Cruise Report

R/V SEWARD JOHNSON Cruise SJ95-04 to Georges Bank

US GLOBEC

NW ATLANTIC/GEORGES BANK STUDY

27 March - 4 April 1995

Acknowledgments

This report and on-board preliminary data was prepared by Jim Irish, Peter Wiebe, Sean Kery, Paul Fucile and crew from cruise logs and notes as a first draft document of the activities, positions, data collected, etc. We gratefully acknowledge the friendly support provided by Captain Dan Schwartz and the crew of the R/V SEWARD JOHNSON. Their hard work at retrieving our wayward South Flank scientific mooring, getting the moorings turned around, searching for the BIOMAPER acoustics package and taking CTD profiles helped us accomplish our primary scientific goals.

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GLOBEC R/V SEWARD JOHNSON Cruise SJ95-04

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GLOBEC R/V SEWARD JOHNSON Cruise SJ95-04
U.S. State Department Cruise No. 95-029
Woods Hole to Georges Bank to Woods Hole
27 March - 4 April 1995

Purpose:

The primary purpose of GLOBEC SJ95-04 Cruise was to service the instrumented buoys deployed in late October 1994 on Georges Bank as part of the US GLOBEC Long-Term Moored Program and take supportive CTD profiles. If time permitted, additional supportive CTD profiles were to be taken along the Stratification Mooring section. A second purpose of this cruise was to locate and recover the BIOMAPER acoustics package lost on the tip of Georges Bank mid-February 1995.

Accomplishment Summary

The GLOBEC Long-Term Scientific mooring on the Southern Flank broke loose about 1 March and drifted slowly westward down Georges Bank. The SEWARD JOHNSON was able to recover the buoy and instrumented array on GLOBEC Cruise SJ9503 in mid-March after it was sighted by a fishing boat. Therefore, this mooring could not be serviced on SJ9504 and will be deployed later on GLOBEC Cruise SJ9506. The Crest mooring was recovered, serviced, sensors and telemetry electronics replaced and reset in the same location with a bio-optical package at 10 m depth. Based on initial ARGOS telemetry to the SEWARD JOHNSON after deployment, the Crest system appears to be working well. At the South Flank Site, one guard mooring with inoperative guard light was pulled and a surlyn foam buoy deployed to replace it with PMEL temperature sensors at 1, 10, 20 and 50 meters depth. The bottom mounted ACDP/BP instrument was recovered, the ADCP replace and redeployed between the two guard buoys at the Southern Flank site.

CTD profiles were made along the Long-Term Moored Section from the Crest through the Southern Flank site into deep water. The profiles from the Crest site through the Southern Flank site were well mixed vertically, showing no spring stratification, with the cooler, fresher water offshore. The two offshore stations showed warmer, saltier north Atlantic water.

A side scan survey for BIOMAPER was conducted at the tip of the bank based on GPS positions where the instrument was lost. Several acoustic targets were noted. These records will be read by side scan experts, and corrected for position to determine the most probable position for BIOMAPER. Then a submersible or ROV will be used for final recovery.

Figure 1 shows the cruise track for SJ9504. The Crest and South Flank mooring sites are indicated as well as the BIOMAPPER survey region.

