NOT TO BE CITED WITHOUT PRIOR
REFERENCE TO THE AUTHOR(S)

Northwest Atlantic Fisheries Organization

Serial No. N2404 NAFO SCR Doc. 94/36

SCIENTIFIC COUNCIL MEETING - JUNE 1994

Monthly T/S from NE Newfoundland and S. Labrador Shelves

by

Savi Narayanan

Science Branch, Department of Fisheries and Oceans
P. O. Box 5667, St. John's, Newfoundland, Canada A1C 5X1

Abstract

Time series of temperature (T) and salinity (S) collected using current meters and thermistor chains deployed on the NE Newfoundland and southern Labrador shelves from 1990 to 1993 are analyzed to examine the month-to-month T/S variability in this region. Even though the T/S variability is quite often referred to as an annual cycle, the monthly averaged data indicate that at many of the sites, these appeared as short pulses rather than cyclic. Furthermore, the timing of these pulses shifted from one year to the next, as well as from location to location. Even at locations where the month-to-month variability is more cyclic, the higher frequency variability could be on the same order of magnitude as the annual cycle (for example, near the shelf edge and in the saddles), so that T/S time series compiled from ships-of-opportunity CTD profiles may be aliased.

INTRODUCTION

The historic archive of temperature (T) and salinity (S) data from the Newfoundland and Labrador shelves has been used in the past to construct time series of these variables at selected locations. However, due to the near-absence of long-term moorings in this region, these time series have irregular sampling intervals and contain significant data gaps corresponding to periods of ice-cover, and between surveys. Even though the time series thus constructed, have been shown to be useful in delineating certain aspects of the interannual and annual variability of the shelf waters, they may be limited in their applications due to aliasing, especially to examine the variability at higher frequencies. The comprehensive mooring program that was initiated in 1990 as part of the Northern Cod Science Program (NCSP), however, has annual cycle estimated from historical data. The shorter data sets from FI1 and WB2 (not shown) exhibit similar characteristics. The monthly data also show that the range of values and the standard deviations are small in the inshore region except during the warming and cooling periods.

The annual harmonics of T and S on the eastern Newfoundland Shelf, estimated using time series constructed from profiles collected during research surveys (Petrie et al., 1991) showed that, at Station 27 the surface amplitudes of the annual component of T and S are 7° C and 0.7 respectively, and decrease with depth to values of about 0.2°C for T and less than 0.1 for S near the bottom. The maximum at the surface, corresponding to the annual harmonic, occurs on day 242 (August 30) for T and on day 88 (29 March) for S. The phases of both increase linearly with depth in such a way that the phase of T (S) at 175 m lags T(S) at the surface by 171 d (177 d). Thus the maximum T(S) at the bottom (175 m) occurs on 16/17 February (22 September). On the NE Newfoundland Shelf (DT1 in Fig.1, Petrie et al., 1991, surrounding the inshore mooring sites BB3, FI1 and WB2), the T amplitude decreases with depth much like at Station 27, but is smaller at the surface than that to the south. The T phase on the other hand was comparable to that at Station 27 at the surface, and though it increased with depth, below about 50 m, the rate of increase was slower than that at Station 27. Consequently, the T maximum at 200 m in DT1 occurs in December (Fig. 5 in Petrie et al., 1991), instead of February. Thus the warming event at the bottom in the shore region occurred a month later in 1991 compared to the average estimated from the historical data.

As was the case with T amplitude, the amplitude of the annual salinity cycle generally decreased with depth in DT1 (Fig. 5 in Petrie et al., 1991), but, unlike the T phase, the S phase also decreased with depth. However, the 1991 data from BB3 show that the S minimum at the bottom occurred about a month later (in January) compared to the time of occurrence at 75 m, indicating an increase in the S phase with depth. Furthermore, S minimum at this location occurred several months later than what was estimated in Petrie et al. (1991). These differences between the estimated annual cycle and the observations in 1991 may be due to the uncertainty in the estimate of the annual cycle from a time series which has a strong bi-annual component, and is dominated by short pulses rather than cyclic events, as noted in Petrie at al. (1991).

On the outer shelf, the variability in T and S is significantly larger than those in the near-shore region as indicated by the high standard deviations in the data from BB1, FI3 and WB1 (Figs. 2, 5 and 7). The high standard deviations are primarily caused by the changes in the structure and location of the shelf edge front which separates the cold and fresh shelf waters from the warm and saltier Labrador Sea waters (Narayanan et al., 1990). These frontal oscillations typically have periods of about 7 d. At lower frequencies the temperature and salinity behave differently. The month-to-month variability in temperature appears more or less like an annual harmonic, with T maximum occurring in November at 75 m (Fig. 2). The structures at the other two been instrumental in the acquisition of several T and S time series from the NE Newfoundland Shelf (Fig. 1) using current meters and thermistor chains. In this report, monthly temperature/salinity statistics are presented based on data from the moored instruments on the Newfoundland and Labrador Shelves.

DATA

The data set used to compute the monthly average, minimum, maximum and standard deviation of temperature and salinity (Figs. 2 - 9) is a subset of the data collected during the NCSP (Narayanan, 1994), selected in such a way that the sampling period for each time series covers at least 12 separate months. Data from all locations were used to compute the statistics over the total deployment period (Tables 1, 2). For the mooring inshore of Hamilton Bank, where several years of data were collected, the monthly means in each year are compared with the average for each month over the entire sampling period (Fig. 10), to highlight the anomalous temperatures during the recent years.

RESULTS

The monthly time series highlight the need for careful selection of sampling frequencies at each site, especially during the warming and cooling phases, since at several of the mooring sites these appear as short pulses rather than cyclic (BB3 in Fig. 3, for example). Furthermore, even at sites where the month-to-month variability is cyclic and can reasonably be represented by a periodic function (WB1 in Fig. 7, for example), the amplitude of the weather-band (2 d to 10 d) variability may be comparable to that of the annual cycle (note the range for each month in comparison with the range of monthly means), and consequently errors could be introduced in the estimates of annual cycle due to aliasing.

There were three moorings, BB3, FI1 and WB2, deployed on the inner part of the NE Newfoundland Shelf. The monthly means of T and S at BB3 (Fig. 3) show that the T maximum and T minimum occurred in December and March at 75 m, and in January and May at 215 m. Furthermore, the T peak associated with the warming event and the subsequent cooling, appears as a short pulse rather than cyclic. However, during this warming phase, the water temperatures rise from near-freezing to about 0°C at 75 m and to about 0.5°C at the bottom. The salinity maximum and minimum at BB3, on the other hand, occurred in March/April and December at 75 m, and in July and January at 215 m. Thus the times when high (low) salinities and low (high) temperatures occurred more or less coincided, as one would expect since the winter cooling causes ice formation and salt rejection, and thus an increase in the water salinities. Bear in mind that the time series shown in this paper were from a period which is considered to be anomalously cold compared to the average climate experienced during the last several decades, and consequently, the timing of these events during 1990 to 1993 may differ from what one could expect from an average shelf edge locations are also similar.

Unlike the temperature, the salinity time series at 75 m at the three offshore sites (BB1, FI3 and WB1) does not appear to have a noticeable annual cycle. Instead, the monthly salinities at these three sites seem to be dominated by high frequency variability.

Near the bottom, on the other hand, the annual cycle is evident in the plots, with a salinity minimum in about December and a maximum during July; corresponding periods for the inshore region were January and August.

On the southern Labrador Shelf, inshore of Hamilton Bank, the temperature maximum at the bottom (200 m) occurs in November/December months whereas the minimum T occurs during March/April (Fig. 9). Thus the maximum T at the bottom on southern *Labrador* occurred about a month or so earlier compared to NE Newfoundland Shelf, and about 2 months earlier compared to Station 27.

The long time series from Hamilton Bank also highlight the anomalously cold period of 1990s (Fig. 10) compared to the average over the deployment period (1978-1993). Thus the average T and S computed over the deployment period (Table 1 and 2) will only be representative of the conditions during the last 3 to 4 years, and other similar anomalous periods such as 1984/85 and early 1970s.

REFERENCES

Godin, G. 1972. The *Analysis of Tides*, University of Toronto Press, Toronto, Ontario, Canada, 264 pp.

Narayanan, S., E. B. Colbourne and C. Fitzpatrick, 1991. Frontal oscillations on the NE Newfoundland shelf. ATMOSPHERE-OCEAN 29, 547-562

Narayanan, S., 1994. Current meter observations from Hamilton Bank and NE Newfoundland Shelf, 1990 to 1993. Can. Tech. Rep. of Hydrogr. and Ocean Sci., 157. Unpublished Manuscript.

Petrie, B., J. W. Loder, S. Akenhead and J. Lazier, 1991. Temperature and salinity variability on the eastern Newfoundland Shelf: the annual Harmonic. ATMOSPHERE-OCEAN 29, 14-36.

Table 1. Summary statistics, based on temperature time series from current meters and thermistor chains deployed from 1990 to 1993. The time series data files were filtered using the tide removing filter A_{24} A_{24} A_{25} (Godin, 1978) and subsampled at 6 hr intervals prior to computing the statistics. Columns represent station names (STN), instrument depths (ID), start and end times of data, number of points in the time series (NPTS), minimum (MIN), maximum (MAX), mean and standard deviations (SD) of temperature at each site. * indicates thermistor chain data.

STN	ID (m)	START TIME	END TIME	NPTS	MIN	MAX	MEAN	SD
BB1	40	28-MAY-1992	15-OCT-1992	564	-1.22	2.43	-0.26	0.79
	75	16-JUL-1990	24-MAY-1992	2692	-1.85	2.43	-0.44	0.87
	150	28-MAY-1992	14-OCT-1992	559	0.46	2.92	1.65	0.57
	315	16-JUL-1990	15-OCT-1992	2511	2.08	4.07	3.33	0.36
BB1*	200	13-MAY-1991	1-NOV-1991	688	1.03	3.84	2.40	0.48
	190	13-MAY-1991	1-NOV-1991	688	0.77	3.7	2.16	0.51
	180	13-MAY-1991	1-NOV-1991	688	0.57	3.58	1.95	0.53
	170	13-MAY-1991	1-NOV-1991	688	0.32	3.31	1.68	0.55
	160	13-MAY-1991	1-NOV-1991	688	0.11	3.03	1.43	0.57
	150	13-MAY-1991	1-NOV-1991	688	0.11	3.06	1.33	0.60
	140	13-MAY-1991	1-NOV-1991	688	-0.3	2.56	0.89	0.58
	130	13-MAY-1991	1-NOV-1991	688	-0.46	2.28	0.65	0.57
	120	13-MAY-1991	1-NOV-1991	688	-0.64	2.03	0.38	0.57
	110	13-MAY-1991	1-NOV-1991	688	-0.76	1.8	0.13	0.55
	100	13-MAY-1991	1-NOV-1991	688	-0.91	1.64	-0.09	0.52

Table 1. (Continued)

