CLIMATIC AND LAKE TEMPERATURE DATA FOR WETLAND P1, COTTONWOOD LAKE AREA, STUTSMAN COUNTY, NORTH DAKOTA, 1982-87

By R.S. Parkhurst, A.M. Sturrock, D.O. Rosenberry, and T.C. Winter

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CONVERSION FACTORS

Multiply	By	To Obtain
centimeter (cm)	0.3937	inch
inch	25.40	millimeter
meter (m)	3.281	feet
hectare (ha)	2.471	acre
standard atmosphere	101.3	kilopascal
millibar	0.0145	pounds per square inch
miles per hour	1.609	kilometer per hour
calories per square centimeter (cal/cm)	25.913	watts per square foot

To convert degrees Celsius (°C) to degress Fahrenheit (°F) use the following formula:

$$°F = 9/5(°C) + 32$$

JULIAN DAYS AND CORRESPONDING DATES FOR NON-LEAP YEARS

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

CLIMATIC AND LAKE TEMPERATURE DATA FOR WETLAND P1, COTTONWOOD LAKE AREA, STUTSMAN COUNTY, NORTH DAKOTA, 1982-87

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ABSTRACT

Research on the hydrology of Wetland P1 and the Cottonwood Lake Area includes the study of evaporation. Presented here in a graphical format are those data collected during the open-water seasons of 1982-87 that were needed for energy-budget and mass-transfer evaporation studies. The data include air temperatures, water surface and bottom temperatures, windspeed, radiation, humidity, and precipitation. Data were collected at a raft station and two land stations.

INTRODUCTION

Climatic data and selected surface-water data are being collected at the Cottonwood Lake area by the U.S. Geological Survey and the U.S. Fish and Wildlife Service as part of a continuing study of the hydrology of a group of small lakes and wetlands . The Cottonwood Lake area is one of several lake areas in different parts of the United States that have been selected by the U.S. Geological Survey for intensive study of hydrological and related chemical and biological processes. The rationale for selection of the Cottonwood Lake area is given by Winter and Carr (1980). The Cottonwood Lake study area is located in central North Dakota (fig. 1) and is characterized by hummocky topography. Wetland P1 lies in a depression within an upland surrounded by hills that rise as much as 10 m higher than the wetland. The wetland is small and shallow; it seldom is deeper than 1 m in the middle and, at that depth, has a surface area of 0.2 ha. Although Wetland P1 is classified as semi-permanent, it has dried up every decade or so.

The purpose of this report is to provide graphs of daily and monthly values of selected climate and surface-water data that were used in an energy-budget study from 1982 through 1987. Climatic data for the 1982 (Sturrock and others, 1986) and 1983 (Sturrock and others, 1987) open-water seasons also were published in tabular formats.

DATA COLLECTION AND PRESENTATION

Climatological sensors were located on a raft in the middle of the wetland and at nearby land and radiation stations (fig. 1). Sensors on the raft included anemometers at 2 and 3 m above the water surface, a thermistor psychrometer with dry-bulb and wet-bulb temperature sensors at 2 m above the water surface, and water-temperature sensors at 1 cm.

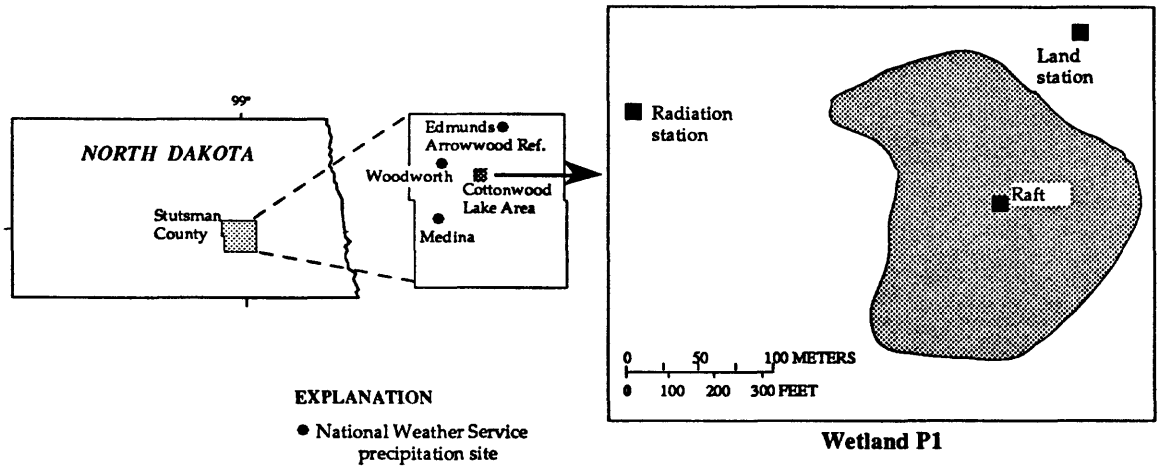

Figure 1.--Locations of Cottonwood Lake area, Wetland P1, National Weather Service precipitation sites, and instrument stations.

below the water surface and 20 cm above the bottoms sediments. The second water-temperature sensor is referred to in the graphs as lake-bottom water temperature. Sediment-temperature sensors were at 0.5 and 1.0 m below the sediment-water interface. A humidity sensor and a secondary air temperature sensor were added at 2 m above the water surface during the 1987 season. Data from these sensors were recorded by a digital-data logger located on the raft. The data logger was programmed to scan the sensors every minute and calculate hourly and daily averages. In addition, for selected sensors, the daily output included maximum and minimum values and the time they occurred. Data from the raft station are for open-water seasons only and the period of record varies from year to year depending on weather, equipment, and personnel. The period of record in Julian days for each year and station is given in table 1.

Table 1. Period of record for data collected at Wetland P1, 1982-87

	Raft station		Land station		Radiation station	
Year	First day	Last day	First day	Last day	First day	Last day
1982	146	263	116	256	146	313
1983	138	263	129	270	138	348
1984	117	263	122	269	4	388 *
1985	122	261	108	273	122	261
1986	114	273	100	225	100	273
1987	100	363	116	279	109	320

* The radiation station started in 1984 and ran until Julian day 22 of 1985.

The radiation station consisted of short- and long-wave radiometers. In September 1983, an anemometer was added to record windspeed at 2 m above land surface. Data were recorded by a digital-data logger that operated similarly to the one on the raft. The annual period of record for the radiation station was often longer than that for the raft station (table 1).

The land station consisted of a hygrothermograph that recorded air temperature and relative humidity and a tipping bucket gage that recorded precipitation. Data were recorded on strip charts. Hygrothermograph data are considered secondary and were used only to fill in missing data. Calibration checks were made weekly with laboratory-quality thermometers and motorized psychrometers. A standard 8-inch rain gage was read weekly and used to calibrate the tipping bucket gage.

Data plotted on the graphs in this report (figs. 2-22) are daily values and monthly summaries of these values. Raft-station data and land-station radiation and precipitation data are considered the primary data record. When the instruments used to collect the primary data were not operating properly, daily values were estimated by regression using data from backup sensors if a satisfactory statistical relation could be established. Data used to establish regressions were selected so that they bracketed the period of missing or inadequate data. Estimated values for the missing data are summarized in table 2. When backup data were not available, no data were estimated. In 1987 the wet-bulb data were incomplete, and were not estimated due to the availability of vapor pressure data. Although only daily and monthly values are shown here, hourly values also were recorded. Daily and hourly values are available on request for all or part of the period of record.

Table 2. - Julian dates of missing energy-budget data for Wetland P1 and procedures used to estimate missing data, 1982-87

[Y=missing data, X=data from back-up instrument; NA, not applicable; R squared, the proportion of variation in Y explained by the regression curve (Iman and Conover, 1983)]

Variable missing	Year	Julian dates of missing data	Source of estimated data	Regression used to estimate data	R squared
Dry-bulb temperature	1982	193-198	hygrothermograph	Y=0.527+0.945X	0.964
Wet-bulb temperature	1982	193-207	hygrothermograph	Y=1.021+0.898X	0.970
Windspeed at 2 meters	1982	146-263	wind at 3m	Y=-0.278+0.962X *	0.992
Windspeed at 3 meters	1982	193-198	Totalizing anemometer	Y=0.926+0.965X	0.599
Long-wave radiation	1982	146-203	Brunt's equation (Koberg, 1964)	NA	NA
Surface-water temperature	1982	193-198	temperature probe	Y=1.312+1.011X	0.948
Bottom-water temperature	1982	172-187	surface-water temperature	Y=0.806+0.95X	0.986
Dry-bulb temperature	1983	169-172	hygrothermograph	Y=-0.429+0.955X	0.996
Wet-bulb temperature	1983	169-172,247-249	hygrothermograph	Y=-1.291+1.031X	0.969
Windspeed at 3 meters	1983	188-200,250-263	wind at 2m	Y=0.499+0.999X	0.996
Bottom-water temperature	1983	144-151	surface-water temperature	Y=0.314+0.986X	0.995
Dry-bulb temperature	1984	164-166,190,242-247,261-263	hygrothermograph	Y=2.101+0.932X	0.932
Wet-bulb temperature	1984	117-137,144-145,148-152, 1984 164-166,178-180,190,193-195, 1984 200-201,203,242-247,216-262	hygrothermograph	Y=-0.764+1.043X	0.974
Windspeed at 2 meters	1984	164-166,190,242-247,261-263	land wind speed at 2m	Y=-0.208+1.26X	0.900
Windspeed at 3 meters	1984	161-170,190,232-236,242-247, 1984 262-263	wind speed at 2m		
Long-wave radiation	1984	117-263	Brunt's equation	NA	NA
Surface-water temperature	1984	164-166,190,242-247,261-262	interpolated from plot of data	NA	NA
Bottom-water temperature	1984	145-152	surface-water temperature	Y=-4.727+1.129X	0.991
Dry-bulb temperature	1985	125-126	hygrothermograph	Y=2.06+1.03X	0.988
Wet-bulb temperature	1985	125-126	hygrothermograph	Y=-0.288+1.06X	0.895
Windspeed at 2 meters	1985	125-126	land wind speed at 2m	1.27+1.02X	0.900
Long-wave radiation	1985	entire year	Brunt's equation	NA	NA
Surface-water temperature	1985	124,125	interpolated from plot of data	NA	NA
Dry-bulb temperature	1986	134-140,142-148,153-155, 1986 169-218,225-239,255-257, 1986 260-264,267-271	hygrothermograph	Y=1.695+1.006X	0.968
Wet-bulb temperature	1986	134-140,143-148,153-155, 1986 169-210,255-257,260-264, 1986 267-271	hygrothermograph	Y=2.521+0.91X	0.912
Windspeed at 2 meters	1986	128,133-140,142-148,151, 1986 155,162,169-210,255-257, 1986 260-264,267-271	land wind speed at 2m	Y=0.331+1.16X	0.929
Long-wave radiation	1986	114-150,252-254,258,259, 1986 265,266,272,273	Brunt's equation	NA	NA
Surface-water temperature	1986	entire year	bottom-water temperature	Y=2.578+1.045X **	0.908
Dry-bulb temperature	1987	140-154,159-263,192-203,	hygrothermograph	Y=0.443+0.951X	0.989
Dry-bulb temperature	1987	243-245	201 probe air temperature	Y=-0.116+0.991X	0.999
Vapor pressure	1987	143-147,149-154,162-182	hygrothermograph	Y=0.708+0.905X	0.982
Vapor pressure	1987	266-272,276-287	Ea equation with dry & wet bulb	Y=0.434+0.924X	0.961
Humidity	1987	143-147,149-154,162-182	hygrothermograph	Y=13.593+0.821X	0.912
Windspeed at 2 meters	1987	143-147,149-154,162-182, 1987 266-272,274,276-287,293-303	land wind speed	Y=0.385+1.14X	0.901
Long-wave radiation	1987	150-171,265-294	Brunt's equation	NA	NA
Surface-water temperature	1987	140-154,159-163,192-203	3-day average of hygro-thermograph air temperature	Y=7.278+0.752X	0.892
Surface-water temperature	1987	242-261	3-day average of dry bulb	Y=1.499+1.043X	0.949
Bottom-water temperature	1987	229-241	surface-water temperature	Y=3.975+0.751X	0.942

*, data from 1983-85 and 1987 were used to derive the regression equation
**, data from 1985 were used to derive the regression equation

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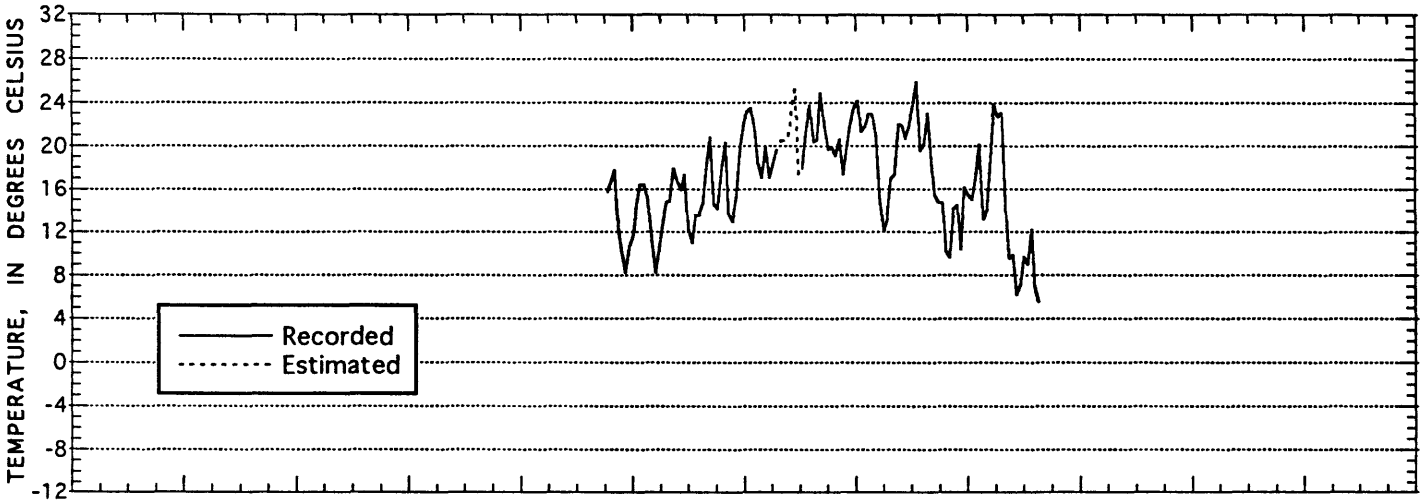
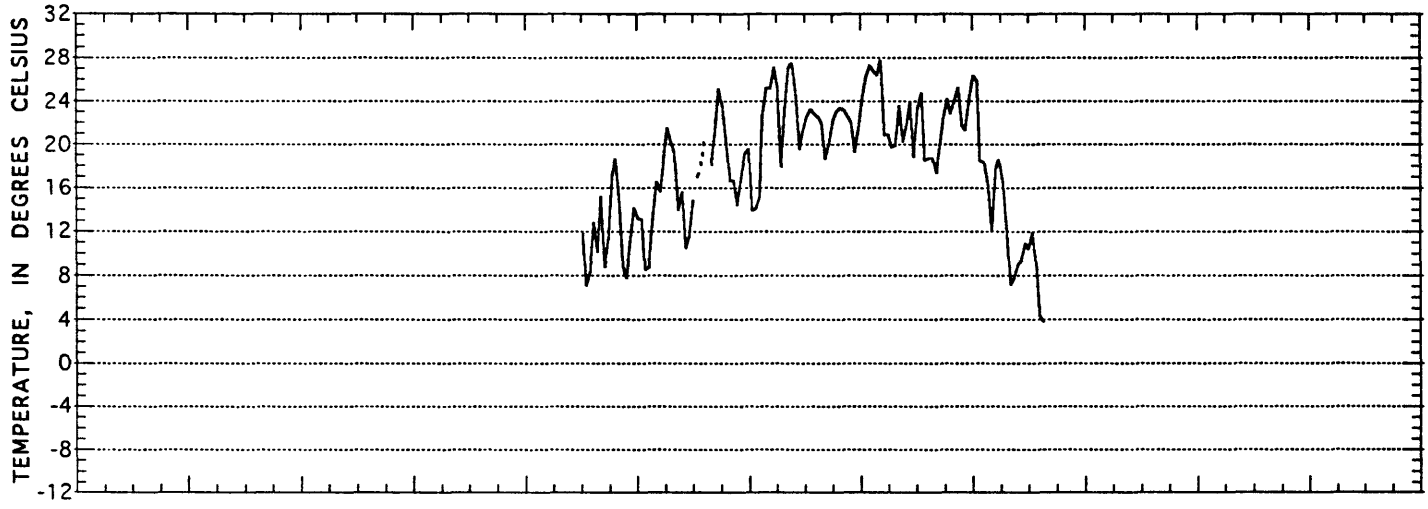




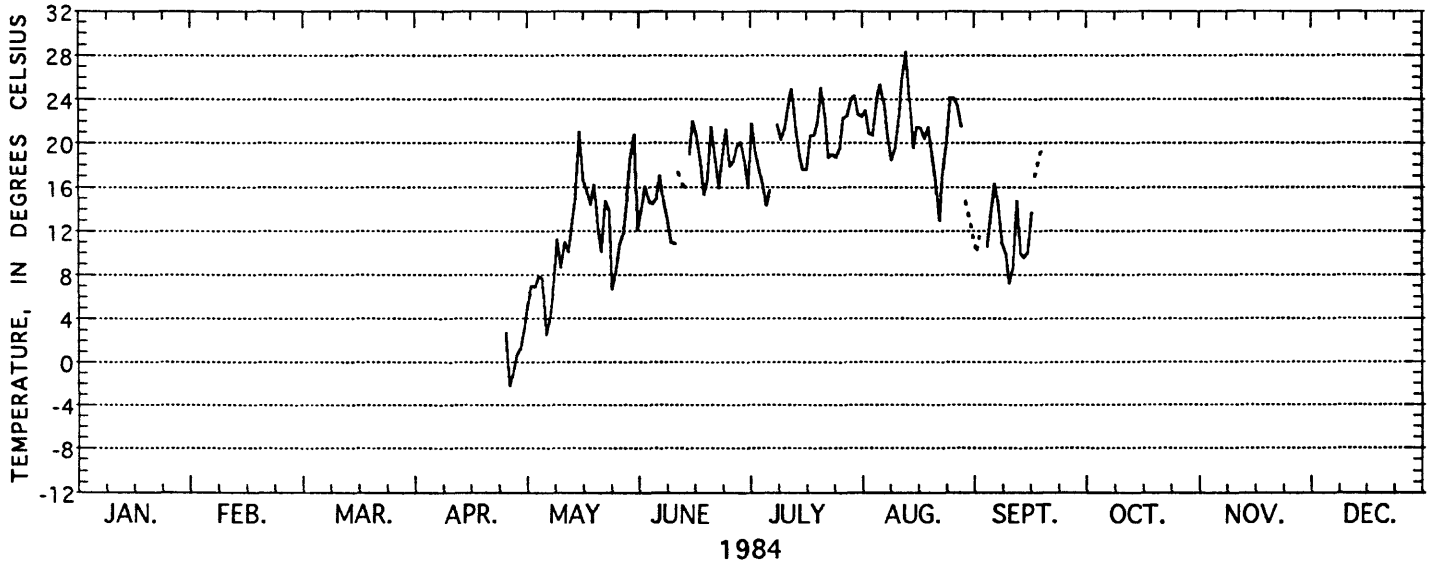


Figure 2.--Average daily dry-bulb air temperature at Wetland P1 raft station, 1982-87.