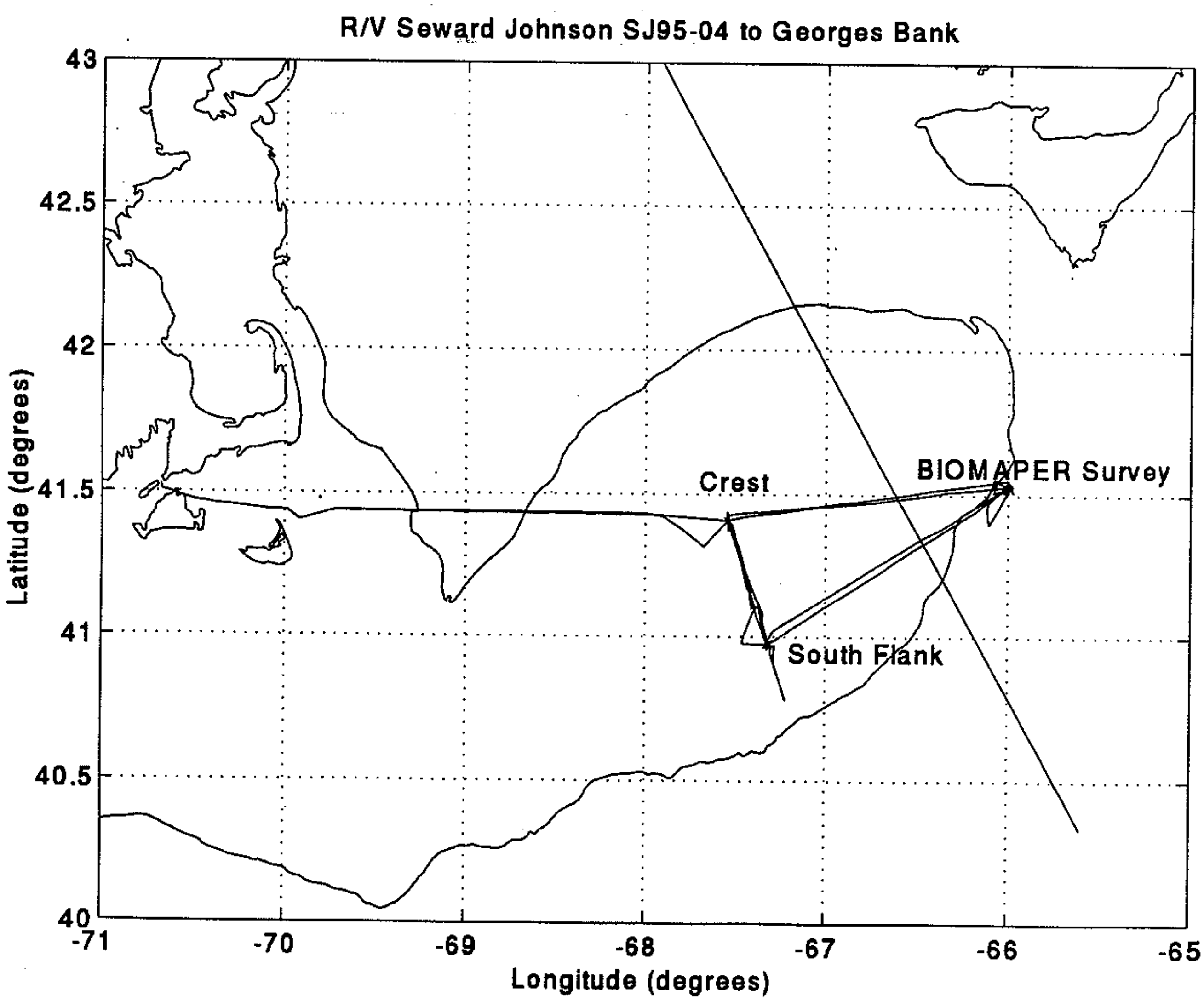

Figure 1. Ships Track of the R/V SEWARD JOHNSON Cruise SJ95-04 from Woods Hole to Georges Bank and back from the ship's GPS log. The 100 m contour is plotted to outline Georges Bank. The Crest and South Flank mooring sites and the BIOMAPER survey area are identified. The Long-Term Main Line CTD Section extends through the Crest and South Flank moorings. The US - Canadian border shows the mooring in US and the BIOMAPER survey in Canadian waters.

CRUISE RESULTS:

South Flank Scientific buoy:

We had planned to recover, service and redeploy the Southern Flank Scientific mooring on this cruise, but where unsure of its status. Both the ARGOS and GOES telemetry started out with near perfect transmission of data and diagnostics when the buoy was deployed in October 1994. However, the telemetry started going bad the first of the year and got progressively worse so that we were receiving no transmissions after late February. (The Crest mooring also stopped transmitting in mid-January for other reasons, see discussion below). On Thursday, 9 March 1995 the NMFS observer in New Bedford, MA informed Jim Manning of the NMFS/WHOI that part of a mooring (acoustic release, subsurface float and some hardware) was on the dock in New Bedford. Pat O'Malley and Sean Kery went over to investigate and brought back the remains. At first they thought they had the bottom of the Crest mooring. This is the mooring that we thought most likely to break loose because of the severe environmental conditions in shallow water on the crest of Georges Bank. However, a check of the acoustic release serial number showed that the parts recovered were from the Southern Flank scientific mooring. A notice to mariners letting them know that this buoy was loose and requesting information was broadcast, and on Thursday morning 16 March 1995, the lobster boat Hetty Brenna out of Newport, RI, reported seeing a yellow buoy matching our description at 40° 01.3'N x 69° 03.6'W , south of the Great South Cannel in about 200 meters of water. Jim Manning, NMFS/WHOI ran the Dan Lynch (Dartmouth) model of the mean circulation on Georges Bank with average March forcing, and predicted the buoy would be south of the Great South Channel in about 200 meters of water 14 days after breaking loose. Bob Beardsley estimated a drift track from the GLOBEC ARGOS drifters (which were in shallower water). He predicted that the buoy would still be on Georges Bank, near the Great South Channel.

