Northeast Fisheries Science Center Reference Document 93-10

Test and Evaluation of the SBE 19 Seacat *Profiler*

by

Tamara Holzwarth-Davis

NOAA/National Marine Fisheries Service
Northeast Fisheries Science Center
Environmental Processes Division
Woods Hole, MA 02543-1097

June 1993

Table of Contents

List of Figures

List of Tables

ABSTRACT

An SBE Model 19 Seacat *Profiler* was purchased to obtain temperature, salinity, and pressure data during plankton tows. A test and an evaluation of the Profiler were conducted aboard the *R/V Delaware II* during Part I of the DEL8909 Larval Herring/Sand Lance Study, November 27 through December 12, 1989. An SBE Model 9 Seabird CTD was used as a standard for comparison. Data collected with the Profiler were compared with those taken with the CTD during two methods of operation: 1) "Tandem" casts as the two instruments made simultaneous vertical profiles; and 2) vertical CTD only casts followed by double oblique Profiler casts with a bongo net. The down and up casts from the *Profiler* were also compared. Ease of operation and feasibility during plankton tows were also evaluated.

The *Profiler* collected data of good quality and compared well to the CTD.

INTRODUCTION

Since May of 1987, hydrographic data have been collected by the Northeast Fisheries Science Center primarily with an SBE Model 9 Seabird conductivity, temperature, and depth (CDT) internally recording device. This CTD is manufactured by Seabird Electronics of Bellevue, Washington. It has been a reliable instrument with good data quality.

A CTD cast can take up to half an hour at deep (200 m) stations. At the time of this test and evaluation, certain cruises (*e.g.*, bottom trawl surveys) did not allow for this extra time in their cruise operations. An expendable bathythermograph (XBT) was used to obtain temperature data throughout the water column. The XBT does not require extra station time as it can be launched while the ship is under way. Although the XBT is faster, it measures fewer data than a CTD and can be costly because the probes are non-retrievable.

An SBE Model 19 Seacat *Profiler* was purchased to obtain salinity, temperature, and pressure data during plankton tows. By deploying the instrument with bongo nets, no additional time is needed for hydrographic data collection.

The *Profiler* was tested aboard the *R/V Delaware II* during the DEL8909 I Larval Herring/ Sand Lance Study. This report presents an evaluation of the instrument's data quality and suitability for use on plankton tows.

DESCRIPTION OF *PROFILER*

The *Profiler* measures 736.6 mm (29 in) long with a diameter of 99 mm (3.9in). It weighs 5 kg (11 lb). The pressure housing is made of Celcon plastic and is capable of withstanding pressure up to 600 m in depth. The SBE-3 thermometer, SBE-4 conductivity meter, and precision semiconductor strain-gauge pressure transducer are the same sensors as those on the CTD. The manufacturer claims the following sensor accuracies:

Temperature:	0.01°/6 months
Conductivity:	0.0001 Siemans/m/month
Pressure:	0.5% of full scale range (approx. 3 m).

The *Profiler* is powered by 6 D-cell alkaline batteries that can provide up to 48 hr of continuous data operation and a 2 year data retention reserve. The memory of 64K bytes permits 1.5 hr of recording. The sampling rate is two scans per second (the CTD rate is eight scans per second). The *Profiler* does not have a submersible pump as does the CTD; therefore, the conductivity cell is "free flushing".

Data retrieval for both instruments is via an RS-232 link to an IBM-PC compatible computer. Seabird Electronics provides software that can communicate with the instrument's memory, retrieve, plot, and store the data. This software also derives salinity values and can average the data into specified depth intervals. Although the pressure sensor actually measures pressure and the data are recorded as decibars, it is common to refer to the pressure as depth and to substitute meters for decibars. This substitution is accurate to approximately 0.5%.

In order to attach the *Profiler* to the wire above the bongo nets, a few modifications were made to the *Profiler*. Two blocks of PVC with a slot cut in the side to accommodate the wire and a notched screw with a wing nut were taken off Niskin bottles and hose-clamped to the *Profiler* housing. For safety purposes, a snap shackle was attached to an eyelet in each endcap on the *Profiler*.

Table 1. Station operations for DE8909 I

Standard Station #	Consecutive Station #	Bongo	Type of Work		Tandem	Salt	Comment
			Profiler	CTD			
1	1	x		x		x	
2	2	x		x			
3	3	x	x	x		x	
4	4	x	x	x			
5	5	x		x		x	
6	6	x		x			
7	7	x		x			
8	8	x		x		x	
9	9	x		x			
10	10	x		x			CTD data lost
11	11	x	x	x		x	*Profiler* data lost
12	12	x	x	x			*Profiler* data lost
13	13	x		x			
14	14	x		x			
15	15	x	x	x		x	
16	16	x	x	x			
17	17	x	x	x			
18	18	x	x	x			
144	19	x	x	x		x	
19	20	x	x	x			
145	21	x	x	x			
20	22	x	x	x			
21	23	x	x	x			
22	24	x	x	x			
23	25	x	x	x		x	
24	26	x	x	x			
26	27	x	x	x			
25	28	x	x	x			
27	29	x	x	x		x	
28	30	x	x	x			
30	31	x		x			
33	32	x	x				
34	33	x	x				No *Profiler* upcast data
35	34	x	x				
36	35	x	x				

METHODS

DEPLOYMENT

Both the CTD and the *Profiler* are designed for use as vertical profilers with optimal data collection occurring on the downcast. For this test, the *Profiler* was deployed in two ways: 1) attached as a vertical profiler to the cage of the CTD and, 2) mounted above the bongo net and towed obliquely through the water column.

During part I of the cruise, the CTD was used on 63 of the 72 stations (see Table 1). On nine of these CTD casts, the *Profiler* was also used. The *Profiler* was shackled to the cage with its sensors directed down. This placed the sensors of both instruments at the same sampling depth and less than half a meter apart. Both instruments were attached to the wire while on deck. A Niskin bottle was clamped to the wire directly above the CTD after placing the units over the side of the ship. This "tandem" cast was lowered and stopped within 5 m of the bottom, then a "messenger" was sent down the wire to trip the Niskin bottle and collect a water sample. Water samples are used to calibrate the conductivity sensor on each instrument. The wire was brought up and the Niskin bottle removed. Then the CTD and *Profiler* were swung onto the deck and removed from the wire.