STN	ID (m)	START TIME	END TIME	NPTS	MIN	MAX	MEAN	SD
BB2	40	28-MAY-1992	16-OCT-1992	564	-1.66	3.75	-0.48	1.09
	75	15-JUL-1990	3-OCT-1991	329	-1.62	-0.84	-1.30	0.16
	150	28-MAY-1992	16-OCT-1992	564	-1.31	1.29	0.03	0.60
	215	8-JUN-1993	24-JUL-1993	185	-0.08	1.51	0.80	0.37
	310	4-AUG-1991	17-JUL-1992	1371	0.99	3.51	2.54	0.48
BB3	40	3-JUN-1992	17-OCT-1992	544	-1.44	4.23	-0.19	1.48
	75	20-MAY-1991	31-MAY-1992	1497	-1.80	0.66	-1.43	0.51
	150	3-JUN-1992	17-OCT-1992	544	-1.66	-1.13	-1.49	0.14
	215	15-JUL-1990	17-OCT-1992	1845	-1.66	-0.10	-1.29	0.29
BB4	200	13-MAY-1991	1-NOV-1991	691	2.60	4.24	3.77	0.38
	400	13-MAY-1991	24-MAY-1992	1496	2.81	4.13	3.69	0.29
	900	13-MAY-1991	24-MAY-1992	1496	2.99	3.47	3.18	0.11
BB5	40	4-JUN-1992	17-OCT-1992	540	-1.61	5.22	0.00	1.73
	315	4-JUN-1992	17-OCT-1992	540	-0.86	2.15	1.27	0.77
CB1	40	4-JUN-1992	16-OCT-1992	540	-1.31	4.82	-0.00	1.23
	150	4-JUN-1992	16-OCT-1992	540	-1.74	-1.11	-1.56	0.14
FI1	40	12-JUL-1992	26-OCT-1992	428	-1.45	5.30	0.52	1.99
	150	12-JUL-1992	26-OCT-1992	428	-1.30	-0.31	-0.90	0.22
	325	25-JUL-1991	8-MAY-1992	1140	0.77	2.33	1.70	0.28
	455	7-NOV-1991	26-OCT-1992	1408	1.65	2.87	2.57	0.19
FI2	40	11-JUL-1992	27-OCT-1992	432	-1.38	5.26	0.54	1.64
	75	25-JUL-1991	8-JUL-1992	1385	-1.86	1.42	-1.13	0.70
	150	11-JUL-1992	27-OCT-1992	432	-0.62	1.18	0.32	0.44
	245	25-JUL-1991	8-JUL-1992	1385	0.62	2.79	1.70	0.43
FI3	75	14-MAY-1991	27-MAY-1992	1412	-1.78	2.81	-0.70	0.75
	150	30-MAY-1992	28-OCT-1992	604	-0.07	2.59	1.08	0.56
	275	14-MAY-1991	28-OCT-1992	2108	1.87	3.91	2.81	0.39
FI3*	200	14-MAY-1991	27-MAY-1992	1504	-0.06	3.48	1.72	0.54
	190	14-MAY-1991	27-MAY-1992	1504	-0.29	3.46	1.53	0.57
	180	14-MAY-1991	27-MAY-1992	1504	-0.47	3.38	1.31	0.60
	170	14-MAY-1991	27-MAY-1992	1504	-0.59	3.24	1.09	0.61
	160	14-MAY-1991	27-MAY-1992	1504	-0.73	2.99	0.87	0.62
	150	14-MAY-1991	27-MAY-1992	1504	-0.84	2.7	0.66	0.63
	140	14-MAY-1991	27-MAY-1992	1504	-0.98	2.34	0.46	0.63
	130	14-MAY-1991	27-MAY-1992	1504	-1.08	2.21	0.28	0.62
	120	14-MAY-1991	27-MAY-1992	1504	-1.21	2.11	0.10	0.64
	110	14-MAY-1991	27-MAY-1992	1504	-1.26	2.0	-0.06	0.64
	100	14-MAY-1991	27-MAY-1992	1504	-1.6	1.93	-0.24	0.68
SP1	200	19-NOV-1991	12-JUL-1992	945	1.12	3.92	2.70	0.44
	300	19-NOV-1991	11-JUL-1992	944	2.04	4.05	3.11	0.40
	500	19-NOV-1991	11-JUL-1992	944	2.56	4.04	3.35	0.40
SP2	205	19-NOV-1991	28-MAY-1992	767	1.43	3.99	2.85	0.47
	305	19-NOV-1991	28-MAY-1992	767	2.31	4.08	3.28	0.44
	505	19-NOV-1991	28-MAR-1992	514	2.80	4.02	3.66	0.33
WB1	75	19-JUL-1990	29-JAN-1992	2213	-1.75	2.88	-0.48	0.92
	150	14-JUL-1992	24-OCT-1992	408	-0.54	2.51	0.71	0.66
	325	19-JUL-1990	24-OCT-1992	2681	2.05	3.93	3.21	0.33
WB1*	200	19-JUL-1990	11-JUL-1992	2465	-0.69	3.33	1.43	0.68
	190	19-JUL-1990	11-JUL-1992	2465	-0.89	3.24	1.24	0.71
	180	19-JUL-1990	11-JUL-1992	2465	-1.08	3.12	1.03	0.76
	170	19-JUL-1990	11-JUL-1992	2465	-1.09	2.96	0.86	0.77
	160	19-JUL-1990	11-JUL-1992	2465	-1.19	2.82	0.69	0.80
	150	19-JUL-1990	11-JUL-1992	2465	-1.45	2.71	0.51	0.83
	140	19-JUL-1990	11-JUL-1992	2465	-1.54	2.59	0.35	0.85
	130	19-JUL-1990	11-JUL-1992	2465	-1.55	2.45	0.19	0.86
	120	19-JUL-1990	11-JUL-1992	2465	-1.55	2.42	0.02	0.87
	110	19-JUL-1990	11-JUL-1992	2465	-1.64	2.36	-0.11	0.87
	100	19-JUL-1990	11-JUL-1992	2465	-1.63	2.32	-0.24	0.87
WB2	235	19-JUL-1990	5-NOV-1991	1182	-1.16	1.11	-0.31	0.58

Table 1. (Continued)

STN	ID (m)	START TIME	END TIME	NPTS	MIN	MAX	MEAN	SD
WB3	40	14-JUL-1992	18-OCT-1992	385	-1.58	4.40	0.04	1.51
	75	2-AUG-1991	17-MAY-1992	1147	-1.85	0.87	-0.74	0.93
	150	14-JUL-1992	18-OCT-1992	385	-0.01	0.73	0.24	0.13
	385	2-AUG-1991	18-OCT-1992	1749	2.41	3.32	2.89	0.21
H1	200	21-JUL-1990	24-FEB-1992	1907	-0.84	4.14	2.52	0.78
	400	21-JUL-1990	12-JUL-1992	2279	2.42	4.20	3.66	0.42
	985	21-JUL-1990	12-JUL-1992	1387	2.93	3.78	3.37	0.20
H2	195	22-JUL-1990	11-AUG-1993	3843	-1.78	1.25	-0.81	0.56

Table 2. Summary statistics, based on salinity time series from current meters deployed from 1990 to 1993. The time series data files were filtered using the tide removing filter $A_{24}\,A_{24}\,A_{25}$ (Godin, 1978) and subsampled at 6 hr intervals prior to computing the statistics. Columns represent station names (STN), instrument depths (ID), start and end times of data, number of points in the times series (NPTS), minimum (MIN), maximum (MAX), mean and standard deviations (SD) of salinity at each site.

STN	ID (m)	START TIME	END TIME	NPTS	MIN	MAX	MEAN	SD
BB1	40	28-MAY-1992	15-OCT-1992	564	33.25	34.28	33.81	0.19
	75	16-JUL-1990	24-MAY-1992	2692	33.36	34.43	33.87	0.21
	150	*28-MAY-1992*	*14-OCT-1992*	*559*	*34.3*	*34.9*	*34.6*	*0.12*
	315	16-JUL-1990	15-OCT-1992	2445	34.54	35.17	34.89	0.10
BB2	75	4-AUG-1991	3-OCT-1991	240	33.02	33.58	33.34	0.14
	150	28-MAY-1992	16-OCT-1992	564	33.71	34.63	34.27	0.20
	215	8-JUN-1993	24-JUL-1993	185	33.89	34.30	34.10	0.11
	310	4-AUG-1991	17-JUL-1992	557	34.45	34.91	34.74	0.10
BB3	*40*	*3-JUN-1992*	*17-OCT-1992*	*544*	*31.68*	*32.81*	*32.47*	*0.25*
	75	20-MAY-1991	31-MAY-1992	1497	32.33	33.14	32.90	0.17
	150	3-JUN-1992	17-OCT-1992	544	32.87	33.49	33.11	0.16
	215	15-JUL-1990	17-OCT-1992	1770	32.61	33.99	33.37	0.29
BB4	200	13-MAY-1991	1-NOV-1991	691	34.82	35.08	34.99	0.06
	400	13-MAY-1991	24-NOV-1991	1496	34.58	35.07	34.86	0.15
	900	13-MAY-1991	1-NOV-1991	691	35.01	35.05	35.04	0.01
BB5	40	4-JUN-1992	17-OCT-1992	540	31.78	32.86	32.48	0.24
	315	4-JUN-1992	17-OCT-1992	540	33.59	34.40	34.16	0.20
CB1	40	4-JUN-1992	16-OCT-1992	540	31.48	32.41	32.14	0.19
	150	4-JUN-1992	16-OCT-1992	540	32.97	33.53	33.17	0.14
FI1	40	12-JUL-1992	26-OCT-1992	428	32.65	33.42	32.99	0.19
	150	*12-JUL-1992*	*26-OCT-1992*	*428*	*33.71*	*34.12*	*33.91*	*0.09*
	325	25-JUL-1991	3-NOV-1991	406	34.41	34.69	34.60	0.06
FI2	40	11-JUL-1992	27-OCT-1992	432	32.56	33.77	33.16	0.28
	75	25-JUL-1991	8-JUL-1992	1385	32.76	33.83	33.35	0.19
	245	25-JUL-1991	3-NOV-1991	405	34.29	34.80	34.58	0.12
FI3	75	14-MAY-1991	27-MAY-1992	1412	32.71	34.20	33.44	0.29
	150	*30-MAY-1992*	*28-OCT-1992*	*604*	*34.33*	*34.97*	*34.61*	*0.15*
	275	14-MAY-1991	28-OCT-1992	2108	34.45	34.94	34.71	0.12
SP1	200	19-NOV-1991	12-JUL-1992	945	34.32	34.93	34.72	0.13

Table 2. (Continued)

STN	ID (m)	START TIME	END TIME	NPTS	MIN	MAX	MEAN	SD
SP2	205	19-NOV-1991	28-MAY-1992	767	34.44	34.93	34.73	0.11
WB1	75	15-MAY-1991	29-JAN-1992	1026	33.18	34.47	33.62	0.21
	150	14-JUL-1992	24-OCT-1992	408	33.73	34.48	34.05	0.16
	325	19-JUL-1990	24-OCT-1992	1700	34.62	35.18	34.83	0.11
WB2	235	19-JUL-1990	5-NOV-1991	1182	33.44	34.33	33.81	0.18
WB3	40	14-JUL-1992	18-OCT-1992	385	32.14	33.03	32.75	0.18
	75	9-NOV-1991	17-MAY-1992	762	32.96	33.71	33.35	0.15
	150	14-JUL-1992	18-OCT-1992	385	34.08	34.26	34.14	0.03
	385	2-AUG-1991	18-OCT-1992	761	34.67	34.84	34.75	0.04
H1	200	21-JUL-1990	24-FEB-1992	1907	33.78	35.40	34.71	0.22
	400	29-JUL-1991	26-OCT-1991	357	35.01	35.15	35.11	0.30
	985	29-JUL-1991	7-NOV-1991	404	35.30	35.34	35.32	0.01
H2	195	27-JUL-1991	11-AUG-1993	1376	32.76	34.04	33.48	0.20

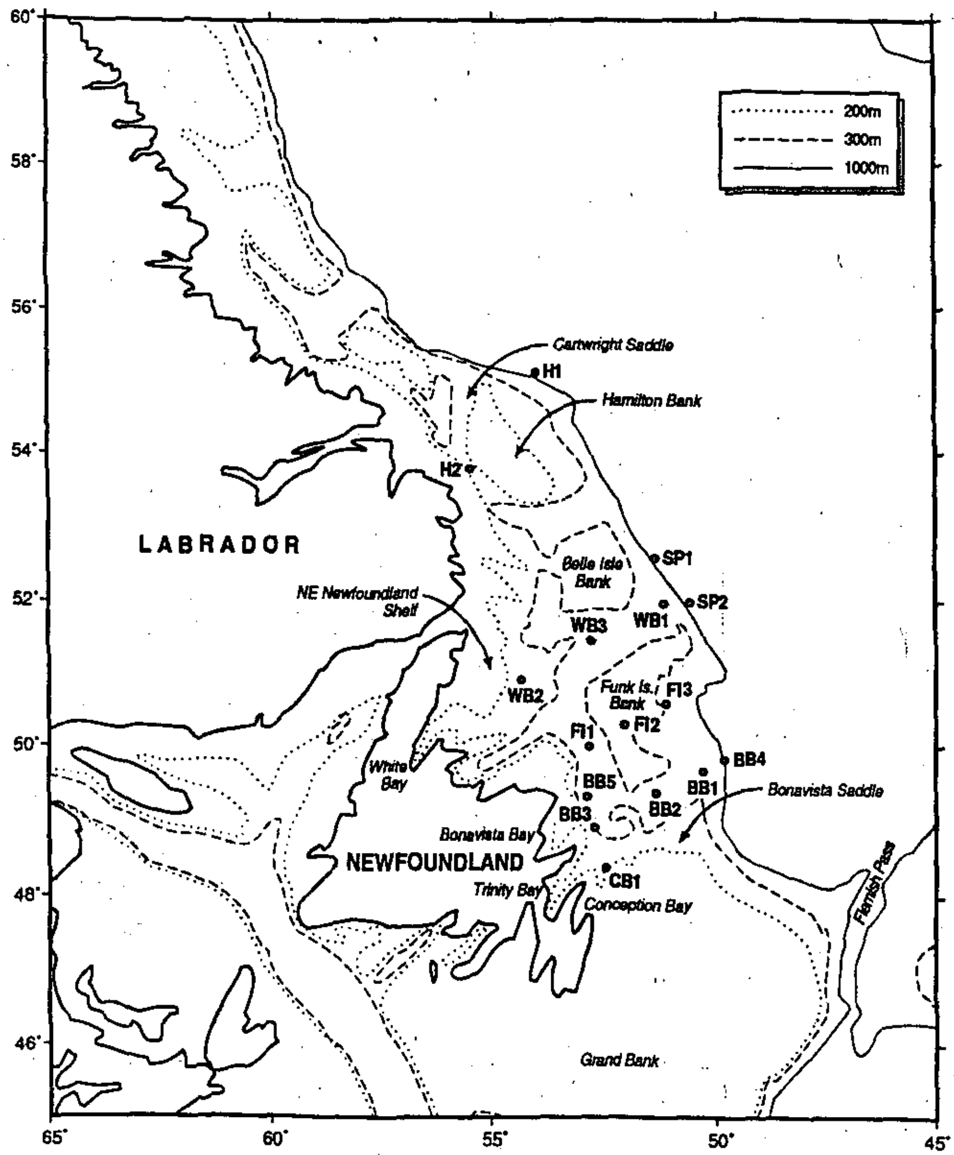

Fig. 1. Area Map showing the locations of moorings deployed under the NCSP.