On Thursday afternoon, 16 March 1995, we formally requested that the R/V SEWARD JOHNSON, then well into a GLOBEC process cruise with Greg Lough, Jim Manning, Larry Madin and their crew, proceed to the last known position and search for our buoy. They had to steam 110 miles to the site, then started a radar and visual search (at night) for the buoy. After about 1 hour, Gray Henrikson with the help of the scientists on board sighted a radar signal, but saw no flashing light. Investigating further they found it was indeed our buoy, and proceeded to recover it. The R/V SEWARD JOHNSON then returned to the biological survey work, loosing about 24 hours of good weather, and brought the buoy, array and sensors back to WHOI on their return to port on Friday, 24 March 1995.

They buoy appeared to be in excellent mechanical condition with very little fouling on the buoy, array cable and sensors. The mooring cable was cut just above the 50 meter sensor pair, and this sensor pair and the top of the elastic tether was lost so that an exact determination of the failure mode could not be made, but we are fairly certain that it was cut by a fisherman, either being cut by a trawl wire, or directly by a fisherman to untangle it from his nets, and not due to a tension failure of the elastic tethers.

Even though the telemetry link was not working, the data system and backup recording system was still functioning and there was 151 days of data in the buoy's backup recorder. This data was dumped to a computer for initial processing and evaluation during our cruise. The buoy's clock was only 2 seconds slow relative to WWV after six months. The two bio-optical packages at 10 and 40 meters depth were recovered with the mooring, and also contained full data records. Therefore, we were extremely fortunate in being able to recover the valuable sensors, buoy hardware and data from this mooring. We plan to repair the mooring after the

SJ9504 cruise and deploy it on the 27 April to 3 May 1995 turbulence cruise on the R/V SEWARD JOHNSON.

Figures 2, 3 and 4 show the preliminary, unedited temperature, salinity and PAR observations returned from the South Flank buoy. Figures 5 and 6 show the preliminary, unedited data from the two bio-optical packages. These unedited, uncalibrated, preliminary results show that the two temperature sensors at 5 and 15 meters failed after 3.6 and 4.5 months respectively. These will be returned to Sea Bird for evaluation and repair. The temperature records plotted on top of one another for most of the time indicating that the water column was well mixed from the surface to 50 meters. The salinities start off on top of one another, but tend to show slow drifts with time, especially at 25 meters. These records will be corrected for drift with data from the broad scale survey CTD profiles. There are occasional times when water masses with vertical structure and different T-S are seen in the region. On day 65, a fresher, cooler pulse of water (Scotian Shelf water?) advected through the region. Also the first ten days or so and about day 132 warm, salty Gulf Steam Ring effects extended up onto the shelf to the position of the mooring. The initial warm core ring water was seen in the CTD section on made during the deployment cruise (see U.S. GLOBEC Cruise Report for R/V ENDEAVOR Cruise EN256, 26-31 October 1994). The end of the records reflect the mooring drift, ride home on the R/V SEWARD JOHNSON and a couple of days on the dock as we were loading for our cruise.

The fluorometer on the bio-optical package at 10 meters (Figure 5) showed higher chlorophyll-a concentrations at the time the warm core ring water was seen at the mooring. Also a slight increase was seen on day 132 when the warm, salty water was again seen. These effects are also seen at 40 meters (Figure 6), but to a lesser extent. The 10 meter depth transmissometer appears to show some drift after 100 days, and the 40 meter transmissometer while it doesn't show any appreciable drift, appears "noisy: in the 120 to 140 day range. The 10 meter depth PAR sensor shows the daily radiation changes, which hardly penetrate to the 40 meter depth. Basically, the Southern Flank Temperature/Conductivity Mooring appeared to be working well, with the except of the telemetry (which did not cause data loss), the two sensor failures, and the mooring being cut loose.

Crest Mooring Turnaround

The Crest mooring was working well after deployment, but started to show signs of low power and related problems late in December. By mid-January, all telemetry (both GOES and ARGOS) appeared to have quit, and diagnostics were that the system batteries were low. Therefore, we were apprehensive about the buoy's survival, but the R/V ENDEAVOR did visually spot the buoy and assure us that it was still in position before we departed on SJ9504.