The *Profiler* also was used on 47 plankton tows. Thirty-six of the tows were preceded by a CTD cast. These 36 "cast *vs* tow" stations provided another method for comparison. Tow procedures began by attaching a 45 kg ball beneath the bongo frame. A bathykymograph (BKG) was placed above the bongo. The *Profiler* was clamped and shackled to the wire directly above the BKG with its sensors directed up. This was all done on deck. The entire assemblage was

Table 1. Continued

Standard Station #	Consecutive Station #	Bongo	Type of Work		Tandem	Salt	Comment
			Profiler	CTD			
37	36	x	x				
38	37	x	x	x		x	
39	38	x	x	x			
40	39	x	x	x			
41	40	x	x	x		x	
123	41	x			x	x	Bad *Profiler* data
124	42	x	x	x			
125	43	x		x			
126	44	x			x	x	
127	45	x			x	x	
128	46	x			x	x	
129	47	x			x	x	
130	48	x	x	x		x	
132	49	x	x	x			
133	50	x	x				
134	51	x	x				
135	52	x	x	x		x	
136	53	x	x				
131	54	x	x	x		x	
137	55	x	x	x			
138	56	x	x	x			
139	57	x	x	x		x	
42	58	x	x	x			
43	59	x	x	x		x	
44	60	x	x	x			
46	61	x			x	x	
45	62	x			x	x	
47	63	x			x	x	
48	64	x			x	x	
49	65	x	x	x		x	
32	66	x	x	x			
50	67	x	x	x			
52	68	x		x		x	
54	69	x		x			
53	70	x		x			
55	71	x		x			CTD data lost
56	72	x	x				

then placed over the side of the ship and lowered. A double oblique sampling protocol was followed. In order to obtain an optimum sampling of the water column, wire angle and wire speeds in and out were carefully monitored. Tow speed of the ship was 1.5 knots.

After the cruise, standard data processing steps were applied. Salinity corrections of +0.043 practical salinity units (PSU) for the CTD and +0.014 PSU for the *Profiler* were determined by comparing the water-sample salinity to the corresponding *in situ* salinity. Data were stored in files containing station information and 1-m averaged data values. These data were obtained from the downcasts.

DATA ANALYSIS

To determine the quality of the data obtained from the *Profiler*, the *Profiler* data were compared with the CTD data. The mean temperature and salinity differences between the two instruments were found for each station where both instruments were used. These mean differences were then divided into two groups, tandem data and cast *vs* tow data (*Profiler* station 123 within the tandem group contained bad data and was not used in any further analysis). The group mean temperature and salinity differences were then calculated by averaging the eight tandem values and the 36 cast *vs* tow values. Using this group mean ± 2 standard deviations, individual outliers within each group were discarded and the group means recalculated. The mean of the standard deviations associated within each group were also calculated.

To account for a possible discrepancy in the pressure sensors of the two instruments, various pressure offsets were applied to the data before determining the individual station mean differences. The group means were then determined in

the same manner as described previously. The pressure offsets originally ranged from -3 to 6 m in one-meter increments. These offsets had the effect of shifting the *Profiler* data up or down in the water column. It was later determined that the *Profiler* showed a consistent difference of -1 m compared with the CTD (see Table 2). Data values portrayed in this report will show values obtained from the direct comparison as well as data in which the +1 m correction was applied to the *Profiler*.

Vertical plots at selected stations were generated using Tell-A-Graf. These plots compare the temperature and salinity values recorded by the two instruments, no pressure offsets were applied.

Another method of data comparison was used to test the capabilities of the *Profiler* itself. This involved comparing the downcasts and the upcasts for each station where the *Profiler* was deployed. Again these data were divided into two groups, tandem data and cast *vs* tow data. Mean temperature and salinity differences were determined in the same way as described for the CTD versus *Profiler* comparison. No pressure offsets were attempted. Tell-A-Graf was again used to generate vertical plots of selected stations to compare the downcast and the upcast data taken with the *Profiler*.

Table 2. Difference in maximum recorded pressure between *Profiler* and CTD during tandem casts

Tandem Station #	Maximum Depth (m) *Profiler*	Maximum Depth (m) CTD	Difference[1]
123	48	49	-1
126	28	29	-1
127	40	41	-1
128	11	15	-4
129	21	23	-2
46	140	141	-1
45	161	162	-1
47	149	150	-1
48	126	127	-1

[1] *Profiler* minus CTD

Horizontal contour plots were generated using Surface III commands on the VAX computer. Plots were made of surface and bottom temperature and salinity for both the CTD and the *Profiler*. A station plot was mapped out showing the various station activities.

Plots showing a time history (time versus depth) of the tow were generated for selected bongo/*Profiler* stations.

Table 3. Mean temperature and salinity differences between the CTD and the *Profiler* for the two cast groups, T: tandem and CVT: cast *vs* tow, at 0 and 1 m offsets

Offset	Group	# Observations [1]	$\bar{x}$	Standard[2] Deviation	Mean[3] Standard deviation
			TEMPERATURE (°C)		
0	T	8	+0.029	+0.022	+0.016
0	CVT	33	+0.020	+0.024	+0.031
+1m	T	8	+0.016	+0.014	+0.015
+1m	CVT	33	+0.020	+0.024	+0.031
			SALINITY (PSU)		
0	T	8	-0.014	+0.026	+0.032
0	CVT	34	-0.019	+0.018	+0.052
+1m	T	8	-0.011	+0.024	+0.032
+1m	CVT	34	-0.015	+0.020	+0.049

[1] The number of individual station means that were included in the final statistical analysis

[2] The standard deviation of the station mean differences that were used to determine the overall mean difference, $\bar{x}$;

[3] The mean of the individual station standard deviations.

Table 4. The mean temperature and salinity difference between the down and the up casts of the *Profiler* for both cast groups (refer to Table 3, no pressure offsets)

Group	#Observations	$\bar{x}$	Standard Deviation	Mean Standard Deviation
		TEMPERATURE (°C)		
T	8	-0.014	+0.037	+0.077
CVT	44	+0.004	+0.019	+0.030
		SALINITY (PSU)		
T	8	+0.035	+0.028	+0.042
CVT	44	+0.002	+0.020	+0.034

RESULTS

By directly comparing the maximum pressure values for both instruments during the tandem casts, it was clear that there was a pressure discrepancy between the two (see Table 2). The *Profiler* was nearly consistent in showing a recorded value 1 m shallower than the CTD, while both pressure sensors were at the same level. The group mean temperature and salinity differences did decrease slightly by applying the 1-m pressure offset (see Table 3).

The downcast versus upcast comparison showed smaller mean differences during the bongo tows than during the tandem casts (see Table 4).

Figures 1 and 2, depicting the vertical plots of temperature and salinity data obtained at selected tandem and cast *vs* tow stations, show comparable measurements between two measurements.

The upcast data contained bad records for the near-surface values. Before performing the statistical analysis, as much as 1 to 5 m of data had to be deleted. The vertical plots show data readings that make it appear as though the *Profiler* was out of the water, although the pressure sensor indicates below surface pressures (see Figure 3). The data throughout the rest of the water column, however, were very similar for downcasts and upcasts. This problem also occurs with the SBE 9 CTD on some casts and is believed associated with the strain gauge pressure sensor used on both instruments.

The time history of the tow shows depth *versus* time characteristics of the tow (see Figure 4) for three different stations. These stations range in depths of approximately 50, 100, and 200 m.

Figure 5 shows the locations of all stations during Part I of the cruise.

The contour plots were generated using data from Parts I and II of the cruise to give better coverage of the study area (see Figures 6 and 7). Plots depict surface and bottom temperatures and salinities as collected from each instrument. Differences in the contours are due primarily to the different station locations for the data from the two instruments.

