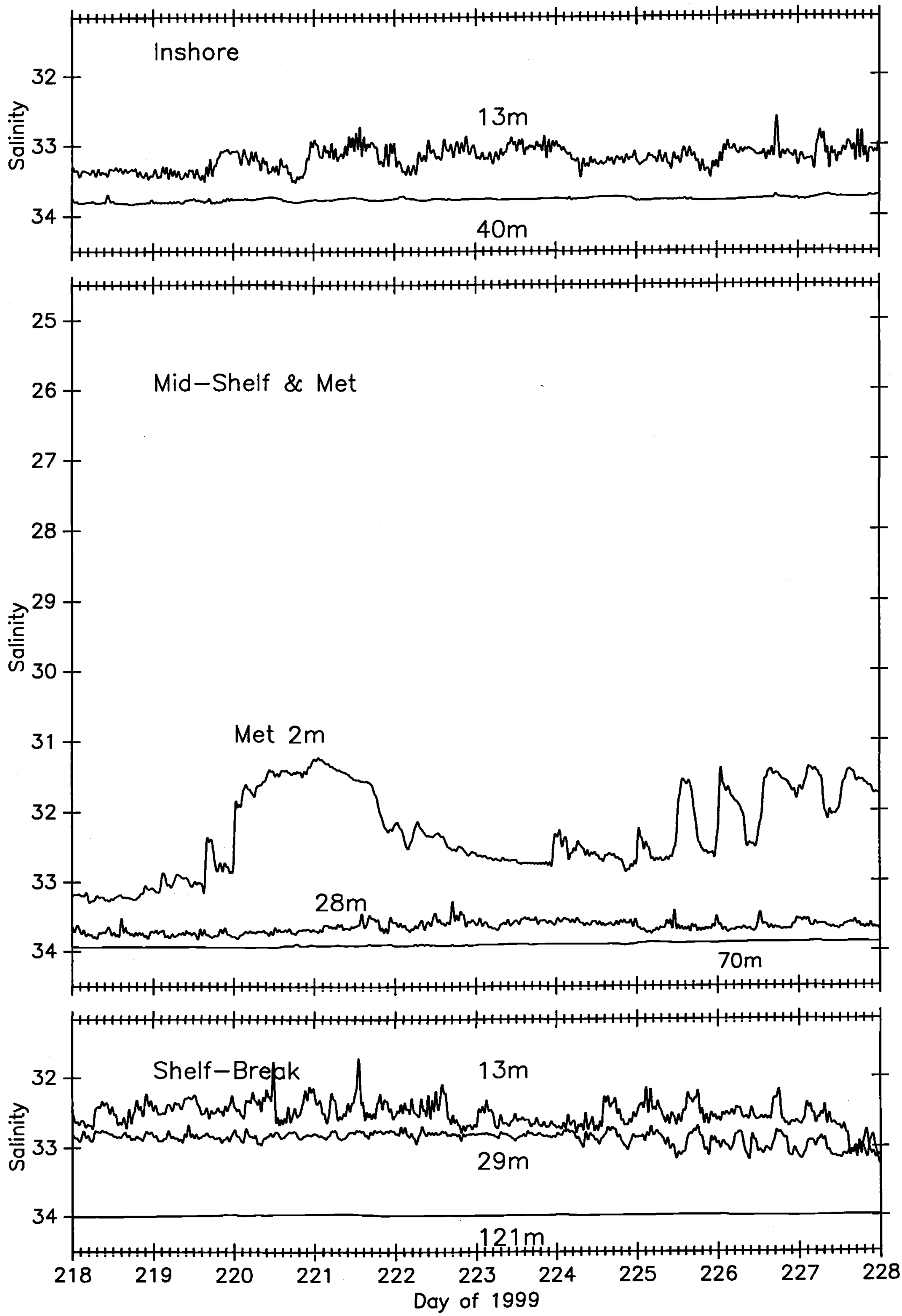
NOPP 1 Hour Filtered Salinities



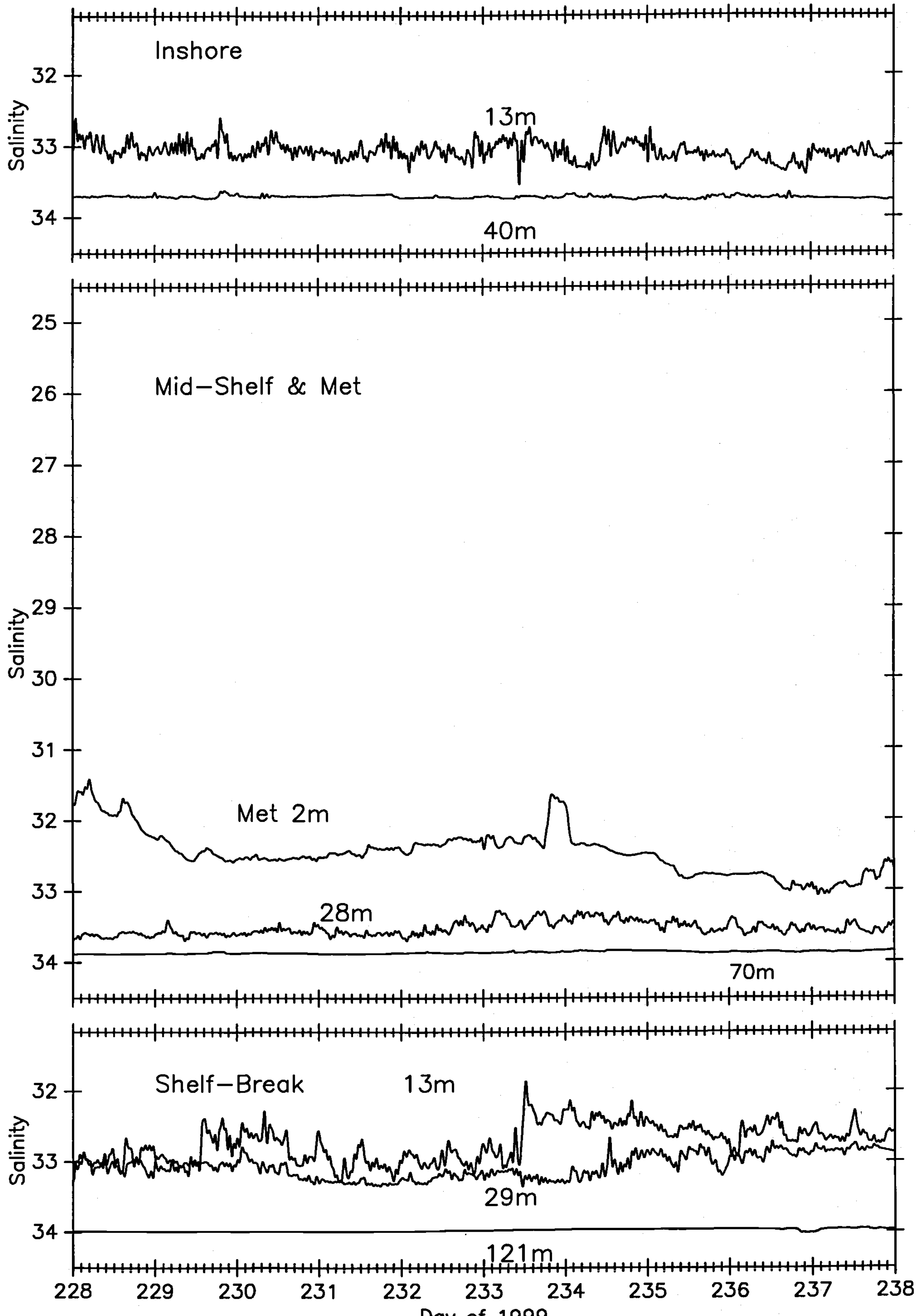
NOPP 1 Hour Filtered Salinities



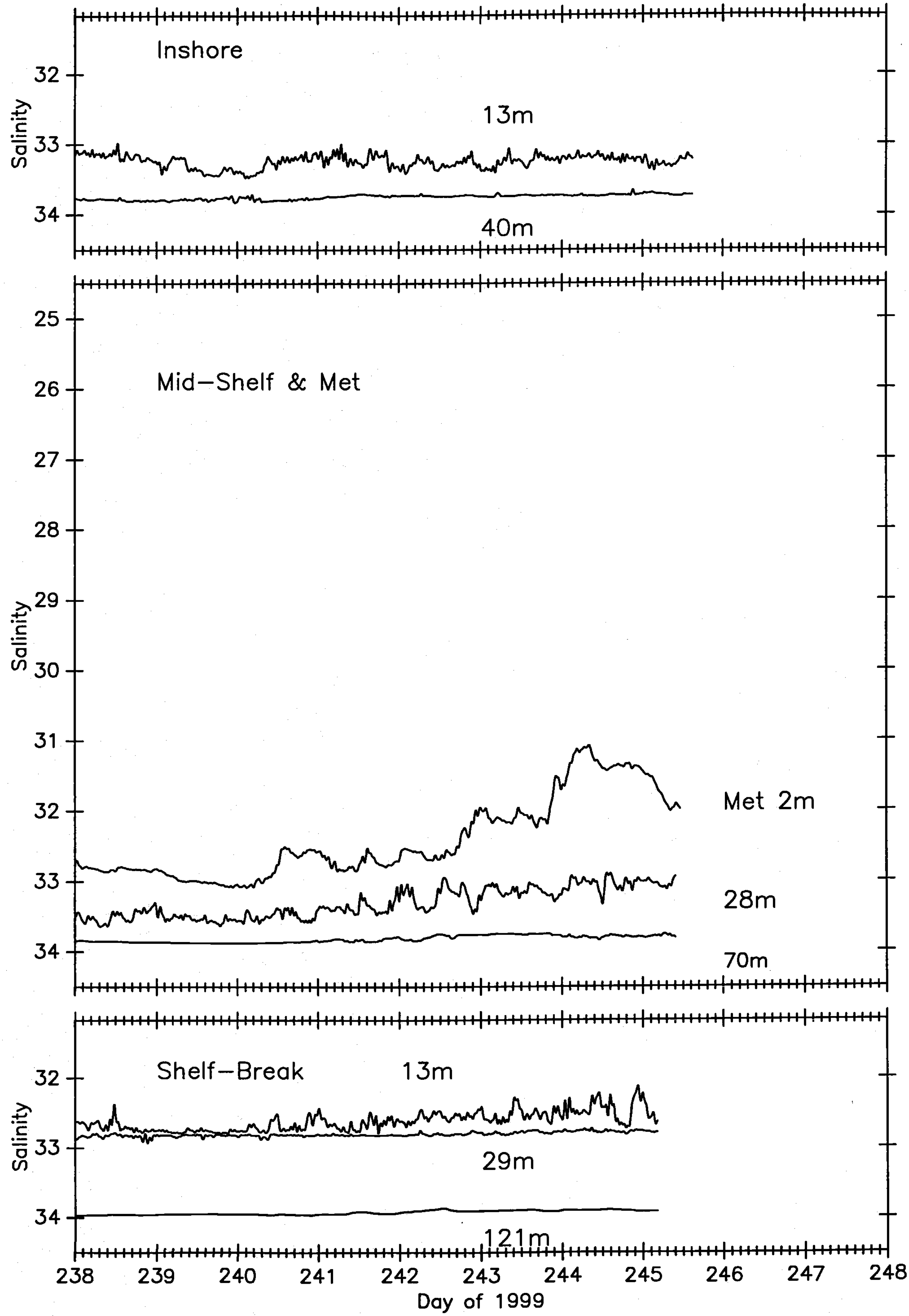
NOPP 1 Hour Filtered Salinities



NOPP 1 Hour Filtered Salinities



NOPP 1 Hour Filtered Salinities



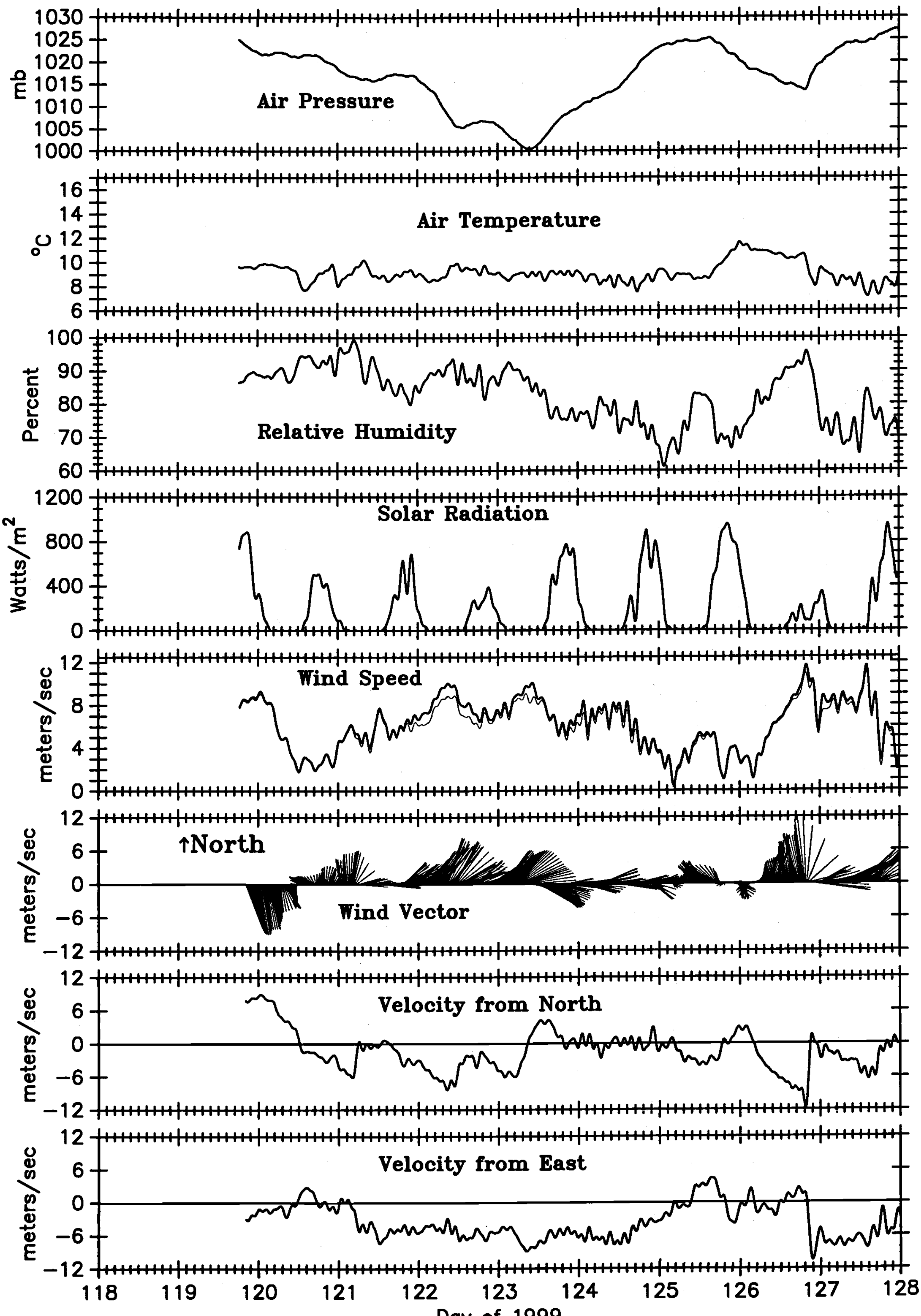
METEOROLOGICAL Time Series

1-hour Low-Pass Filtered

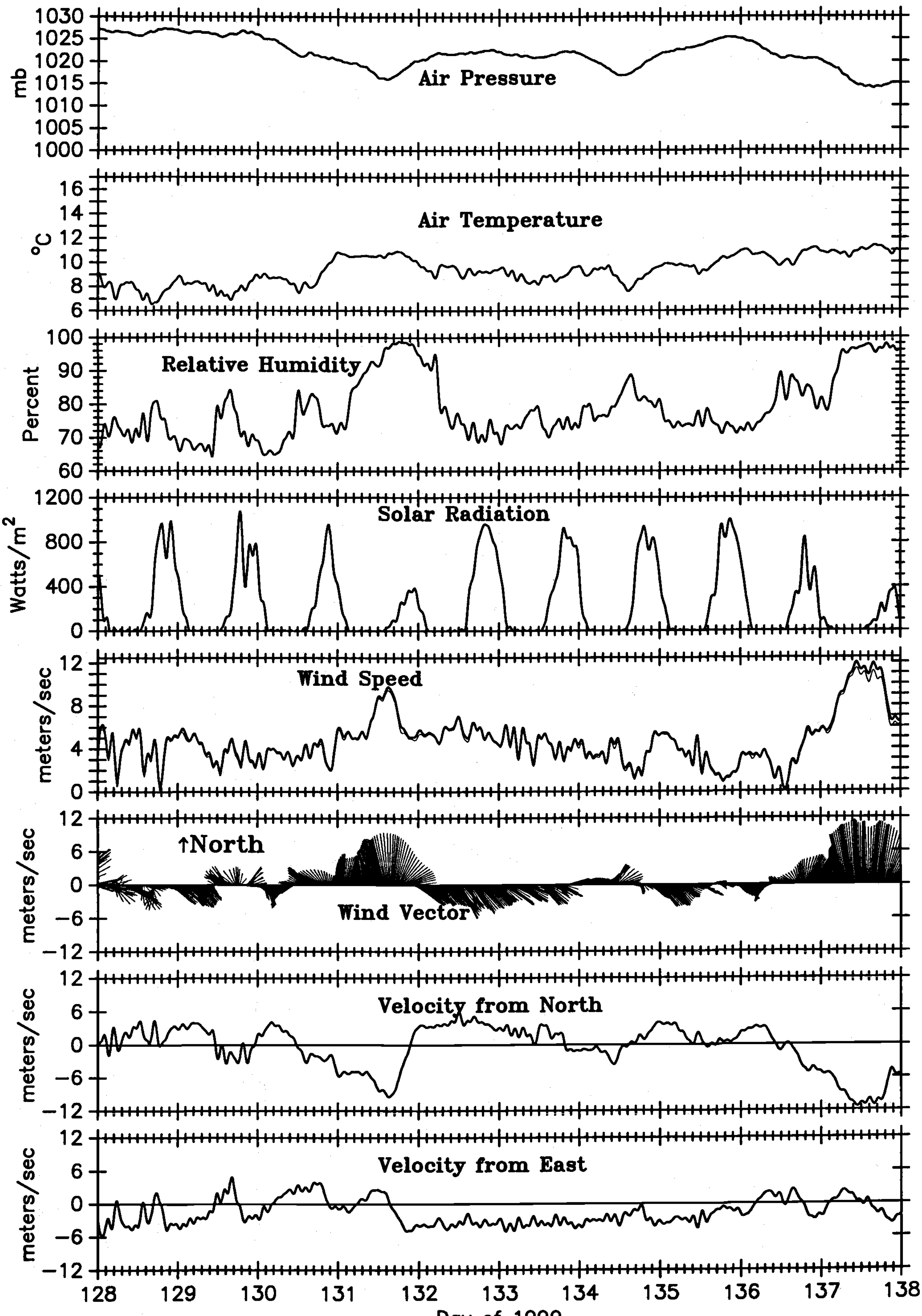
Plots of air pressure, air temperature, relative humidity, solar radiation, wind speed, wind vectors and velocity. Wind velocity components are presented in the meteorological convention: velocity from north and from east. Wind velocity vectors are shown at hourly intervals. Wind speed is plotted both as