The Crest mooring was an engineering test of the Buoy Tech elastic tether technology in the harsh, shallow water environment at the Crest of the bank. The system was released by acoustical command which dropped the anchor and allowed the subsurface float to bring the bottom of the mooring to the surface. The system was retrieved by picking the buoy up first with the ship's crane and securing it on board. Then the mooring (including tethers) down to the

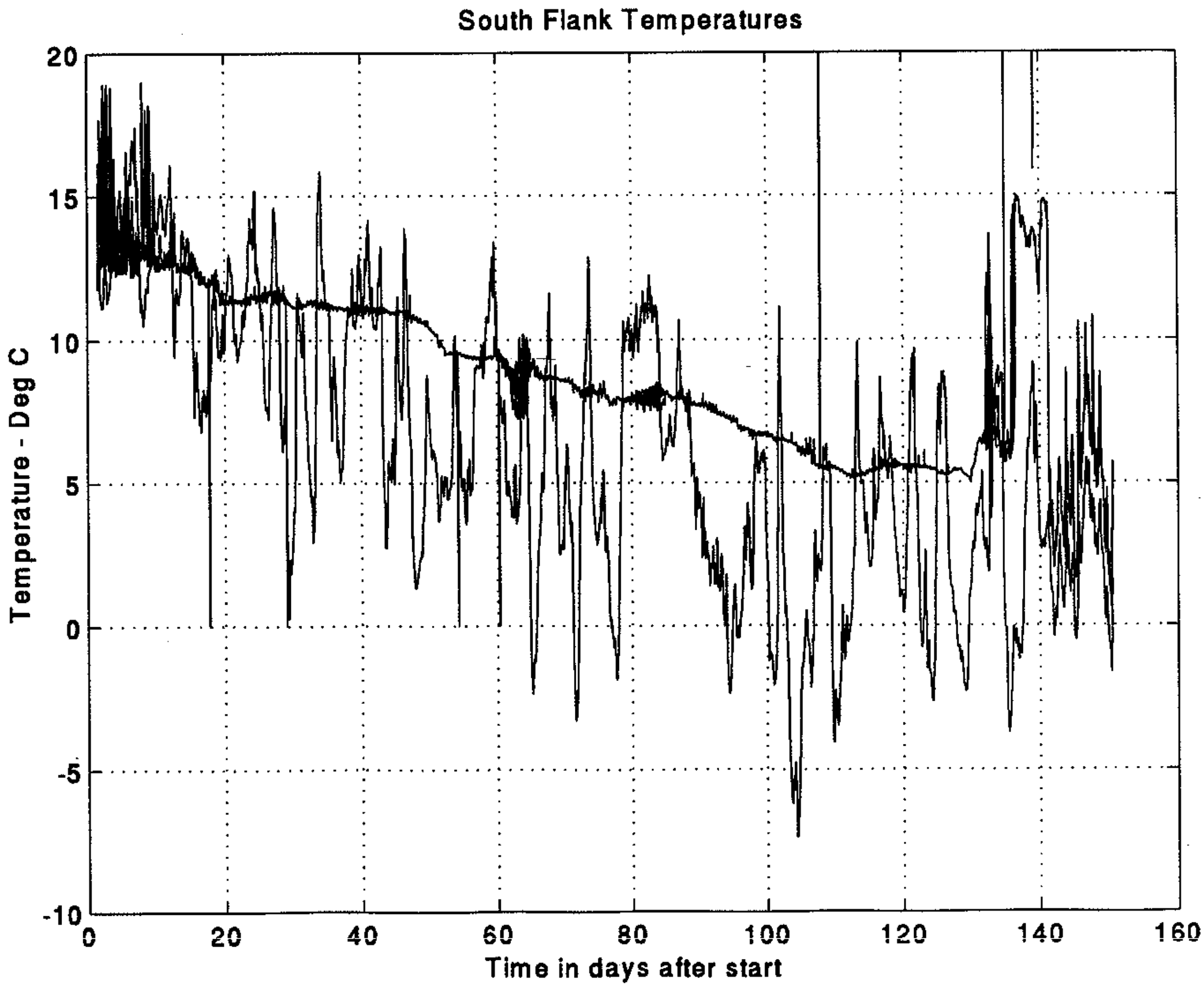

Figure 2. South Flank Moored Temperature. The large fluctuations are from the air temperature sensor 3 meters above the water. Water temperature at 1, 5, 15, 20, 25, 30, 35, 45, and 50 meters are plotted on top of each other to show the isothermal nature of the water column. Exceptions are the warm core ring effects during the first 10 days and around day 132, and the intrusion seen on day 65 in both temperature and salinity (Figure 3).