DISCUSSION

The results from this test show that the *Profiler* compares well to the CTD. The mean differences between the CTD and the *Profiler* were small and no correction was needed for the *Profiler* data. The pressure offset of 1 m is within the 3 m range of manufacturer specifications for the pressure sensor.

It was noted that when the -3 to 6 m offsets were applied to the *Profiler* data, the mean temperature differences did not change for the cast vs tow group but remained at +0.020°C. This can be accounted for by the relative uniformity of the water column during the winter months.

In regard to the mean salinity difference, both instruments were calibrated to an external standard before analysis, so any further difference between the two instruments would be due to "noise" in the water column as the sensor moves through it. The small mean differences (tandem: -0.011 PSU, cast *vs* tow: -0.015 PSU) at the 1 m offset indicate good dynamic response of the sensor. Some salinity spikes were visible on the plots where the *Profiler* passed through thermoclines. This is to be expected from a free-flushing conductivity cell.

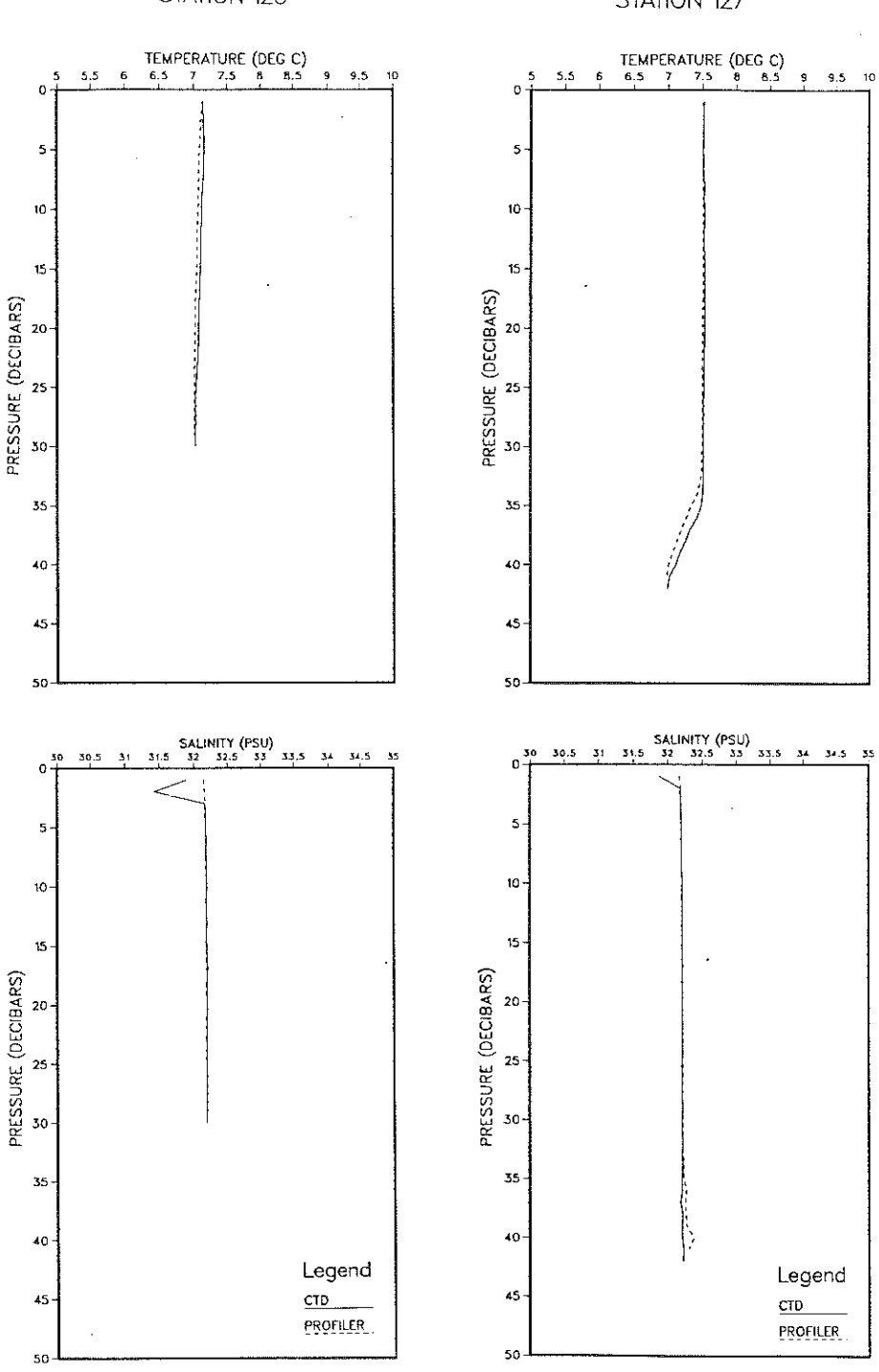

Figure 1. Vertical profiles of temperature and salinity showing data comparison of CTD and *Profiler* during tandem casts.