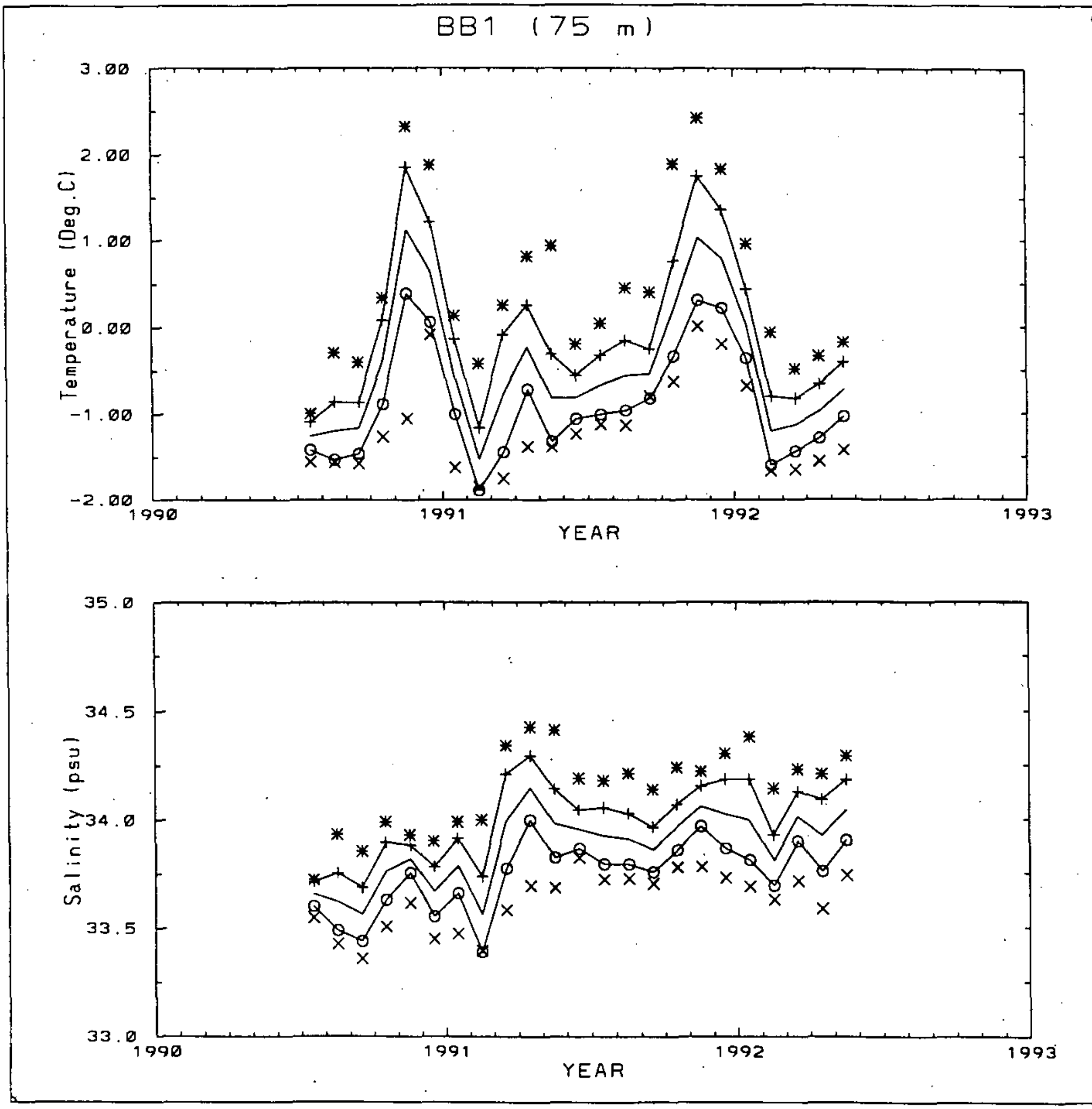

Fig. 2a. T and S monthly time series at BB1: monthly mean (--), mean+standard deviation (x-x), mean-standard deviation (o-o), maximum (*) and minimum: 75 m.

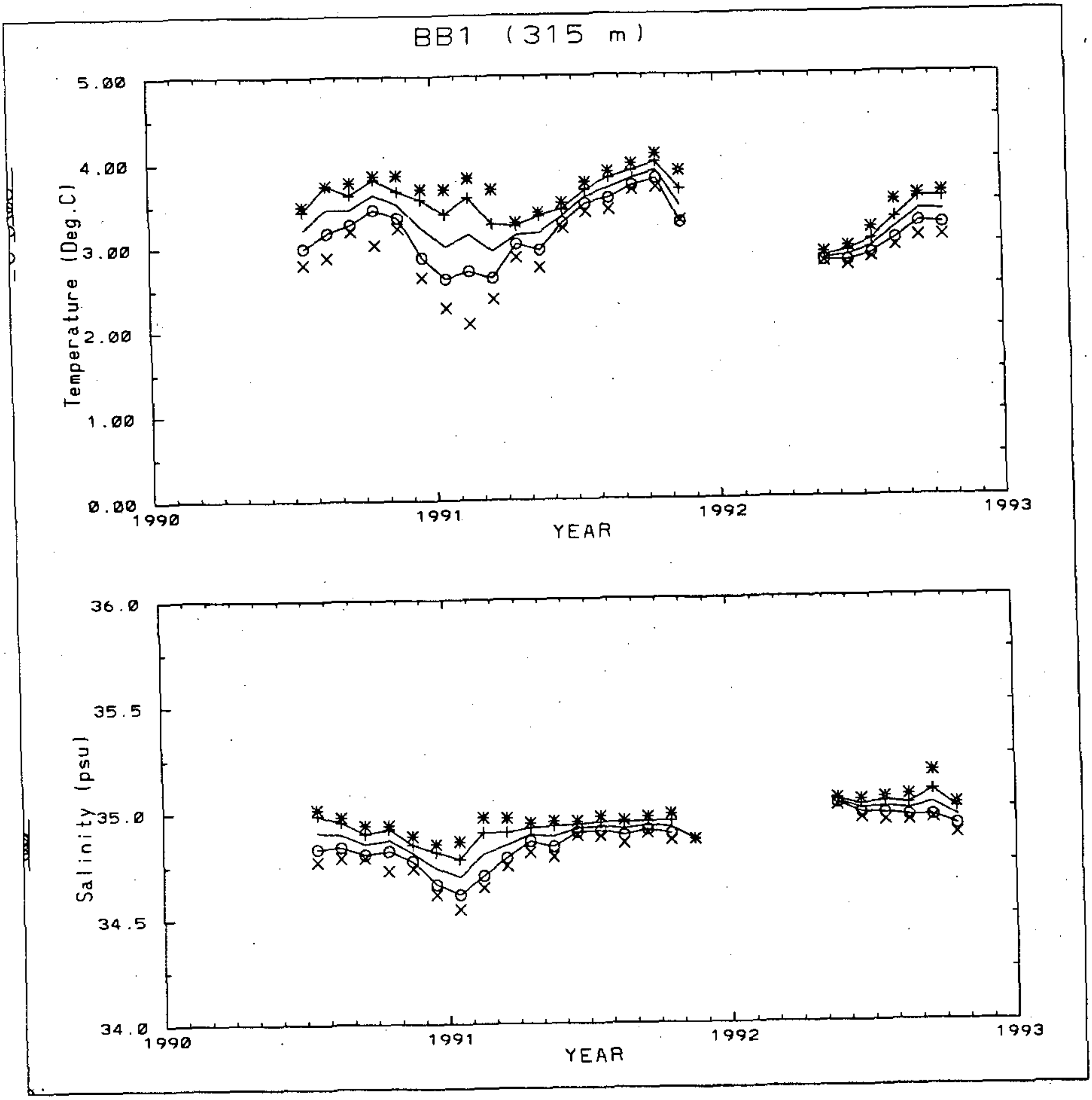

Fig. 2b. T and S monthly time series at BB1: monthly mean (--), mean + standard deviation (x-x), mean-standard deviation (o-o), maximum (*) and minimum: 315 m.

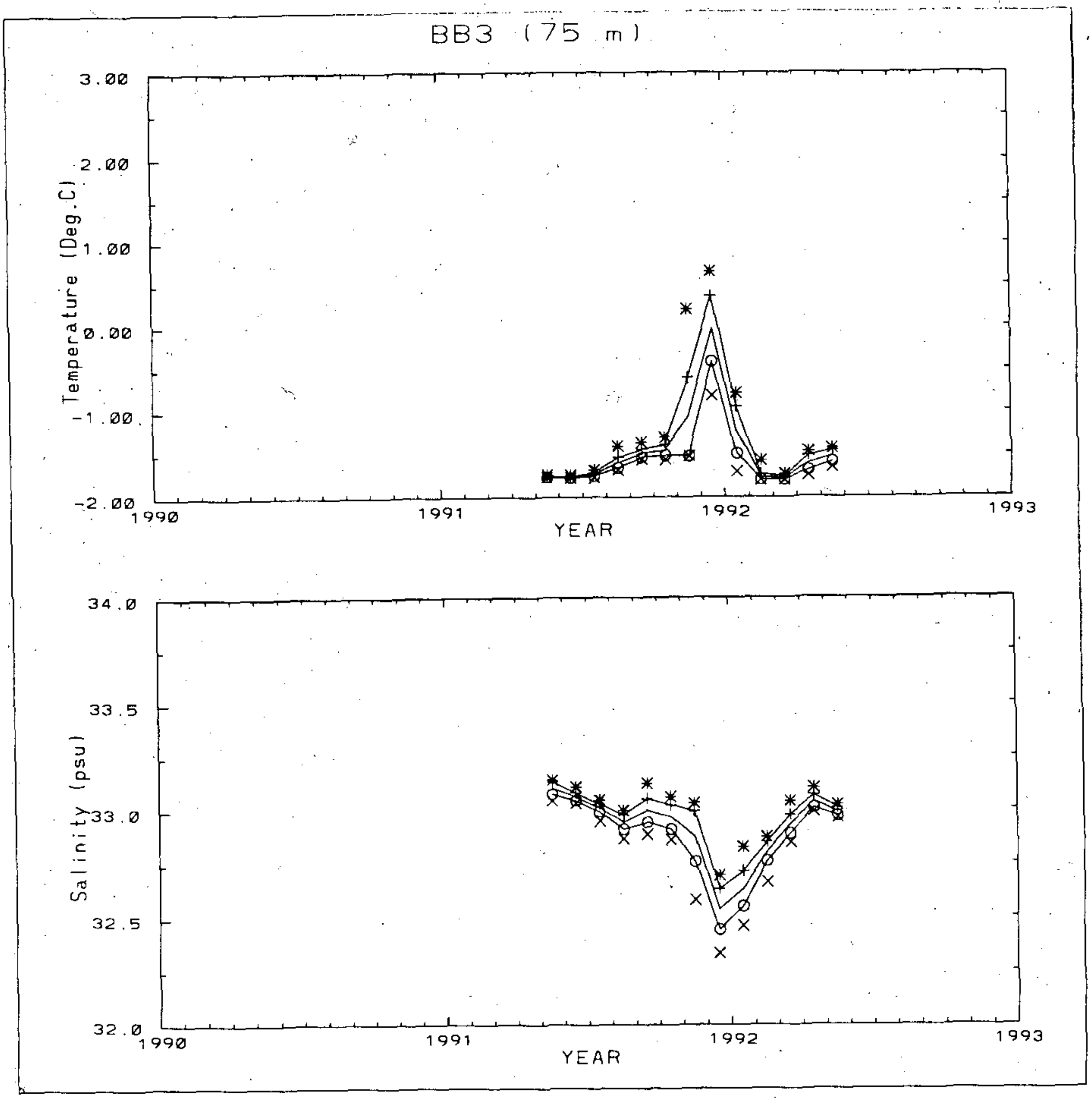

Fig. 3a. T and S monthly time series at BB3: monthly mean (--), mean+standard deviation (x-x), mean-standard deviation (o-o), maximum (*) and minimum: 75 m.