converted anemometer rotor counts (bold line) and as magnitude of the vector-averaged velocity (light line). No wind data is available for the period between loss of the anemometer on day 203 and replacement of the anemometer on day 215. Wind direction is not provided for the period following the anemometer replacement due to ambiguity in the orientation of the replacement anemometer.

Plots of shortwave solar radiation, wind speed (magnitude of the vector-averaged velocity), and 2-m water temperature from the Met, Inshore, and Shelf-Break moorings.

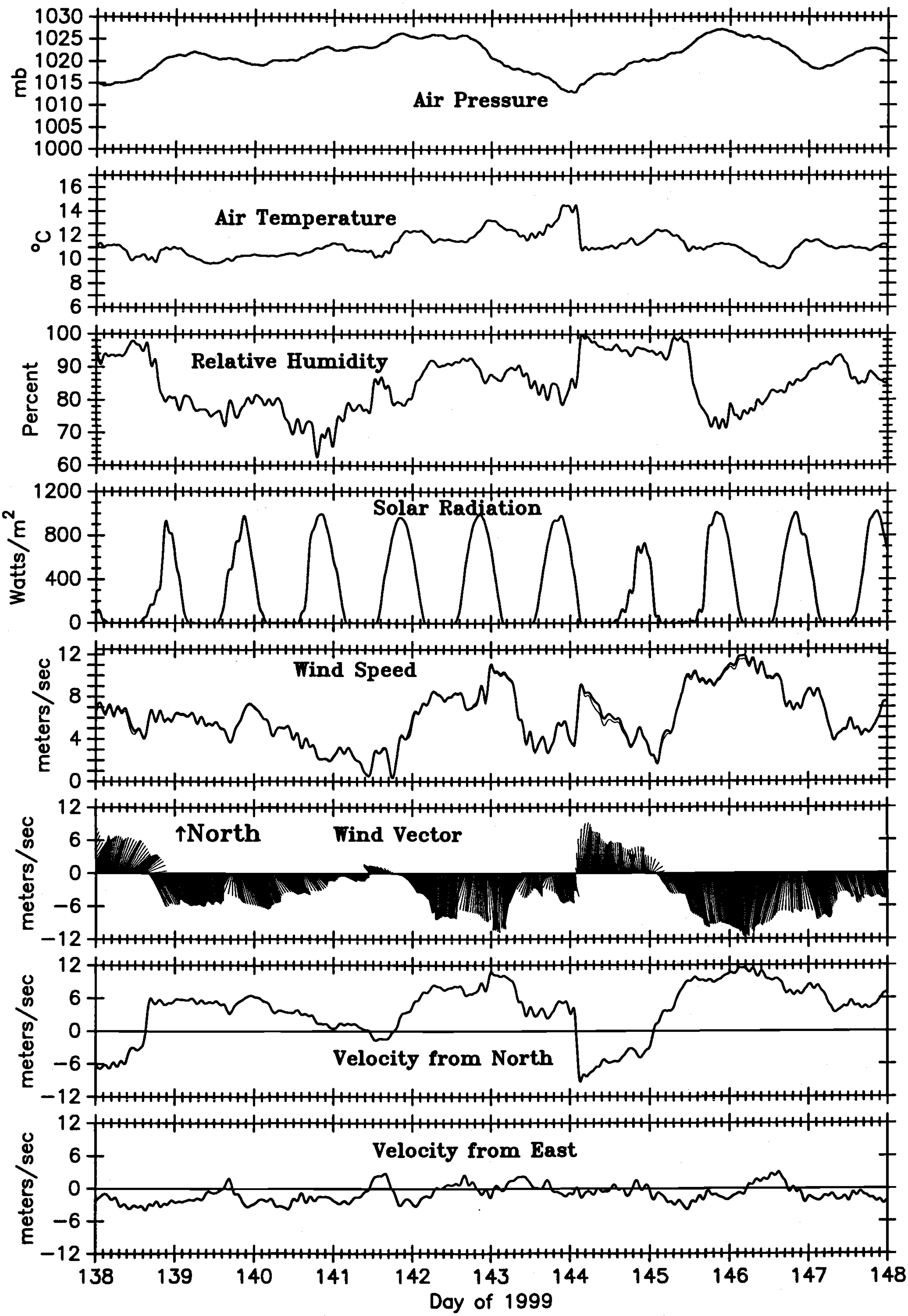
Met Mooring 1 Hour Filtered Meteorological Data



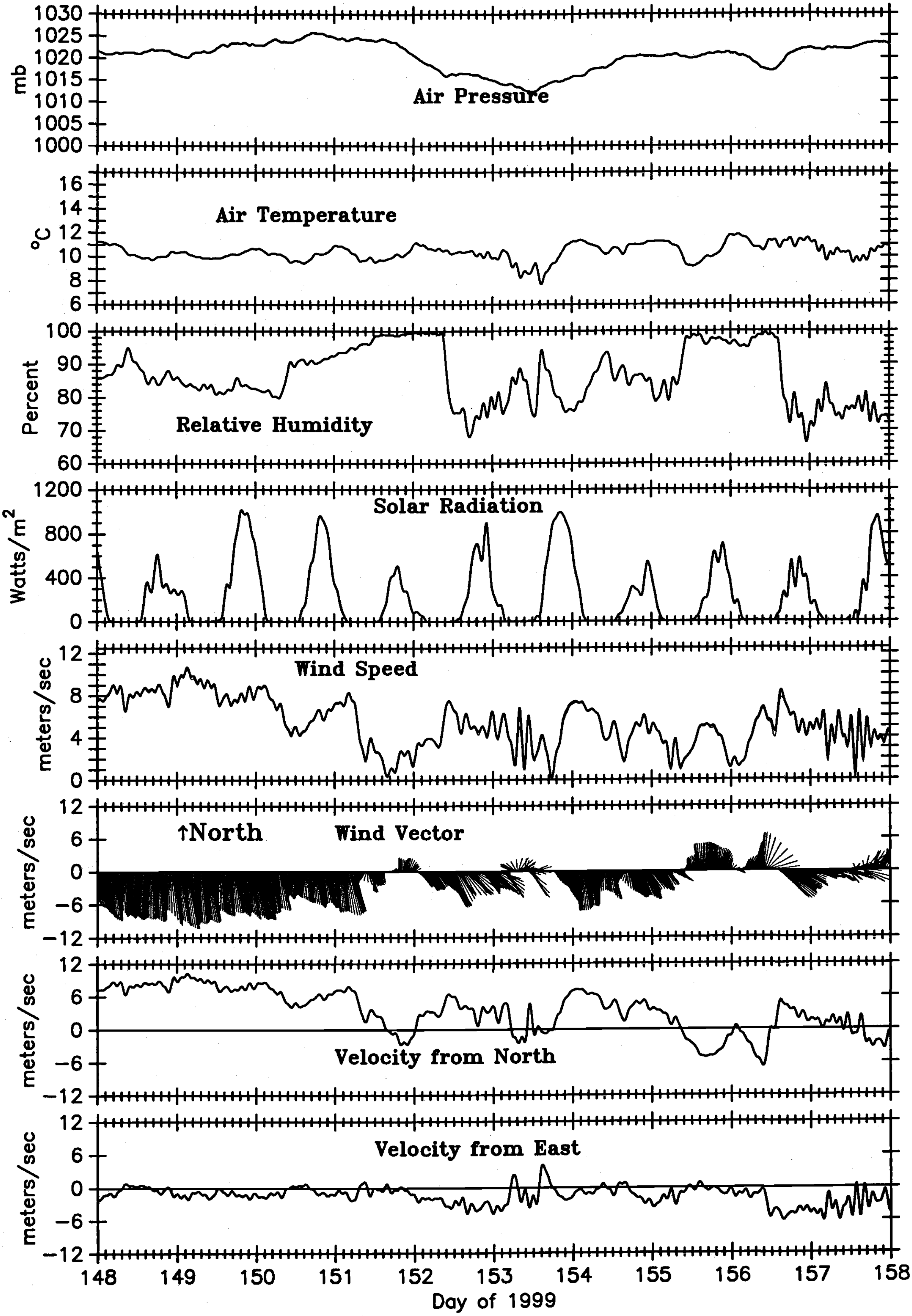
Met Mooring 1 Hour Filtered Meteorological Data