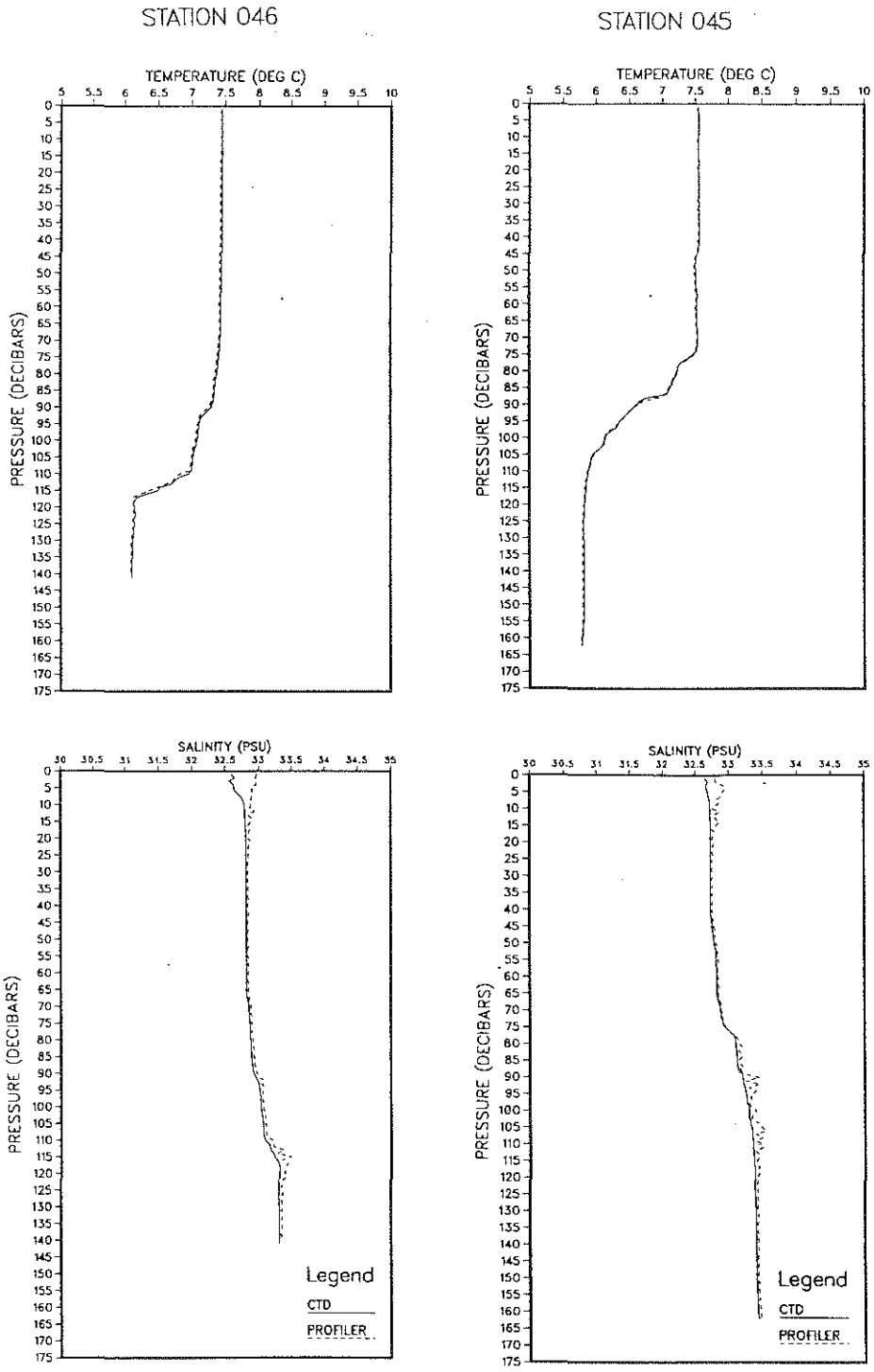

Figure 1. Continued.

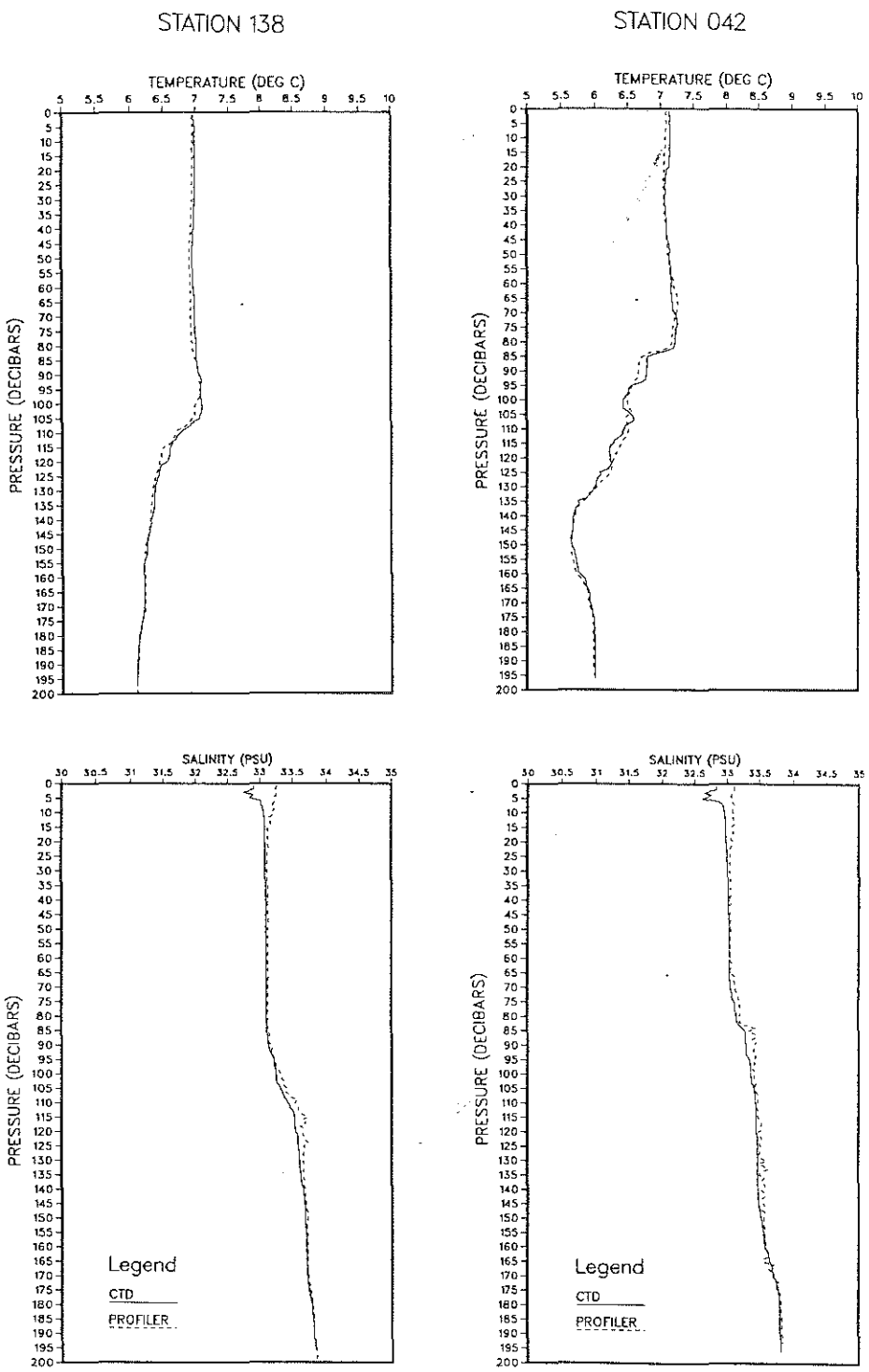

Figure 2. Vertical profiles of temperature and salinity showing data comparison of CTD and *Profiler* during cast *vs* tow.