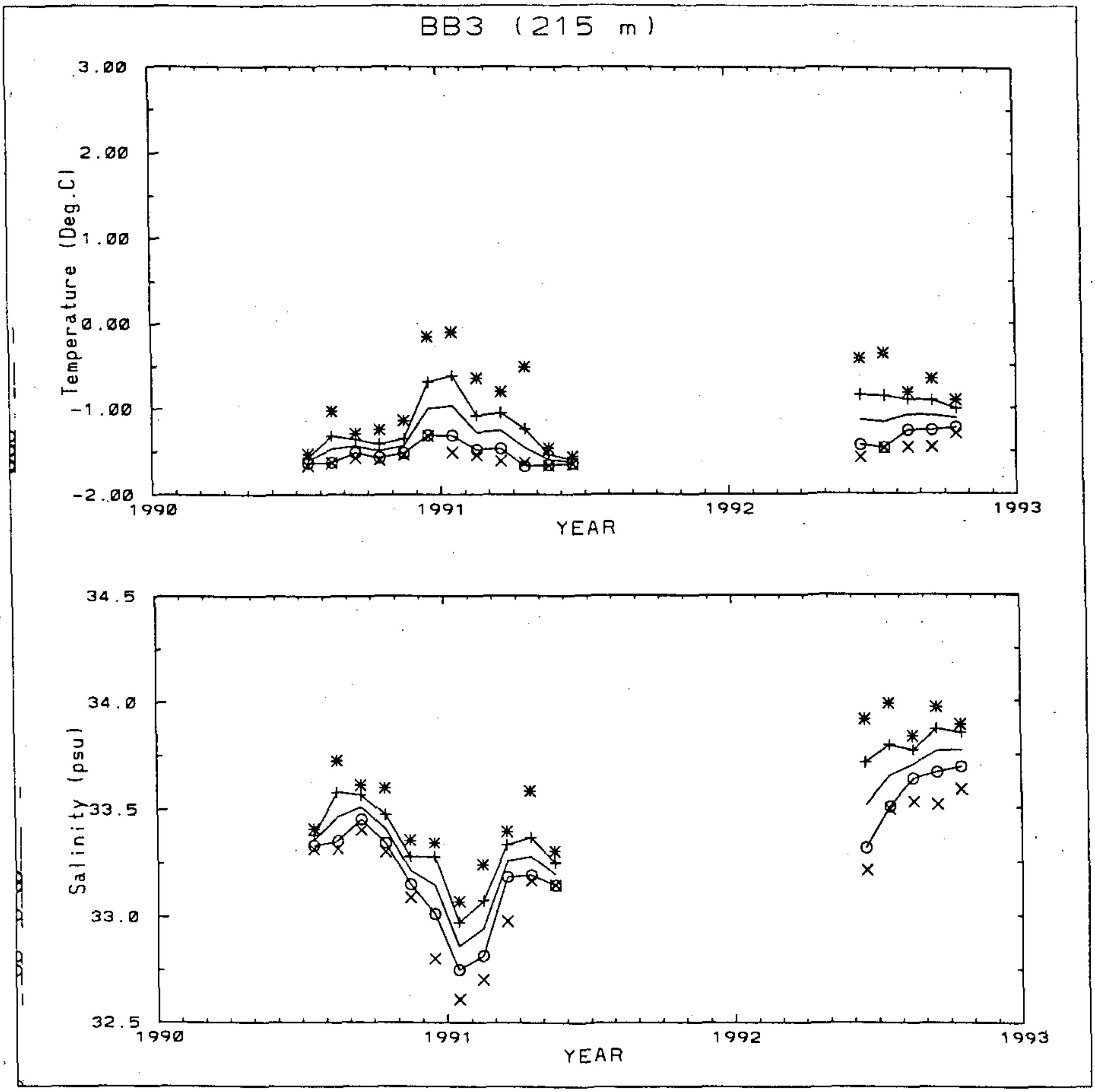

Fig. 3b. T and S monthly time series at BB3: monthly mean (--), mean+standard deviation (x-x), mean-standard deviation (o-o), maximum (*) and minimum: 215 m.

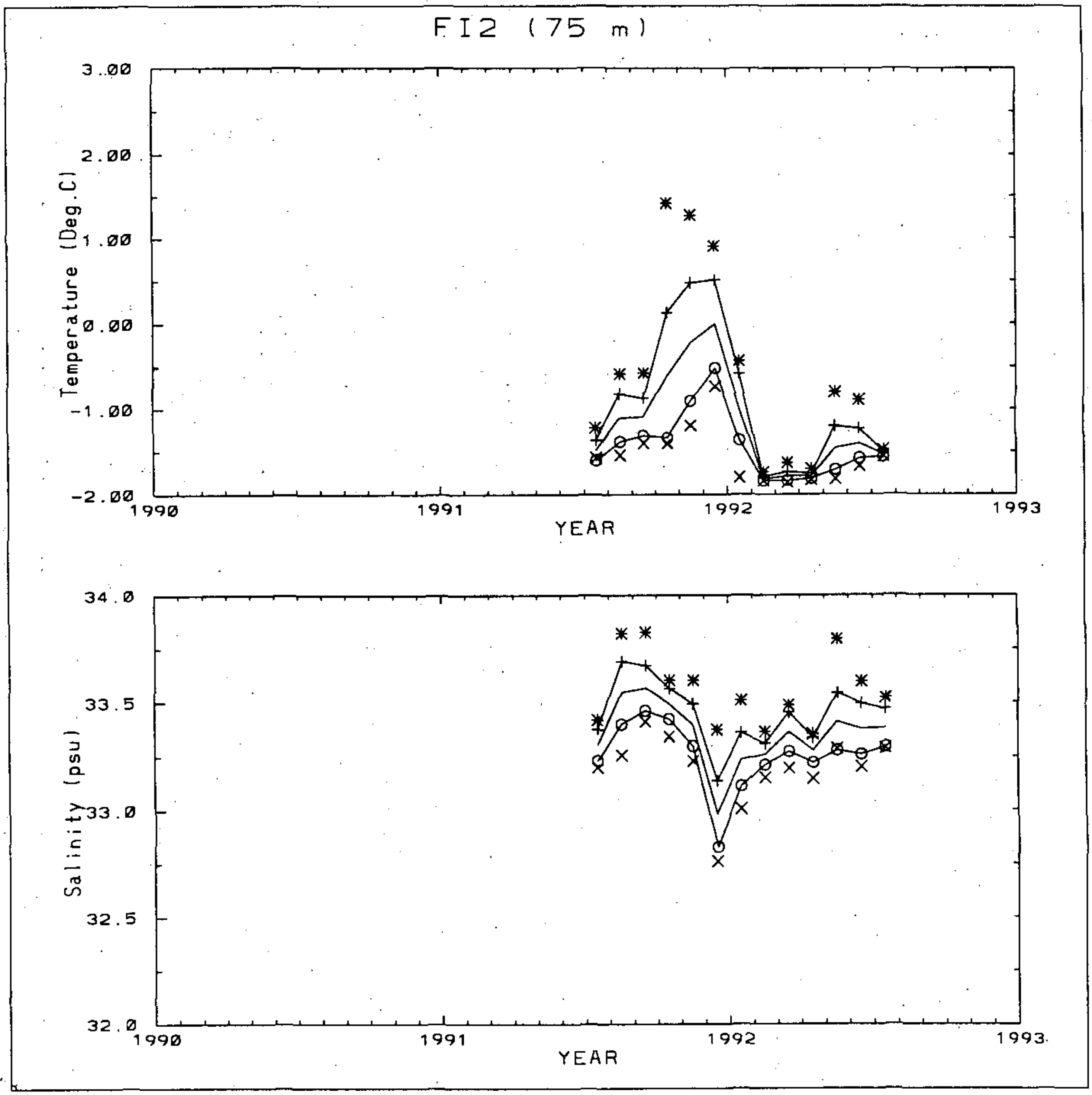

Fig. 4a. T and S monthly time series at FI2: monthly mean (--), mean + standard deviation (x-x), mean-standard deviation (o-o), maximum (*) and minimum: 75 m.

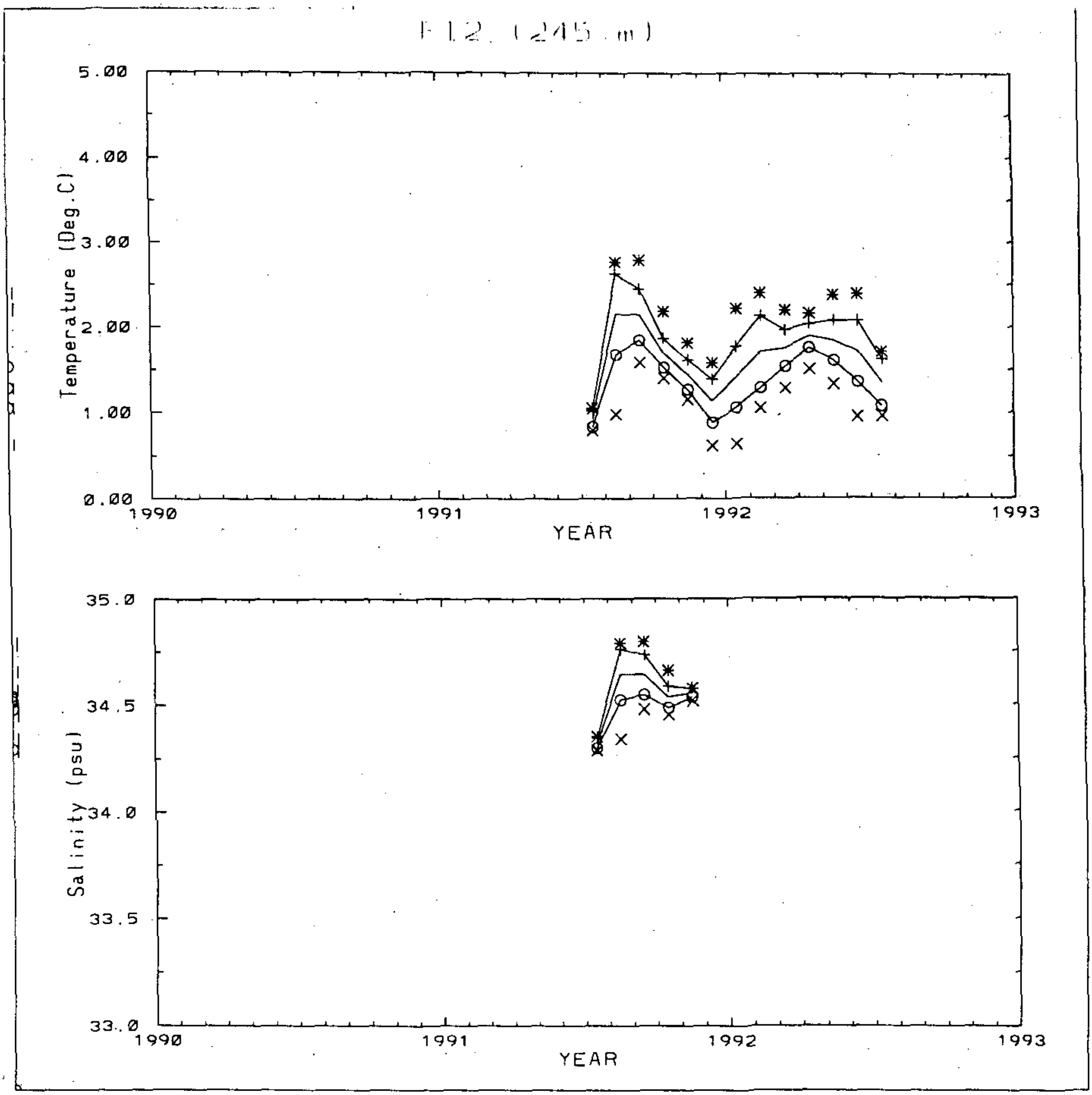

Fig. 4b. T and S monthly time series at FI2: monthly mean (--), mean+standard deviation (x-x), mean-standard deviation (o-o), maximum (*) and minimum: 245 m.

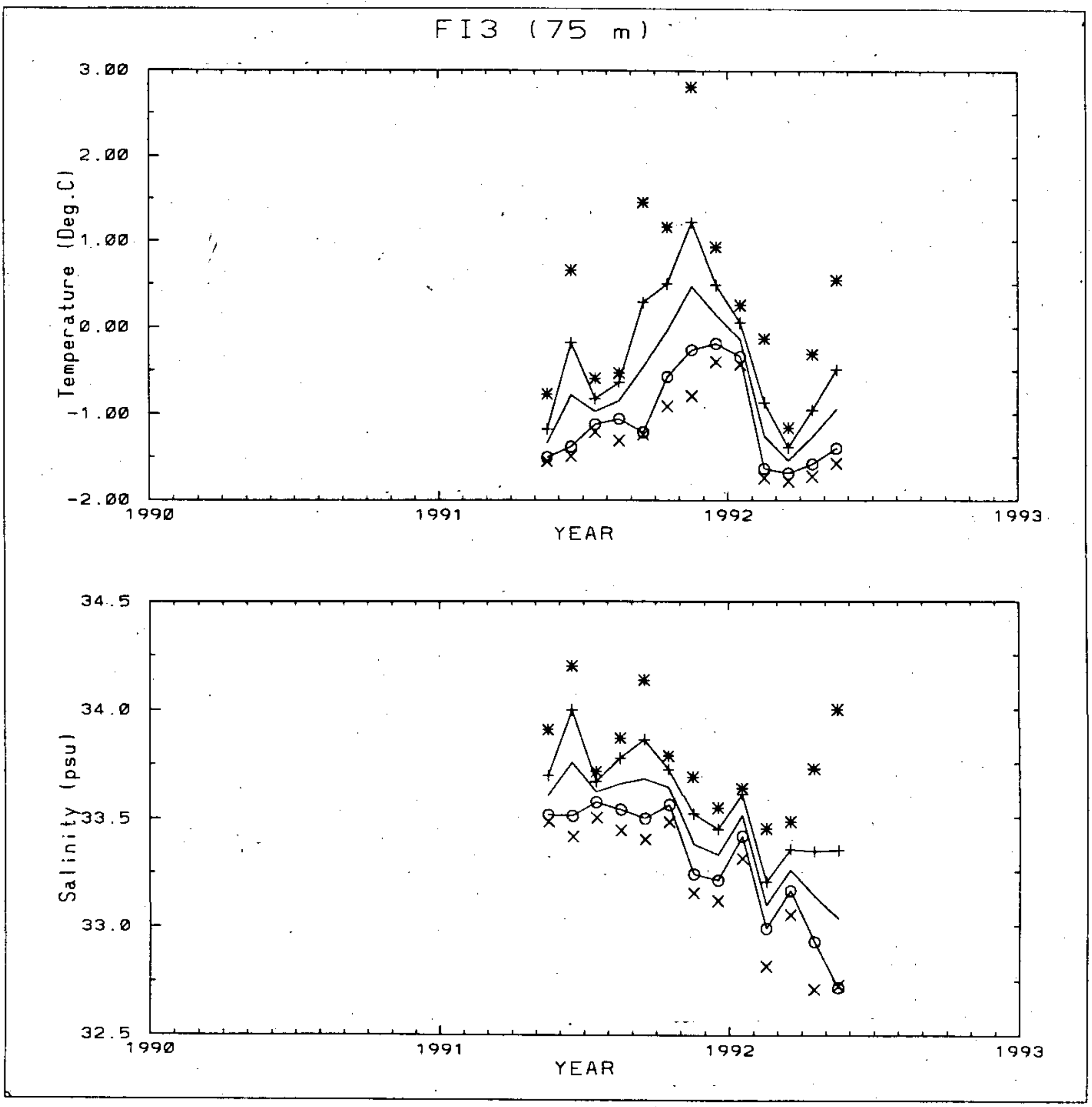

Fig. 5a. T and S monthly time series at FI3: monthly mean (--), mean + standard deviation (x-x), mean-standard deviation (o-o), maximum (*) and minimum: 75 m.