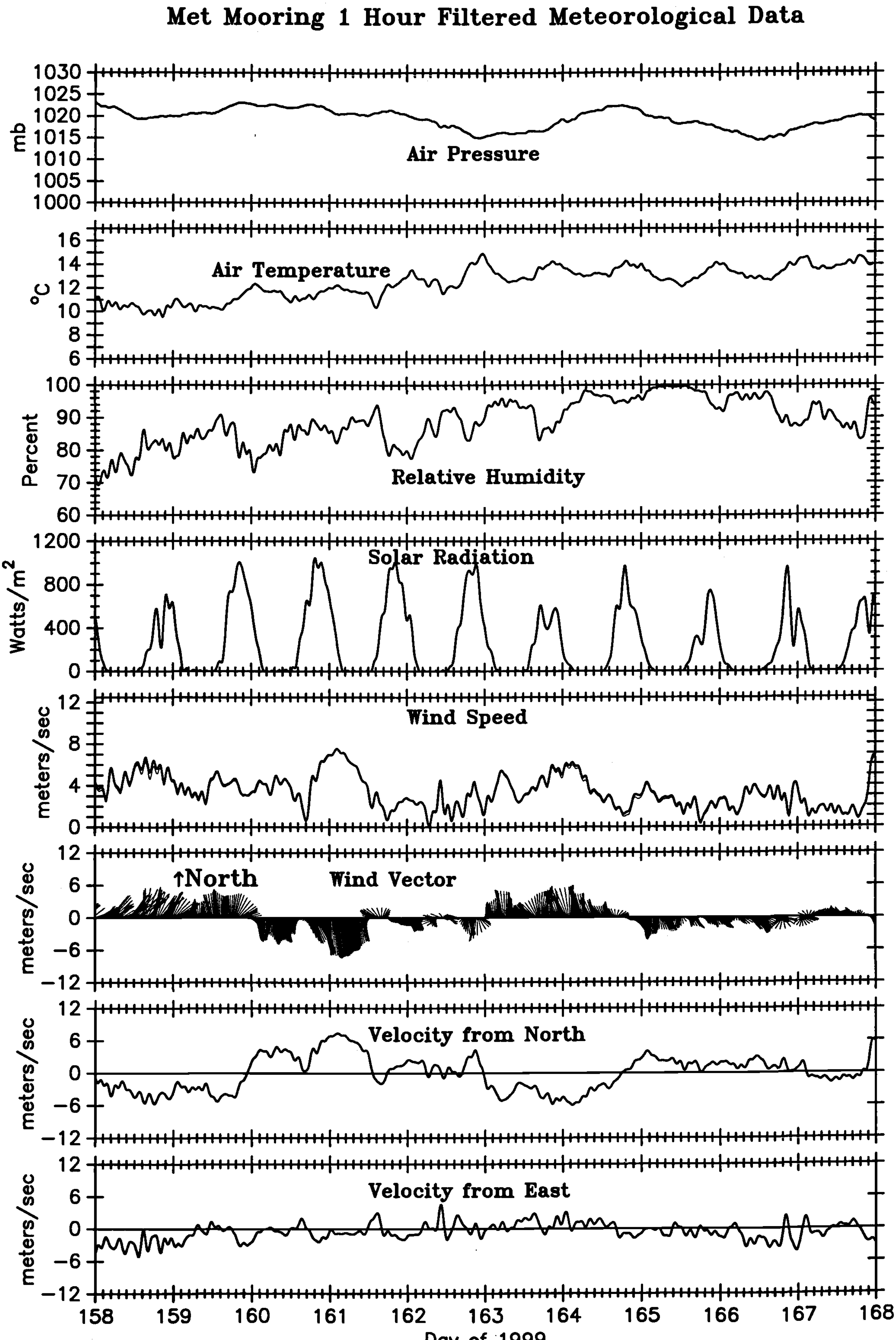


Met Mooring 1 Hour Filtered Meteorological Data

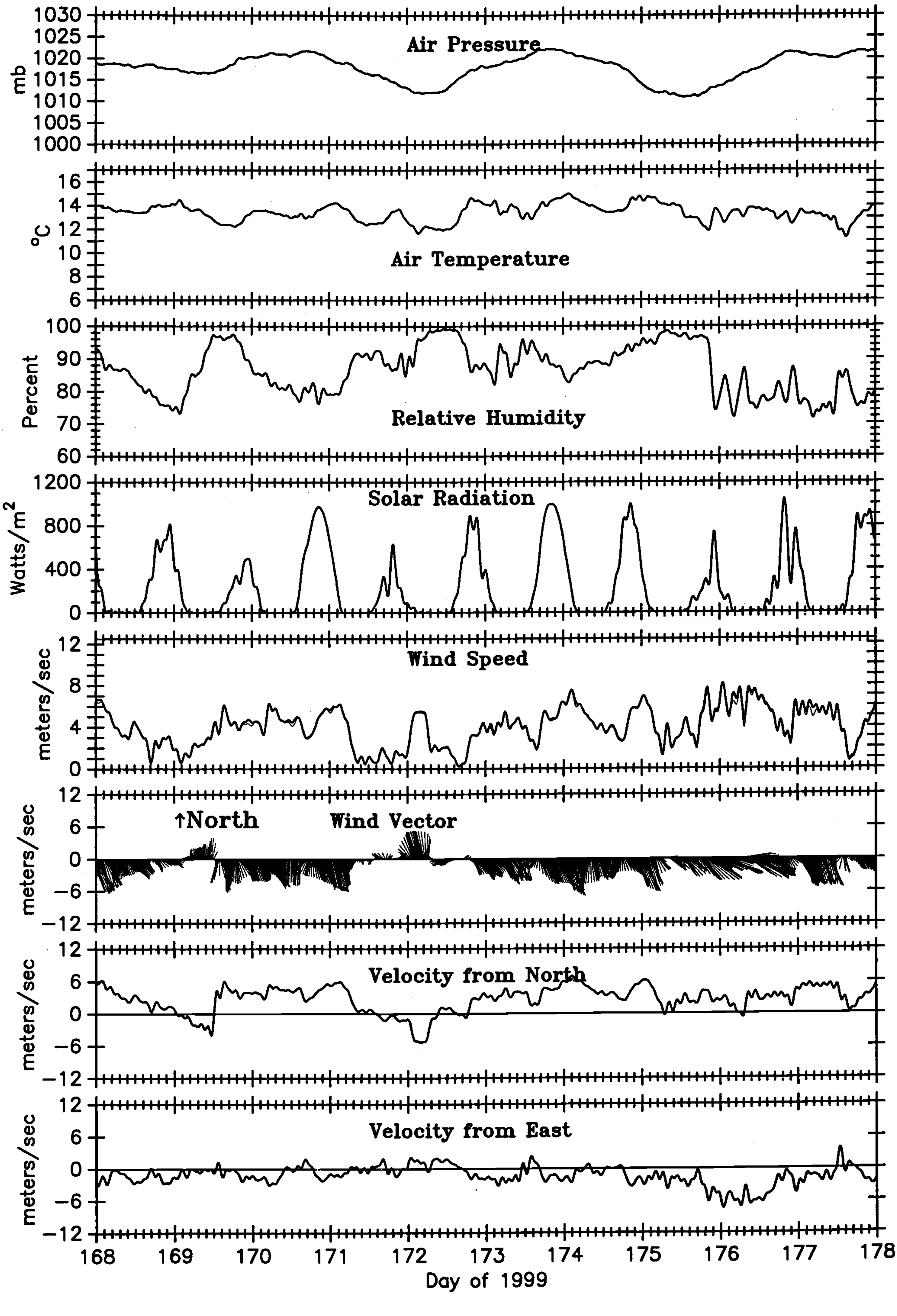


Met Mooring 1 Hour Filtered Meteorological Data

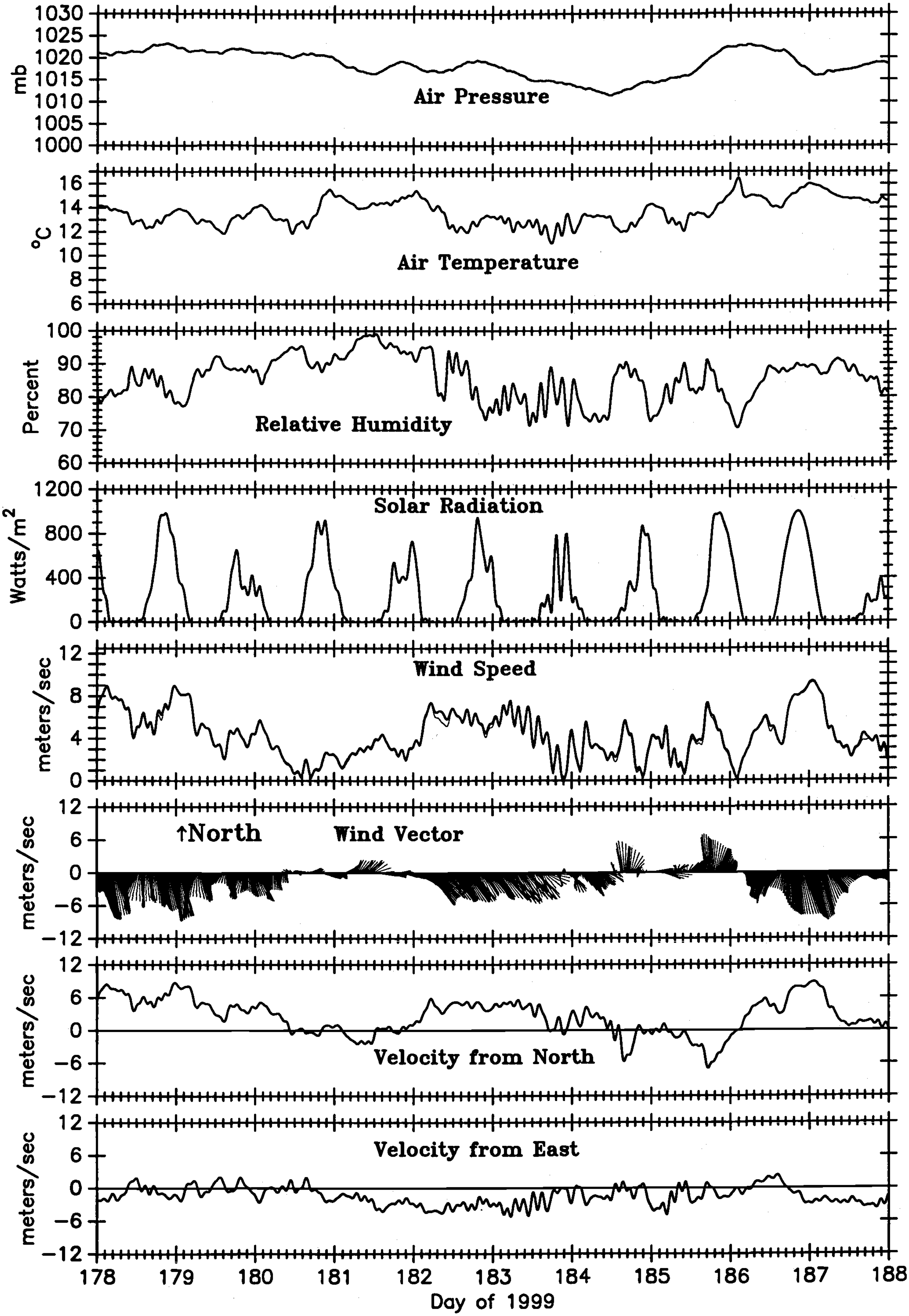



Met Mooring 1 Hour Filtered Meteorological Data
Air Pressure
mb
Air Temperature
°C
Relative Humidity
Percent
Solar Radiation
Watts/m²
Wind Speed
meters/sec
↑North
Wind Vector
meters/sec
Velocity from North
meters/sec
Velocity from East
meters/sec
Day of 1999

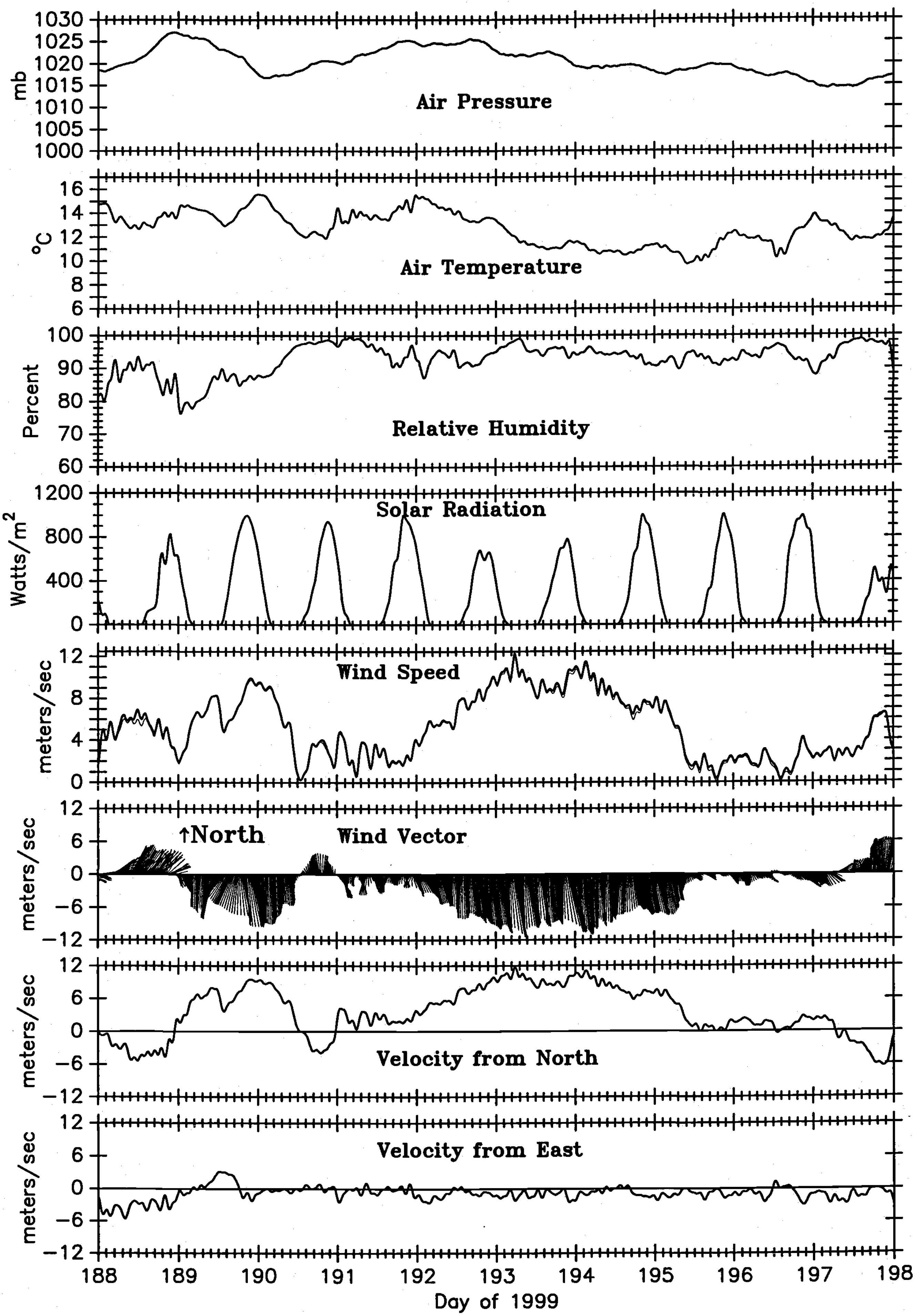
Met Mooring 1 Hour Filtered Meteorological Data