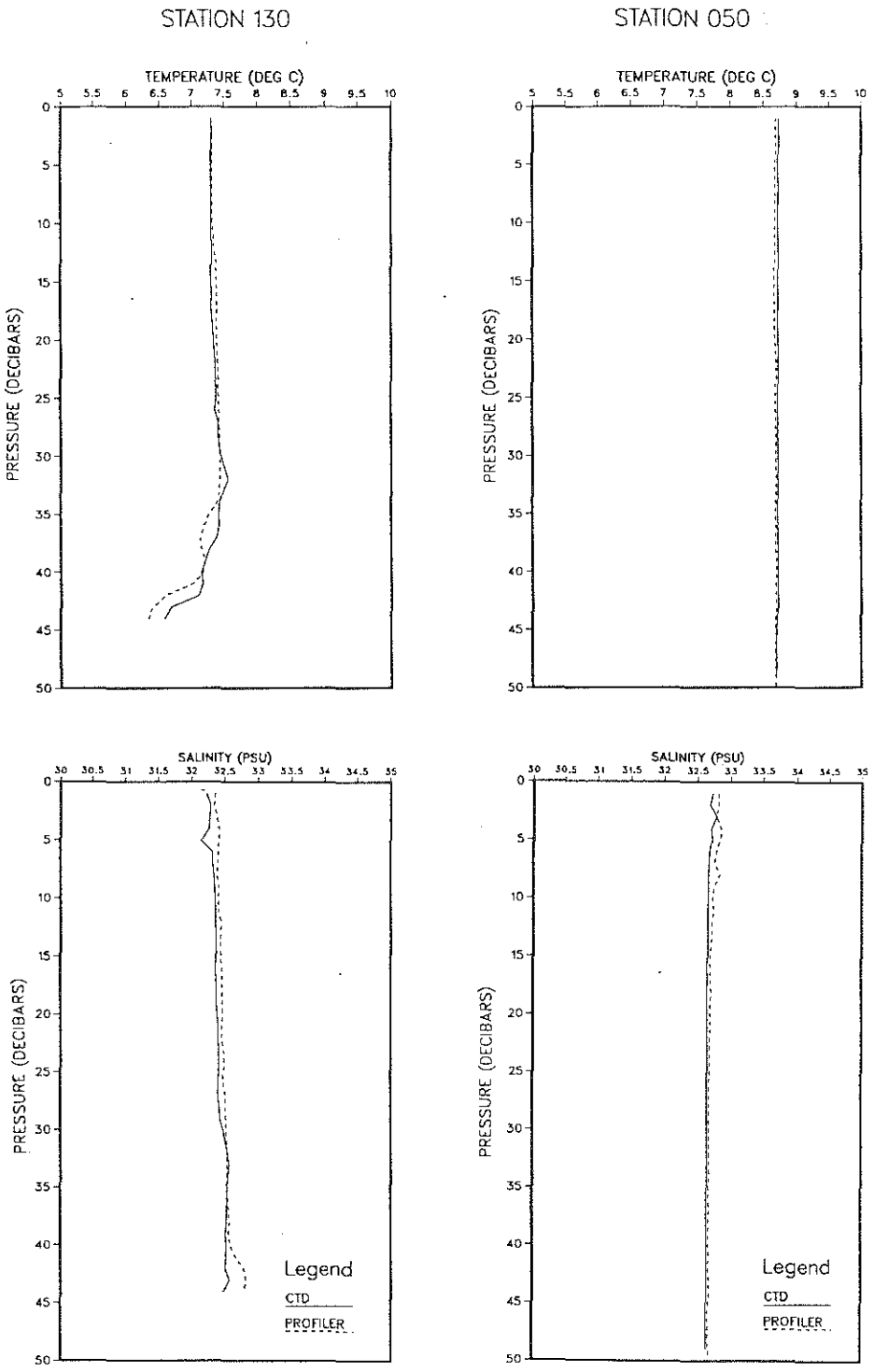

Figure 2. Continued.

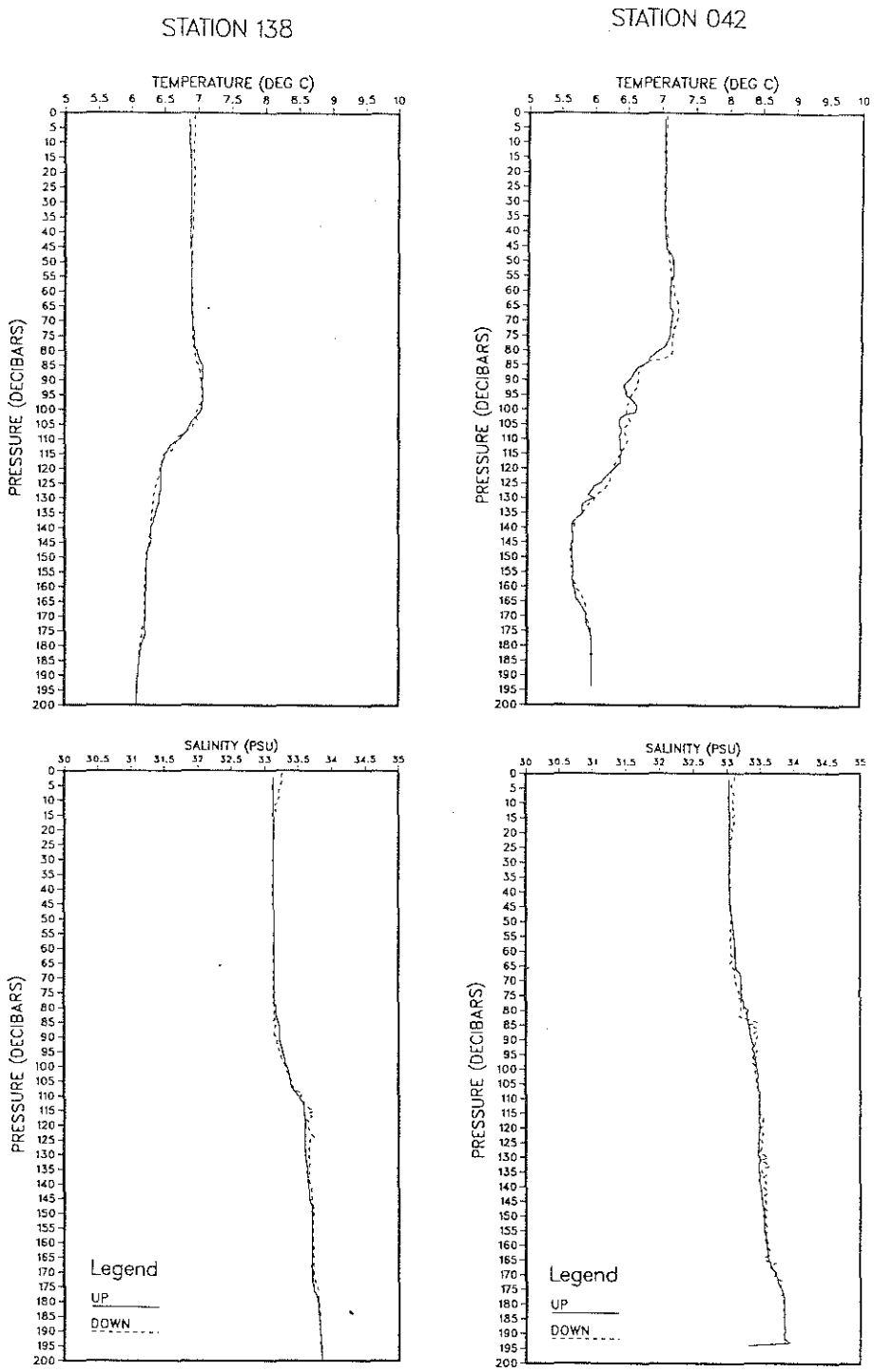

Figure 3. Vertical profiles of temperature and salinity comparing *Profiler* data collected during down and up casts during bongo tows.