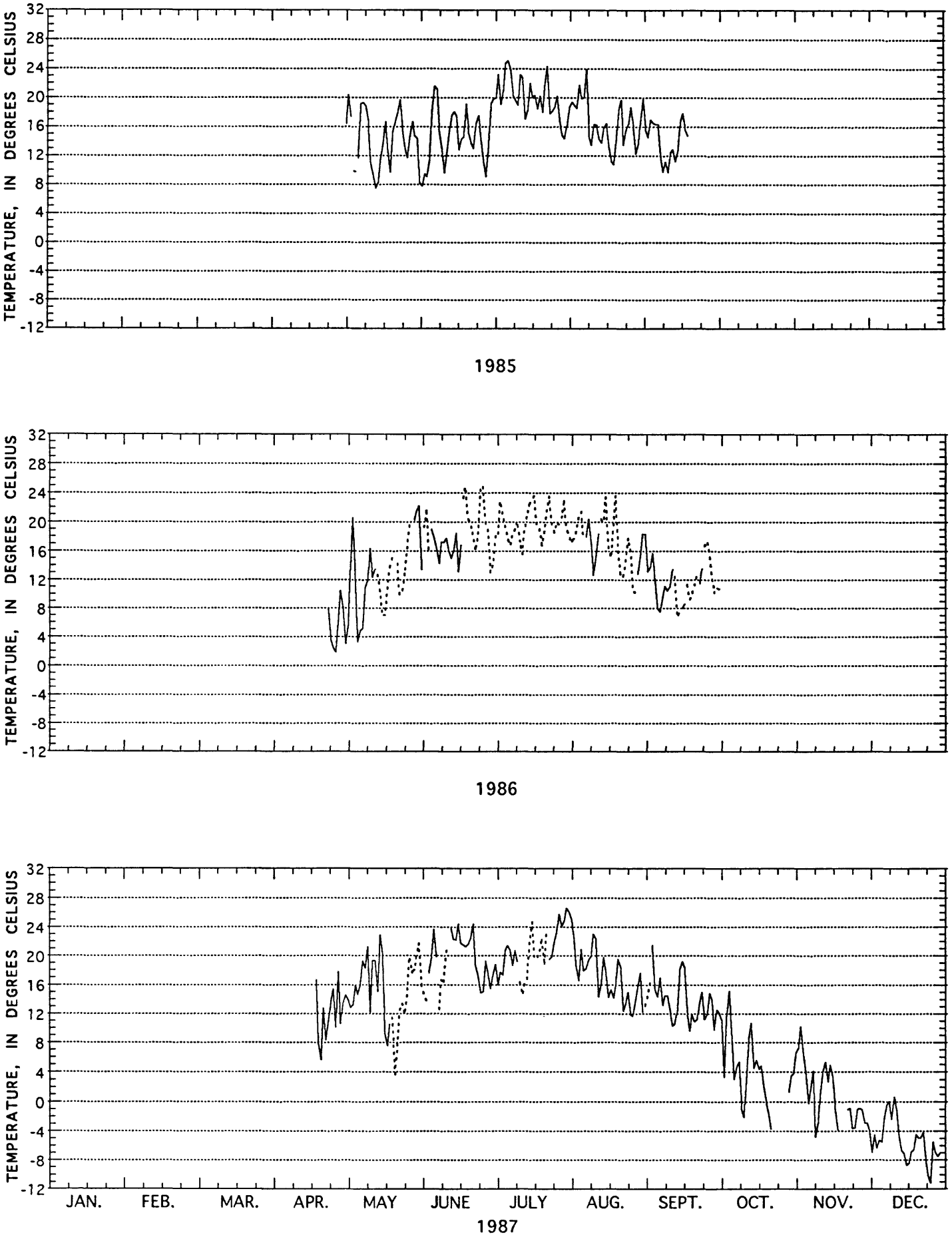


Figure 2.--Average daily dry-bulb air temperature at Wetland P1 raft station, 1982-87--Continued

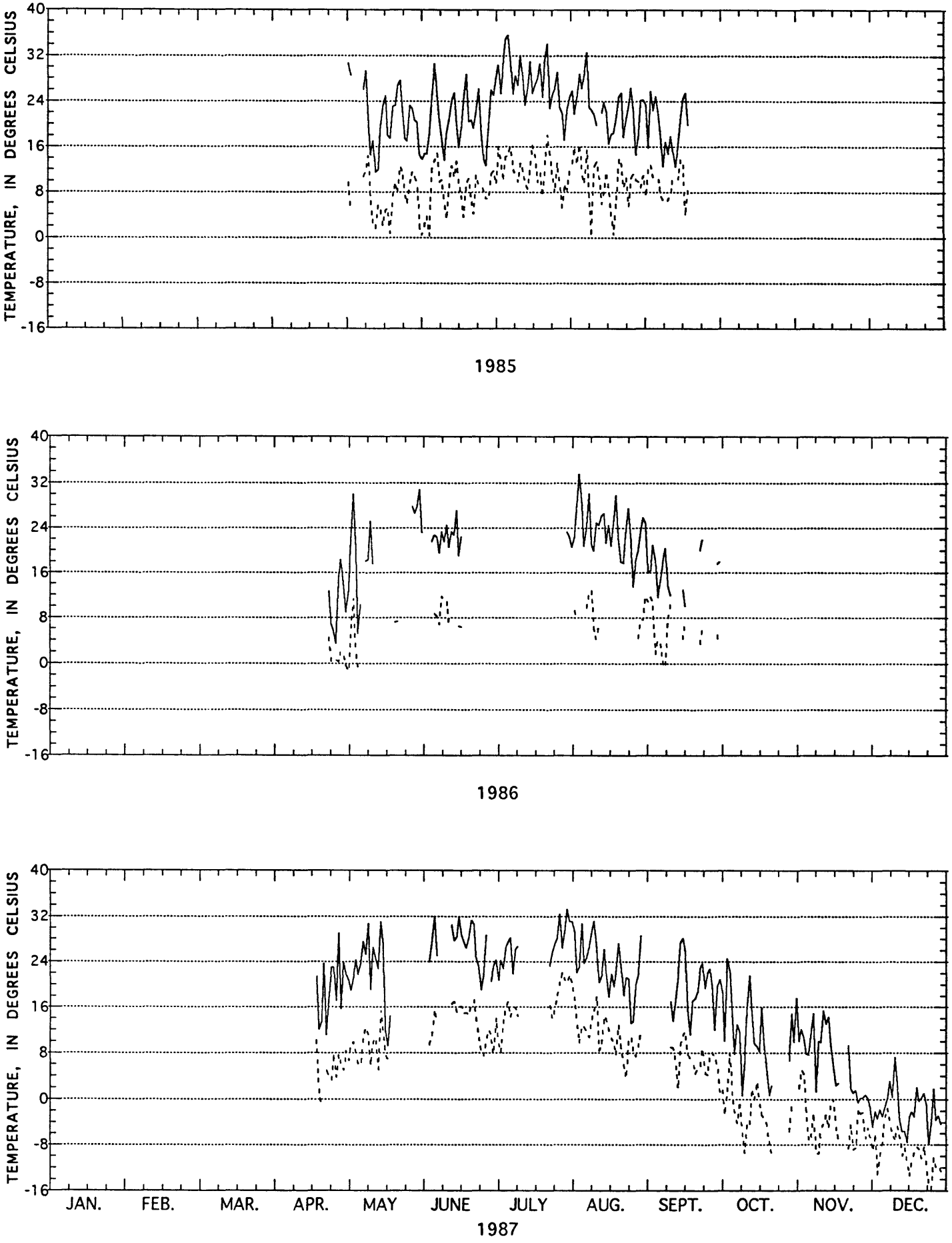


Figure 3.--Maximum and minimum daily dry-bulb air temperature at Wetland P1 raft station, 1982-87--Continued.

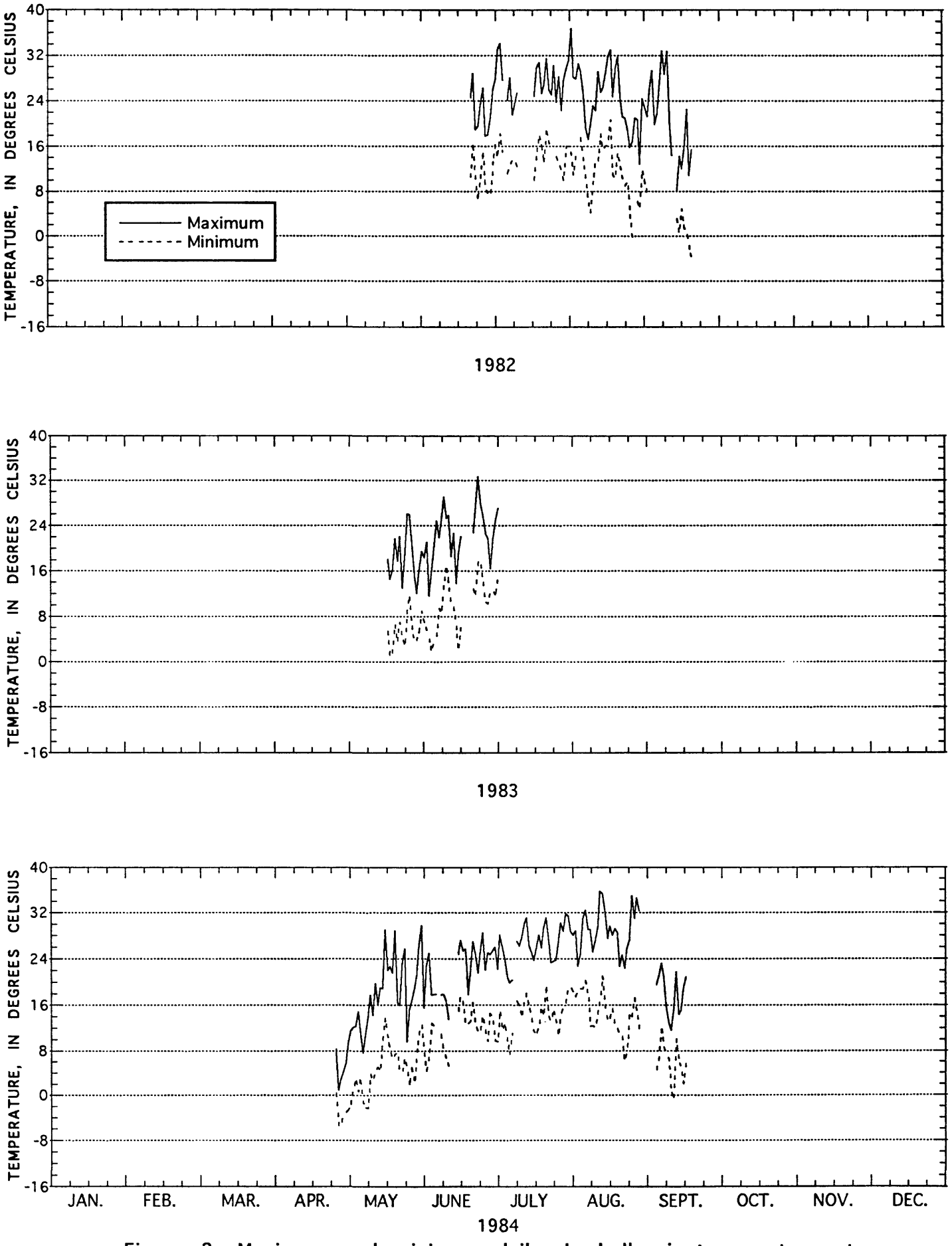
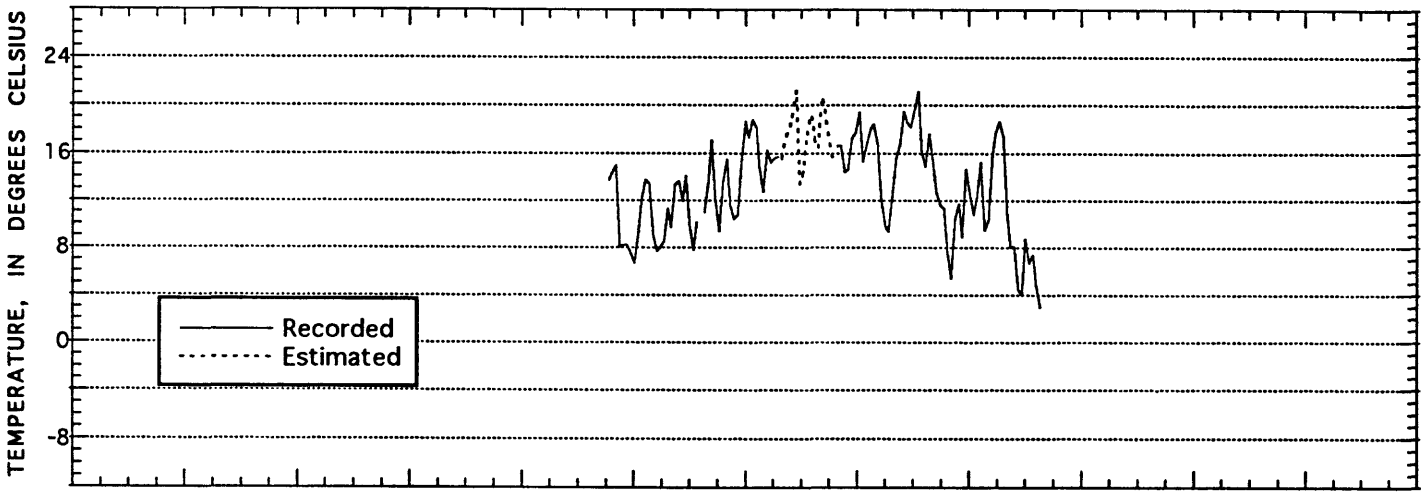
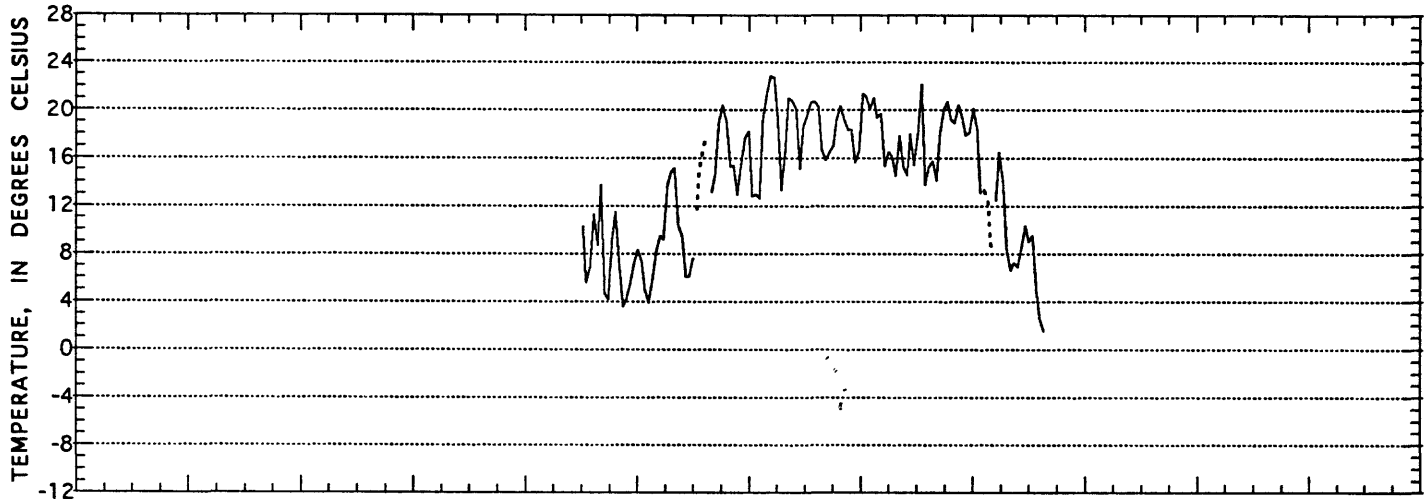


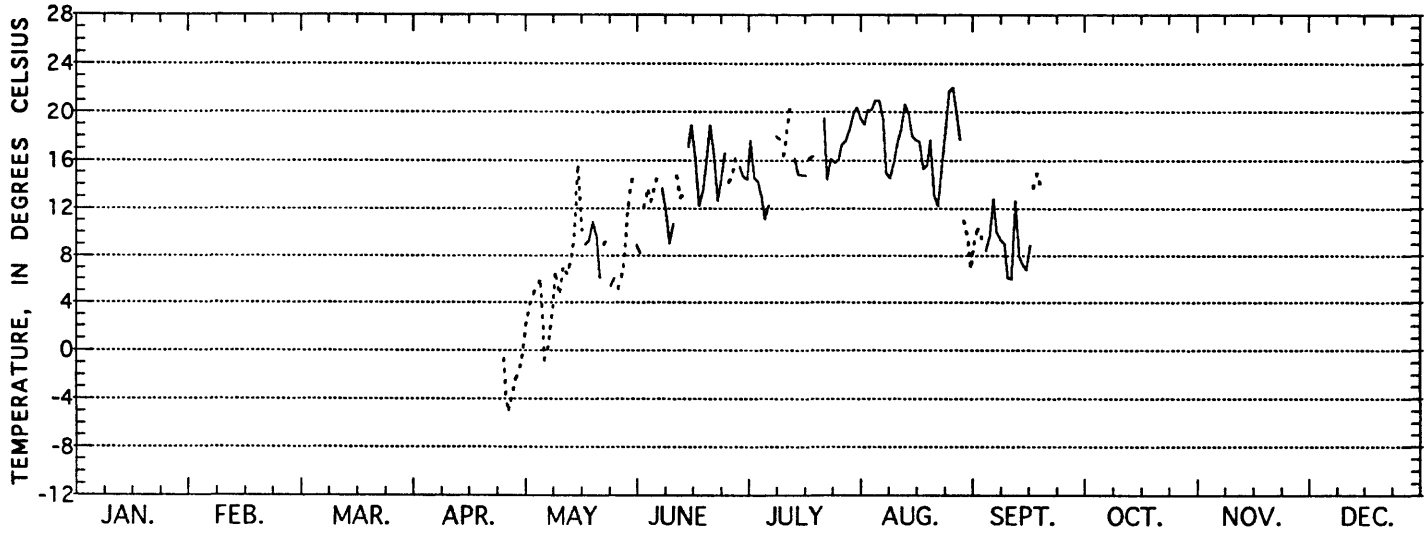
Figure 3.--Maximum and minimum daily dry-bulb air temperature at Wetland P1 raft station, 1982-87.



1982

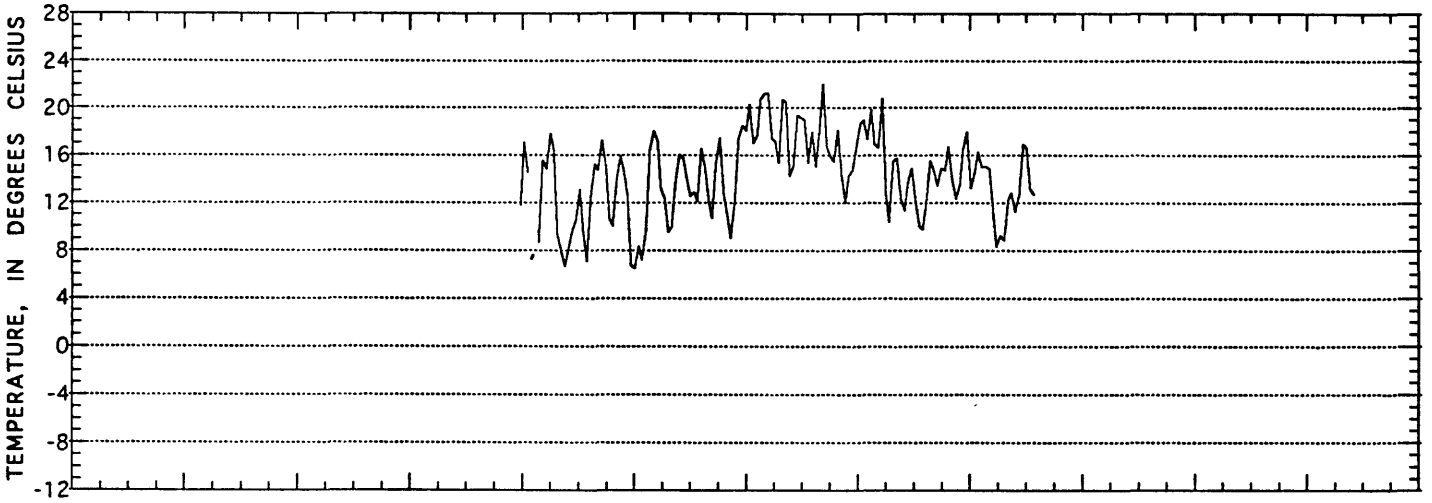


1983

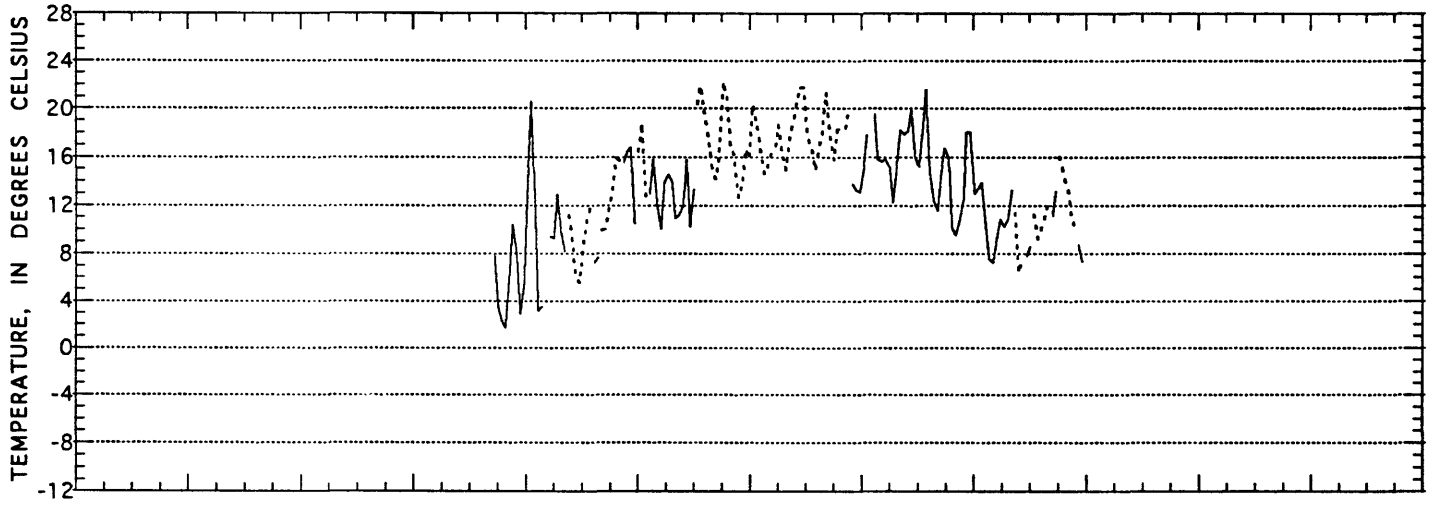


1984

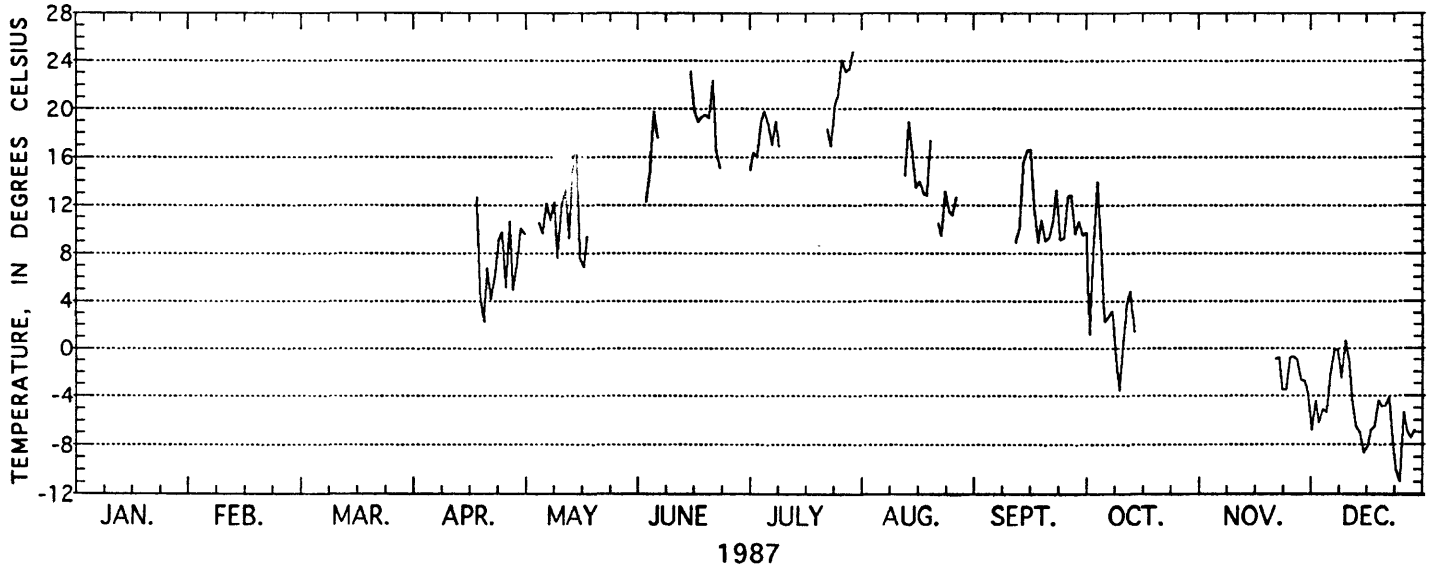
Figure 4.--Average daily wet-bulb air temperature at Wetland P1 raft station, 1982-87.



1985



1986



1987

Figure 4.--Average daily wet-bulb air temperature at Wetland P1 raft station, 1982-87--Continued.