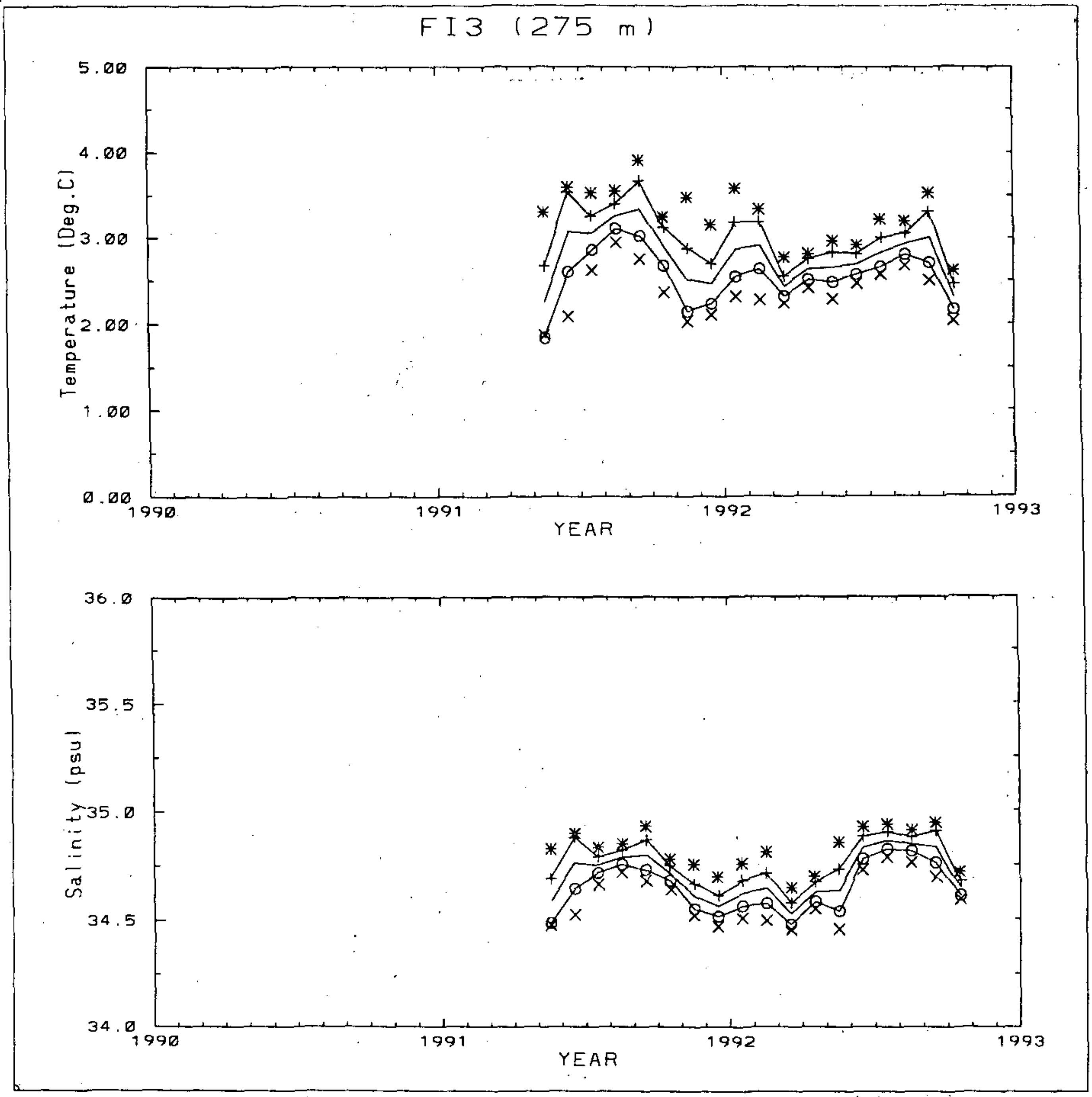

Fig. 5b. T and S monthly time series at FI3: monthly mean (--), mean+standard deviation (x-x), mean-standard deviation (o-o), maximum (*) and minimum: 275 m.

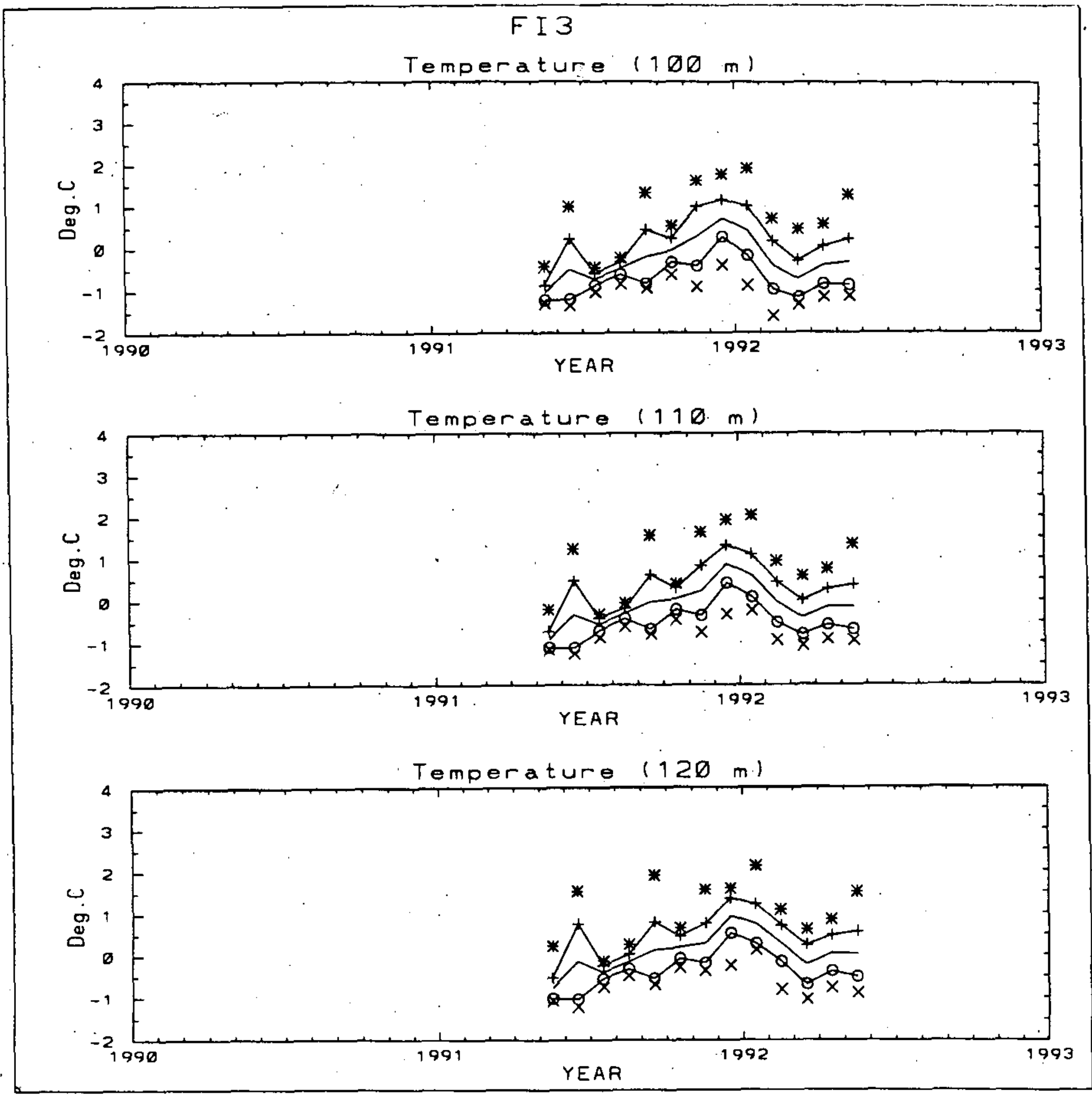

Fig. 6. Temperature monthly time series at FI3: monthly mean (--), mean + standard deviation (x-x), mean-standard deviation (o-o), maximum (*) and minimum: 100 to 200 m.

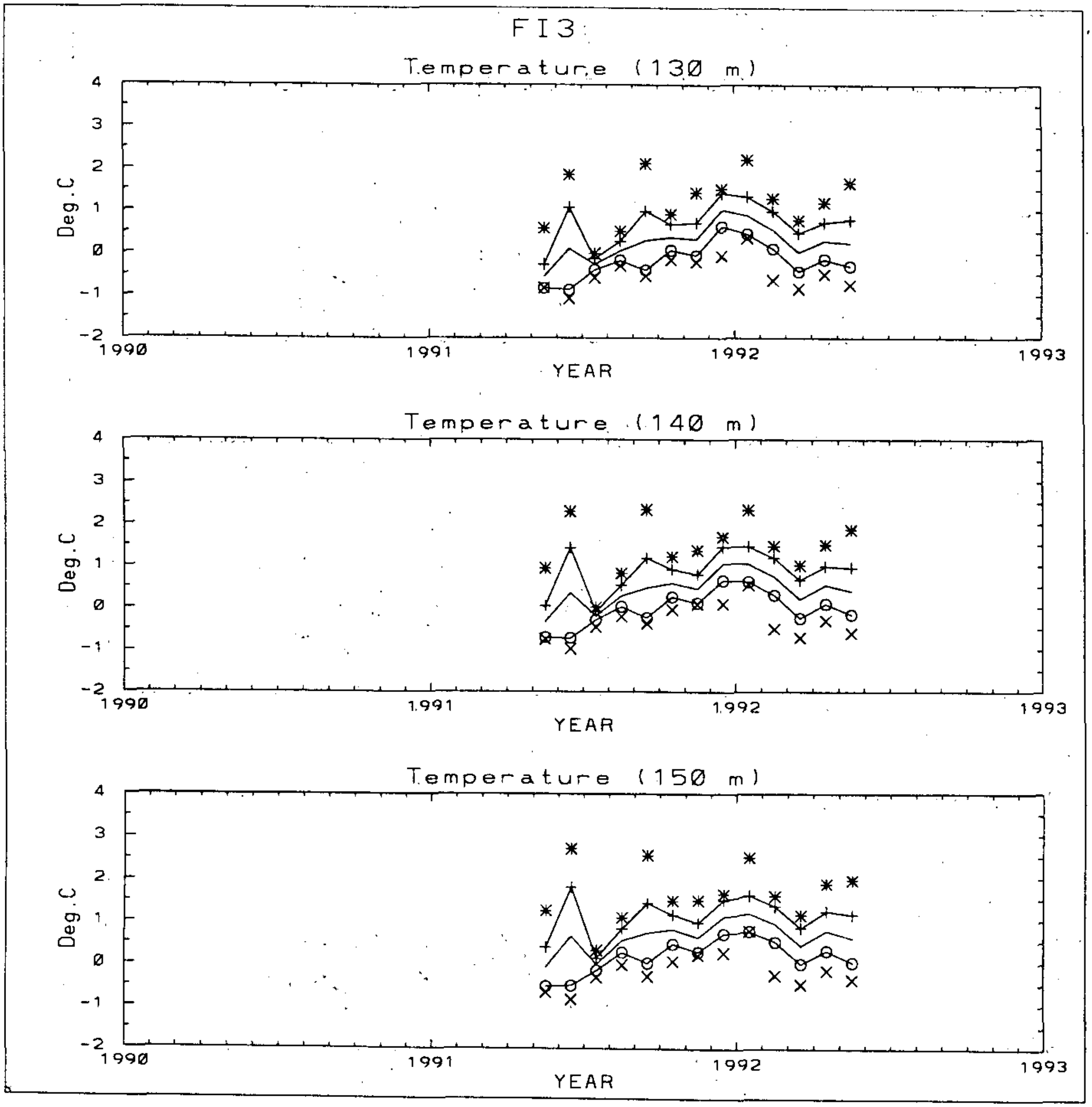
FI3
Temperature (130 m)
Deg.C
4
3
2
1
0
-1
-2
1990
1991
1992
1993
YEAR
Temperature (140 m)
Deg.C
YEAR
Temperature (150 m)
Deg.C
YEAR

Fig. 6. (Cont'd).