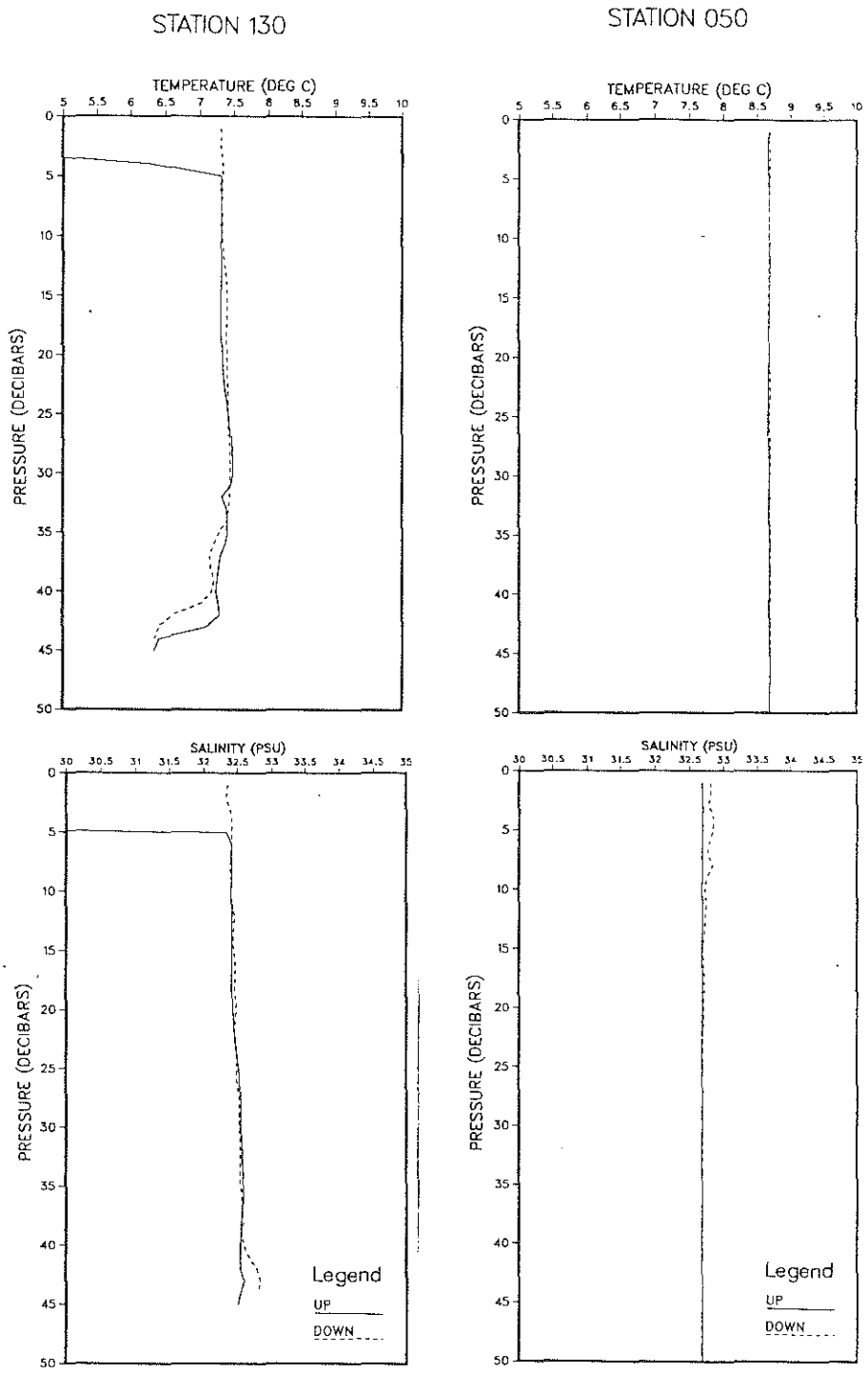

Figure 3. Continued.

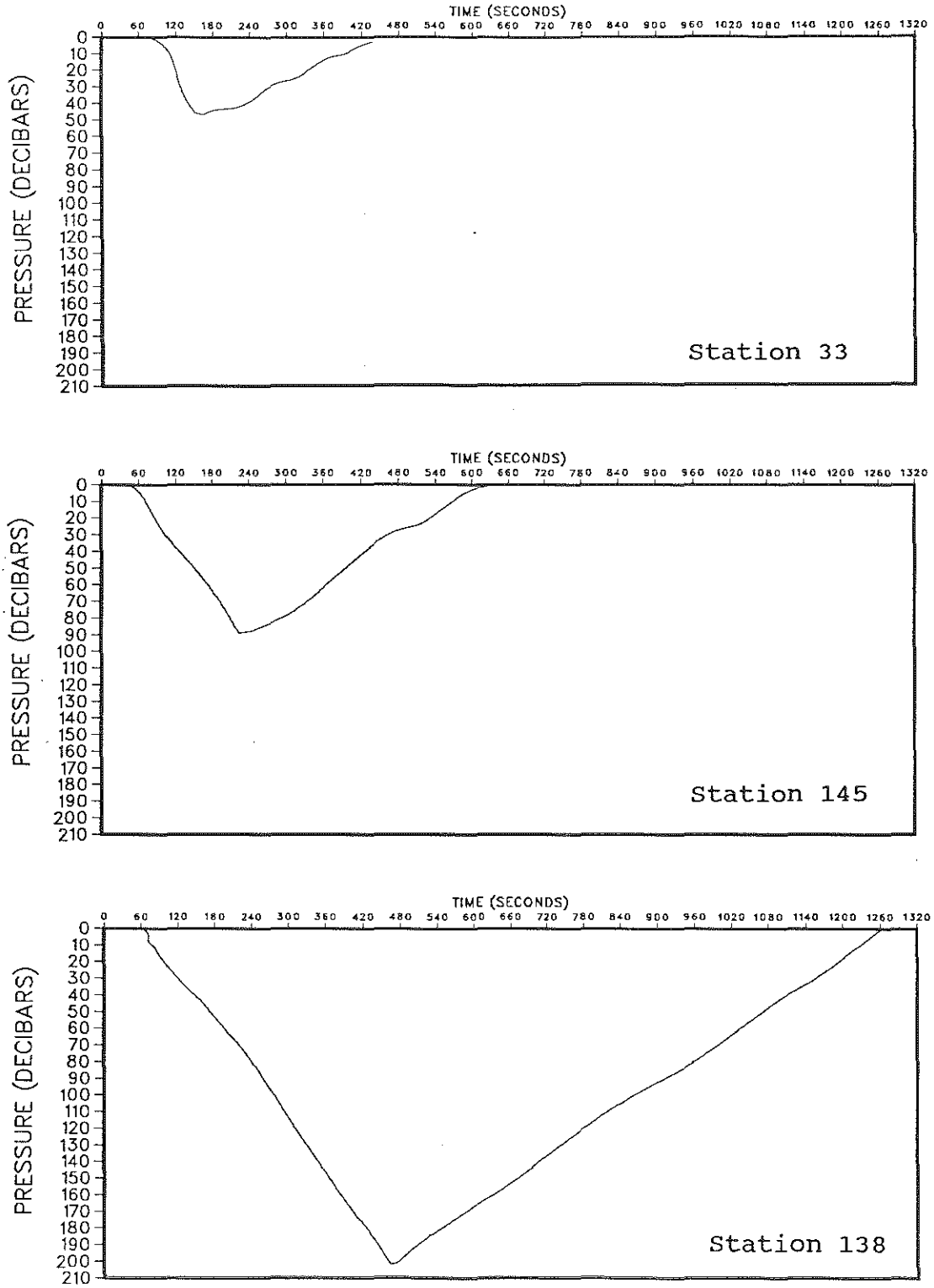

Figure 4. Time history of tow showing time *vs* depth, *Profiler* data.