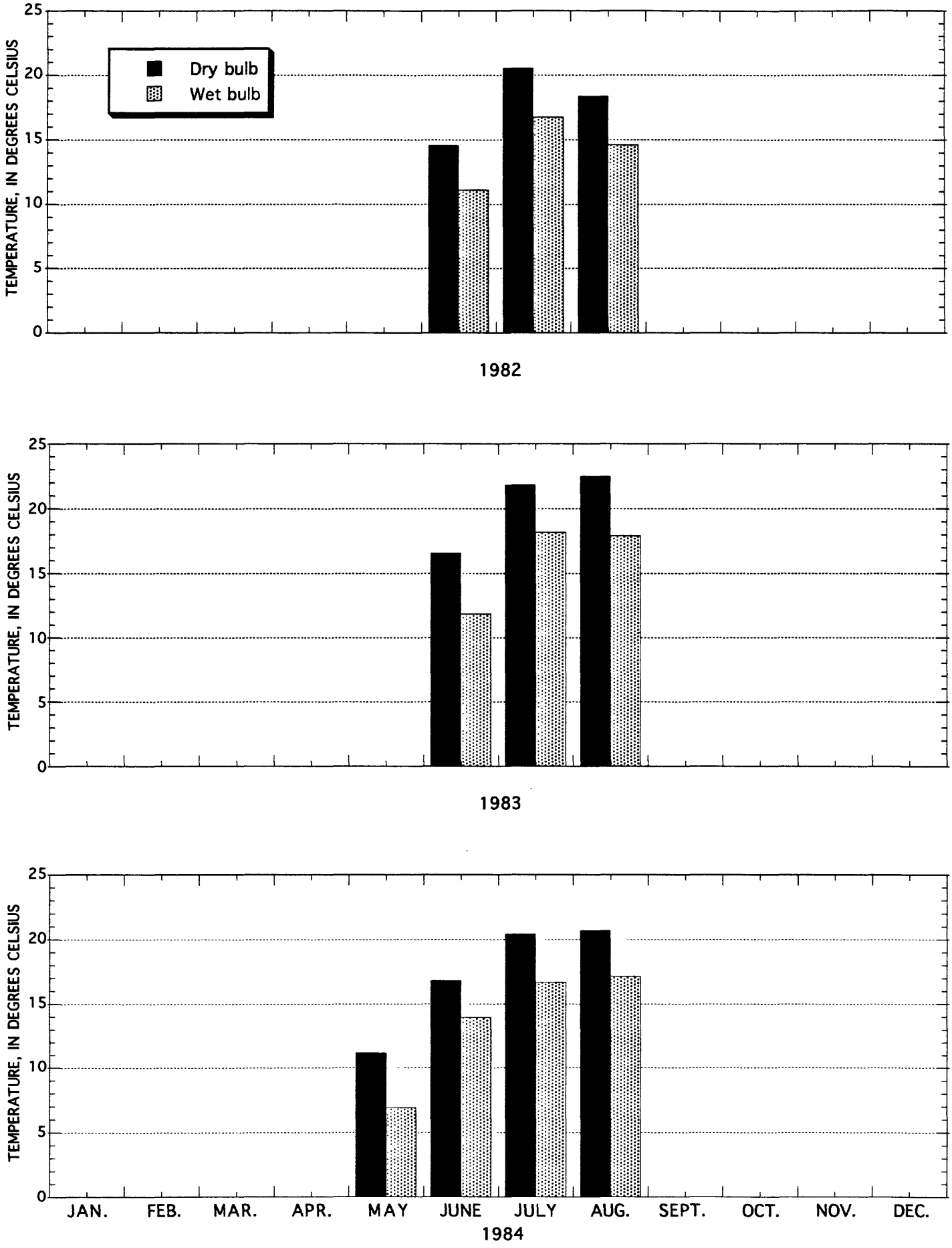
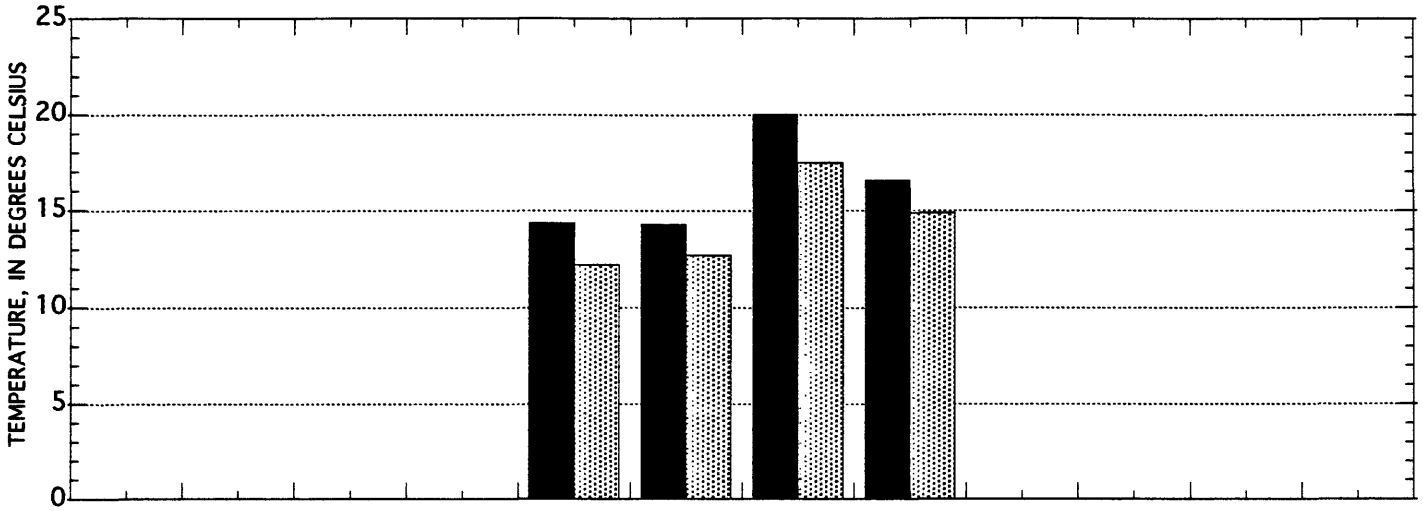


Figure 5.--Average monthly dry- and wet-bulb air temperatures at Wetland P1 raft station, 1982-87.



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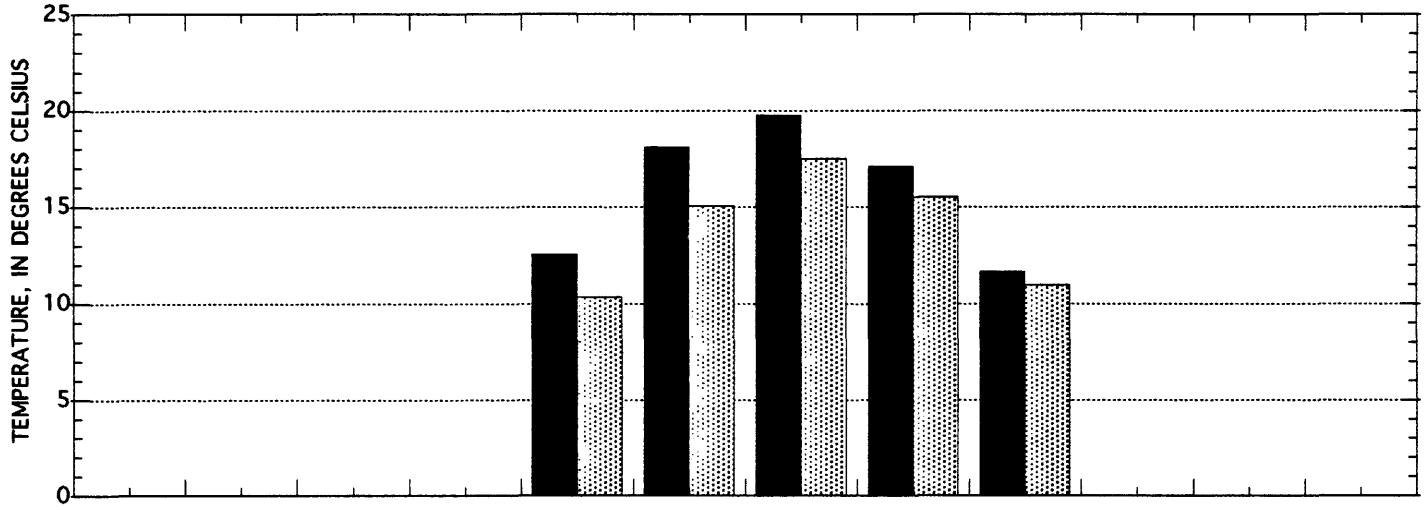

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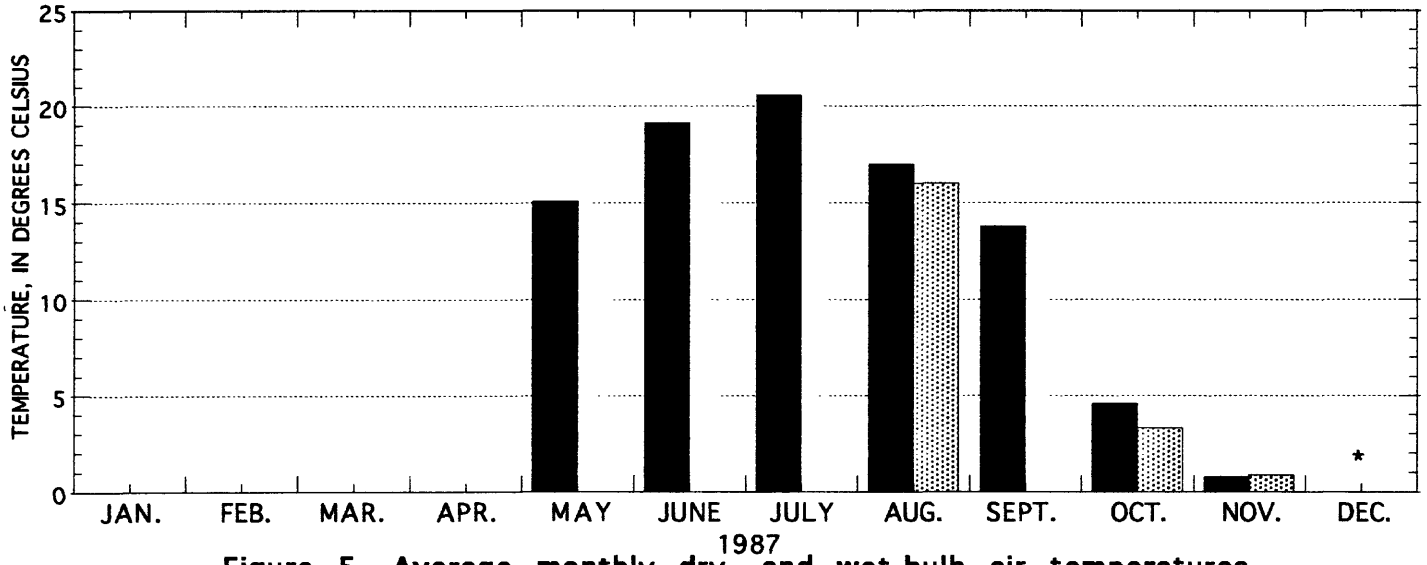
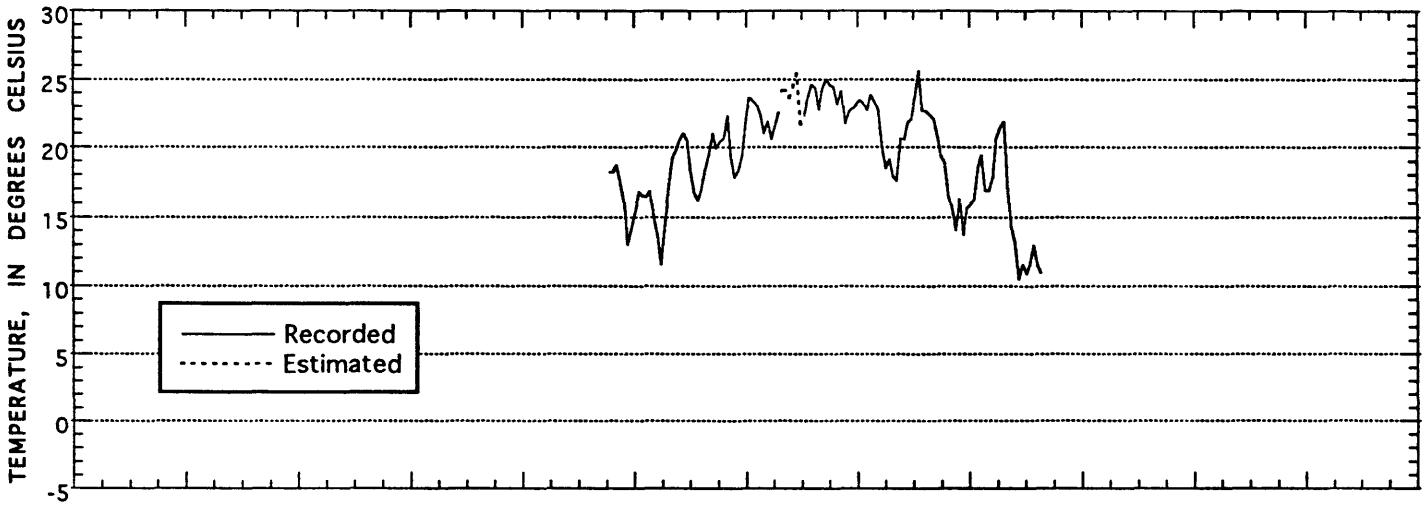
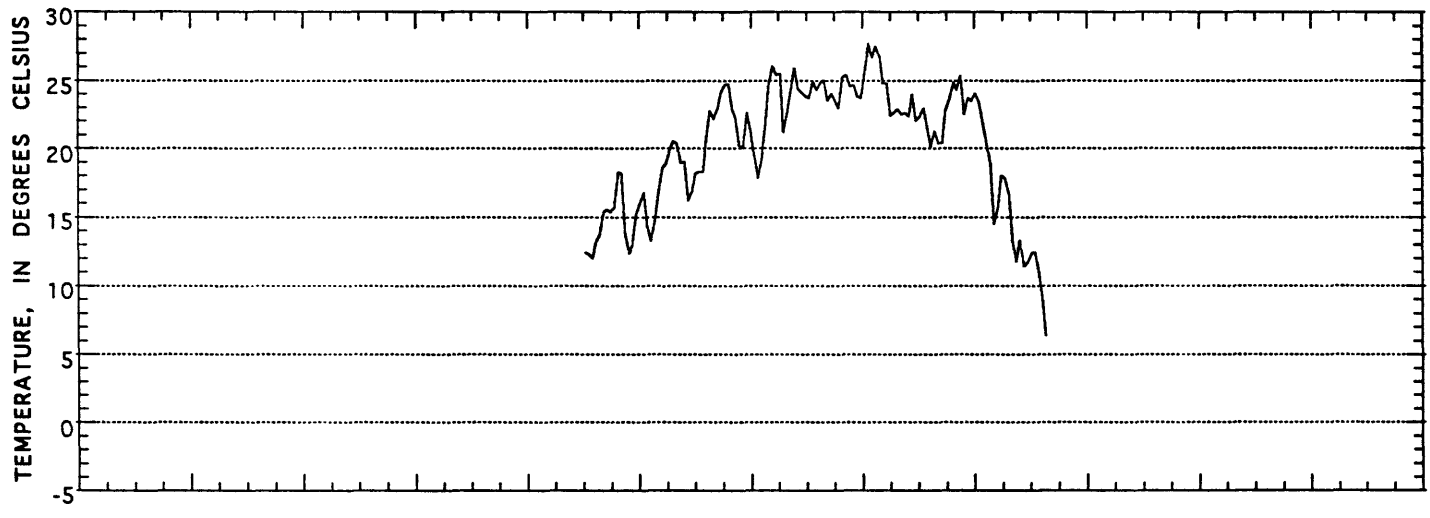


1987

Figure 5.--Average monthly dry- and wet-bulb air temperatures at Wetland P1 raft station, 1982-87--Continued.

[*, in December 1987, the dry- and wet- bulb average was -5.4 degrees Celsius]





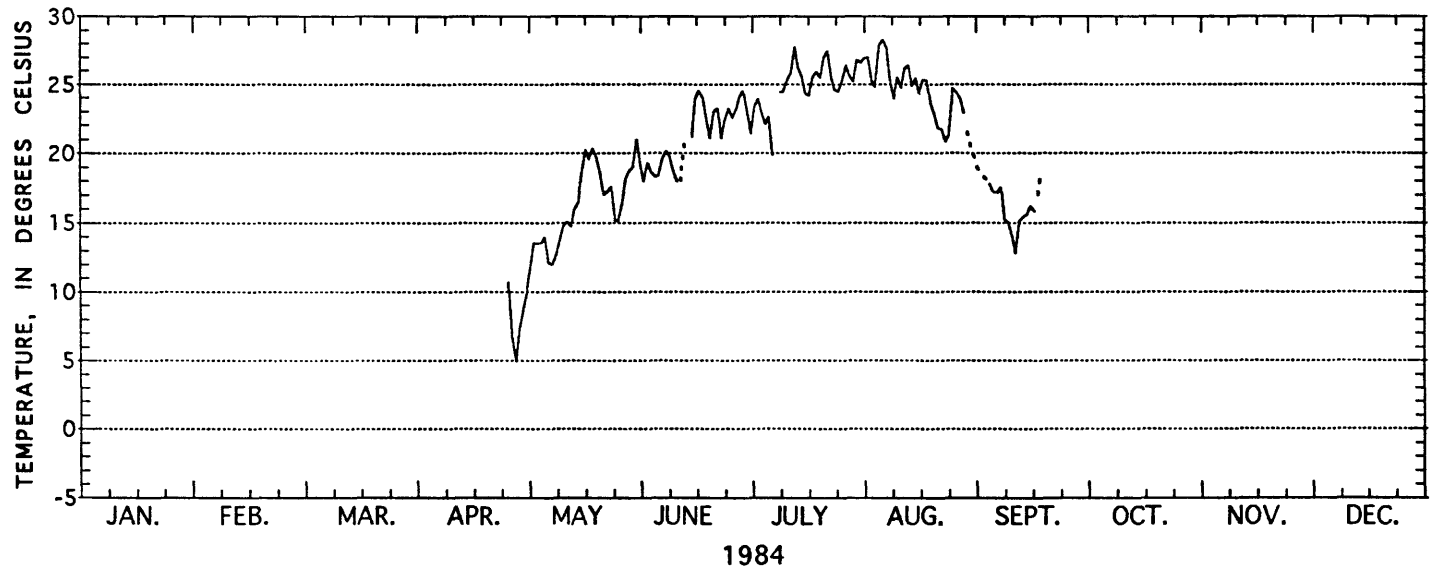


Figure 6.--Average daily water-surface temperature at Wetland P1 raft station, 1982-87.

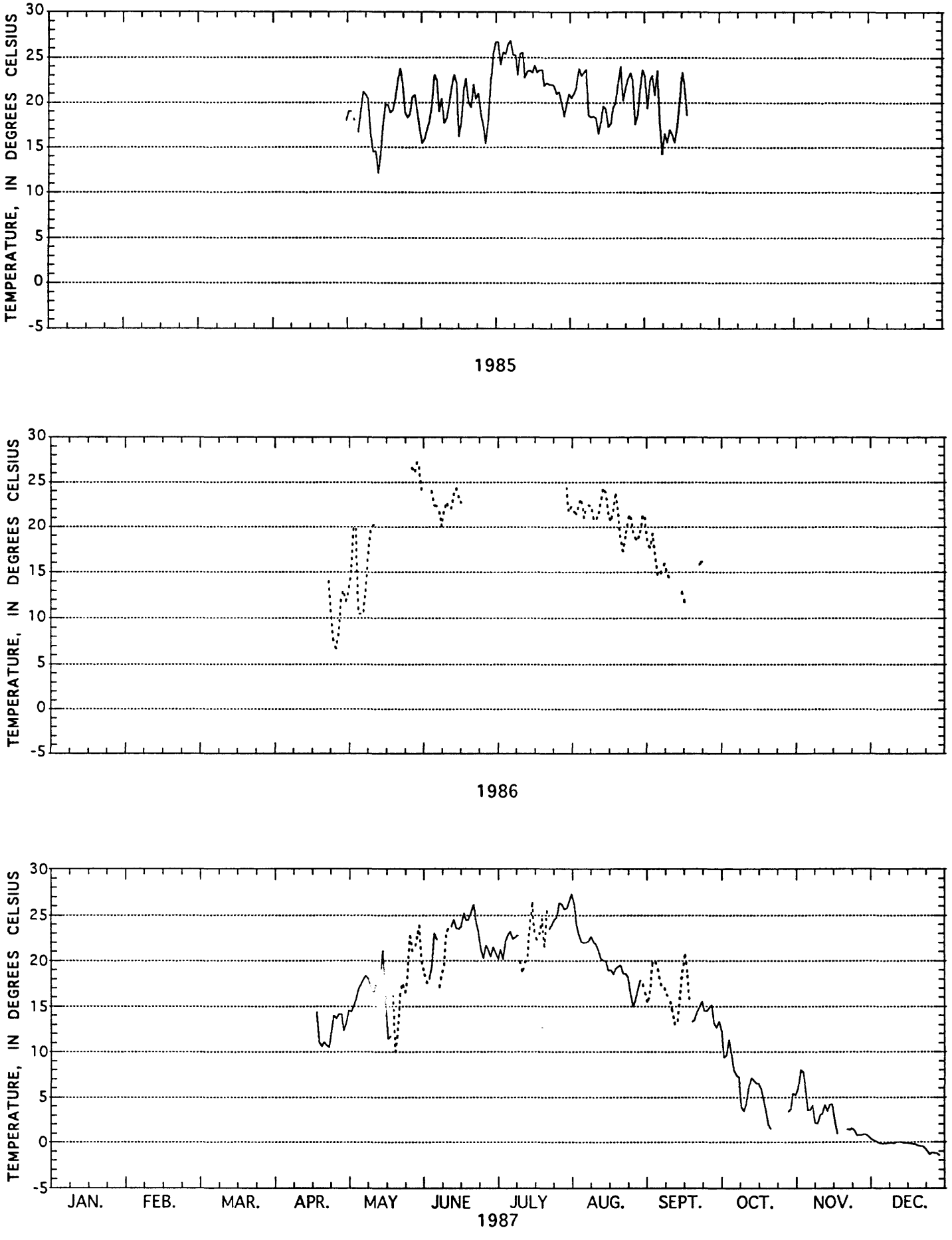


Figure 6.--Average daily water-surface temperature at Wetland P1 raft station, 1982-87--Continued.