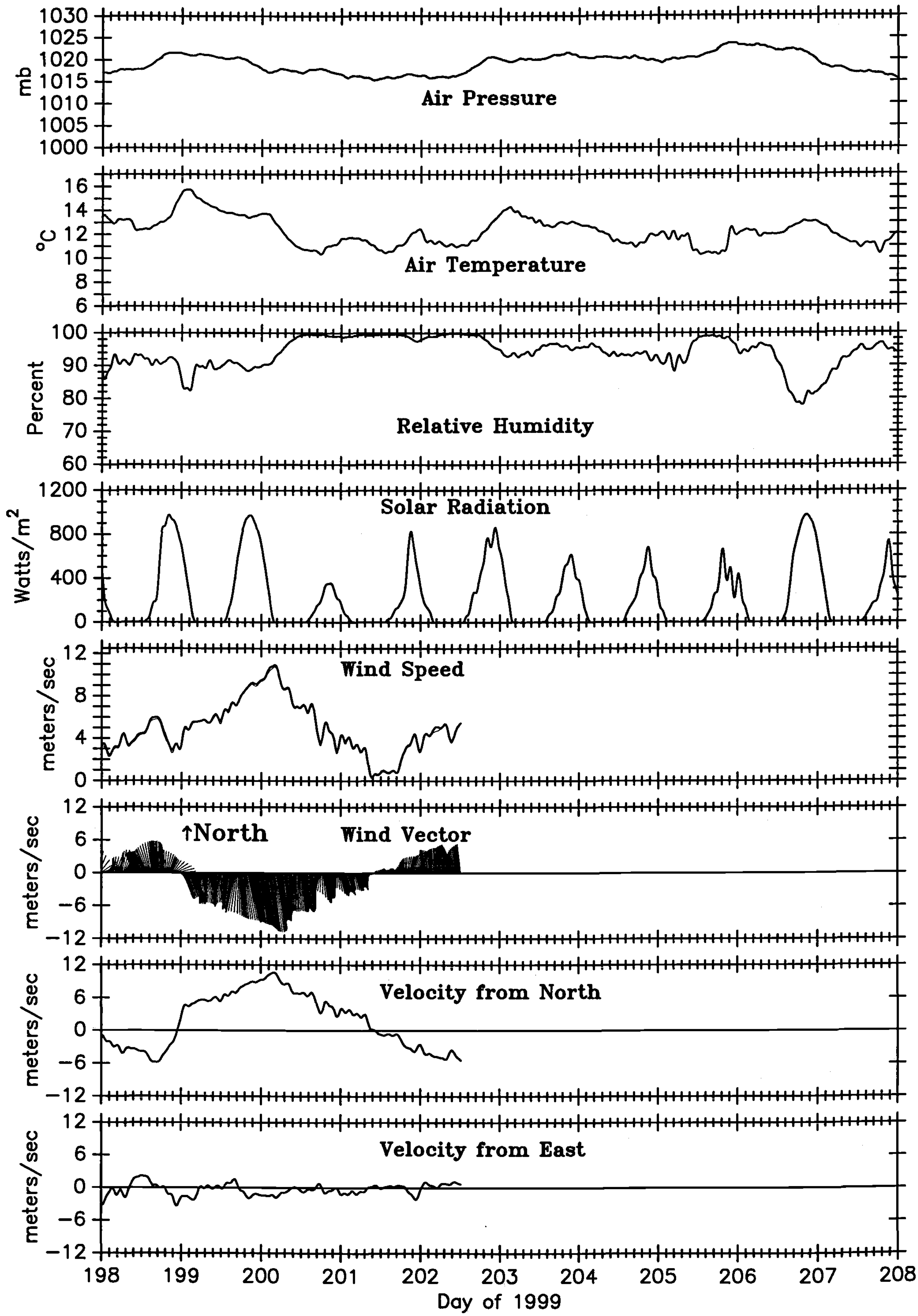
Met Mooring 1 Hour Filtered Meteorological Data



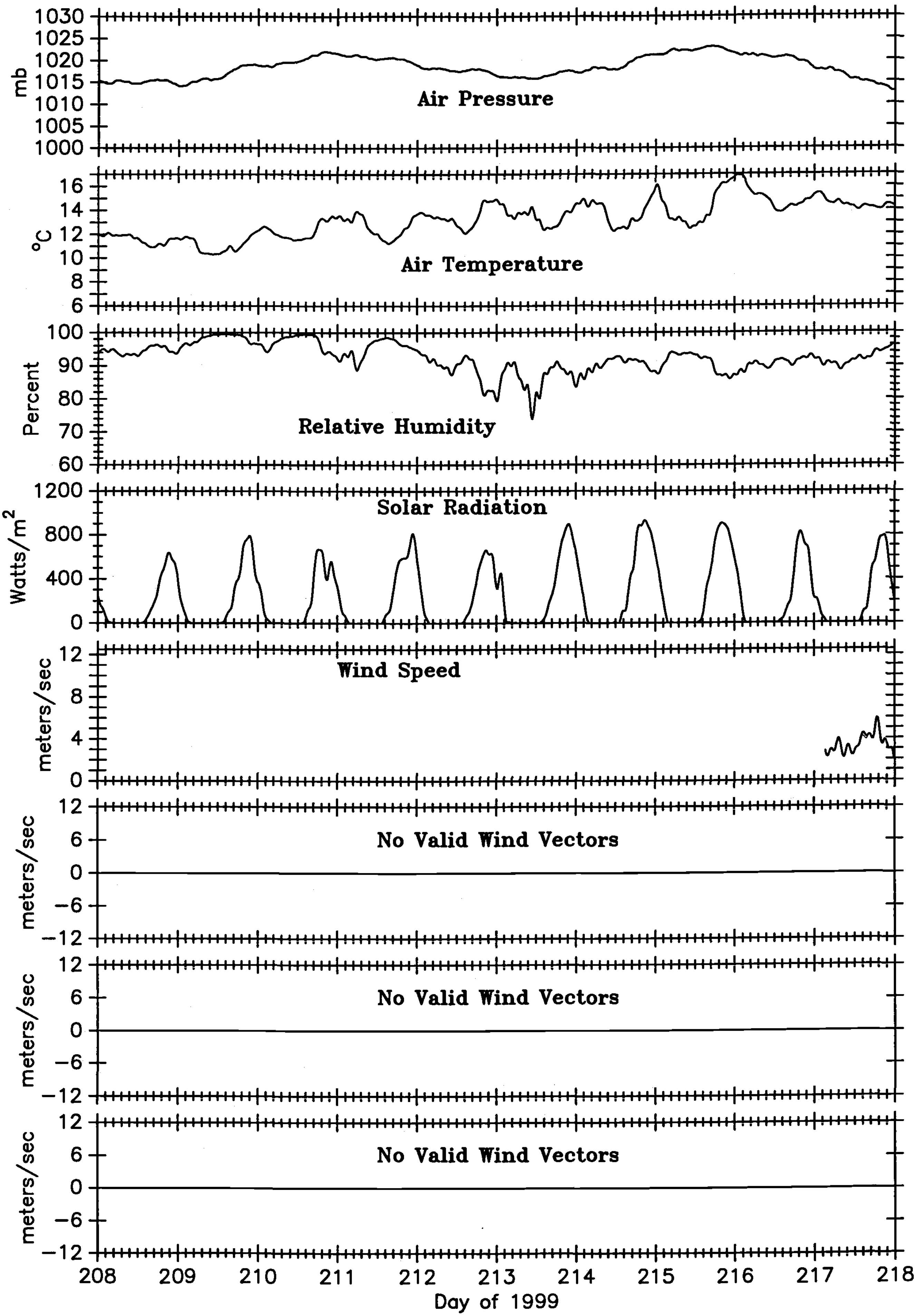
Met Mooring 1 Hour Filtered Meteorological Data



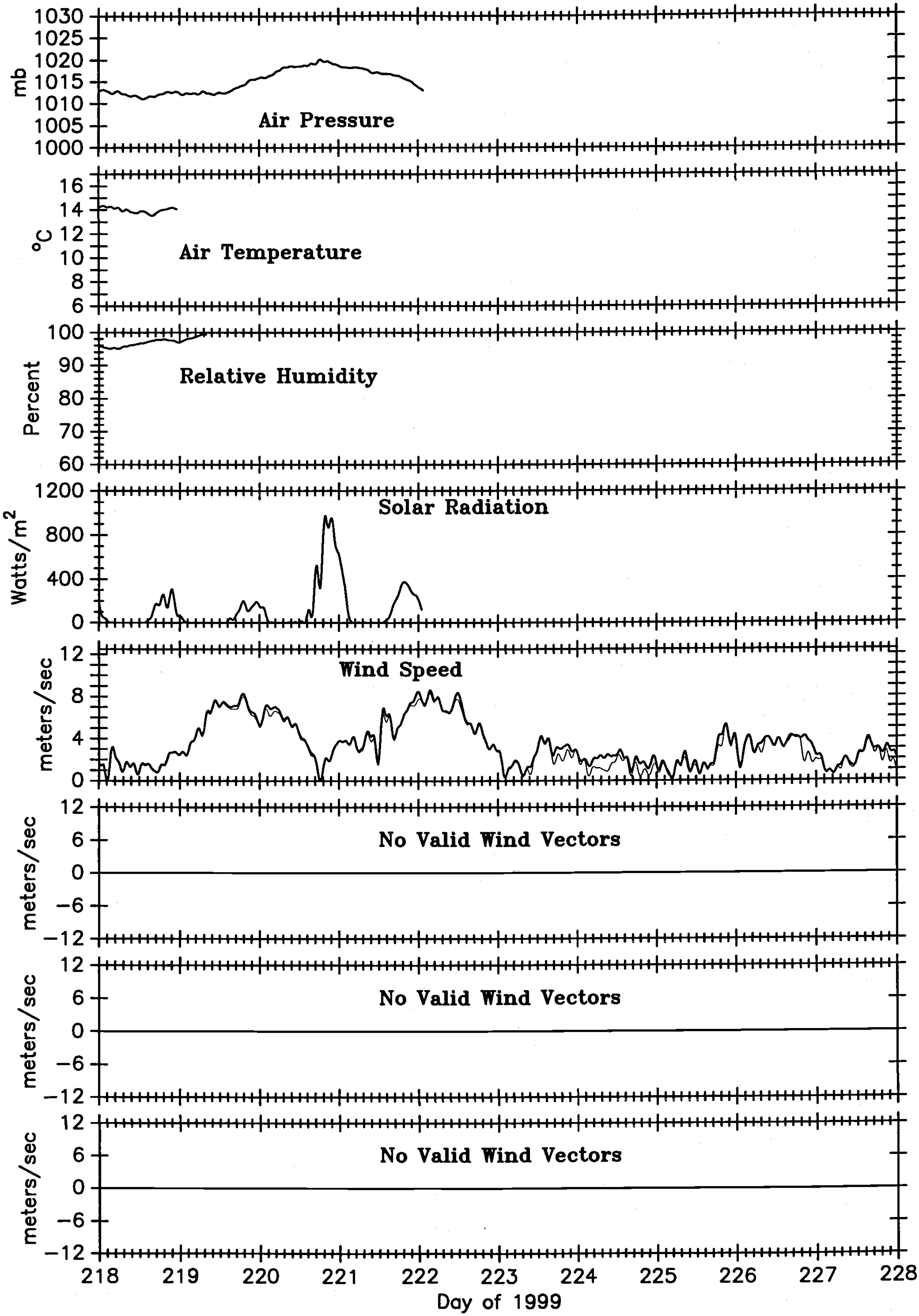
Met Mooring 1 Hour Filtered Meteorological Data



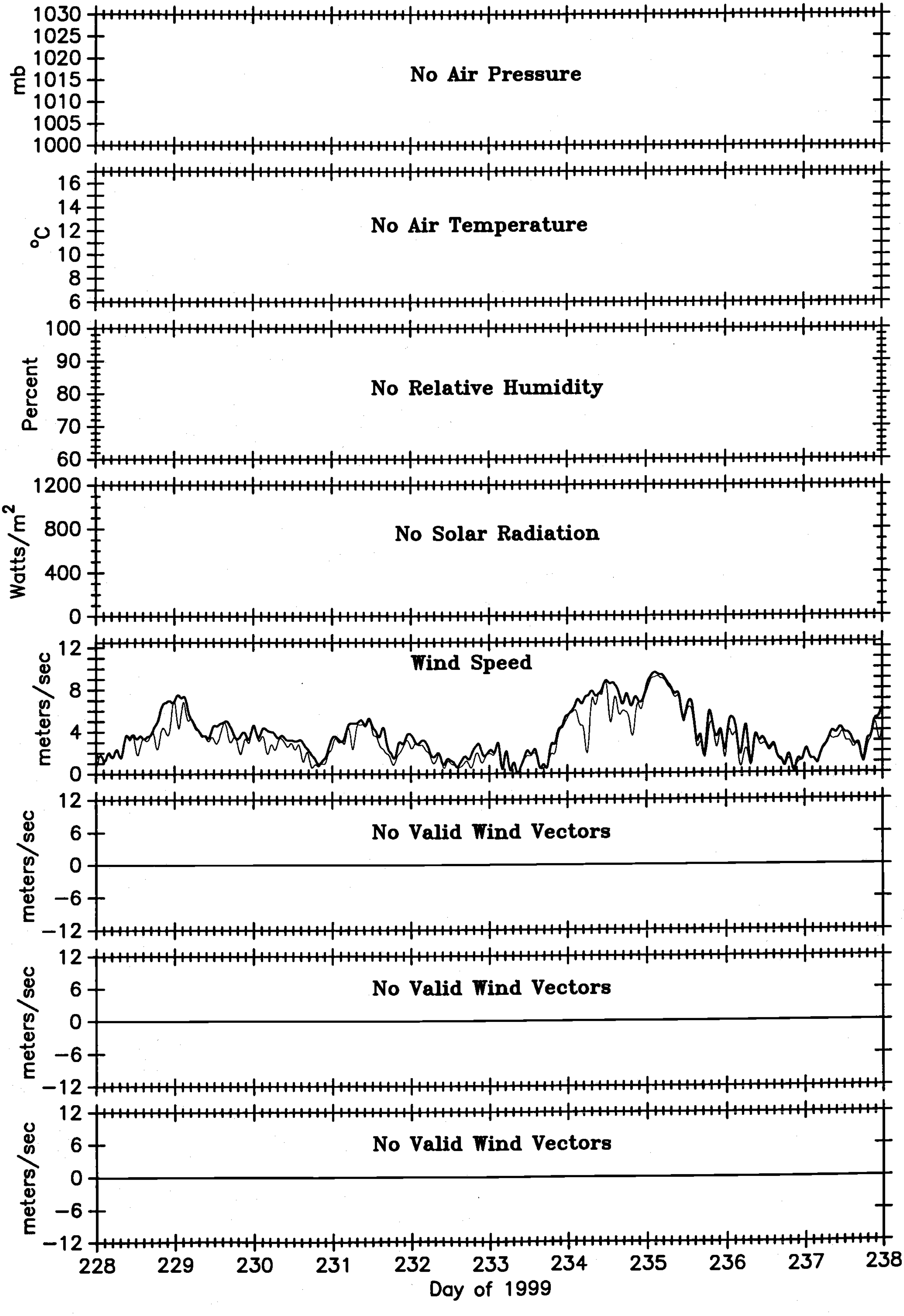
Met Mooring 1 Hour Filtered Meteorological Data