Comparison of the downcasts and the upcasts did show some pressure sensor problems during the upcast. The mismatch of surface pressure values could not be corrected by a discrete 1 or 2 meter offset. As expected, the *Profiler* performed slightly better on the upcast during an oblique tow than on the upcast during a tamdem cast. This is due to the placement (upside down) of the *Profiler* above the bongo nets so that the conductivity cell always encounters undisturbed water during the tow.

The time *versus* depth plots show that time histories of the tow could have useful applications. There is the possibility of using time histories during real time data collection to help maintain optimum towing angle by monitoring the speed of the wire out and in.

The at-sea operations involved no modification to the bongo itself. The *Profiler* was attached while waiting for the ship to position itself on station. It detached quickly and could be carried by one person.

Although data extraction from the unit's memory is quick (5 minutes or less), multiple casts could be stored if time or personnel shortages were a problem. Even someone with little or no experience can be trained in less than an hour to use the computer. The six batteries placed in the *Profiler* lasted the entire cruise, approximately two hours total recording time, without being changed.

CONCLUSION

The *Profiler* performed well within its limits of sensor accuracy and compared favorably with the CTD in terms of data quality.

Using the *Profiler* during bongo tows saved time when compared with doing a CTD cast and a bongo tow, and did not interfere with the bongo net operations.

Since this test, the Northeast Fisheries Science Center has purchased three more SBE 19 Seacat *Profilers* which, in addition to *Profiler* #360, have successfully completed more than 4,000 stations in just three years (1990, 1991, and 1992). Since April of 1991, these instruments have been used routinely in the real-time mode, saving time because data are stored by the computer as it is collected. This real-time use has also simplified bongo tows by allowing the operator to know the exact depth of the instrument during deployment.

ACKNOWLEDGMENTS

The author would like to thank Dr. David Mountain for providing suggestions and comments during the writing of this report and for overseeing its progress. Thanks also to the crew and scientists who cooperated with the instrument testing aboard the *R/V Delaware II*.

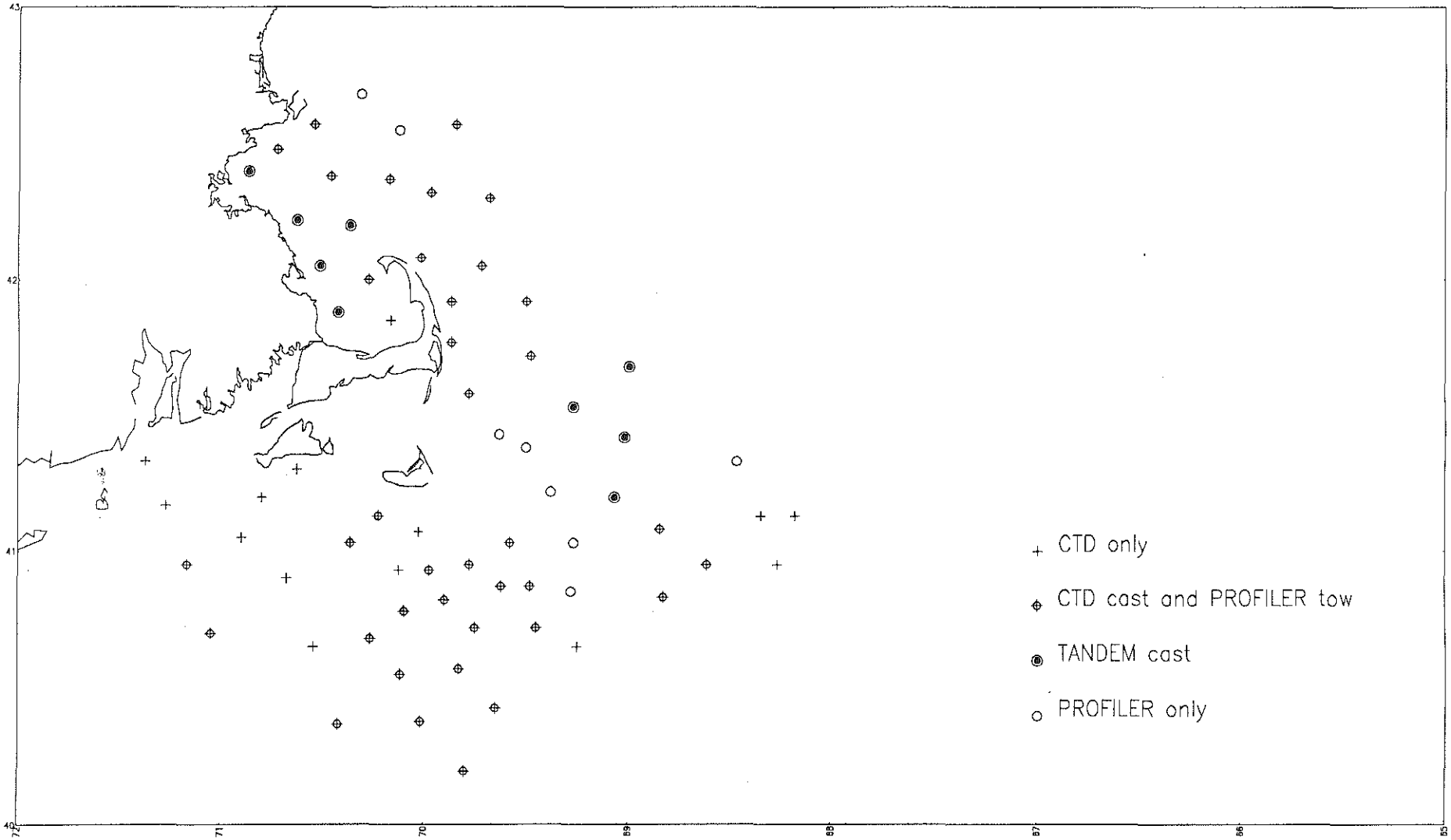

Figure 5. Station plot of DE8909 I showing various station operations.