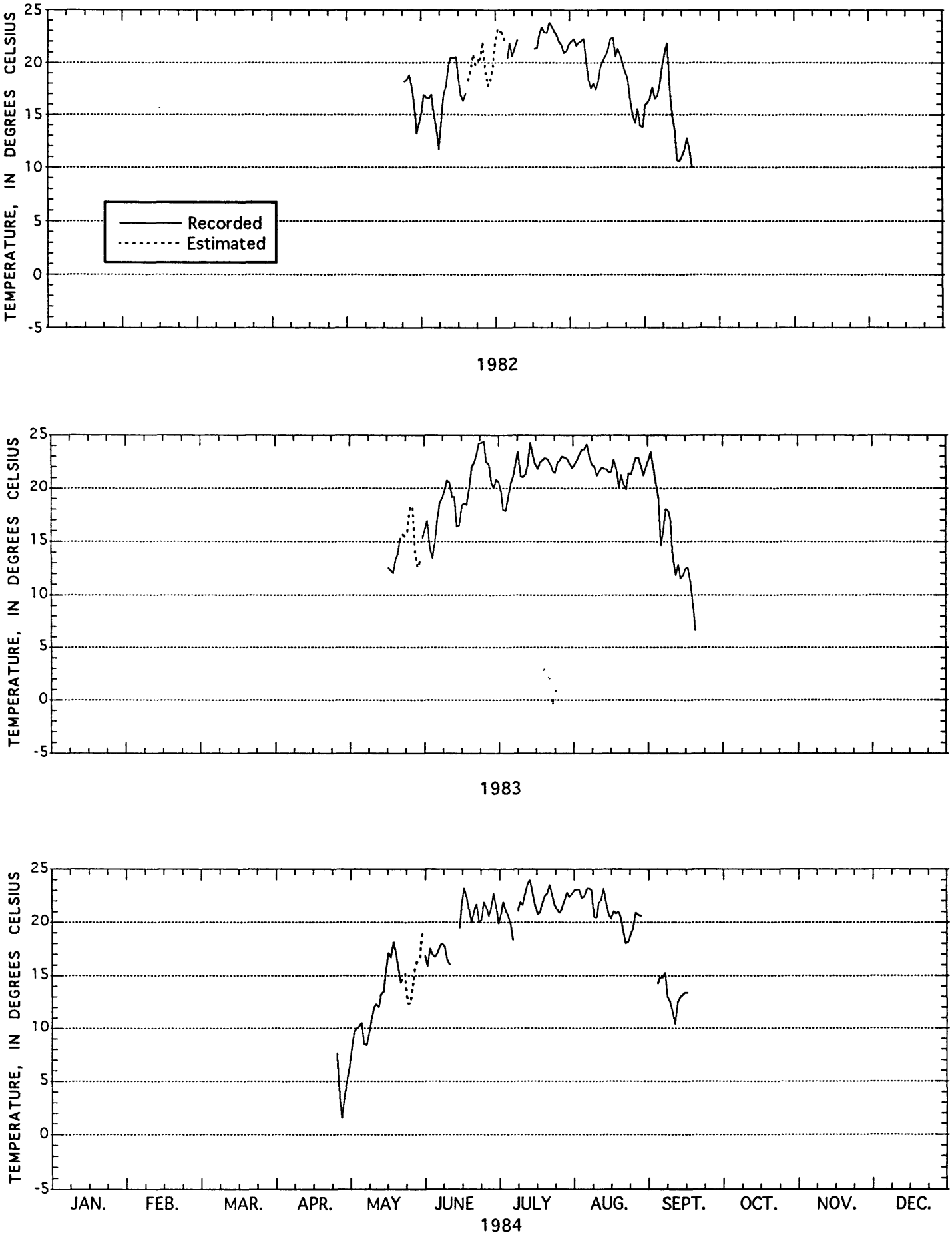


Figure 7.--Average daily lake-bottom water temperature at Wetland P1 raft station, 1982-87.

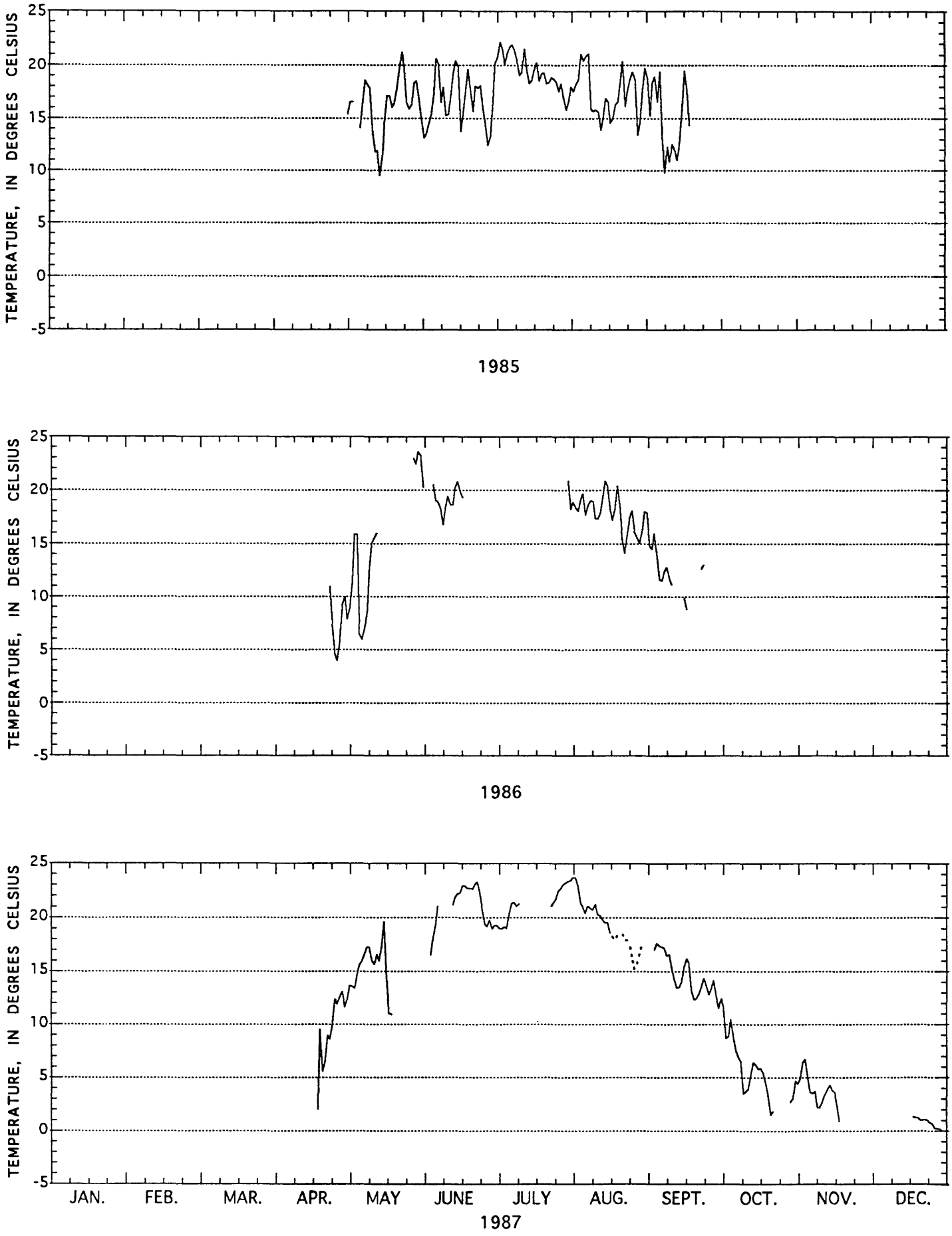


Figure 7.--Average daily lake-bottom water temperature at Wetland P1 raft station, 1982-77--Continued.

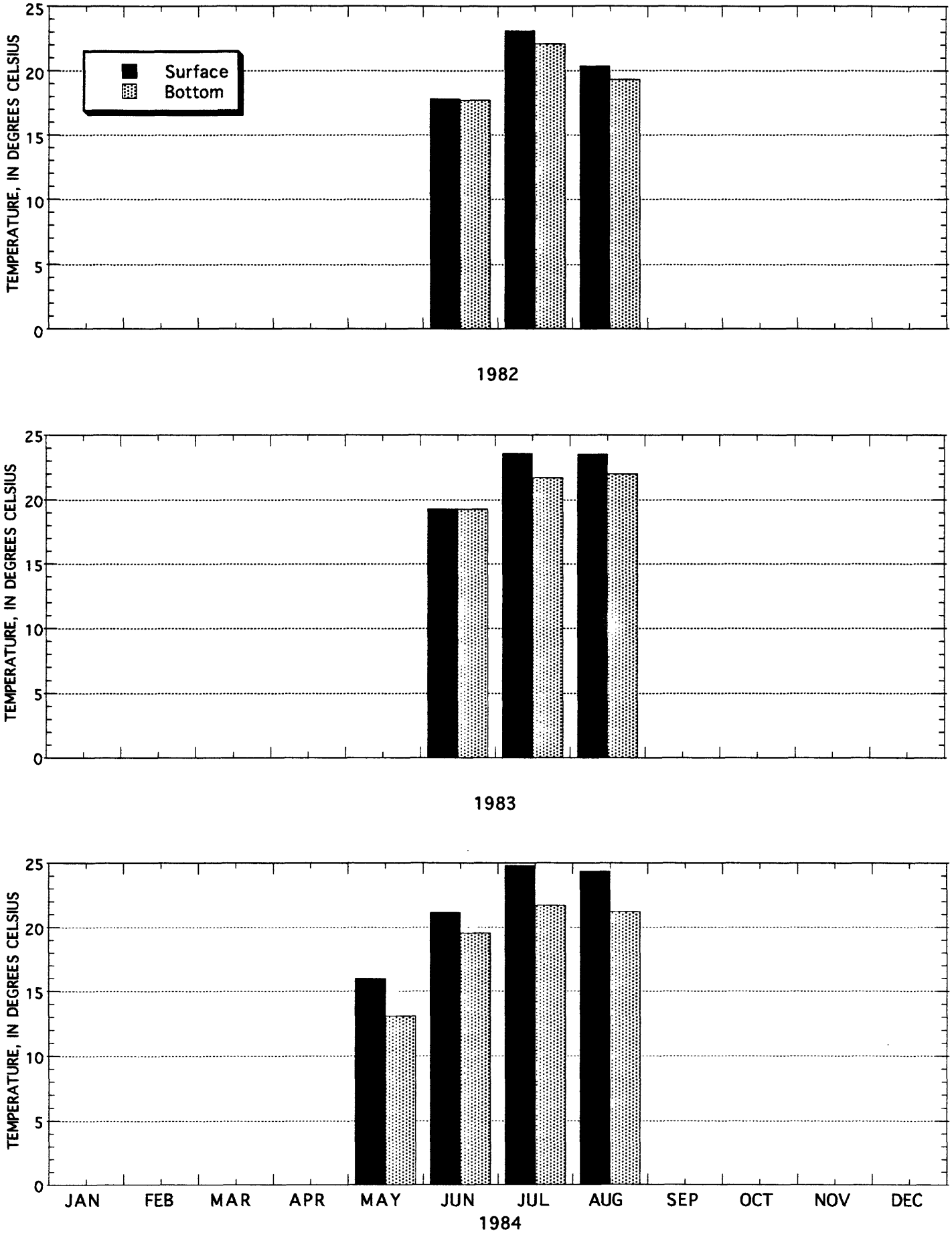
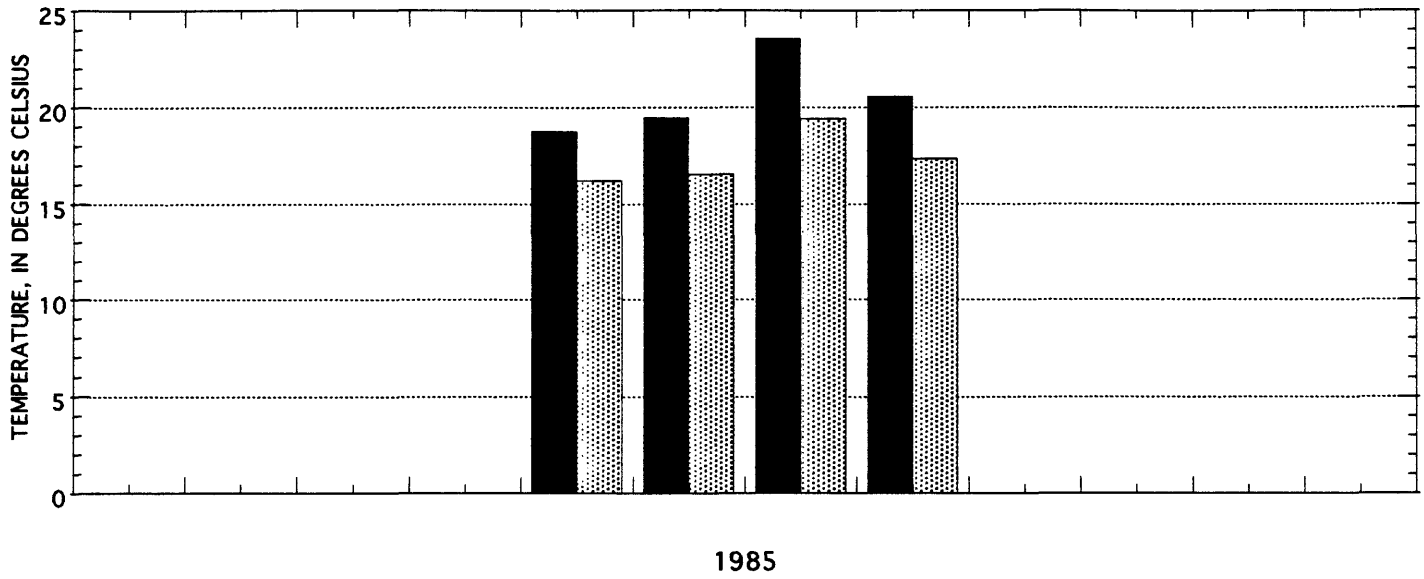
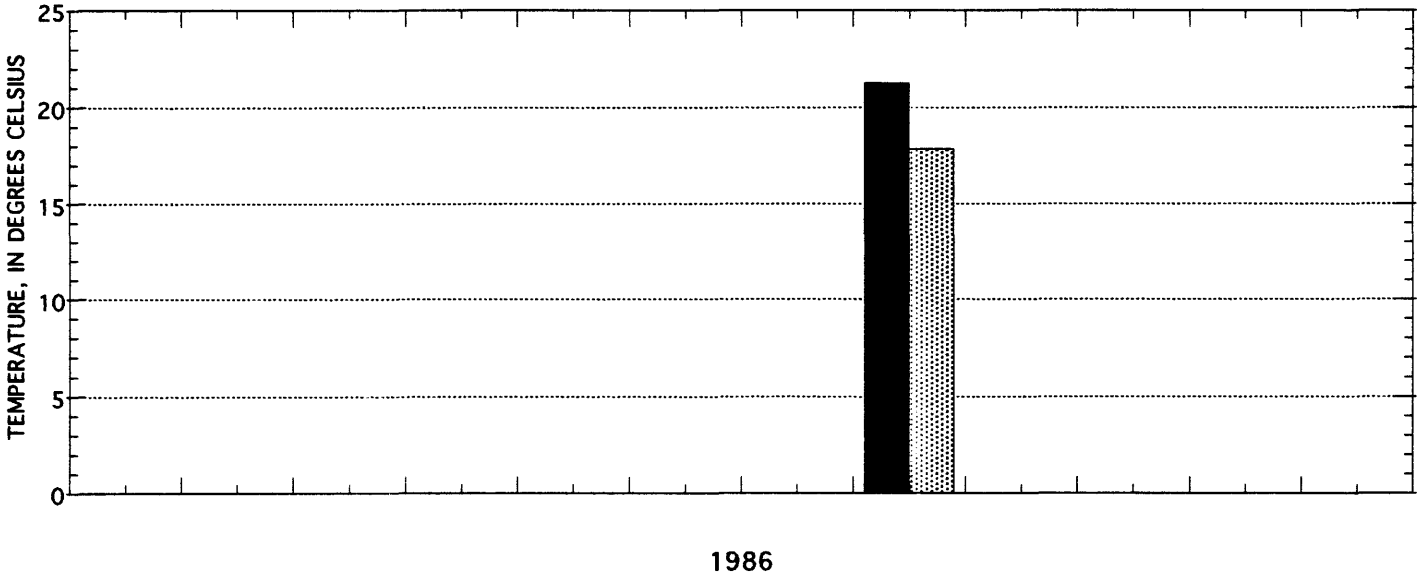


Figure 8.--Average monthly water-surface and lake-bottom temperatures at Wetland P1 raft station, 1982-87.





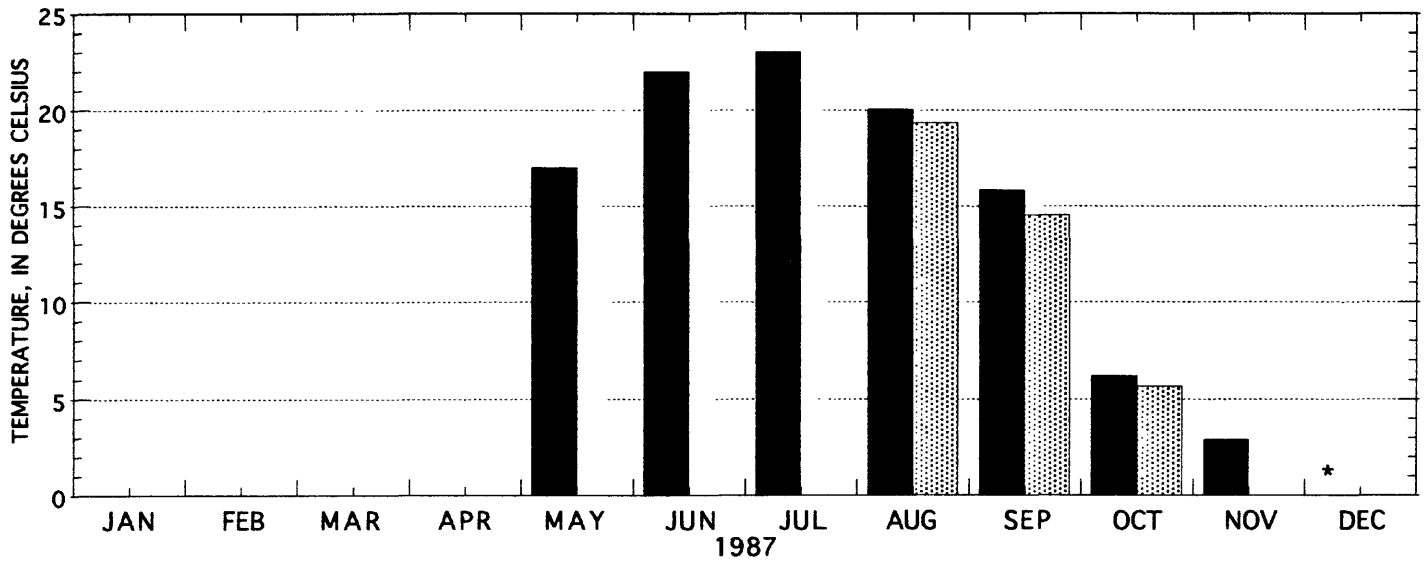


Figure 8.--Average monthly water-surface and lake-bottom temperatures at Wetland P1 raft station, 1982-87--Continued.

[*, average monthly surface-water temperature is -0.4 degrees Celsius]

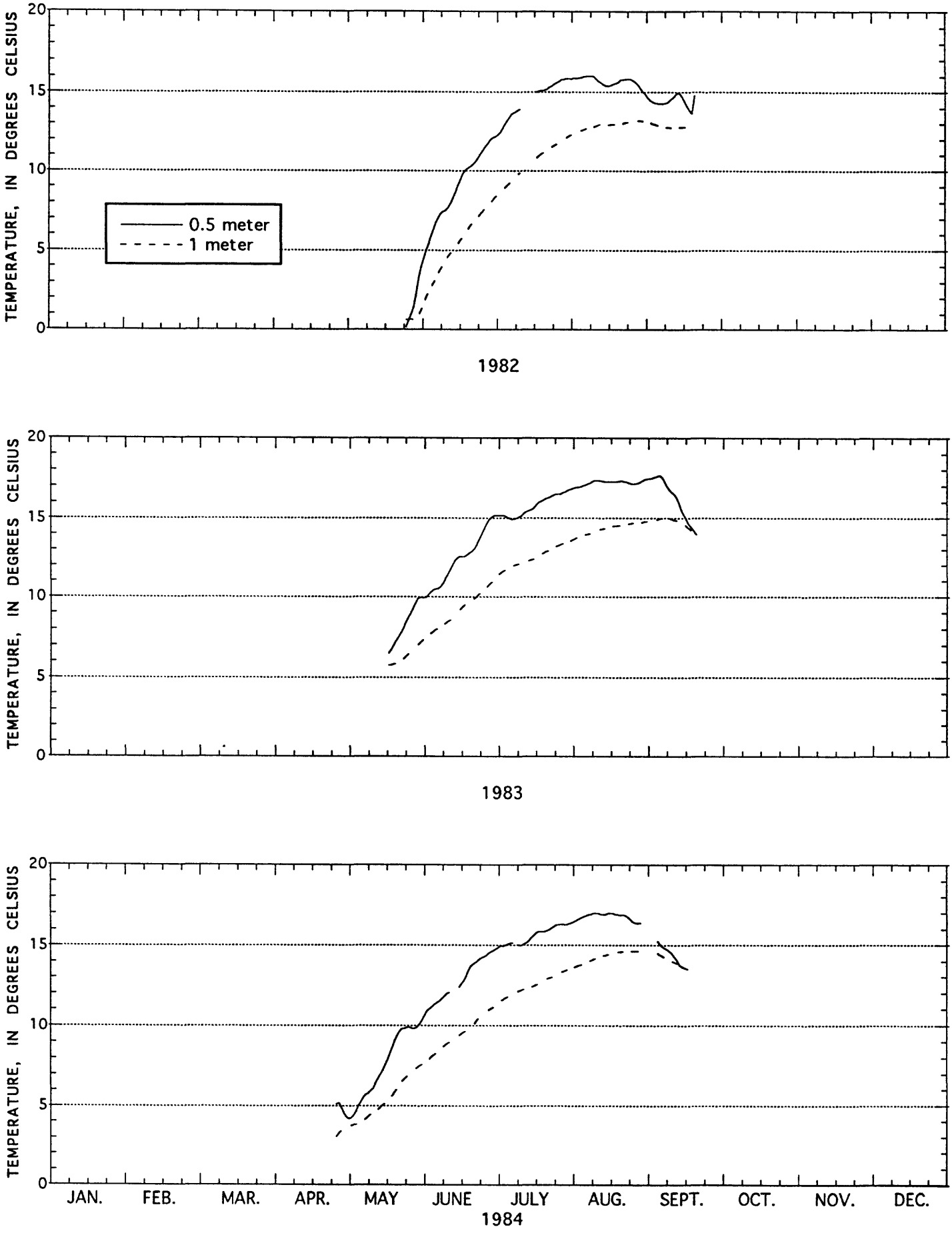


Figure 9.--Average daily sediment temperature at 0.5 and 1 meter depths below Wetland P1 raft station, 1982-87.