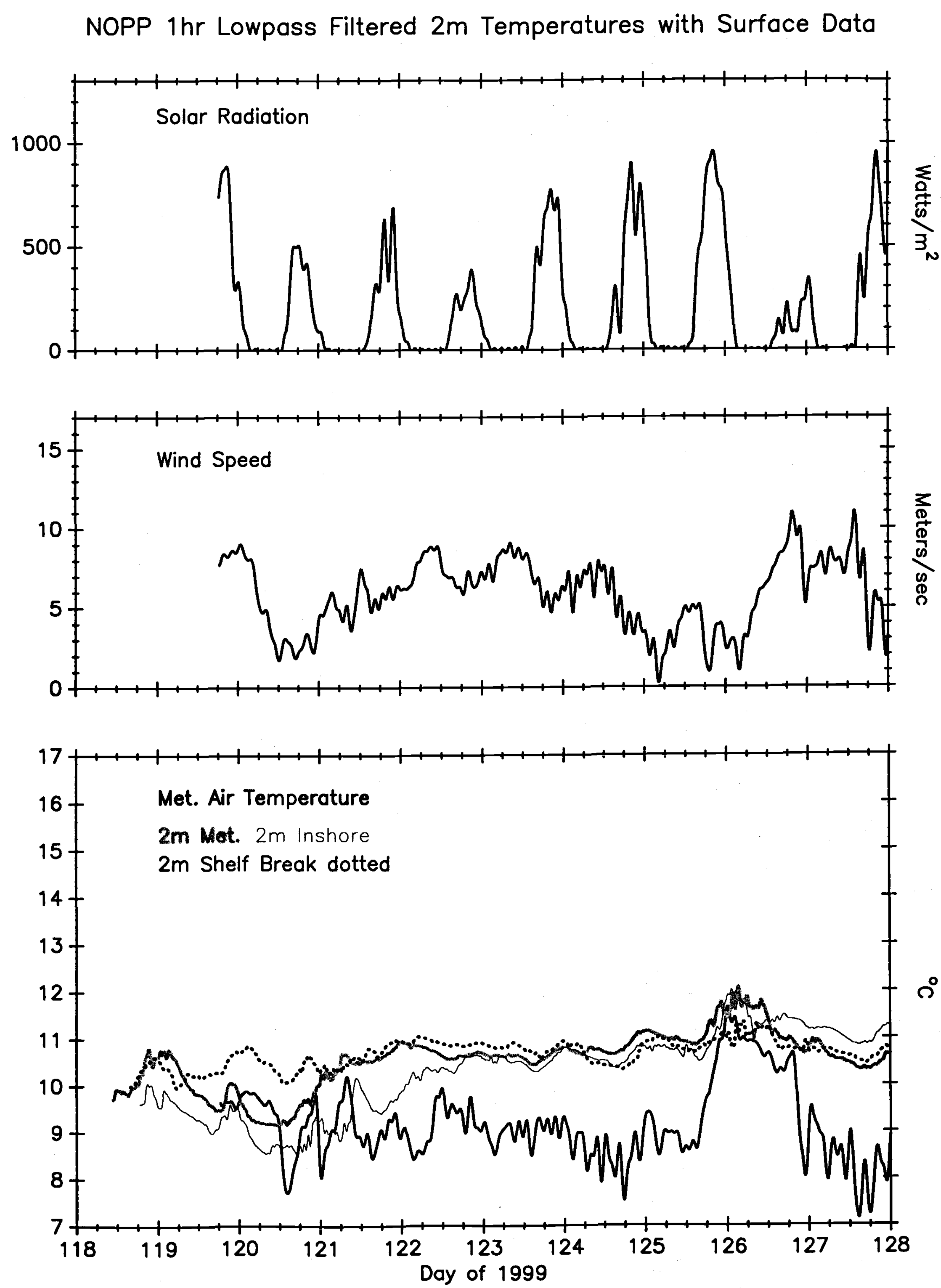


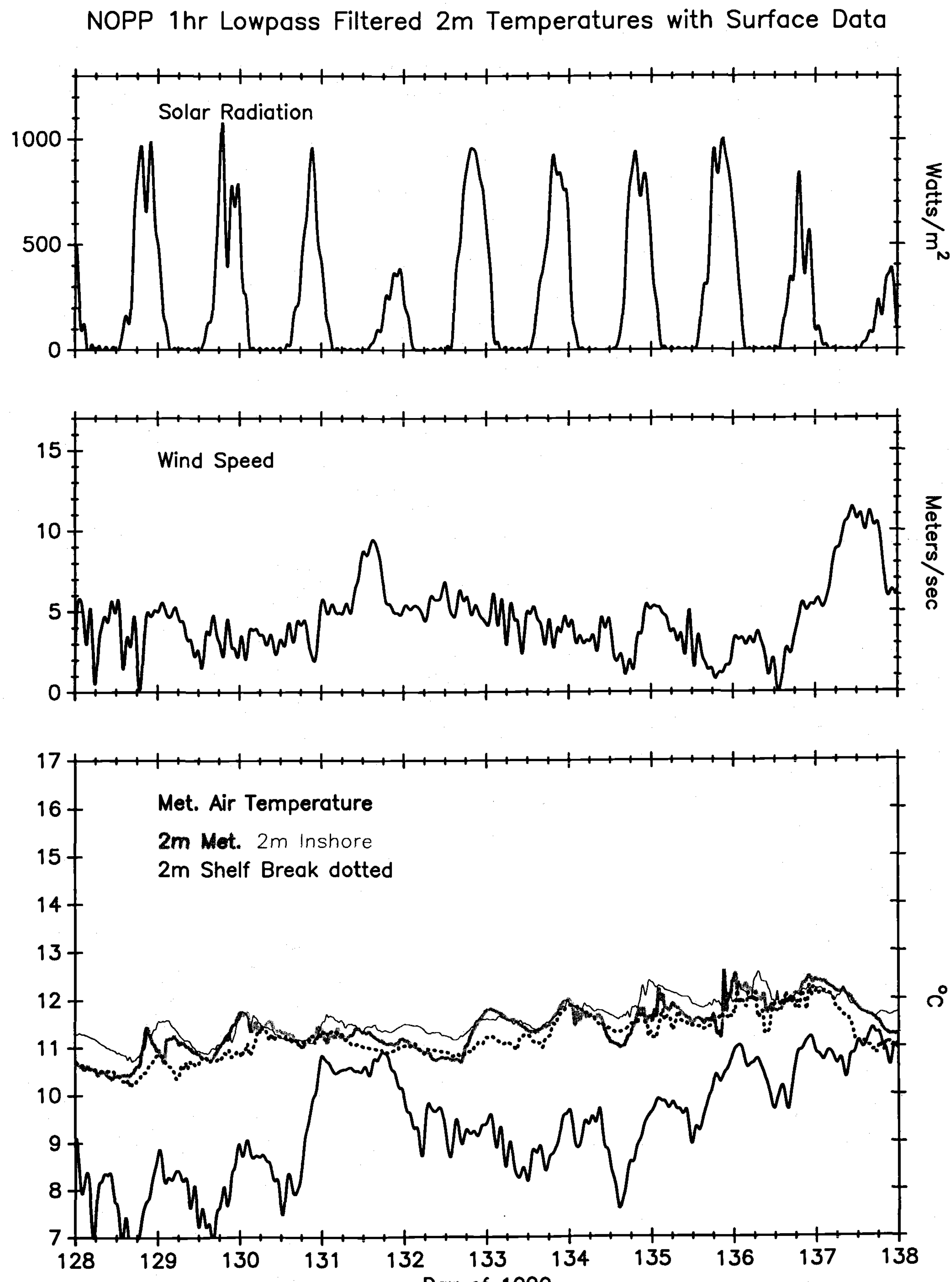
Met Mooring 1 Hour Filtered Meteorological Data