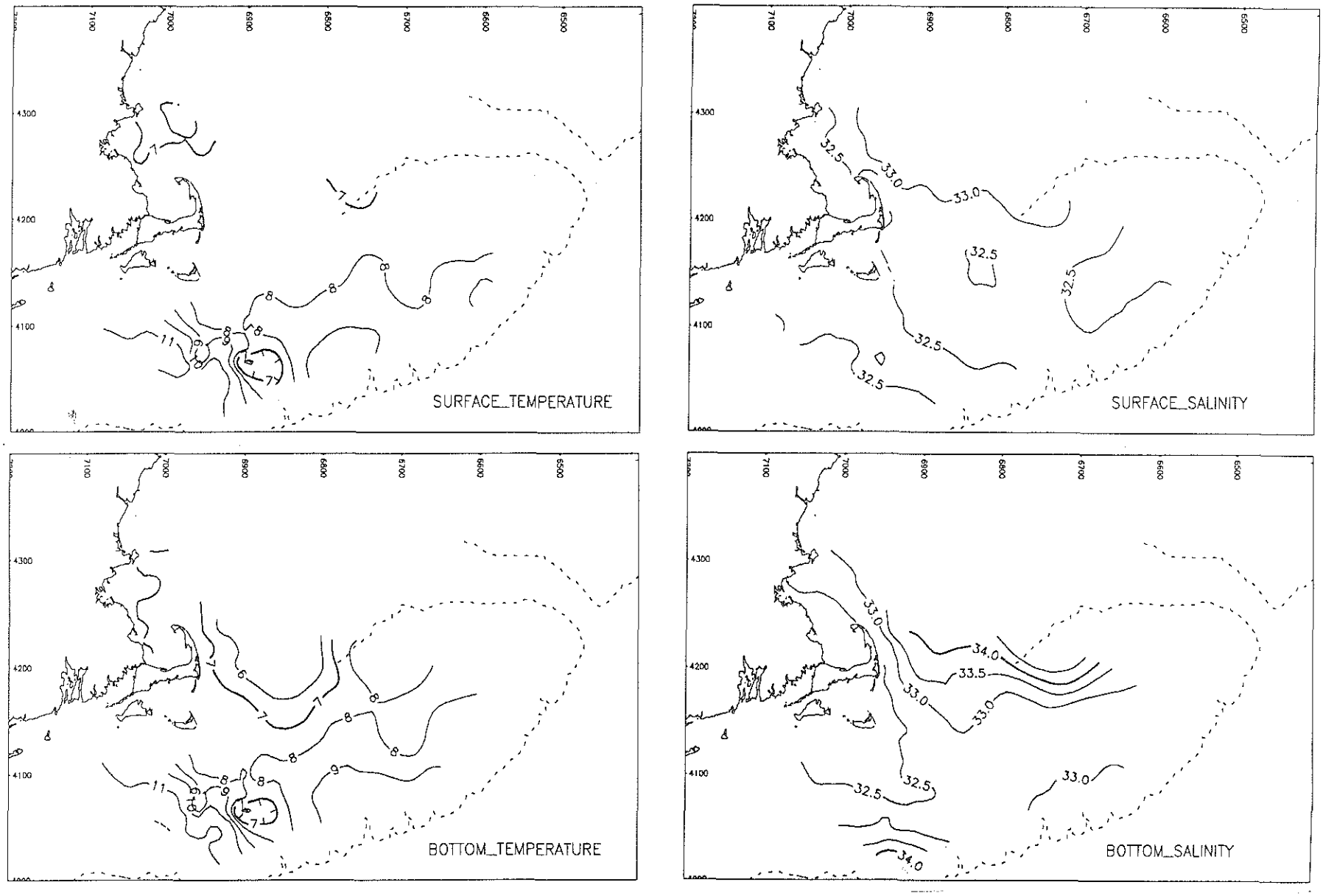

Figure 6. Contour plots of surface and bottom temperature and salinity data taken with *Profiler*.

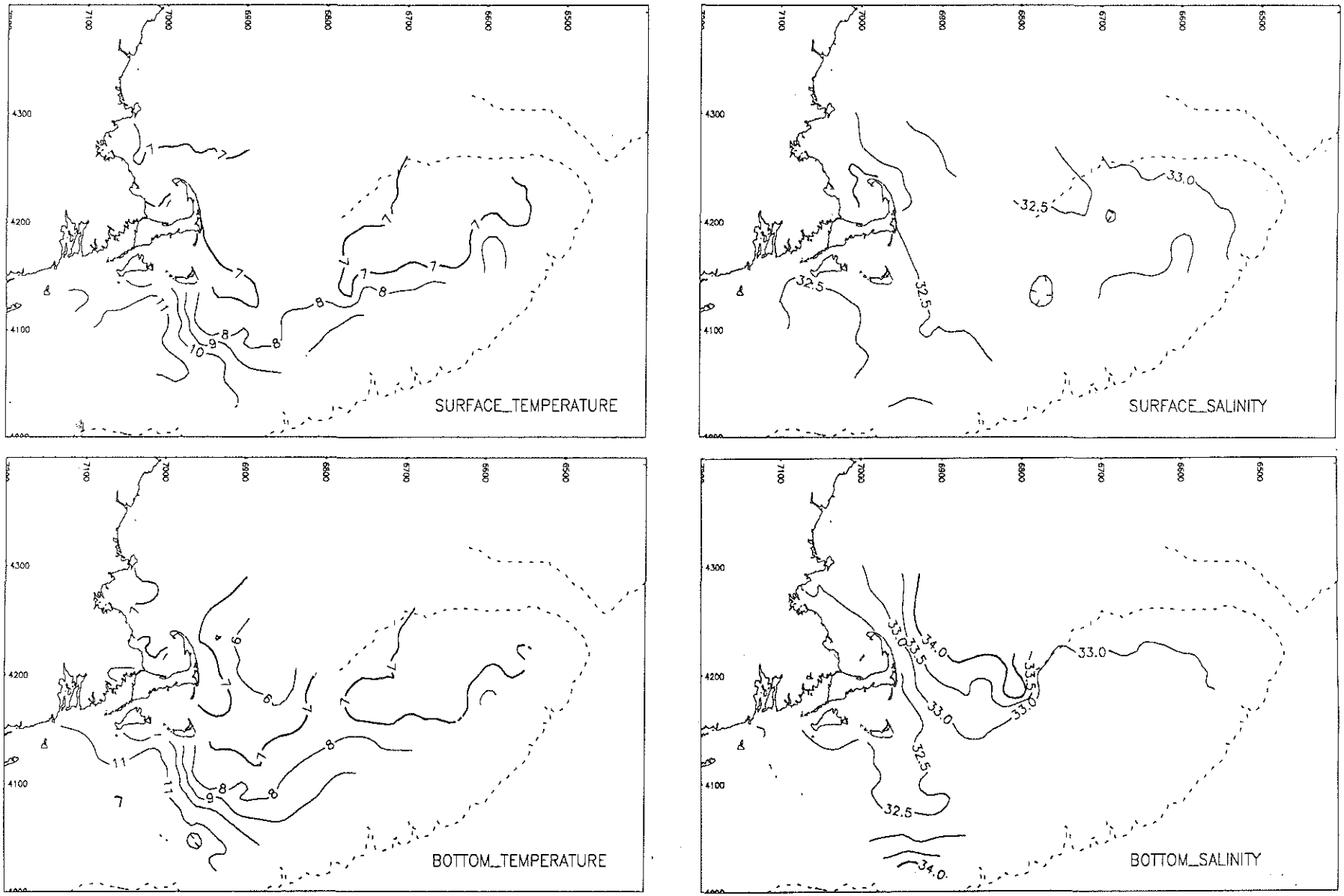

Figure 7. Contour plots of surface and bottom temperature and salinity data taken with CTD.