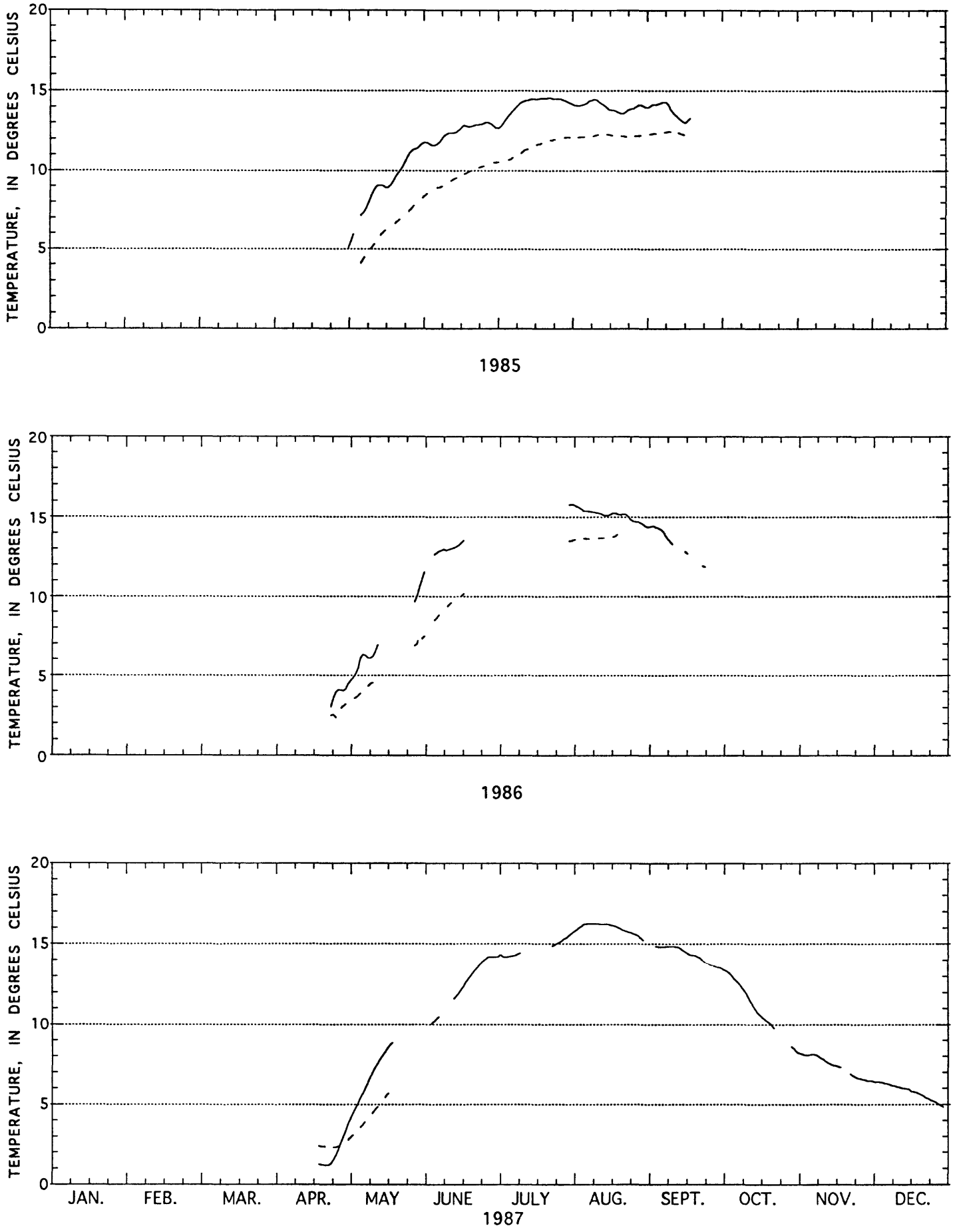


Figure 9.--Average daily sediment temperature at 0.5 and 1 meter depths below Wetland P1 raft station, 1982-87--Continued.

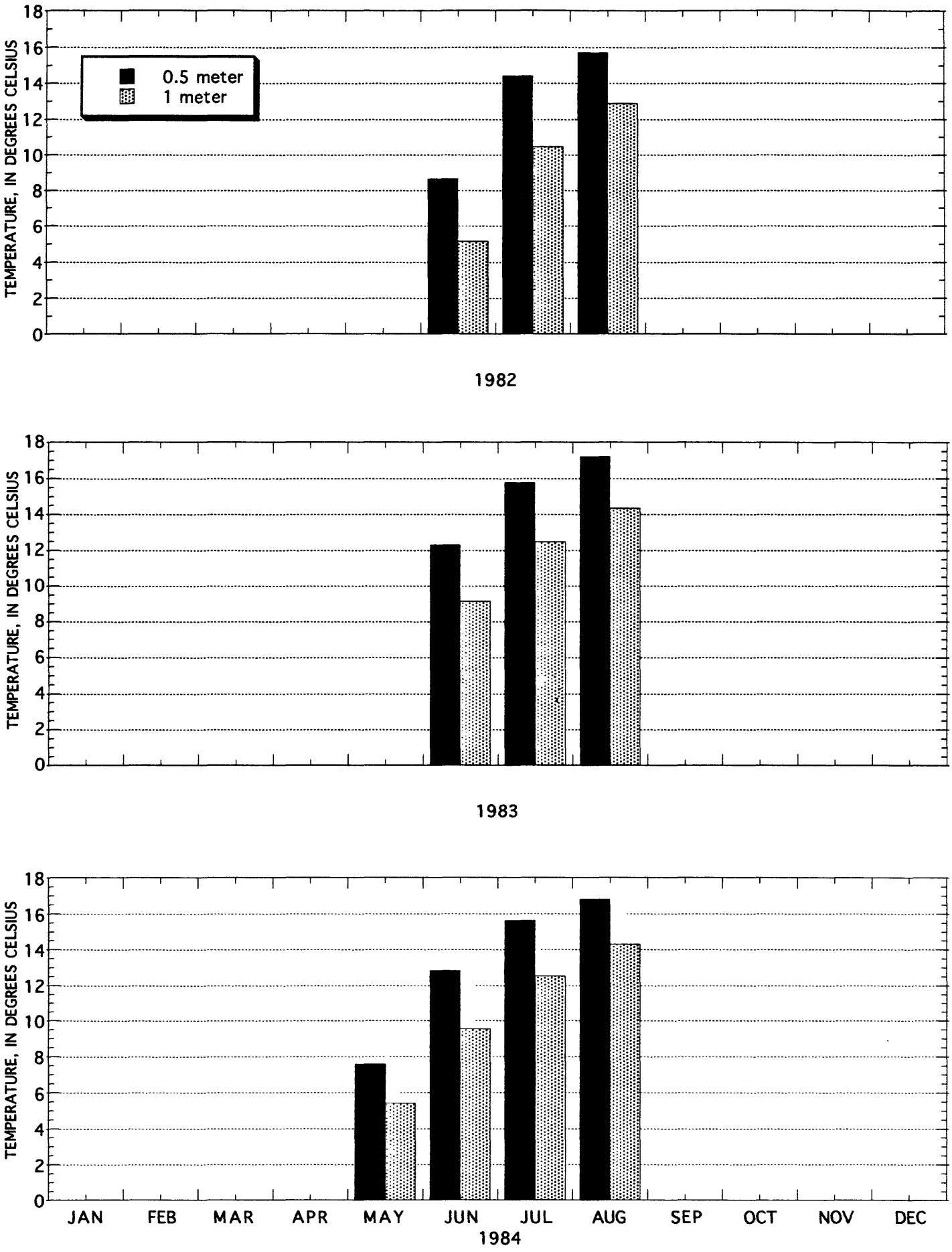
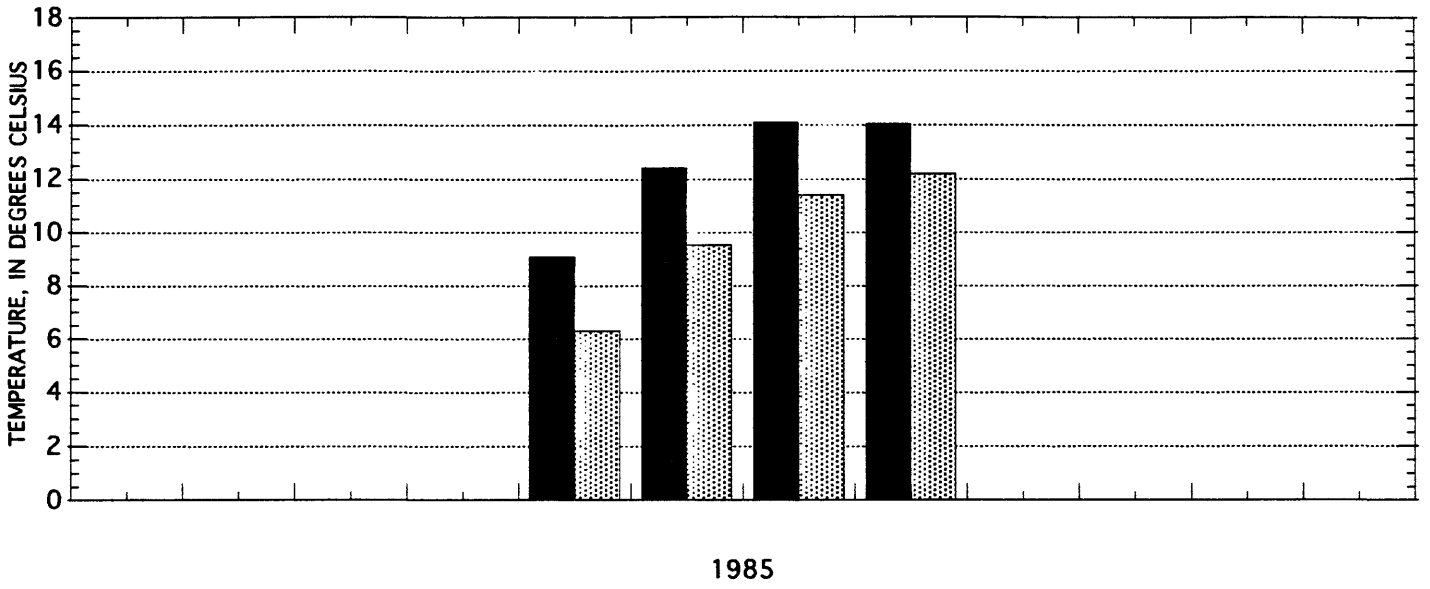
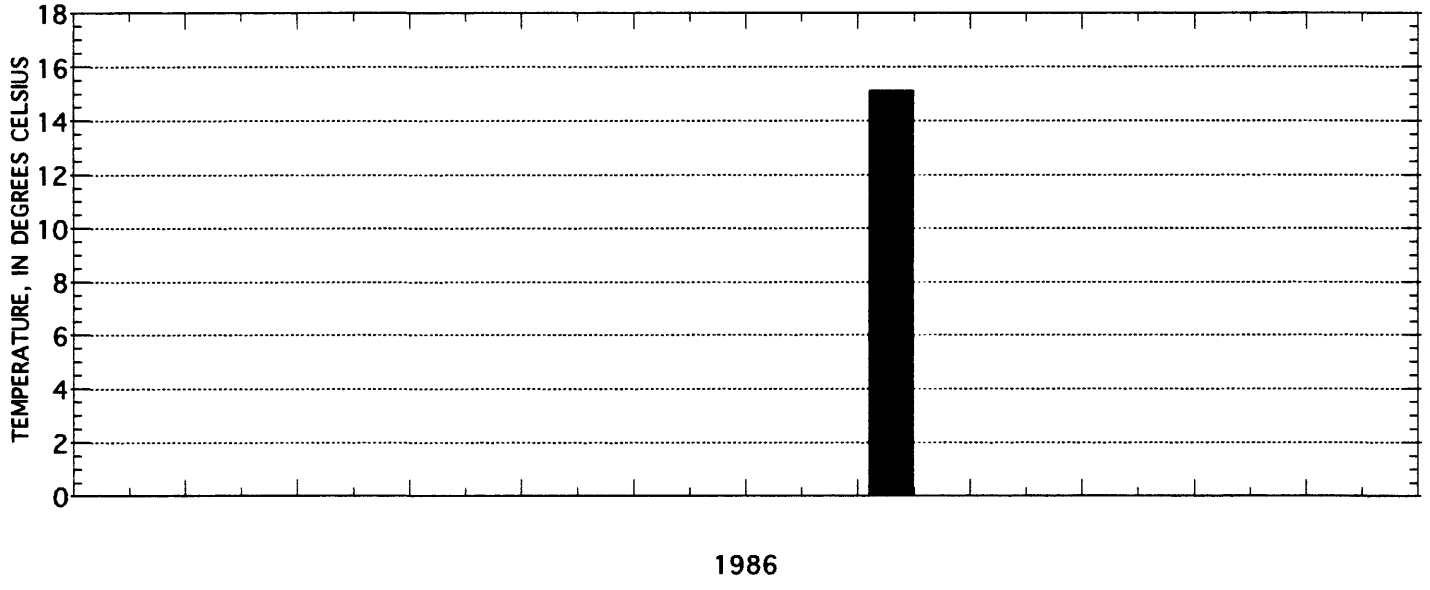


Figure 10.--Average monthly sediment temperature at 0.5 and 1 meter depths below Wetland P1 raft station, 1982-87.





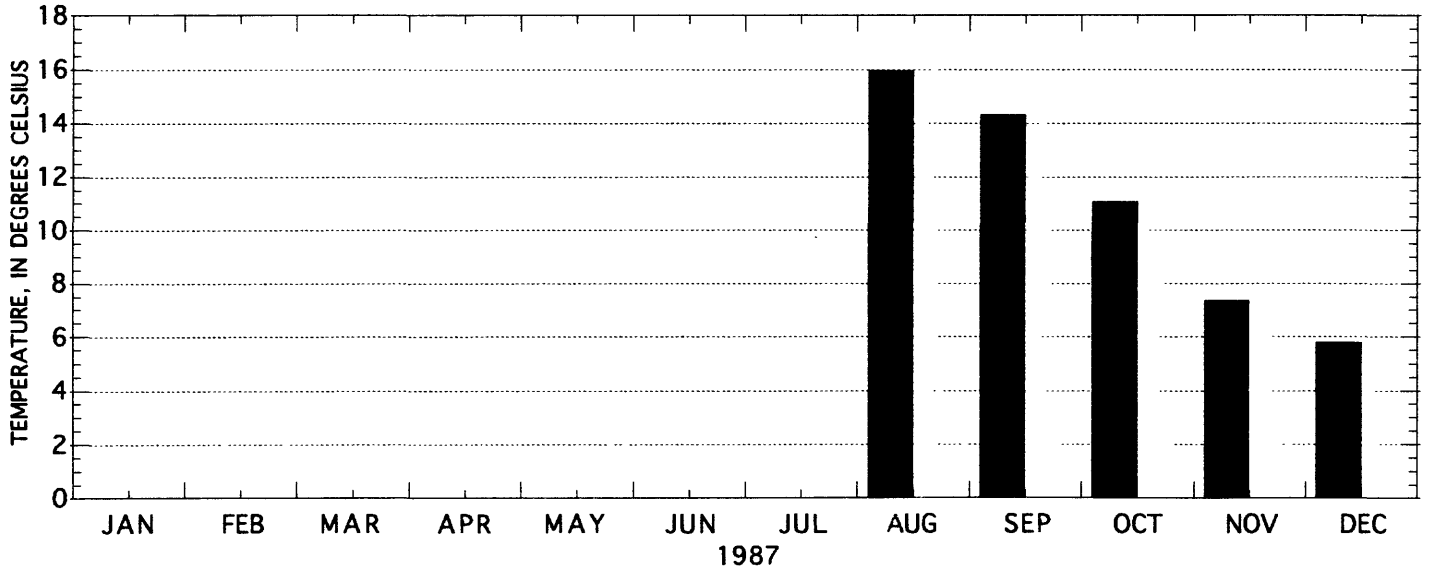


Figure 10.--Average monthly sediment temperature at 0.5 and 1 meter depths below Wetland P1 raft station, 1982-87--Continued.

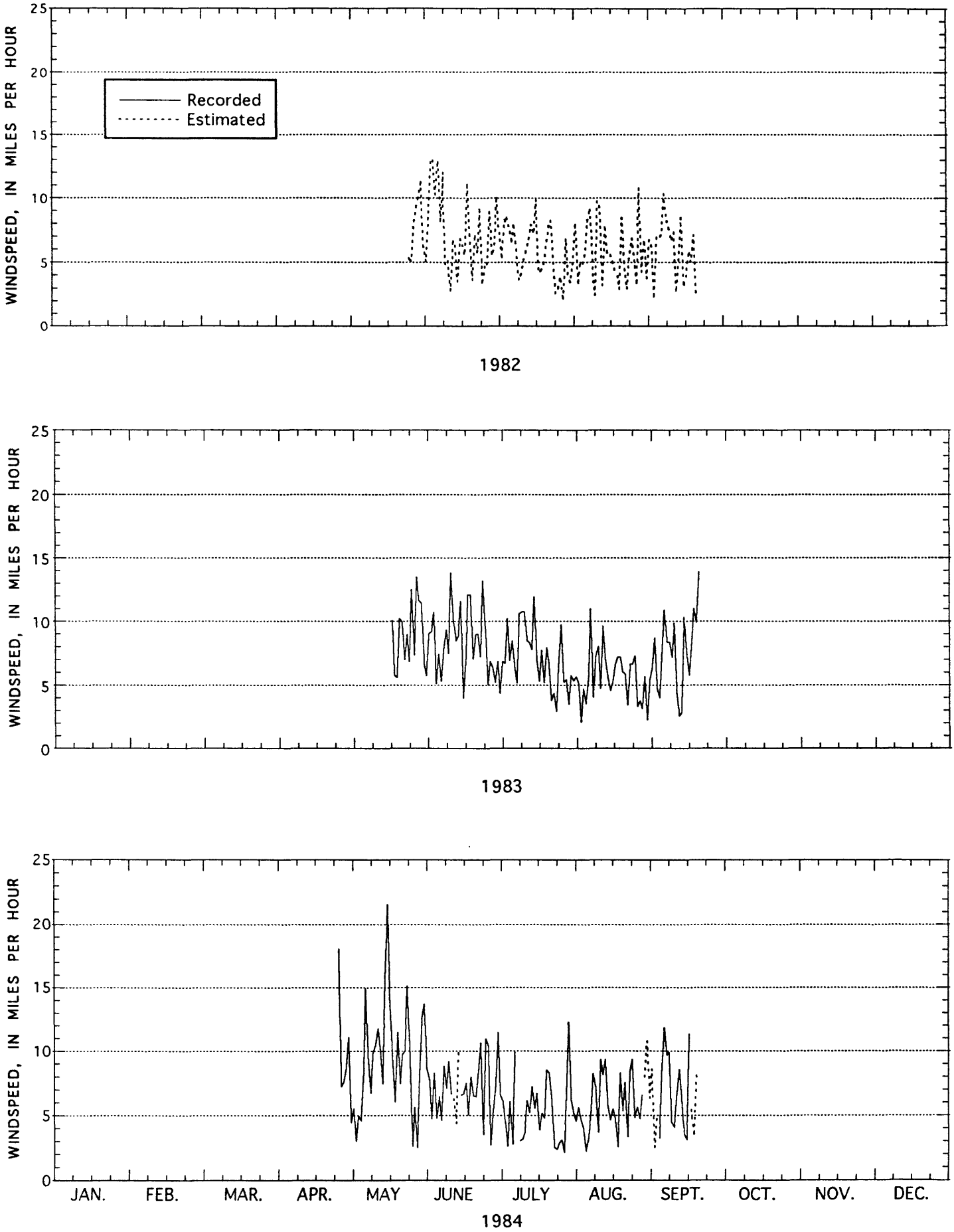
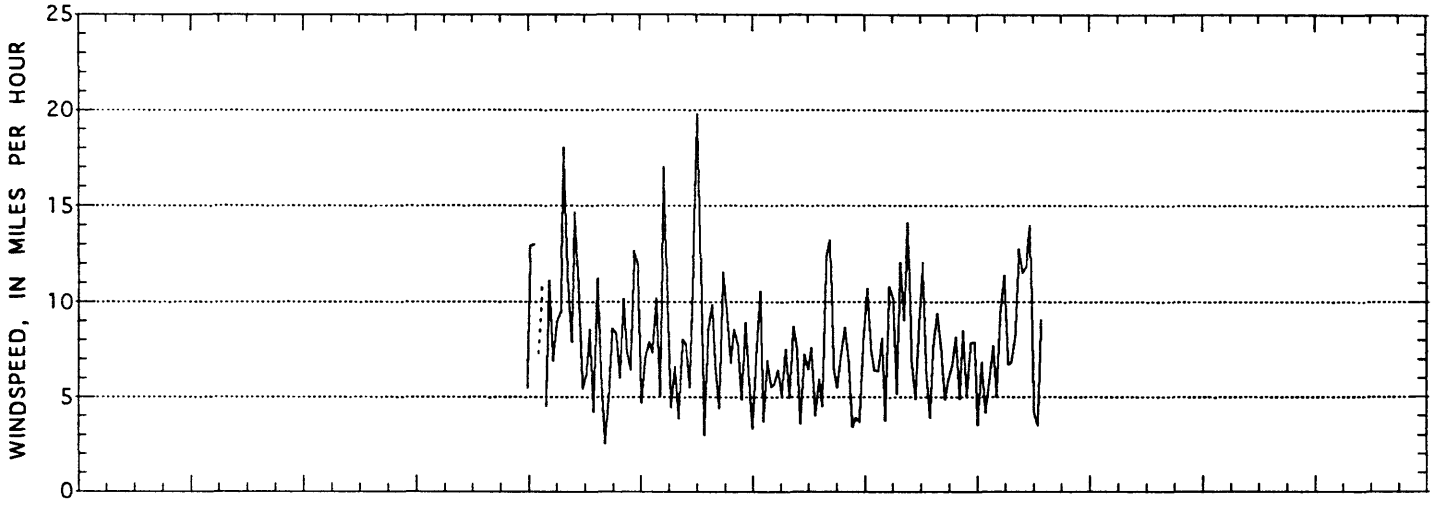
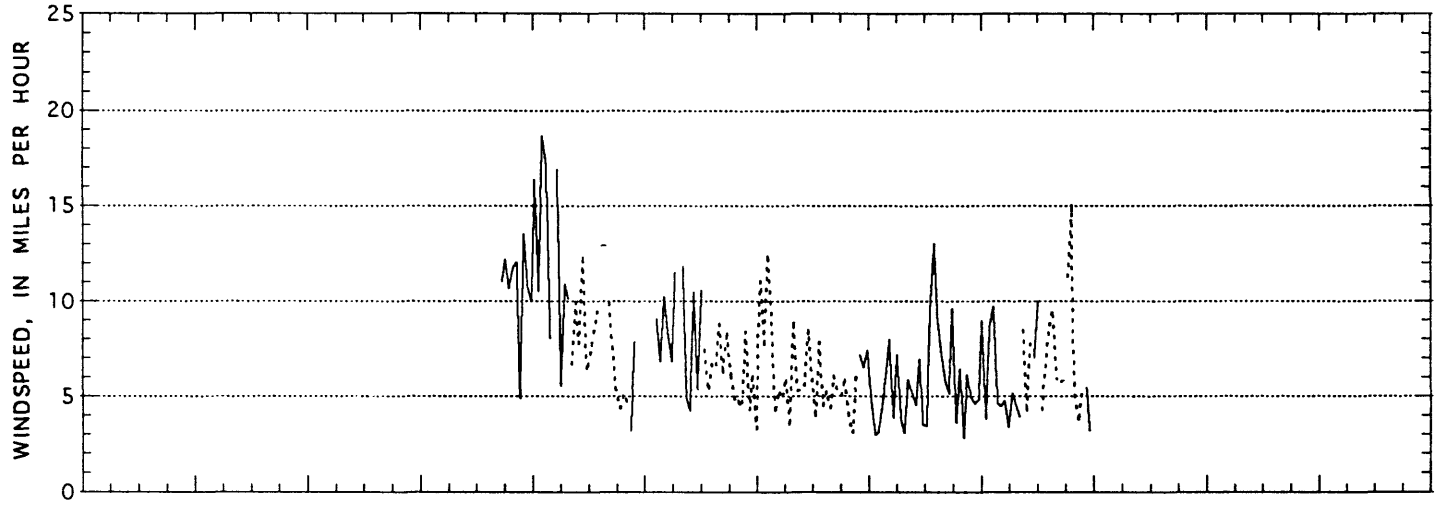