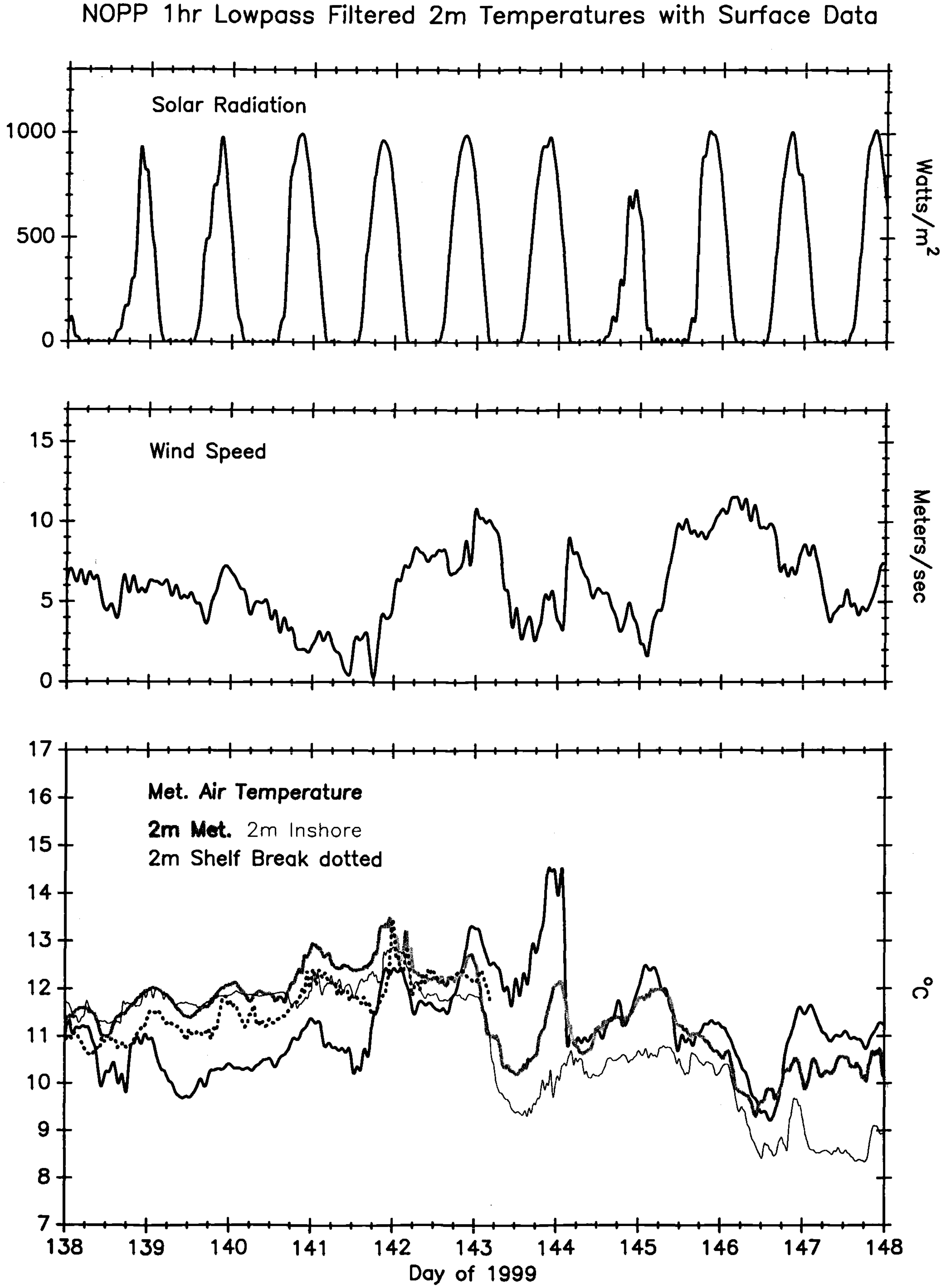


Met Mooring 1 Hour Filtered Meteorological Data

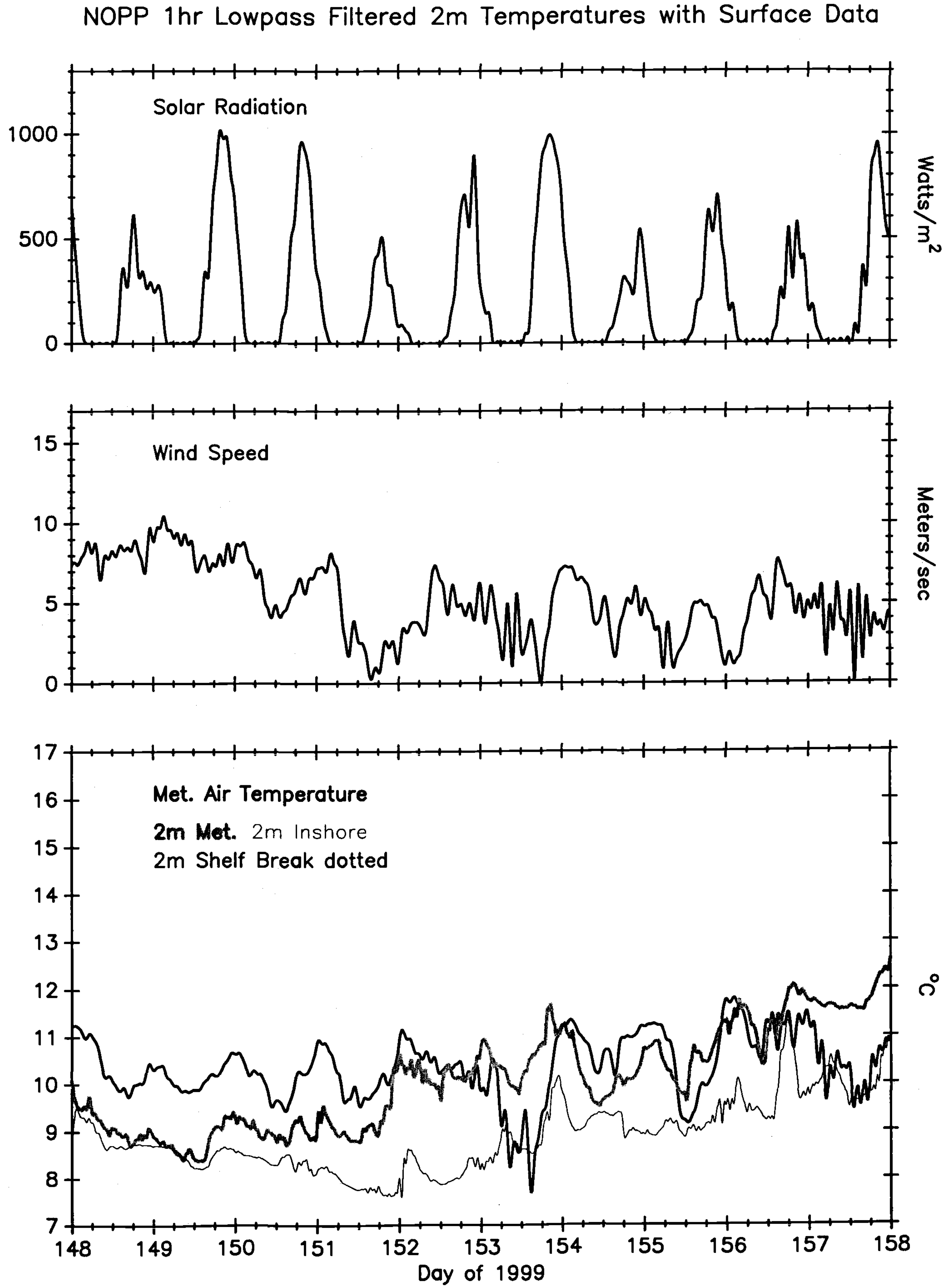


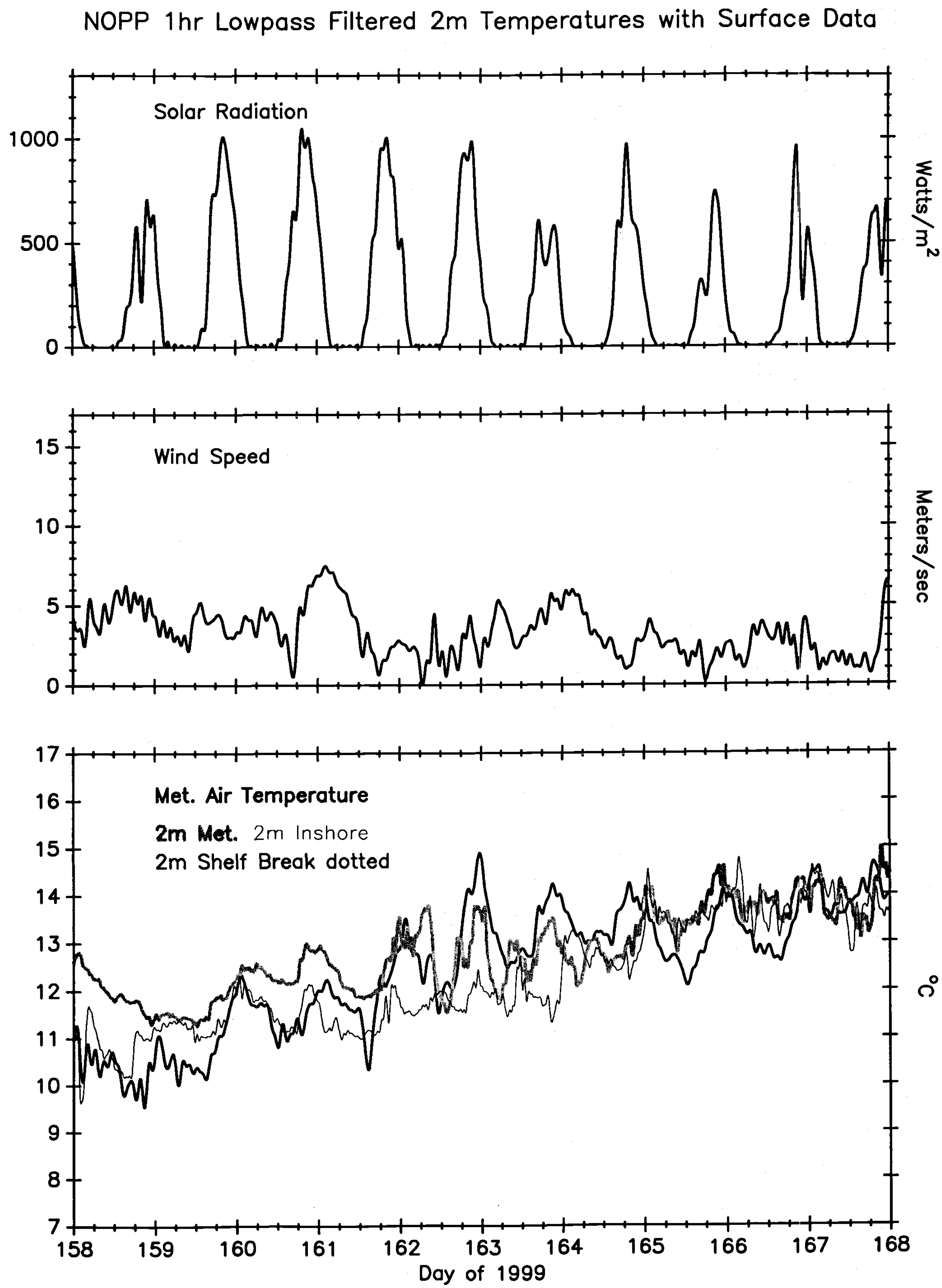

NOPP 1hr Lowpass Filtered 2m Temperatures with Surface Data
Solar Radiation
1000
500
0
Watts/m2
Wind Speed
15
10
5
0
Meters/sec
Met. Air Temperature
2m Met. 2m Inshore
2m Shelf Break dotted
17
16
15
14
13
12
11
10
9
8
7
°C
118
119
120
121
122
123
124
125
126
127
128
Day of 1999


NOPP 1hr Lowpass Filtered 2m Temperatures with Surface Data
Solar Radiation
Watts/m2
0
500
1000
Wind Speed
Meters/sec
0
5
10
15
Met. Air Temperature
2m Met. 2m Inshore
2m Shelf Break dotted
°C
7
8
9
10
11
12
13
14
15
16
17
128
129
130
131
132
133
134
135
136
137
138
Day of 1999

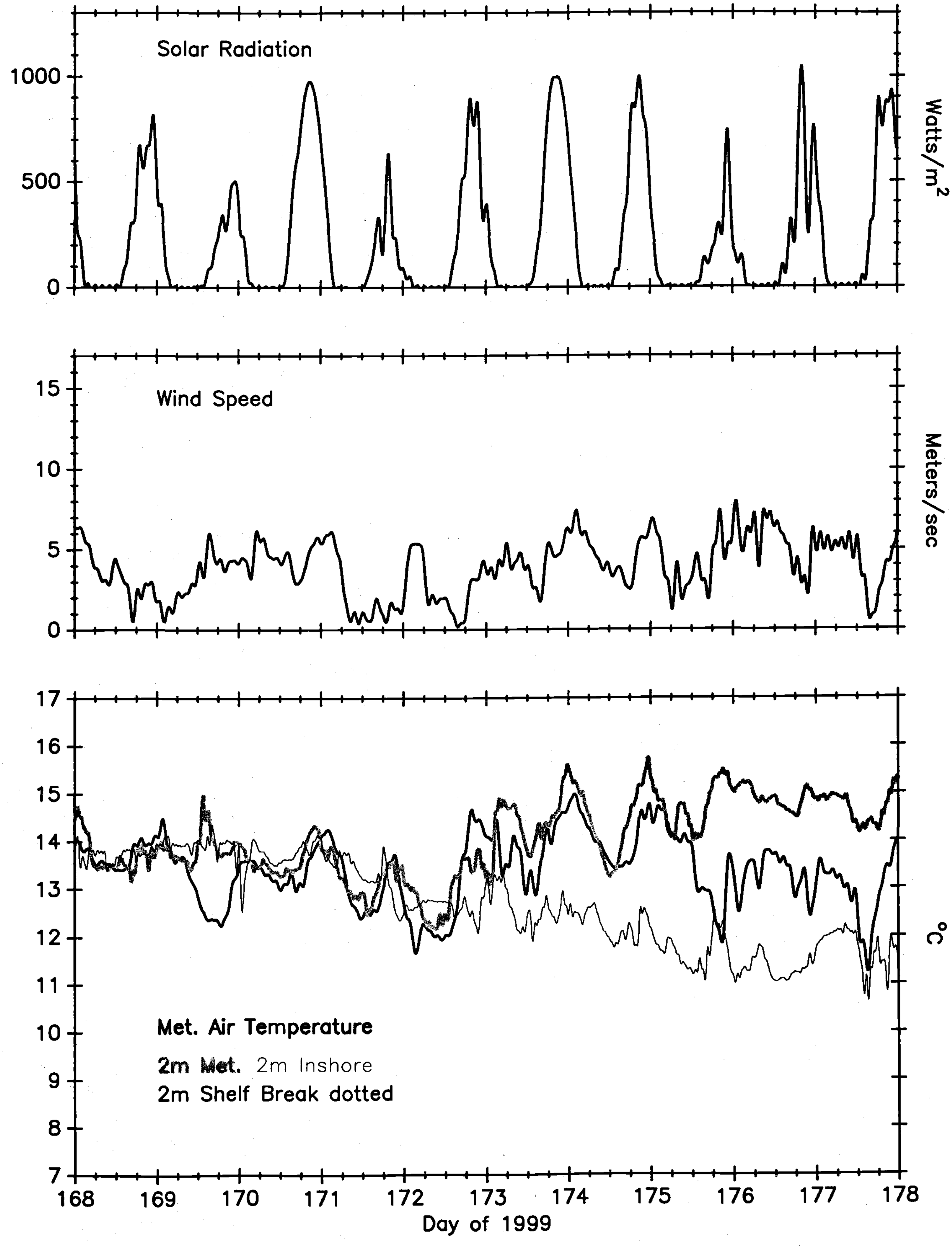


NOPP 1hr Lowpass Filtered 2m Temperatures with Surface Data
Solar Radiation
1000
500
0
Watts/m²
Wind Speed
15
10
5
0
Meters/sec
Met. Air Temperature
2m Met. 2m Inshore
2m Shelf Break dotted
17
16
15
14
13
12
11
10
9
8
7
°C
138
139
140
141
142
143
144
145
146
147
148
Day of 1999

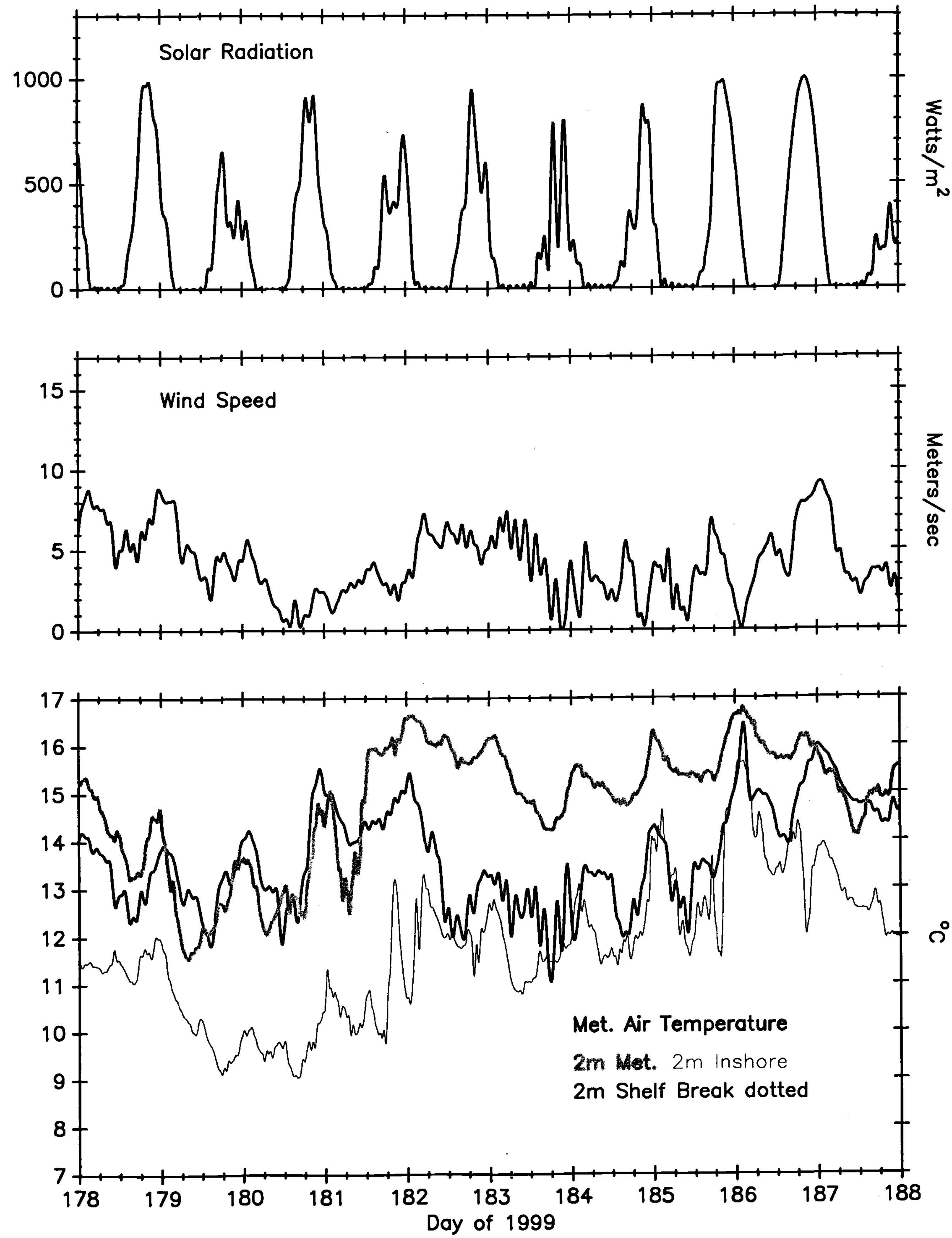

NOPP 1hr Lowpass Filtered 2m Temperatures with Surface Data
Solar Radiation
1000
500
0
Watts/m^2
Wind Speed
15
10
5
0
Meters/sec
17
16
15
14
13
12
11
10
9
8
7
Met. Air Temperature
2m Met. 2m Inshore
2m Shelf Break dotted
°C
148
149
150
151
152
153
154
155
156
157
158
Day of 1999