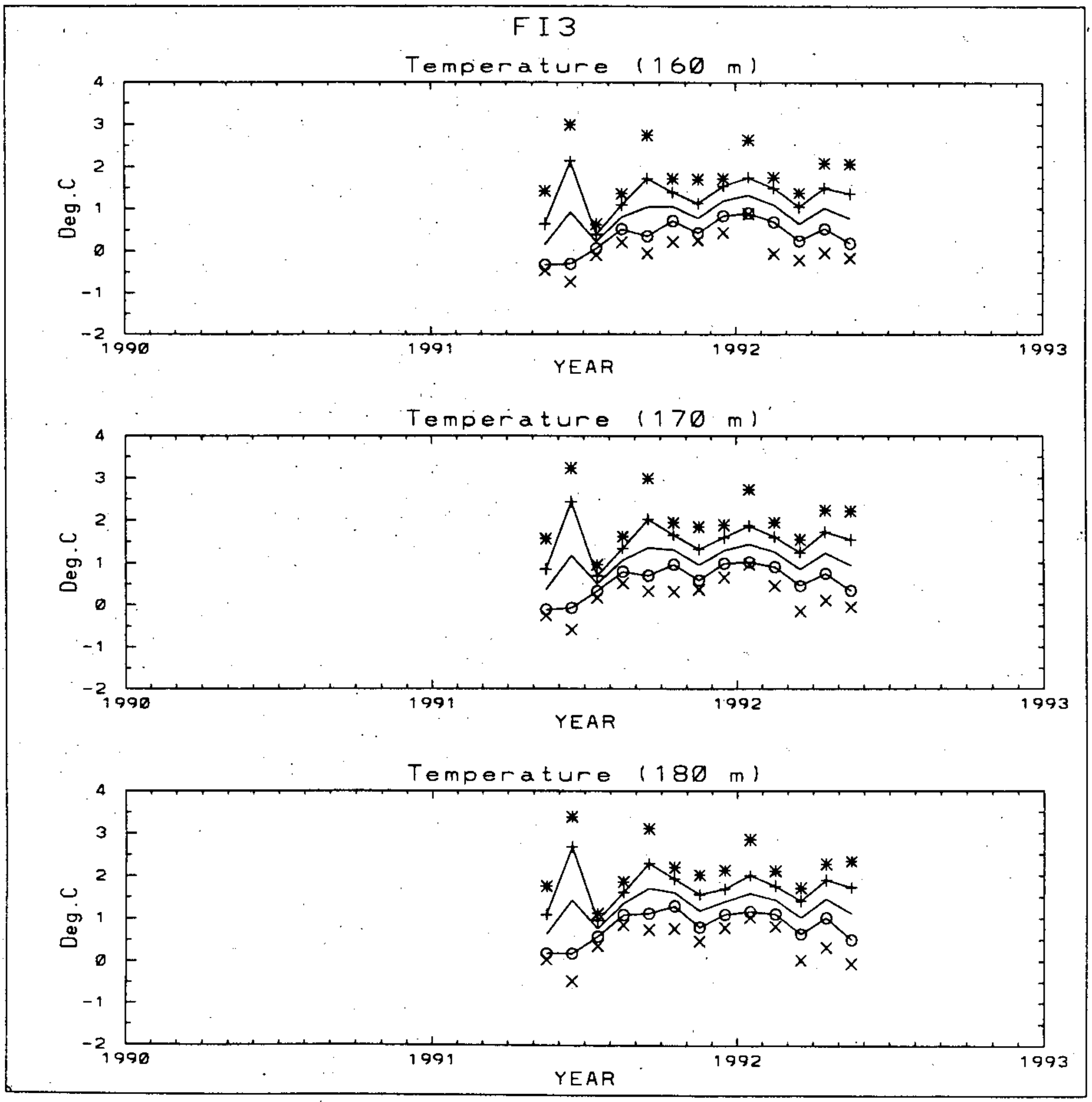
FI3
Temperature (160 m)
Deg.C
4
3
2
1
0
-1
-2
1990
1991
1992
1993
YEAR
Temperature (170 m)
Deg.C
4
3
2
1
0
-1
-2
1990
1991
1992
1993
YEAR
Temperature (180 m)
Deg.C
4
3
2
1
0
-1
-2
1990
1991
1992
1993
YEAR

Fig. 6. (Cont'd).

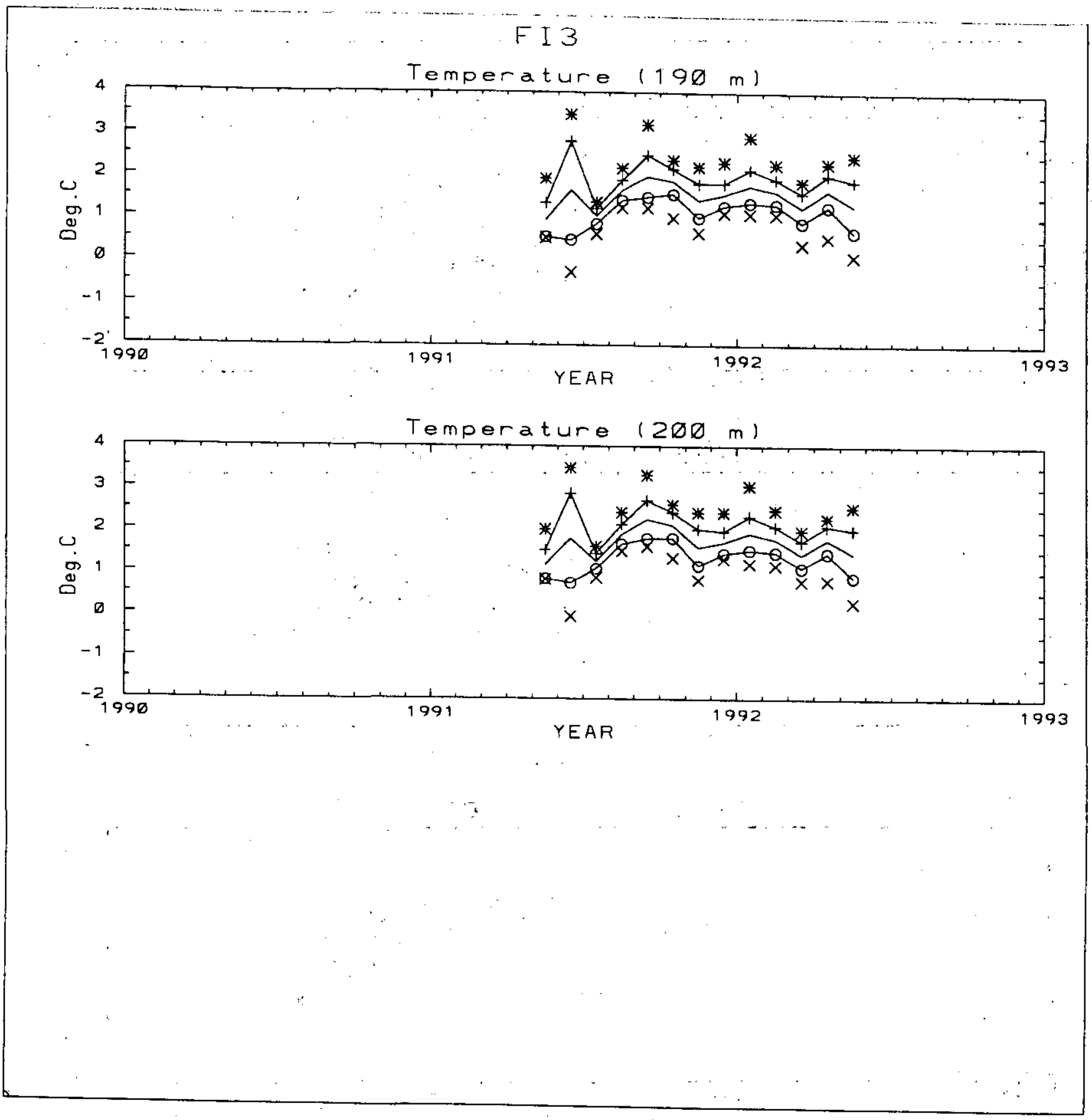
FI3
Temperature (190 m)
Deg.C
4
3
2
1
0
-1
-2
1990
1991
1992
1993
YEAR
Temperature (200 m)
Deg.C
4
3
2
1
0
-1
-2
1990
1991
1992
1993
YEAR

Fig. 6. (Cont'd).

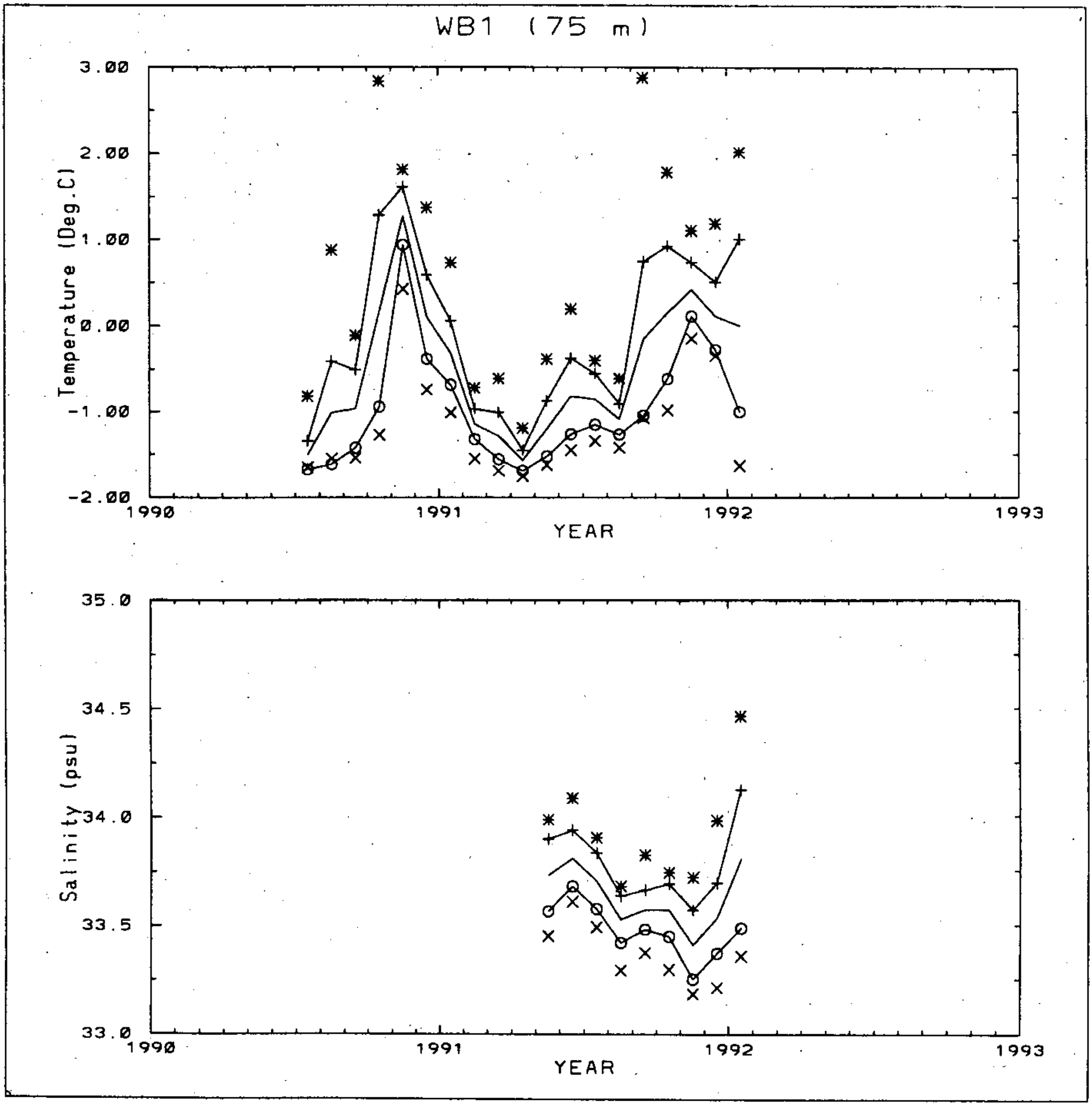

Fig. 7a. T and S monthly time series at WB1: monthly mean (--), mean + standard deviation (x-x), mean-standard deviation (o-o), maximum (*) and minimum: 75 m.