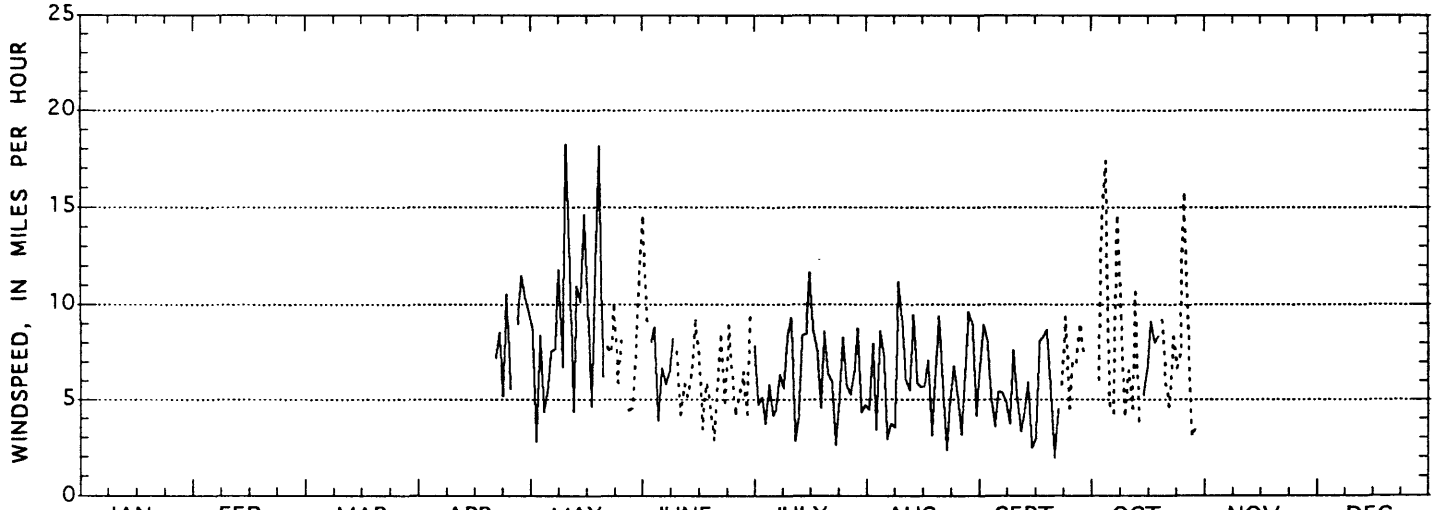
Figure 11.--Average daily windspeed at 2 meters above Wetland P1 raft station, 1982-87.



1985



1986



1987

Figure 11.--Average daily windspeed at 2 meters above Wetland P1 raft station, 1982-87--Continued.

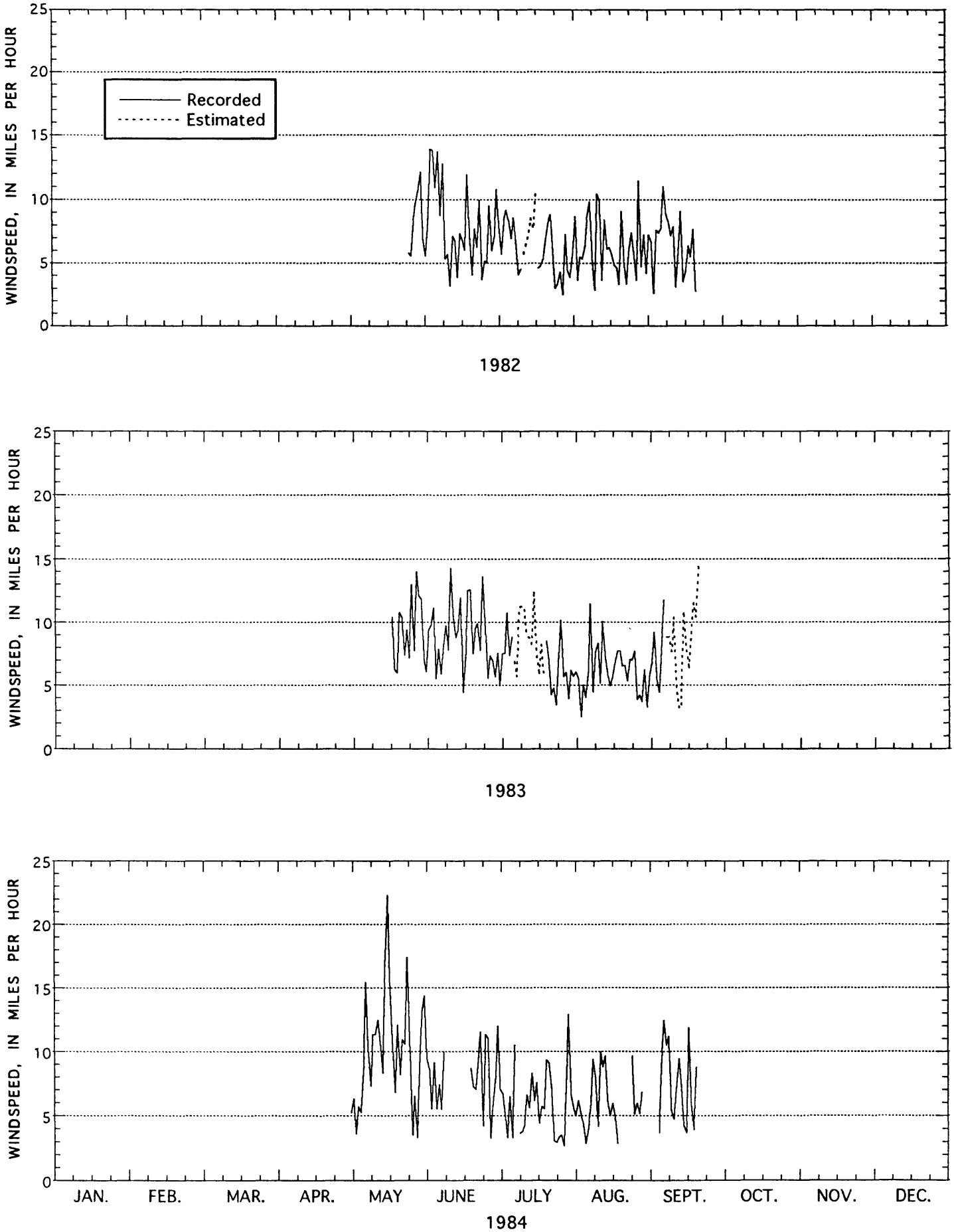
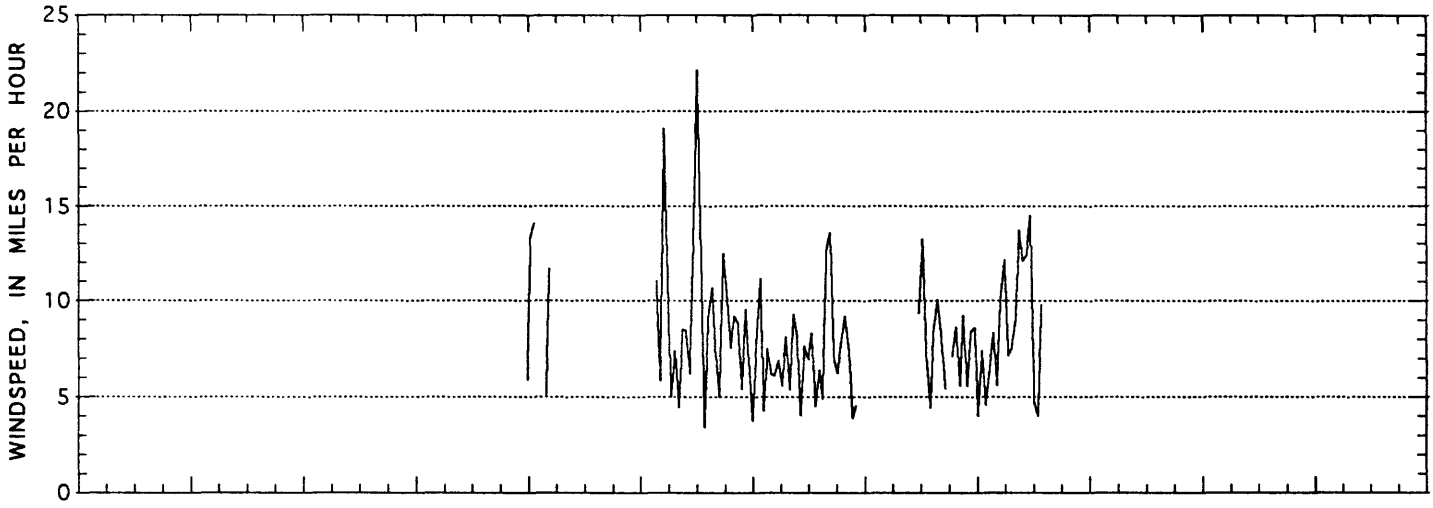
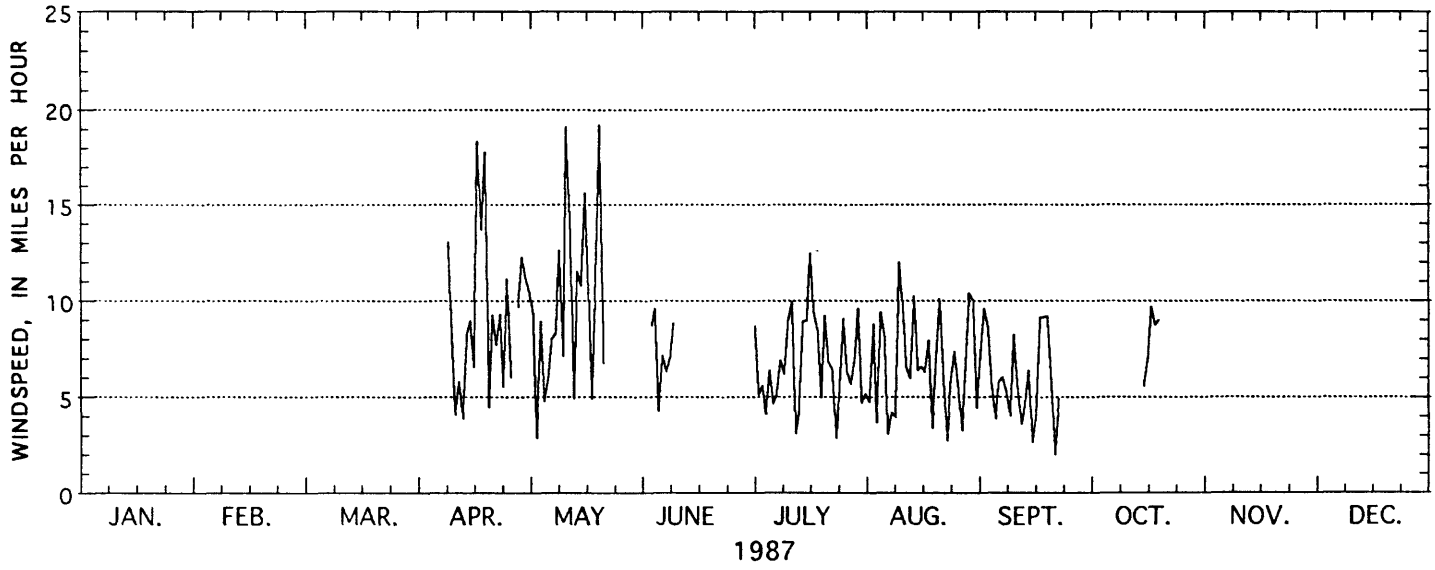


Figure 12.--Average daily windspeed at 3 meters above Wetland P1 raft station, 1982-87.



1985

no data available for 1986



1987

Figure 12.--Average daily windspeed at 3 meters above Wetland P1 raft station, 1982-87--Continued.

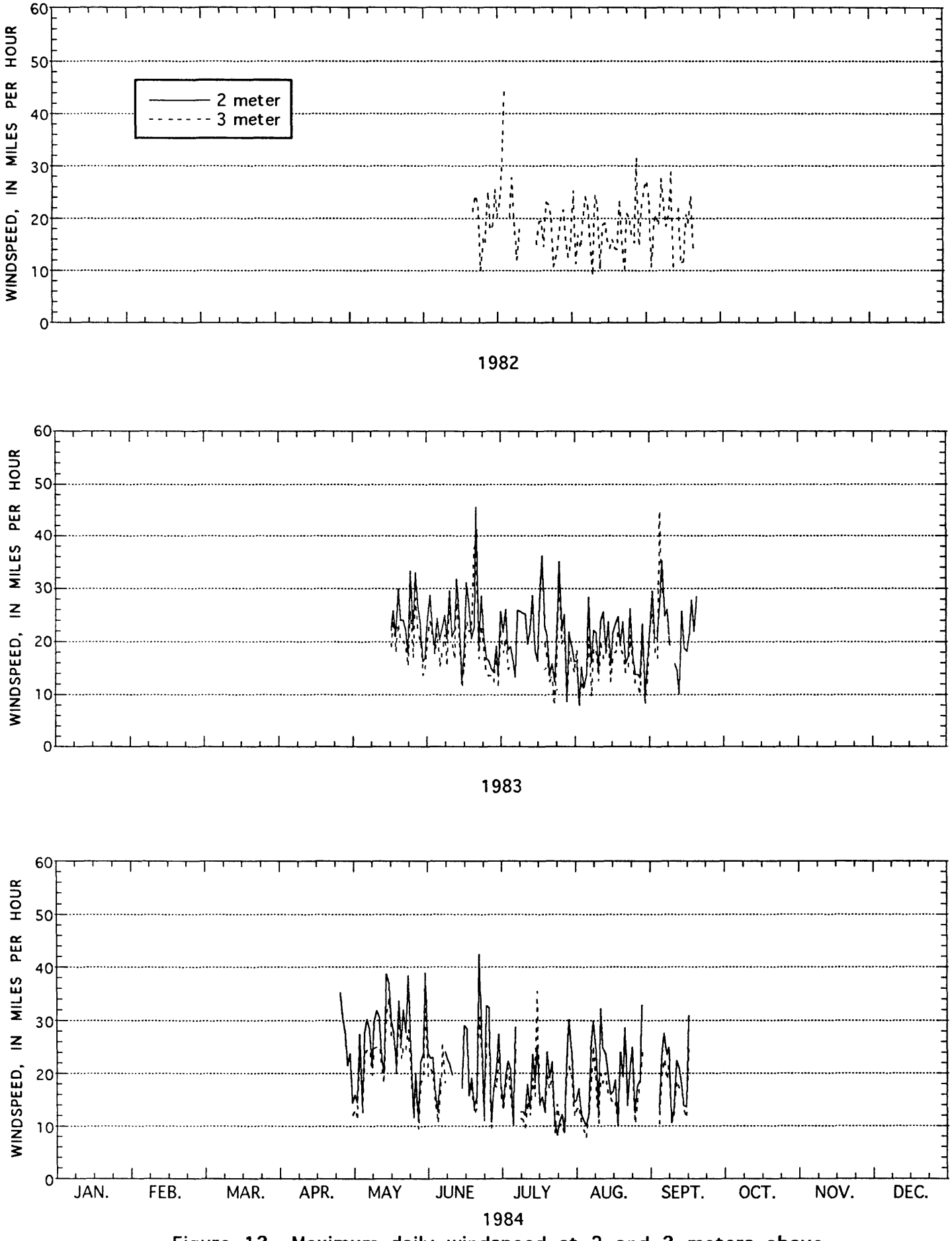
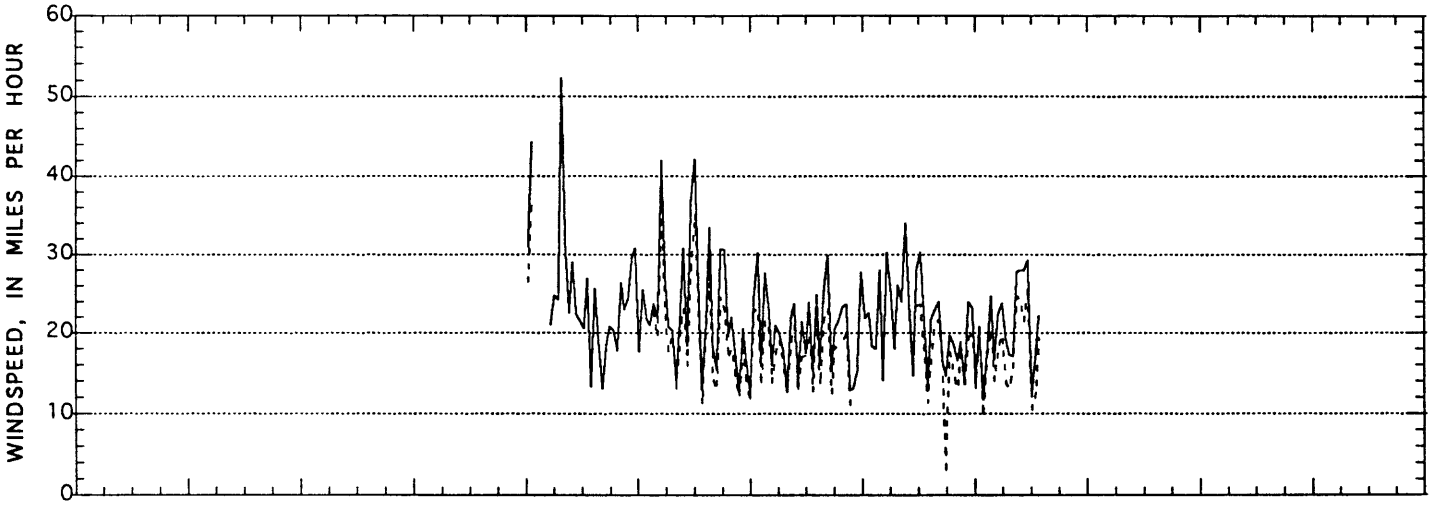


Figure 13.--Maximum daily windspeed at 2 and 3 meters above Wetland P1 raft station, 1982-87.



1985

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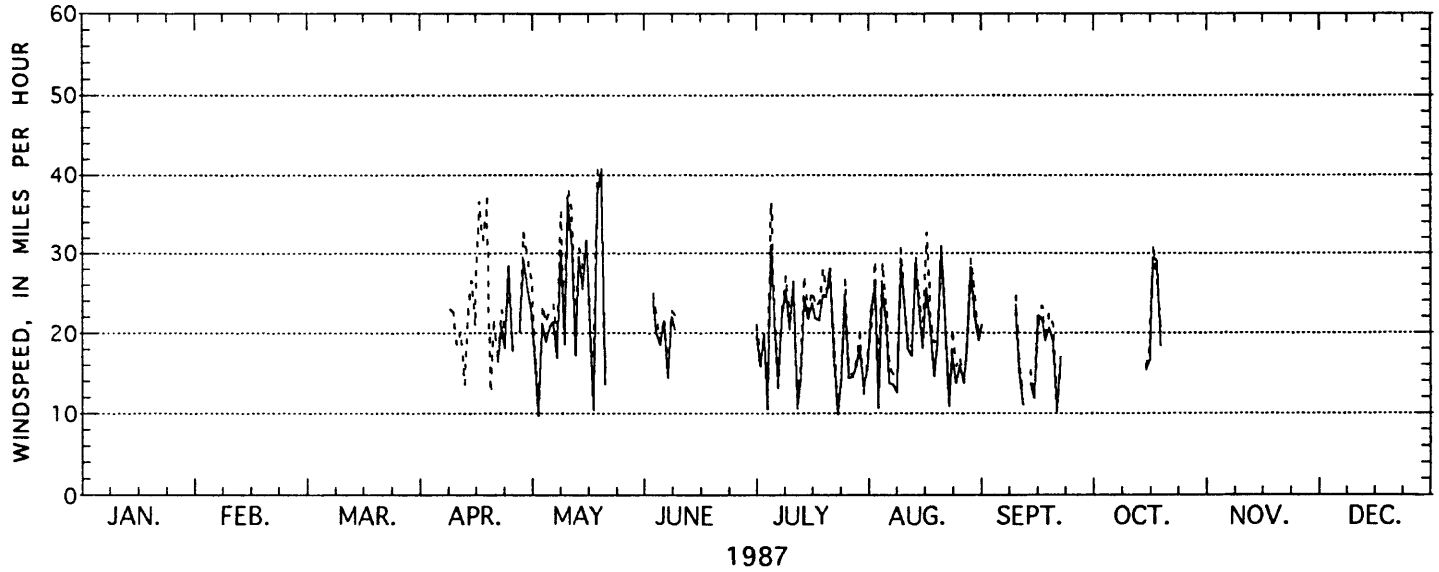

1987

Figure 13.--Maximum daily windspeed at 2 and 3 meters above Wetland P1 raft station, 1982-87--Continued.