NOPP 1hr Lowpass Filtered 2m Temperatures with Surface Data
Solar Radiation
Watts/m2
Wind Speed
Meters/sec
Met. Air Temperature
2m Met. 2m Inshore
2m Shelf Break dotted
°C
Day of 1999
0
500
1000
5
10
15
7
8
9
10
11
12
13
14
15
16
17
158
159
160
161
162
163
164
165
166
167
168

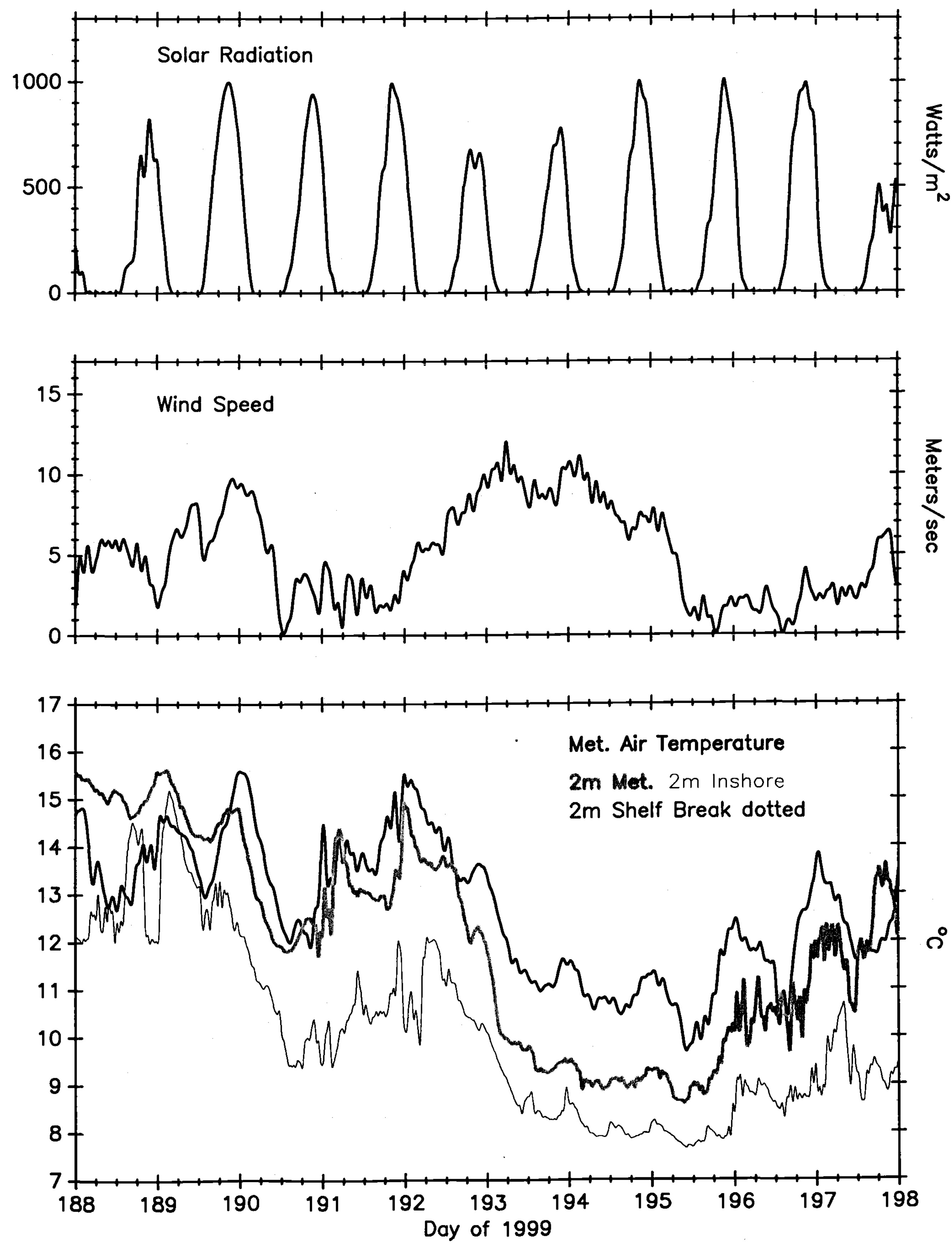
NOPP 1hr Lowpass Filtered 2m Temperatures with Surface Data

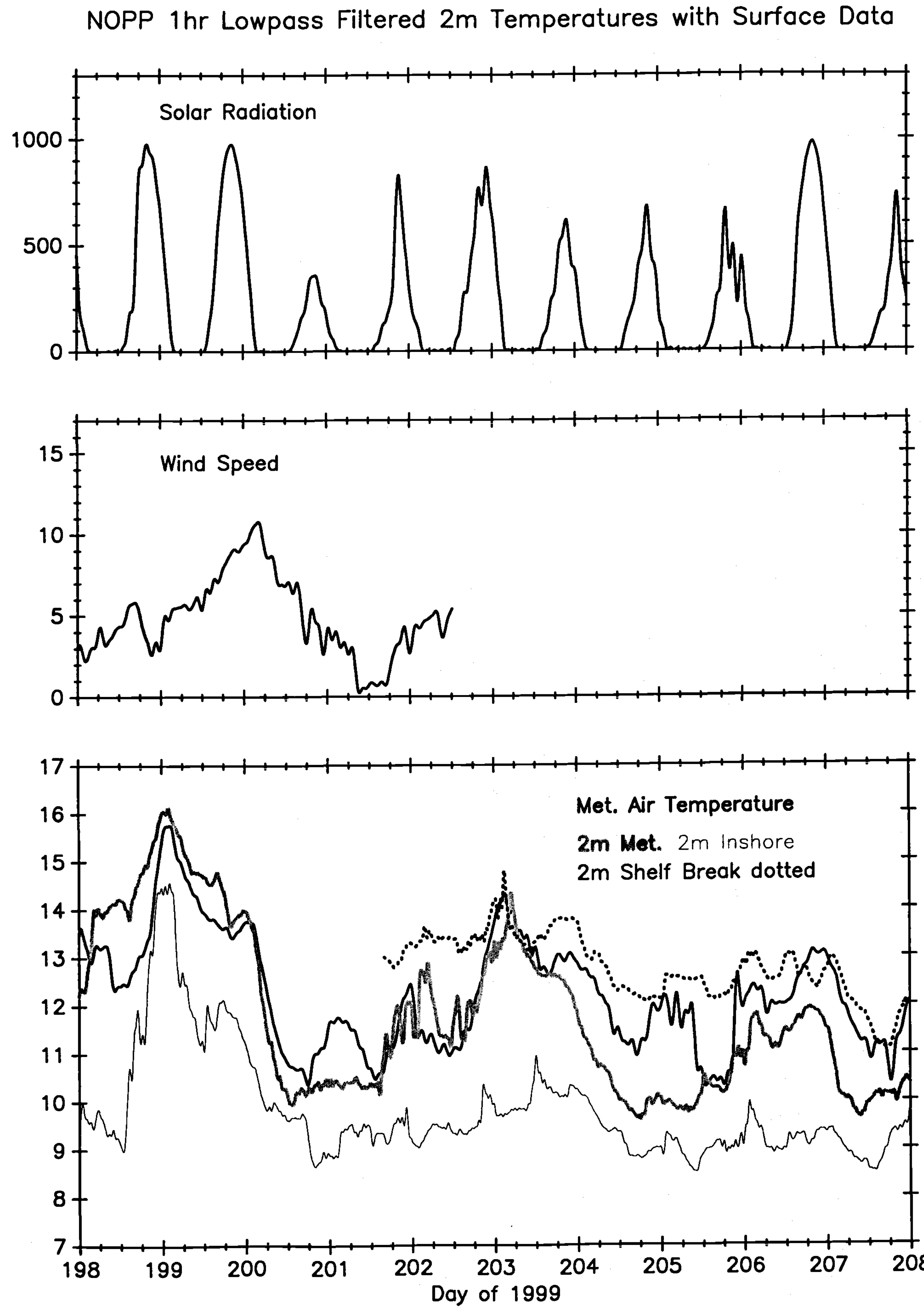


NOPP 1hr Lowpass Filtered 2m Temperatures with Surface Data

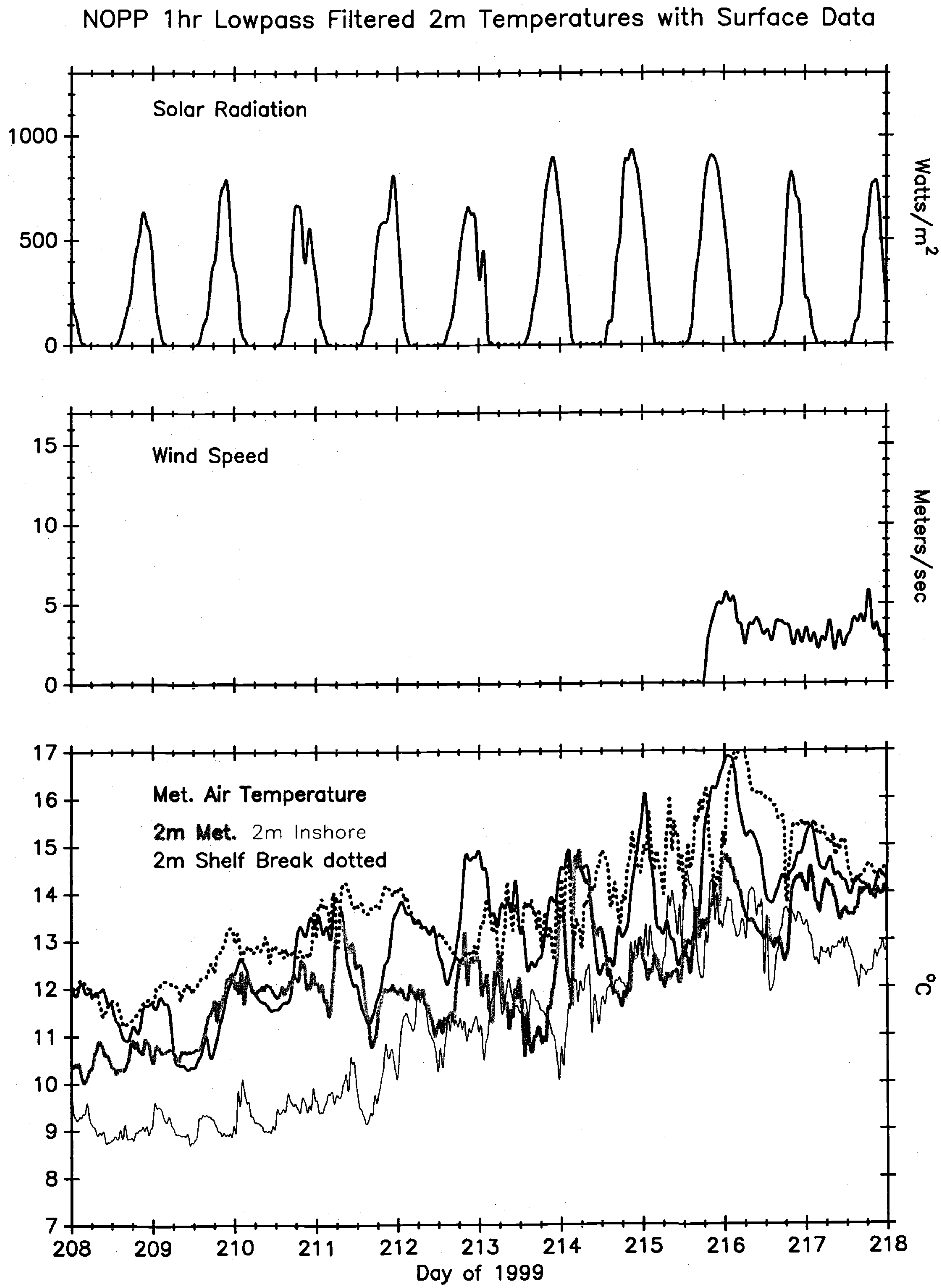


NOPP 1hr Lowpass Filtered 2m Temperatures with Surface Data

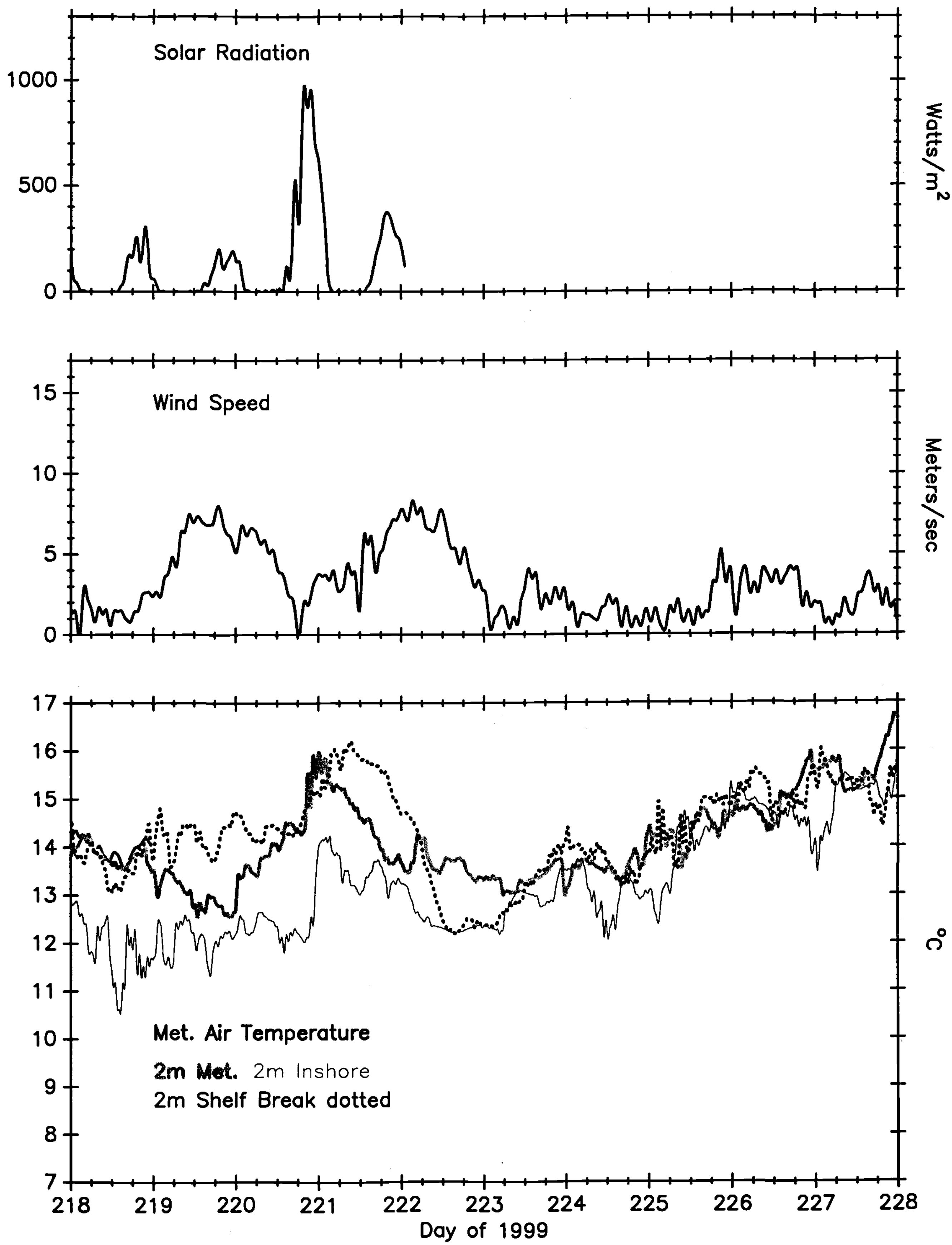




NOPP 1hr Lowpass Filtered 2m Temperatures with Surface Data
Solar Radiation
1000
500
0
Watts/m2
Wind Speed
15
10
5
0
Meters/sec
Met. Air Temperature
2m Met. 2m Inshore
2m Shelf Break dotted
17
16
15
14
13
12
11
10
9
8
7
°C
198
199
200
201
202
203
204
205
206
207
208
Day of 1999