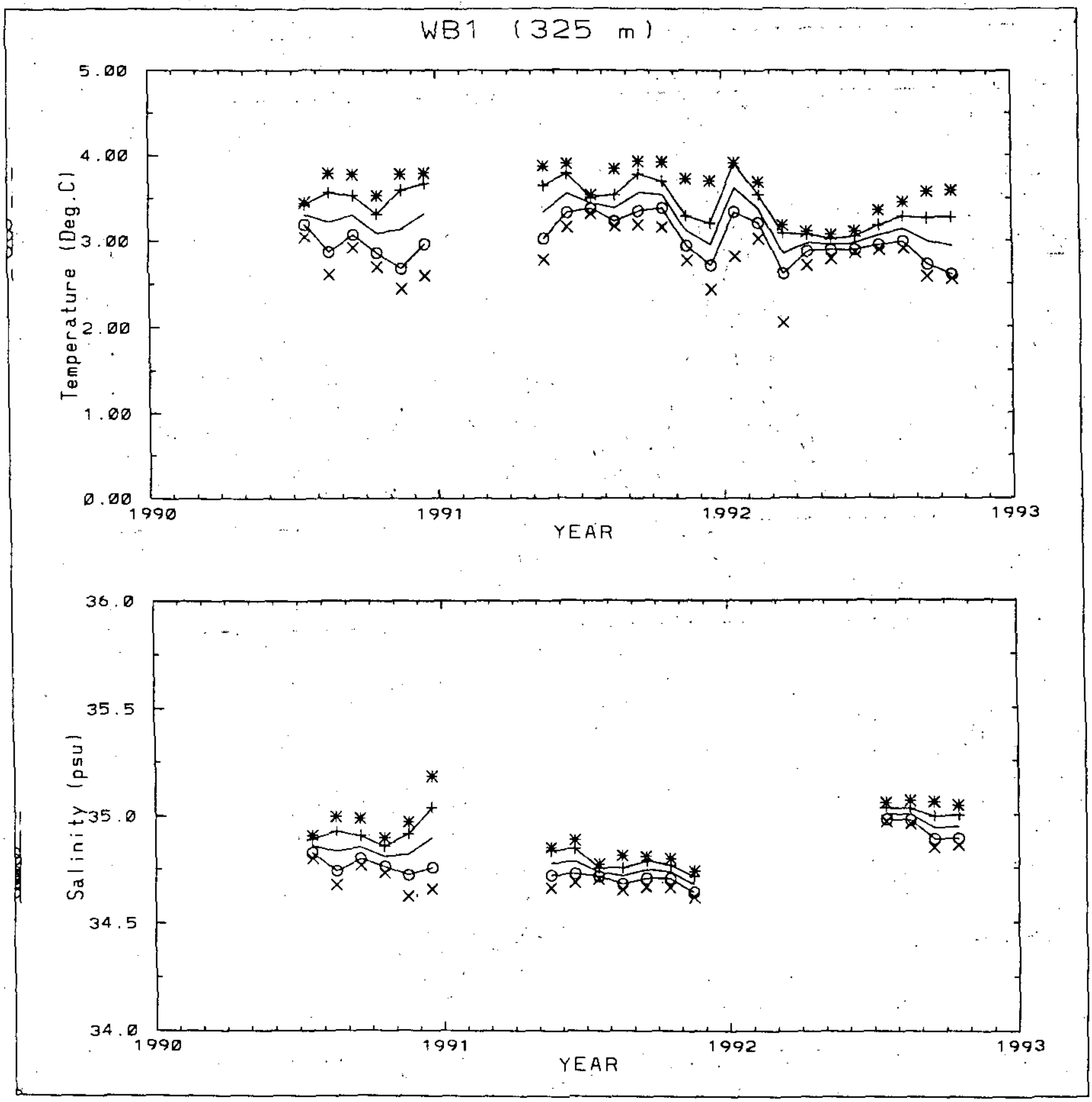

Fig. 7b. T and S monthly time series at WB1: monthly mean (--), mean + standard deviation (x-x), mean-standard deviation (o-o), maximum (*) and minimum: 325 m.

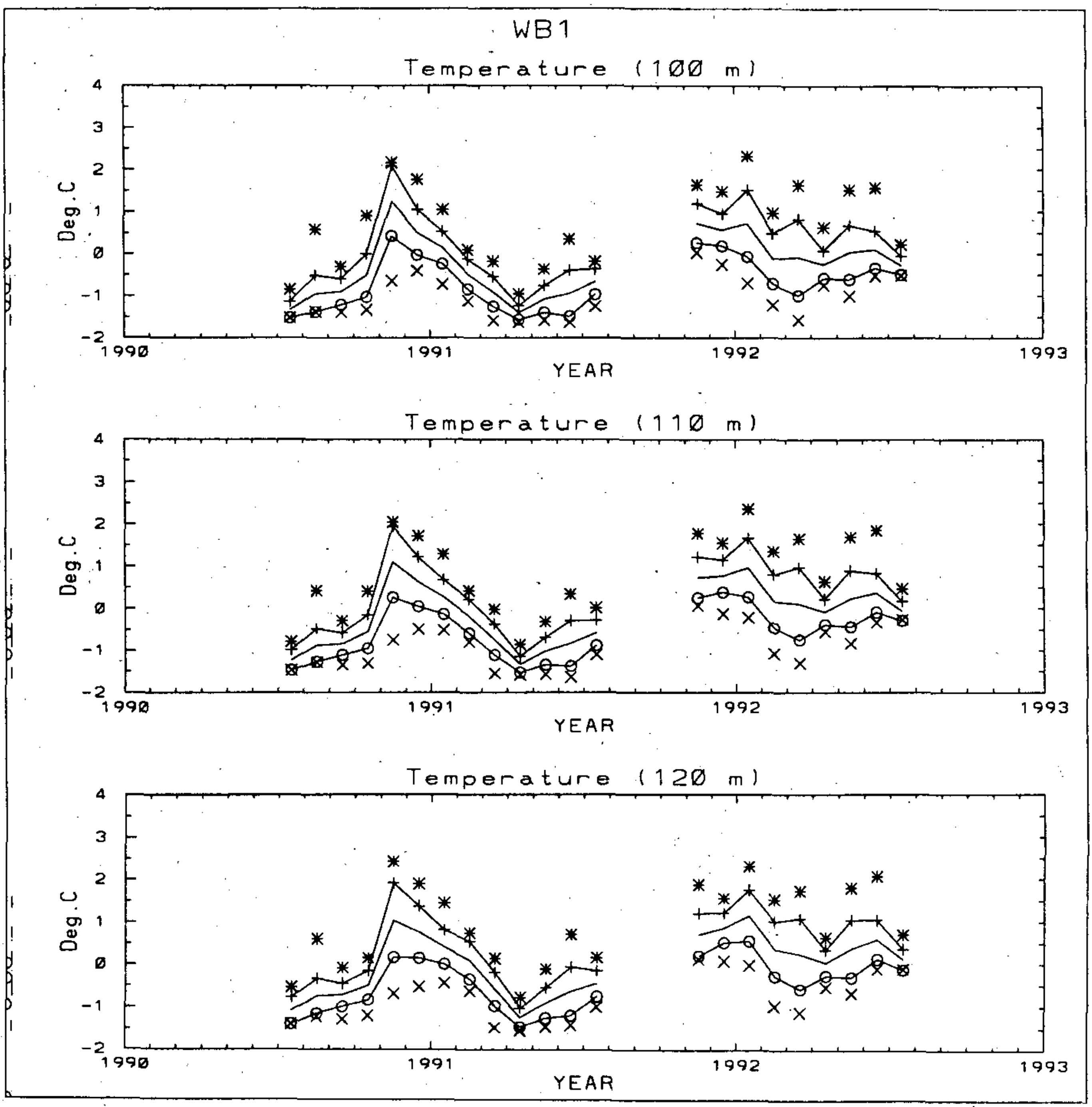

Fig. 8. Temperature monthly time series at WB1: monthly mean (--), mean + standard deviation (x-x), mean-standard deviation (o-o), maximum (*) and minimum: 100 to 200 m.

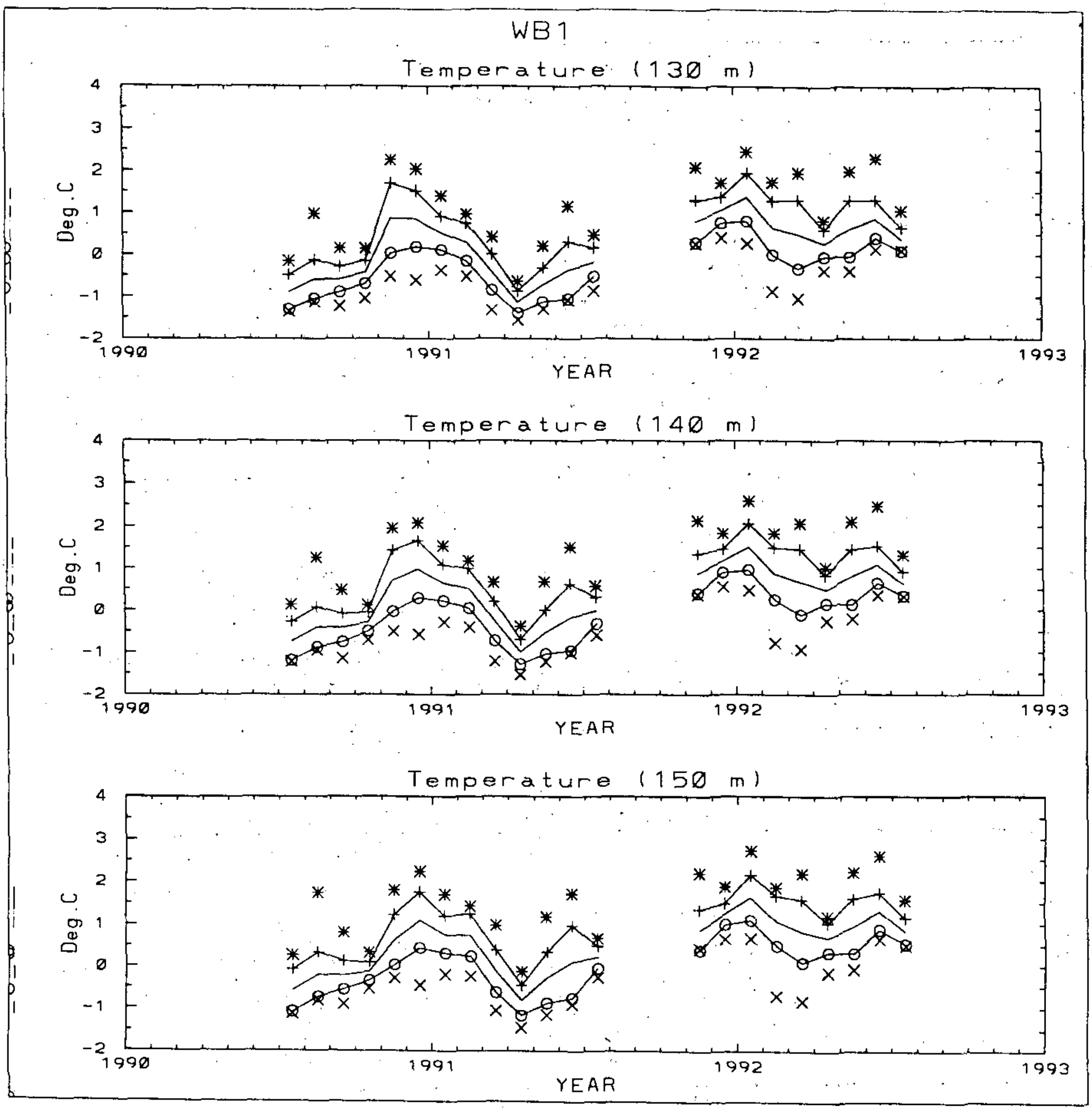
WB1
Temperature (130 m)
Deg.C
YEAR
1990
1991
1992
1993
Temperature (140 m)
Deg.C
YEAR
Temperature (150 m)
Deg.C
YEAR

Fig. 8. (Cont'd).

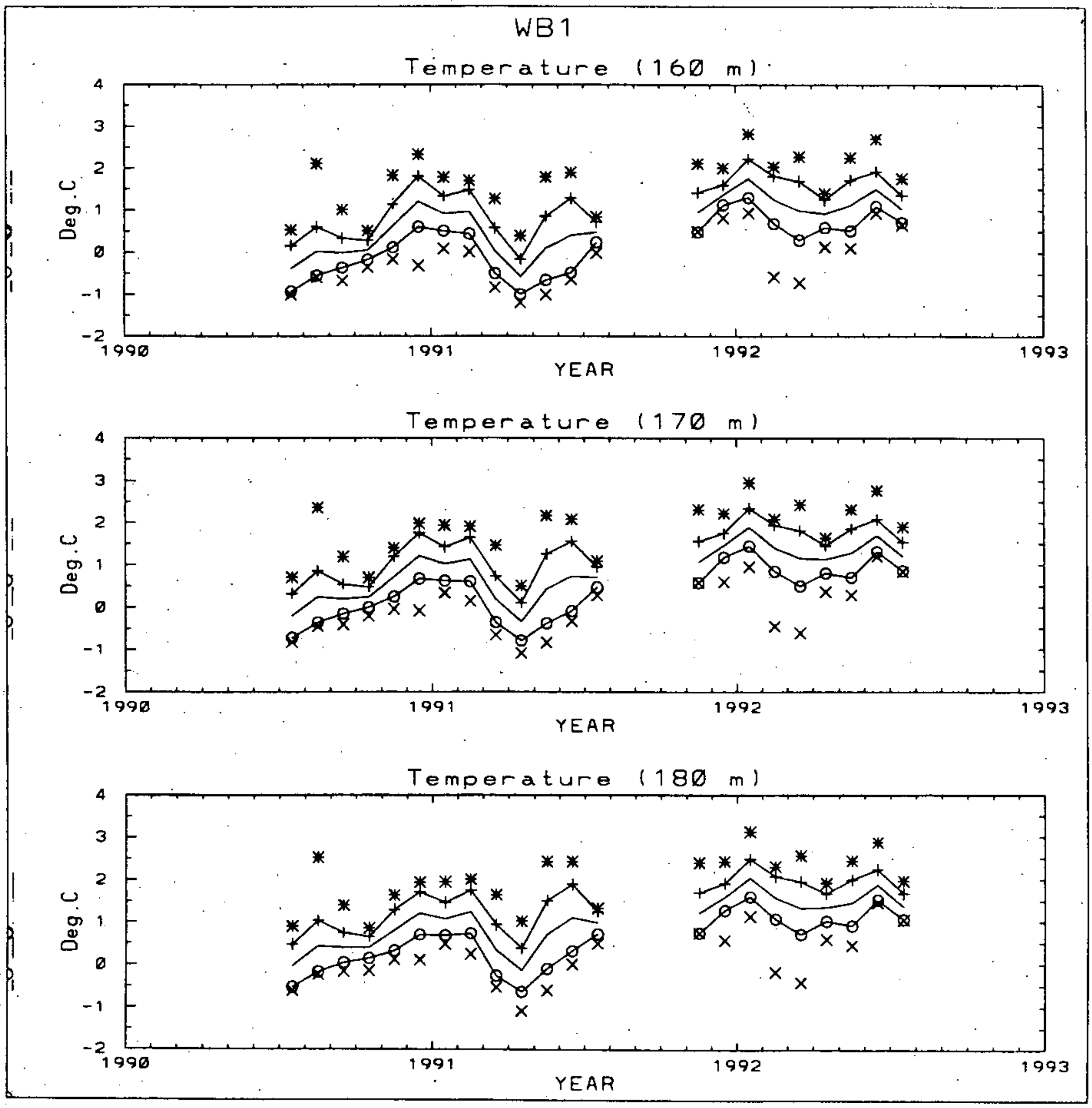
WB1
Temperature (160 m)
Deg.C
4
3
2
1
0
-1
-2
1990
1991
1992
1993
YEAR
Temperature (170 m)
Deg.C
4
3
2
1
0
-1
-2
1990
1991
1992
1993
YEAR
Temperature (180 m)
Deg.C
4
3
2
1
0
-1
-2
1990
1991
1992
1993
YEAR

Fig. 8. (Cont'd).