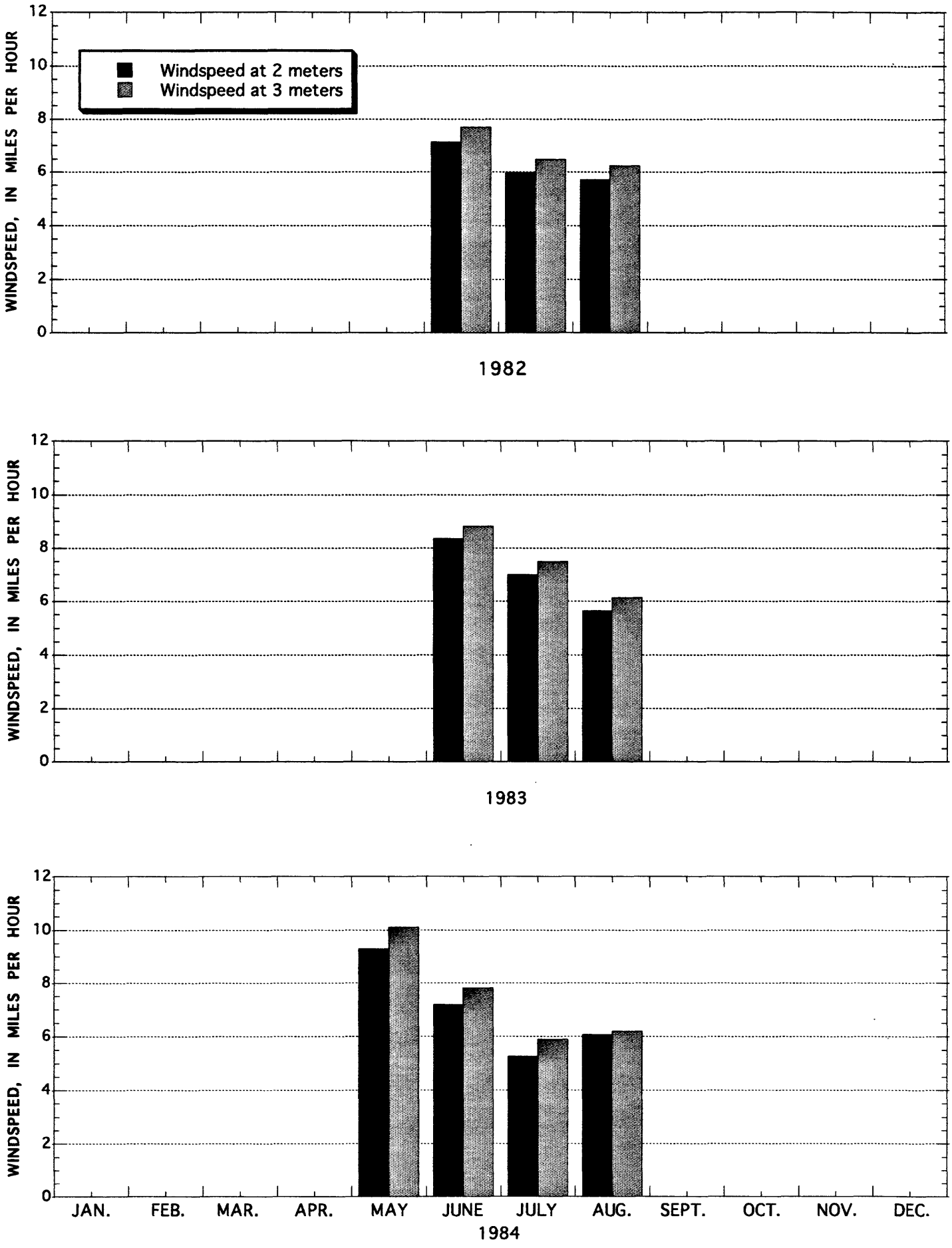

Figure 14.--Average monthly wind speed at 2 and 3 meters above Wetland P1 raft station, 1982-87.

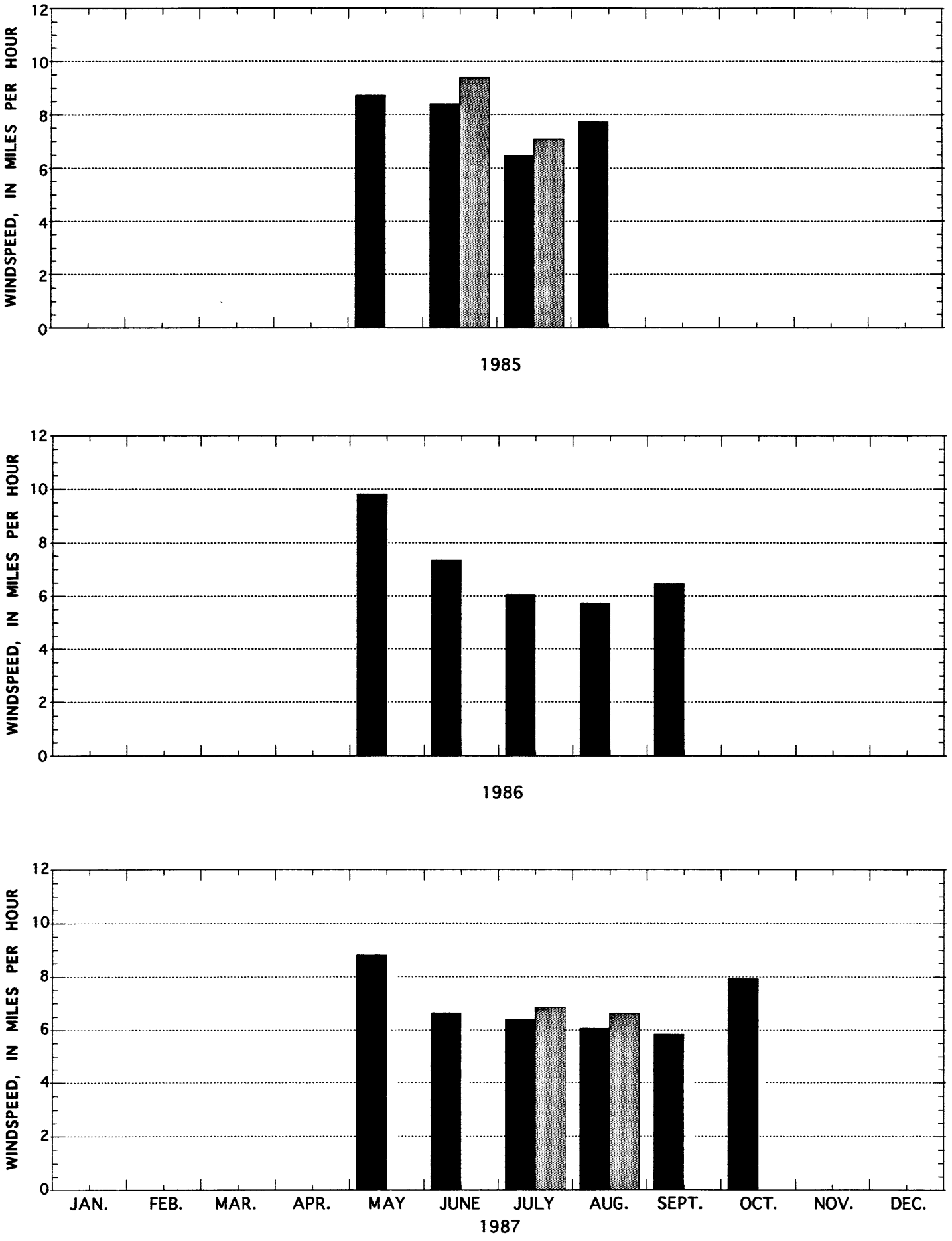

Figure 14.--Average monthly windspeed at 2 and 3 meters above Wetland P1 raft station, 1982-87--Continued.

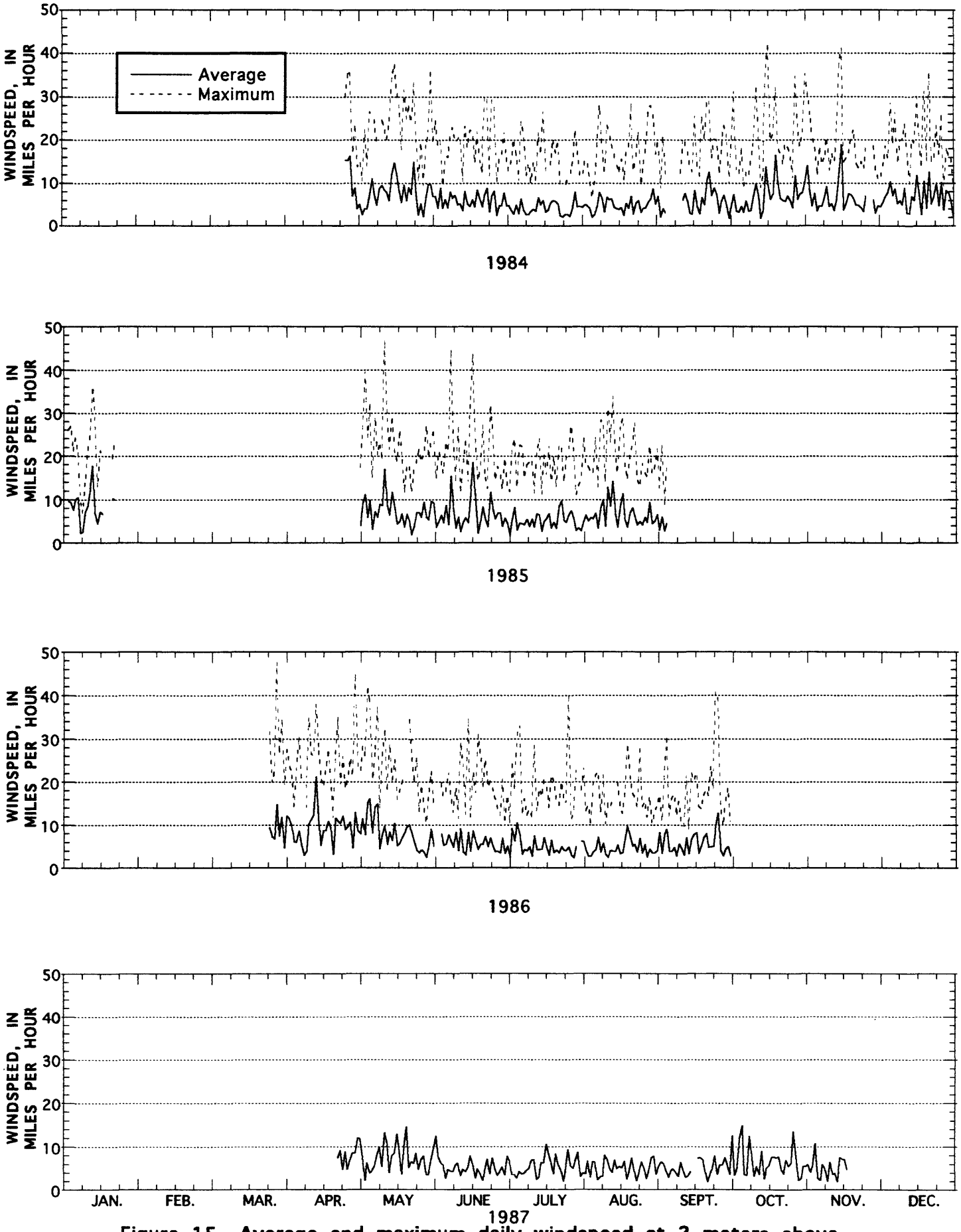

Figure 15.--Average and maximum daily windspeed at 2 meters above Wetland P1 land station, 1984-87.
(Windspeed data for the land station are missing for 1982 and 1983)

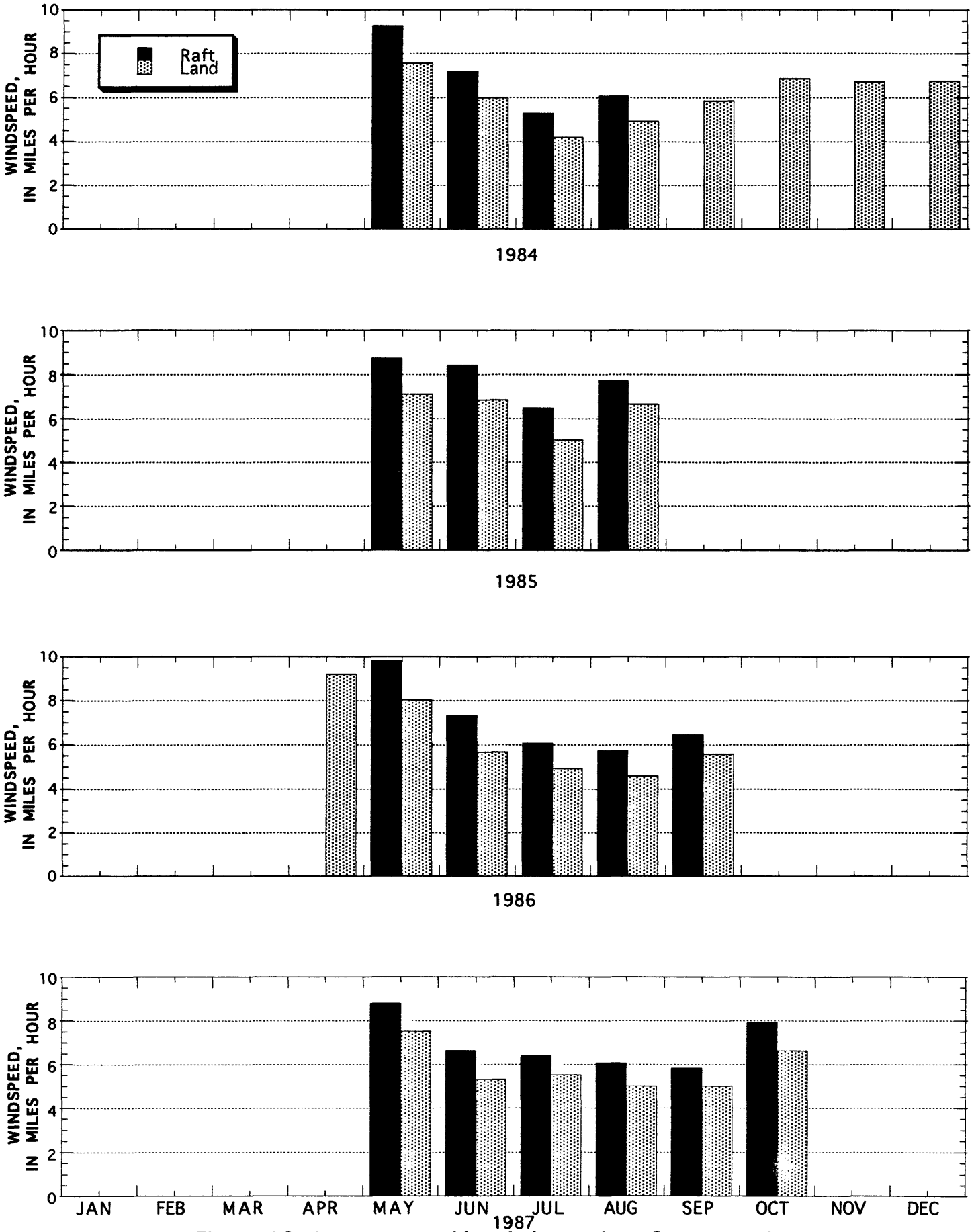

Figure 16--Average monthly wind speed at 2 meters above Wetland P1 raft and land stations, 1984-87
(Windspeed data for the land station are missing for 1982 and 1983)

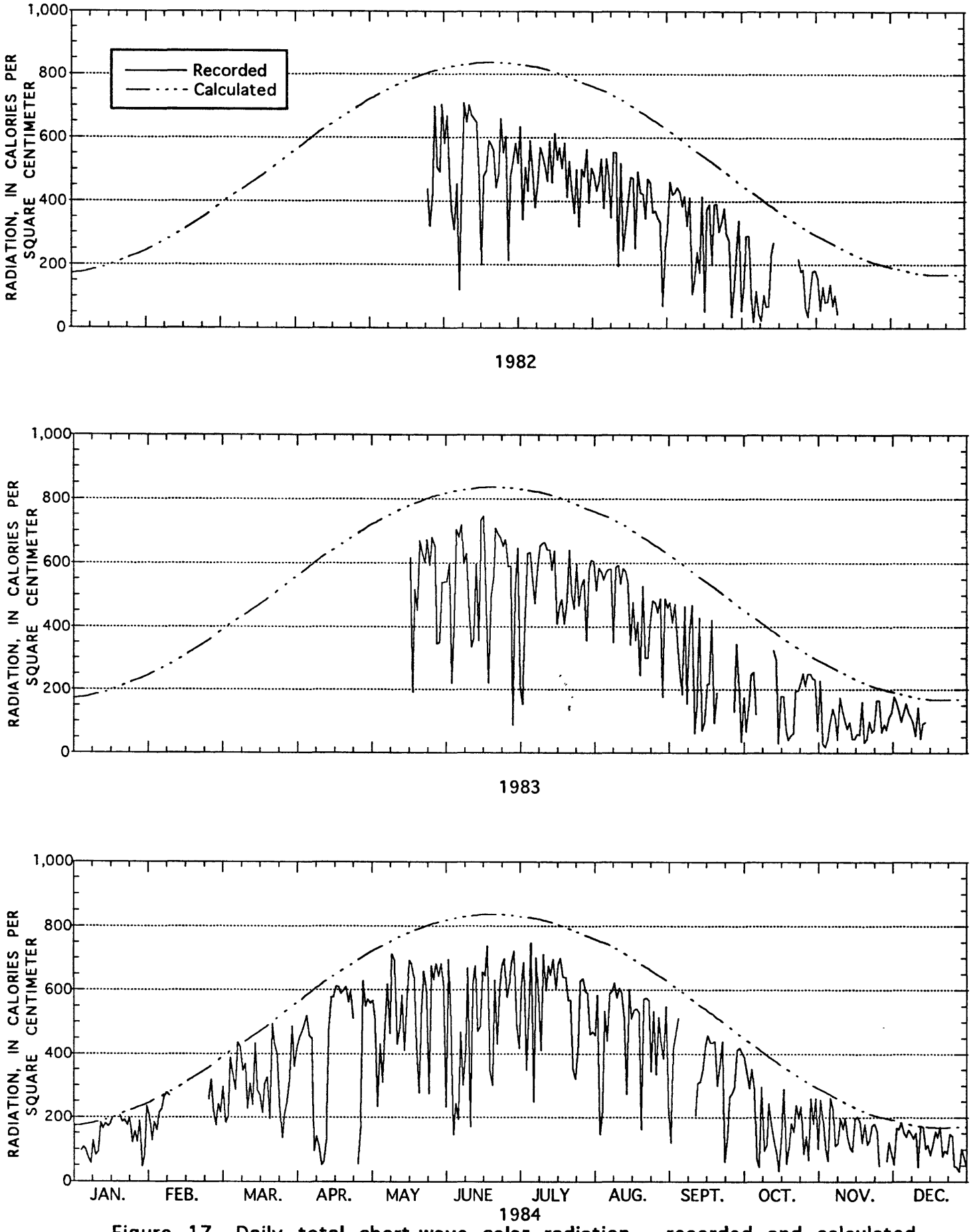

Figure 17.--Daily total short-wave solar radiation, recorded and calculated, at Wetland P1 radiation station, 1982-87.
[Calculated, from solar constant at 47° latitude]

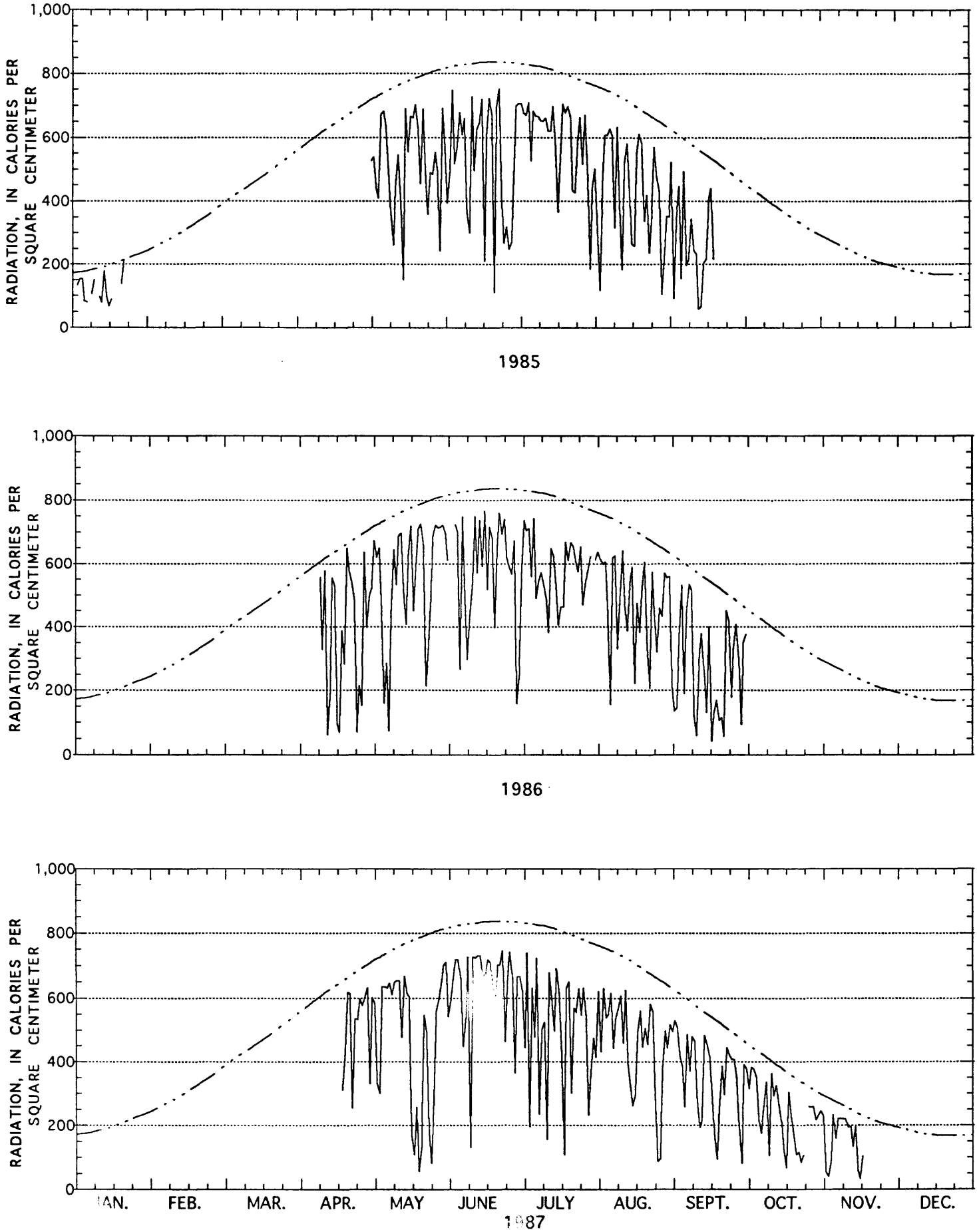

Figure 17.--Daily total short-wave solar radiation, recorded and calculated, at Wetland P1 radiation station, 1982-87 -- Continued.