NOPP 1hr Lowpass Filtered 2m Temperatures with Surface Data
Solar Radiation
Watts/m2
0
500
1000
Wind Speed
Meters/sec
0
5
10
15
Met. Air Temperature
2m Met. 2m Inshore
2m Shelf Break dotted
°C
7
8
9
10
11
12
13
14
15
16
17
208
209
210
211
212
213
214
215
216
217
218
Day of 1999

NOPP 1hr Lowpass Filtered 2m Temperatures with Surface Data

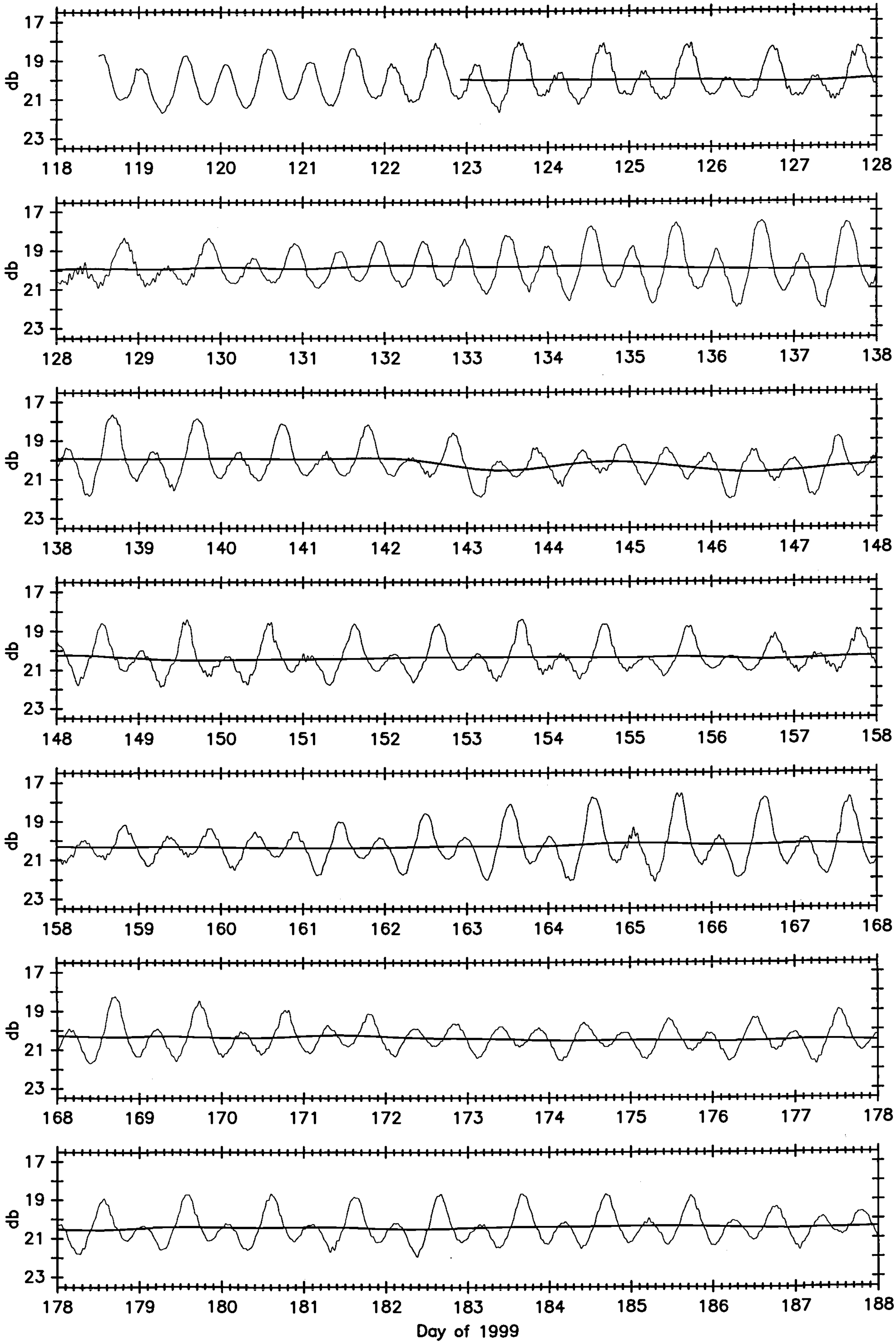


PRESSURE Time Series

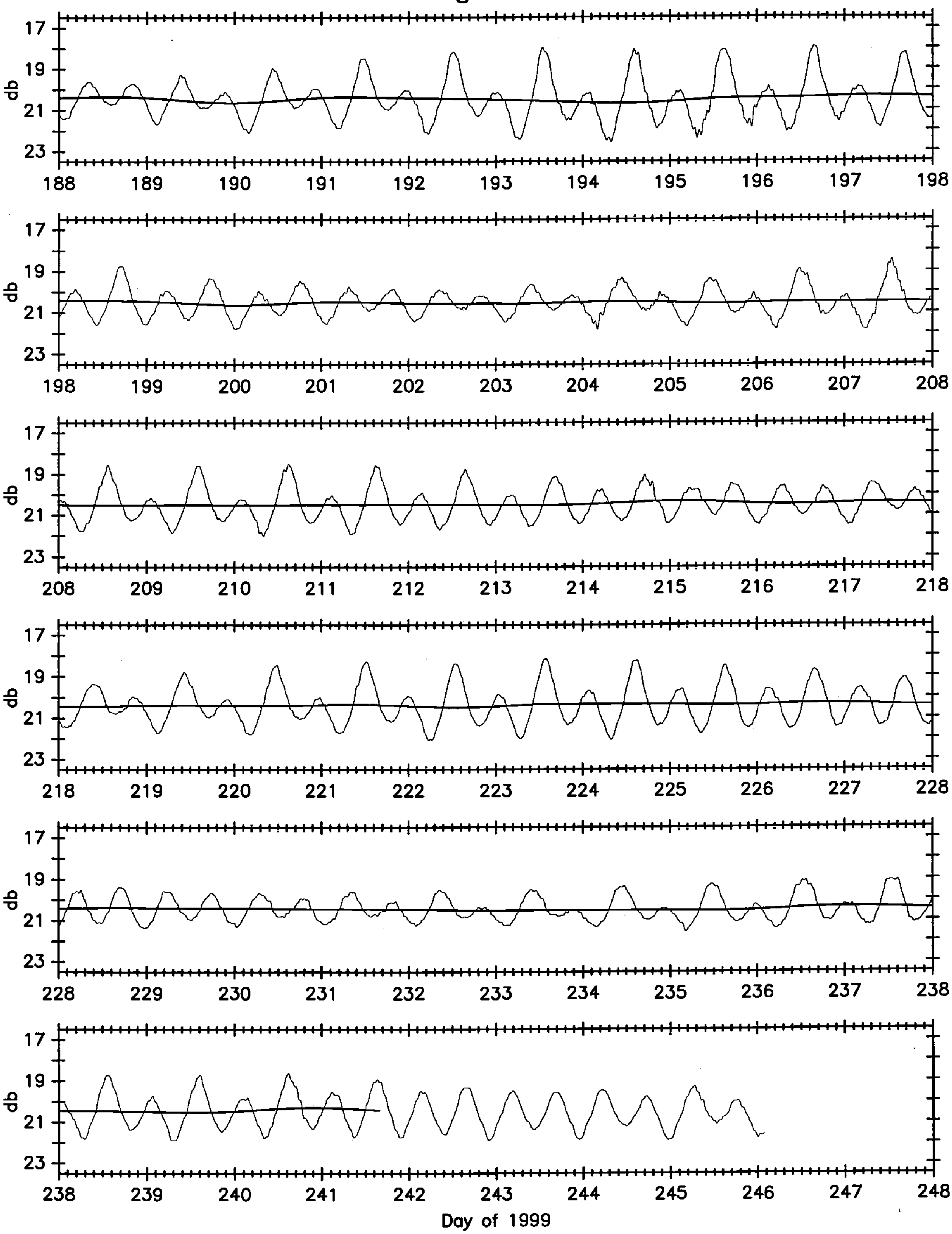
40-hour & 1-hour Low-Pass Filtered

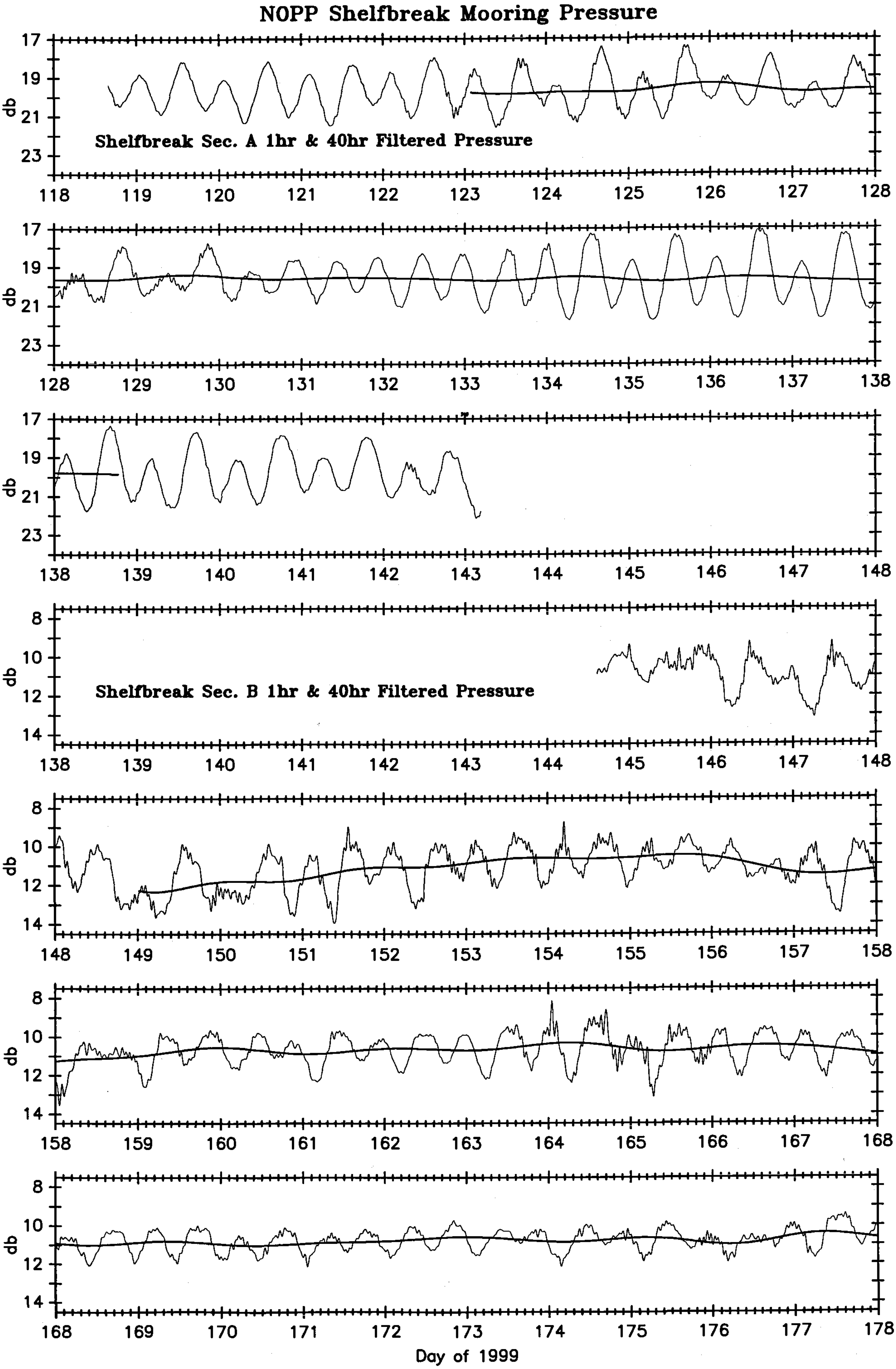
Plots of pressure from the Mid-Shelf and Shelf-Break moorings. The trawler impact of the Shelf-Break mooring on day 143 is evident in the pressure signal as a nearly 10 m upward displacement. Subsequent loss of buoyancy by the Shelf-Break mooring on day 186 is evident in the displacement down to about 21 m. The unfiltered pressure signal also suggests that the Shelf-Break mooring was hit again on day 191. The 1-hour filtered pressure signal from the Mid-Shelf mooring and parts of the Shelf-Break mooring (period A, prior to trawler impact, and period D, following redeployment), show clear semidiurnal signals.

NOPP Midshelf Mooring 1hr & 40hr Filtered Pressure



NOPP Midshelf Mooring 1hr & 40hr Filtered Pressure




NOPP Shelfbreak Mooring Pressure
Shelfbreak Sec. A 1hr & 40hr Filtered Pressure
Shelfbreak Sec. B 1hr & 40hr Filtered Pressure
db
Day of 1999

NOPP Shelfbreak Mooring Pressure