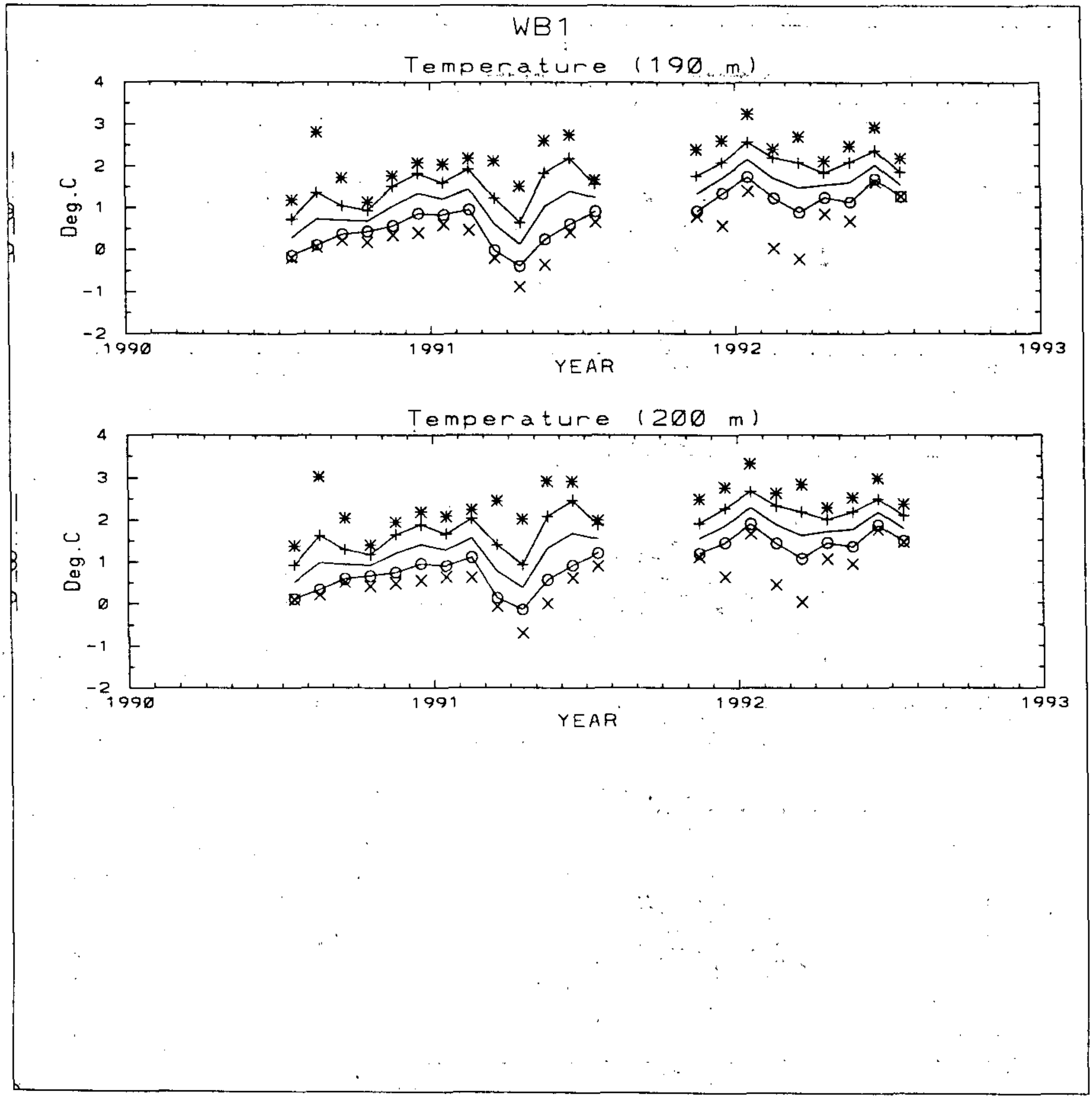
WB1
Temperature (190 m)
4
3
2
1
0
-1
-2
Deg.C
1990
1991
1992
1993
YEAR
Temperature (200 m)
4
3
2
1
0
-1
-2
Deg.C
1990
1991
1992
1993
YEAR

Fig. 8. (Cont'd).

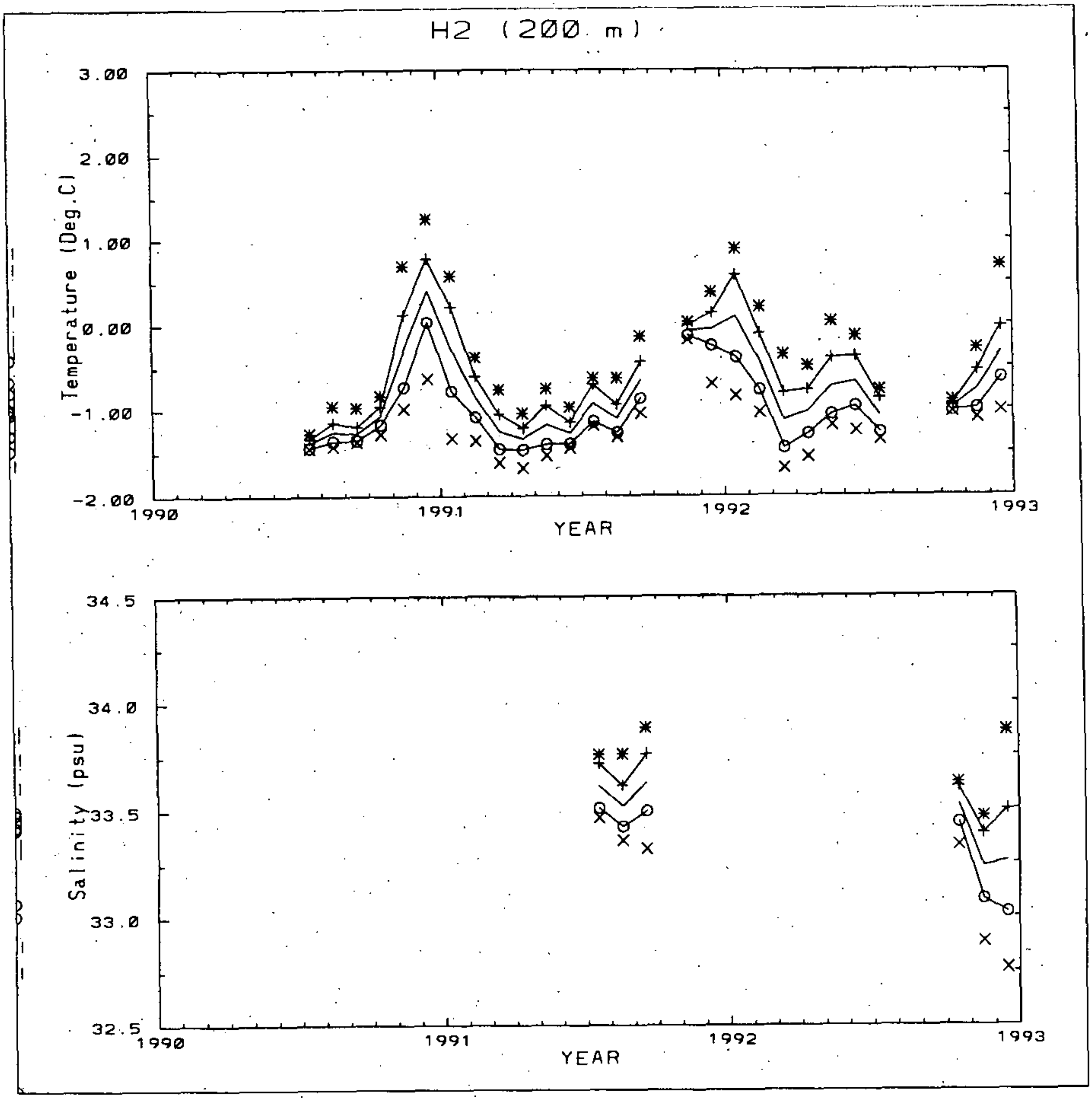

Fig. 9. T and S monthly time series at H2: monthly mean (--), mean + standard deviation (x-x), mean-standard deviation (o-o), maximum (*) and minimum (x): 200 m.

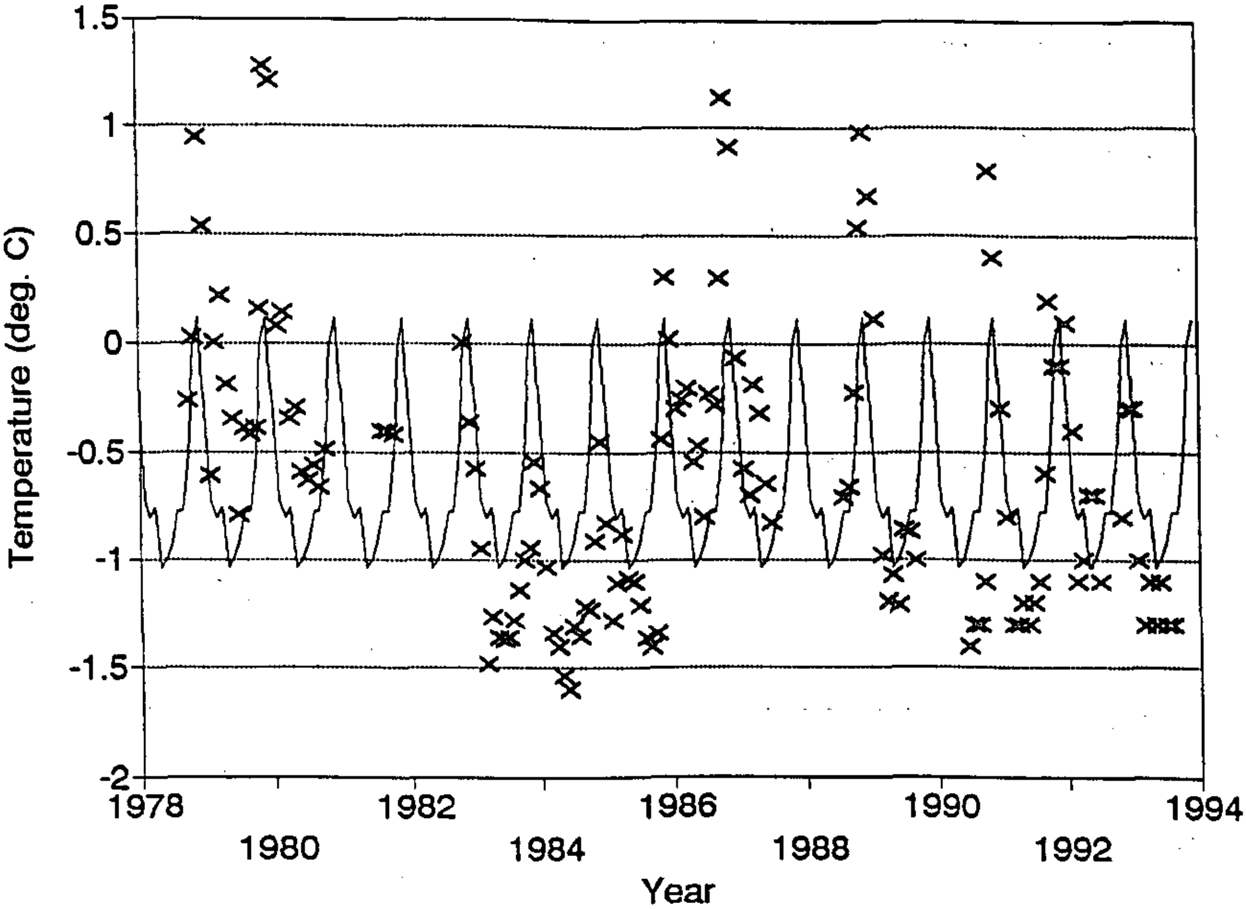

Fig. 10. Comparison of near-bottom (200 m) monthly mean temperature (x) at H2 with the 1978-93 average.