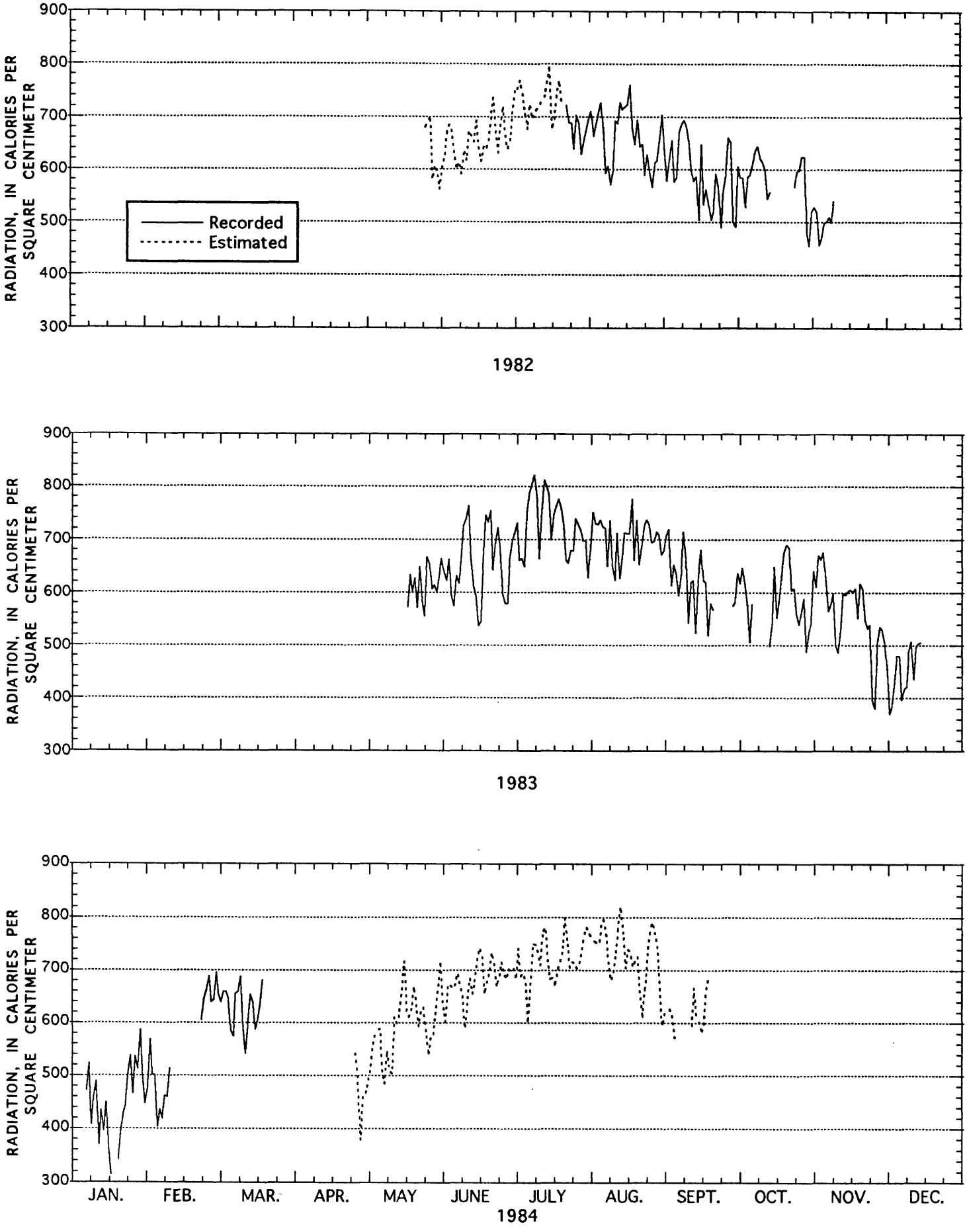

Figure 18.--Daily total long-wave atmospheric radiation at Wetland P1 radiation station, 1982-87.

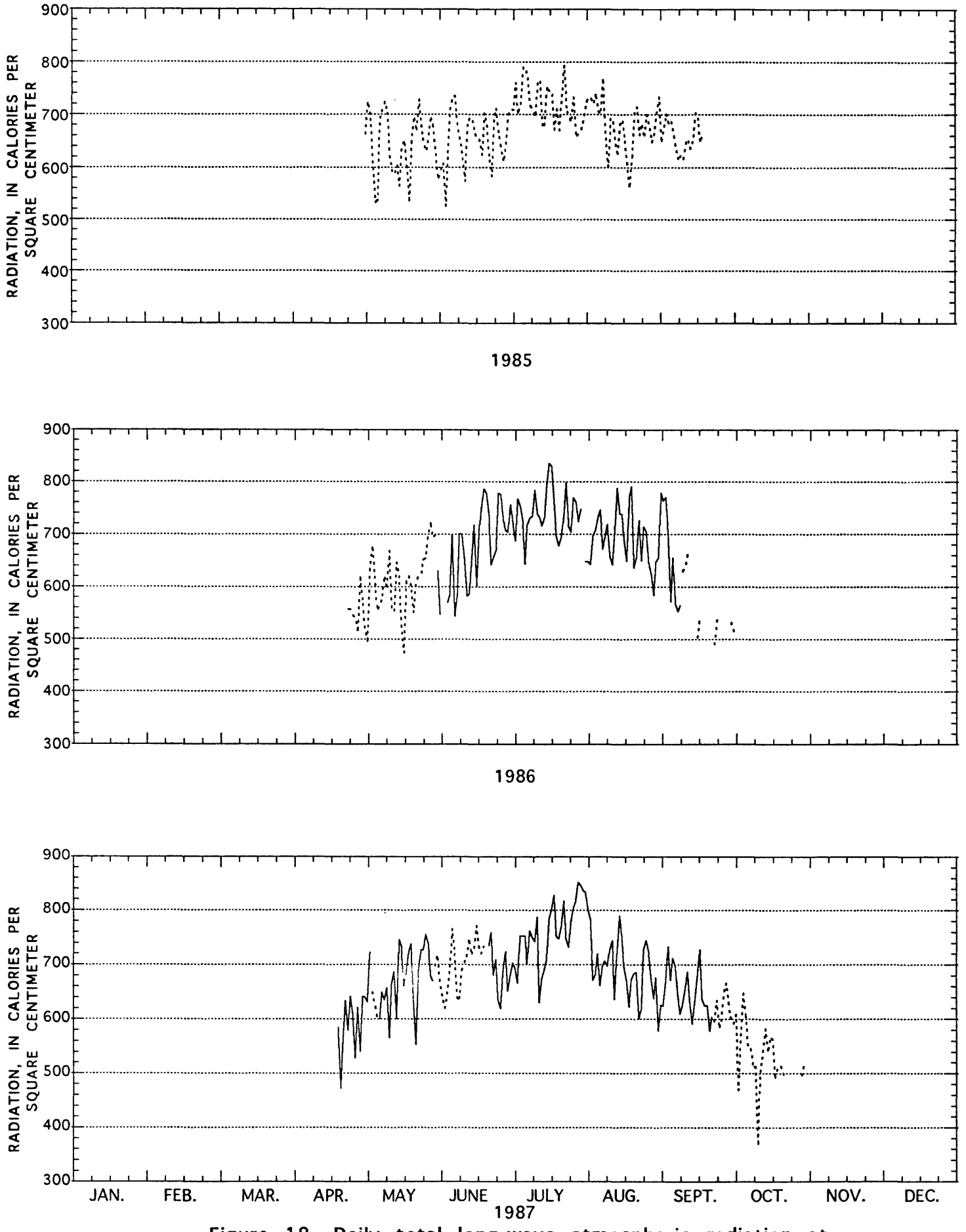

Figure 18.--Daily total long-wave atmospheric radiation at Wetland P1 radiation station, 1982-87--Continued.

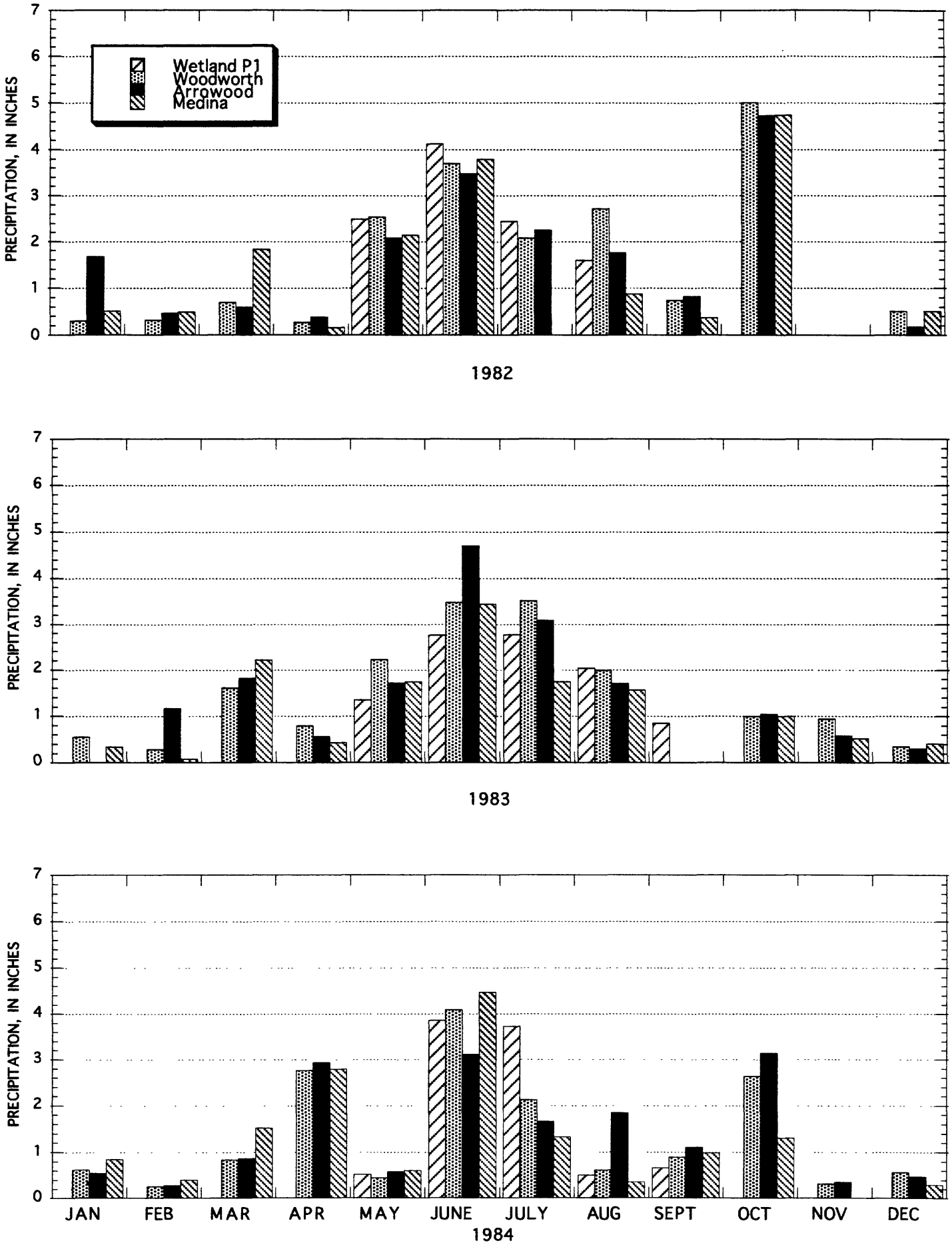

Figure 19.--Monthly total precipitation at Wetland P1 tipping bucket gage and National Weather Service gages, 1982-87.

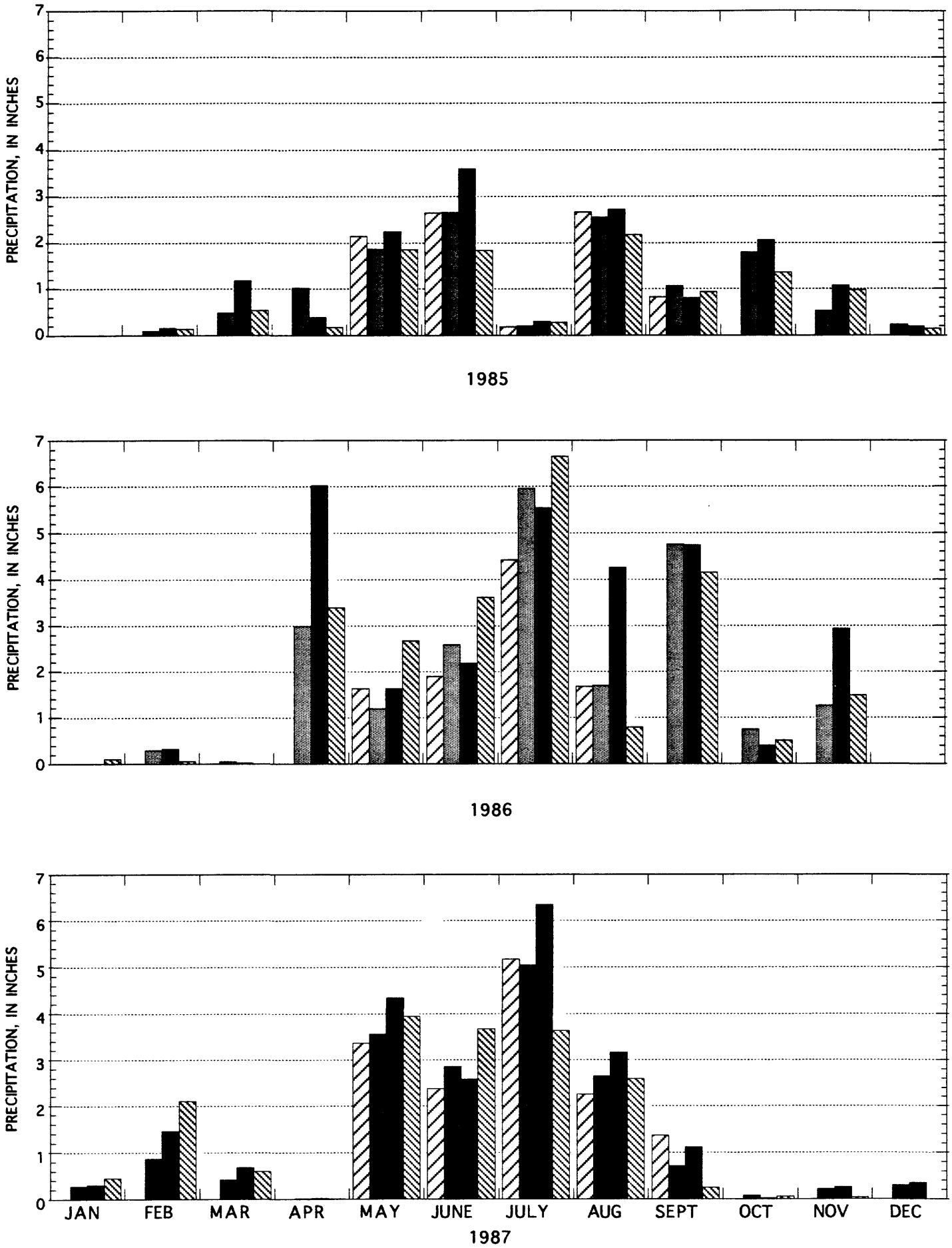

Figure 19.--Monthly total precipitation at Wetland P1 tipping bucket gage and National Weather Service gages, 1982-87--Continued

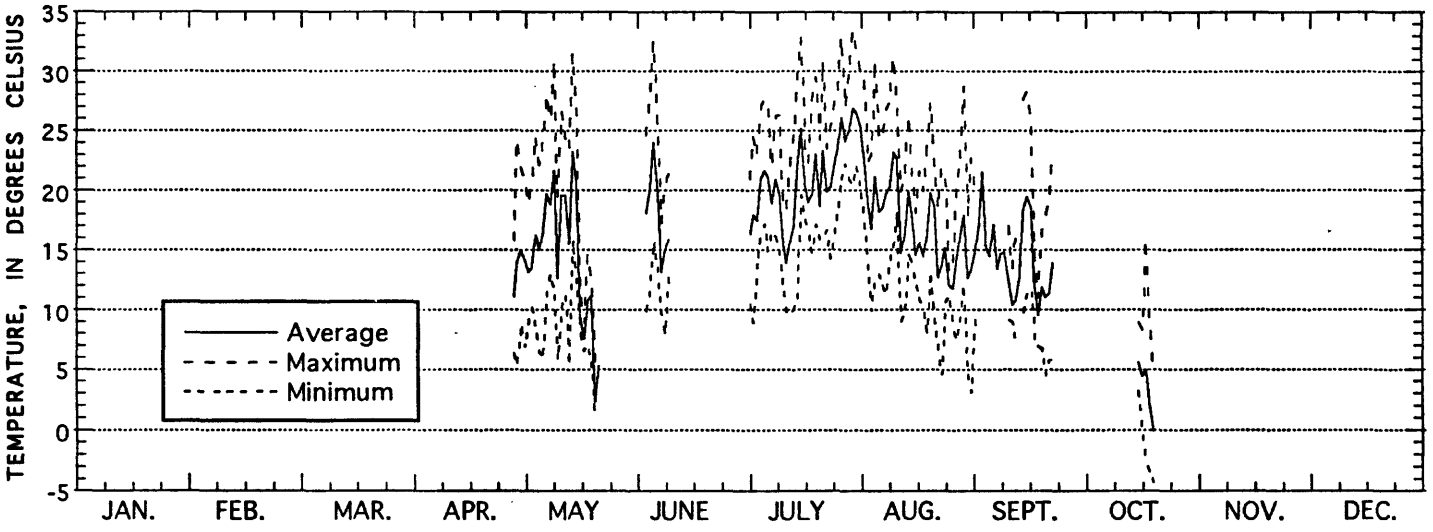

Figure 20.--Average, maximum, and minimum daily secondary air temperature at Wetland P1 raft station, 1987.

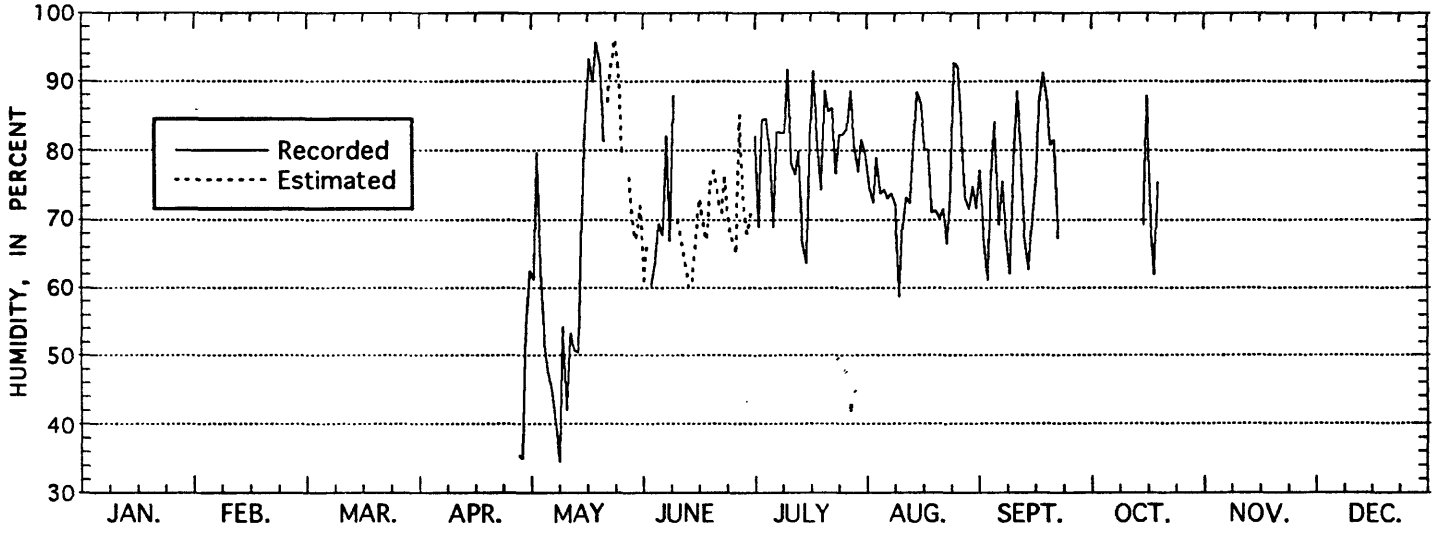

Figure 21.--Average daily humidity at Wetland P1 raft station, 1987.

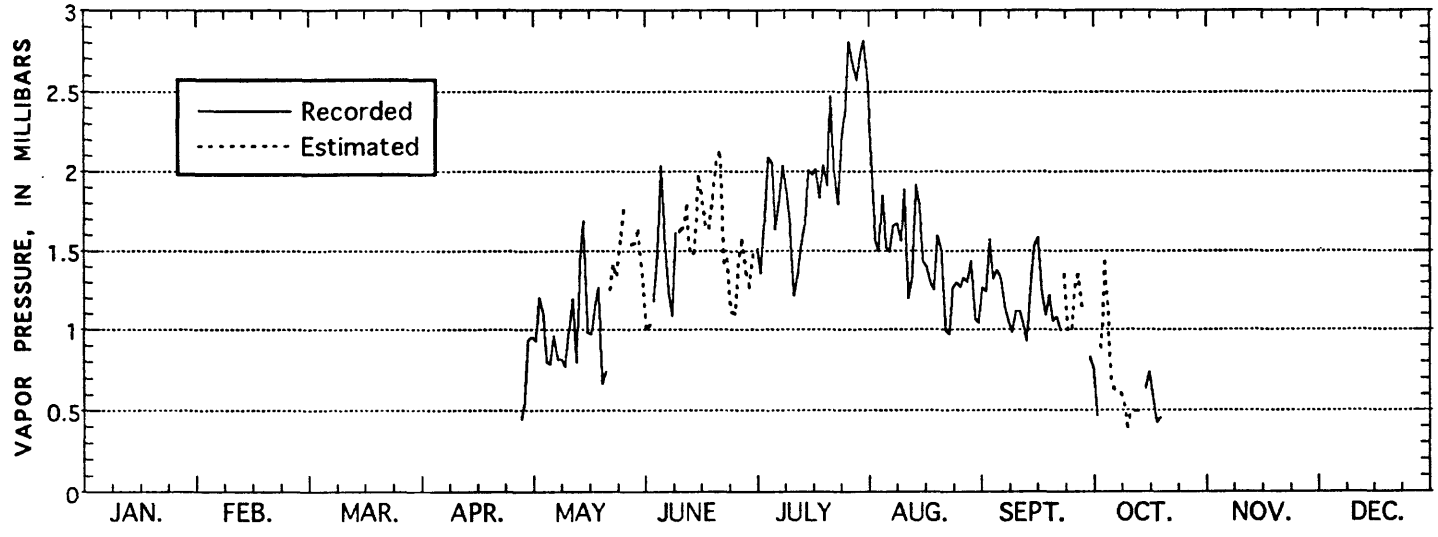

Figure 22.--Average daily vapor pressure at Wetland P1 raft station, 1987.