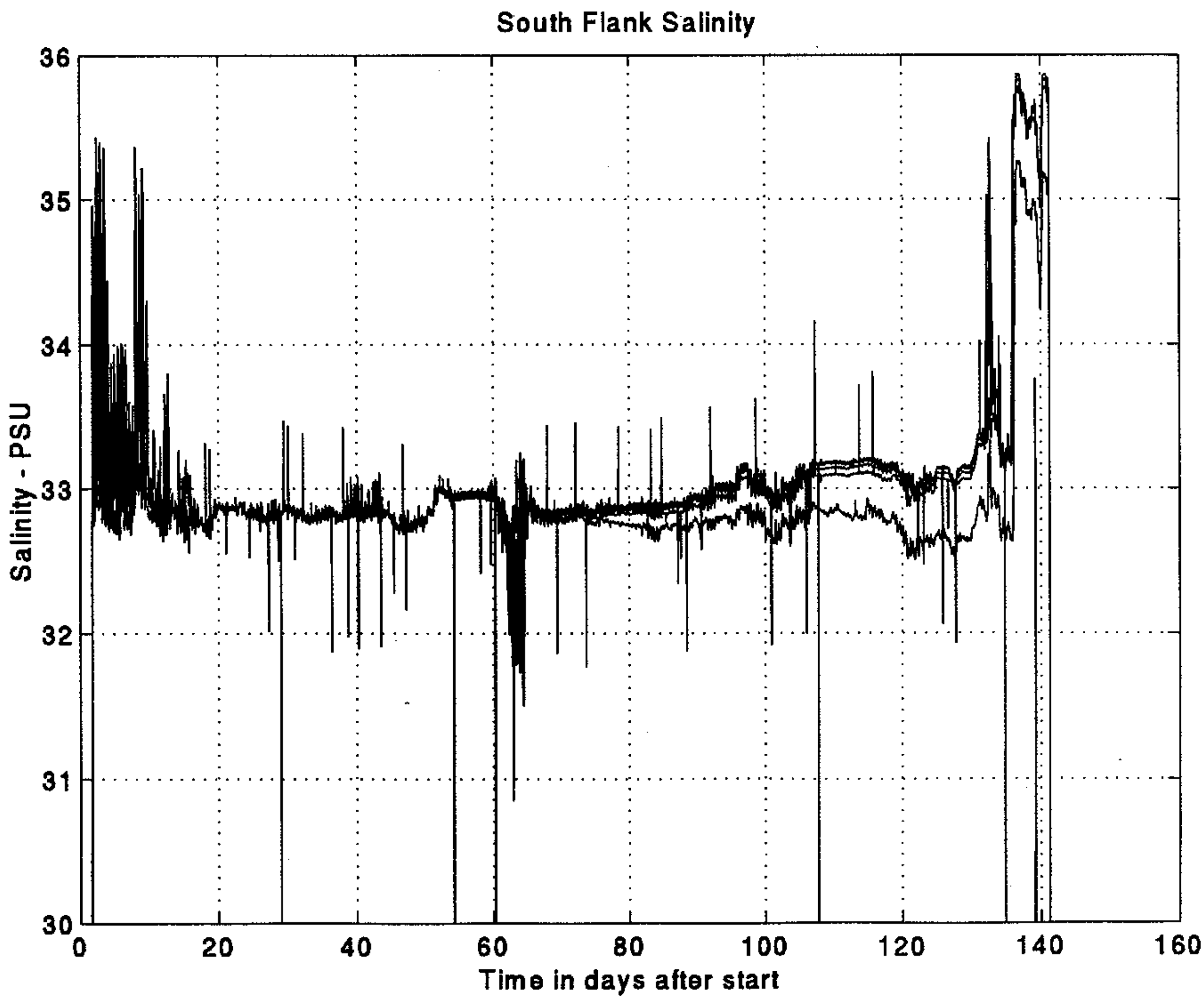

Figure 3. South Flank Moored Salinity. Salinities from 5, 15, 20, 25, 30, 35, 45, and 50 meters are plotted on top of one each other. The drift seen in the salinity records toward the end is probably due to biofouling, and these effects will have to be removed by comparisons with CTD profiles taken on the Broad Scale Survey Cruises.

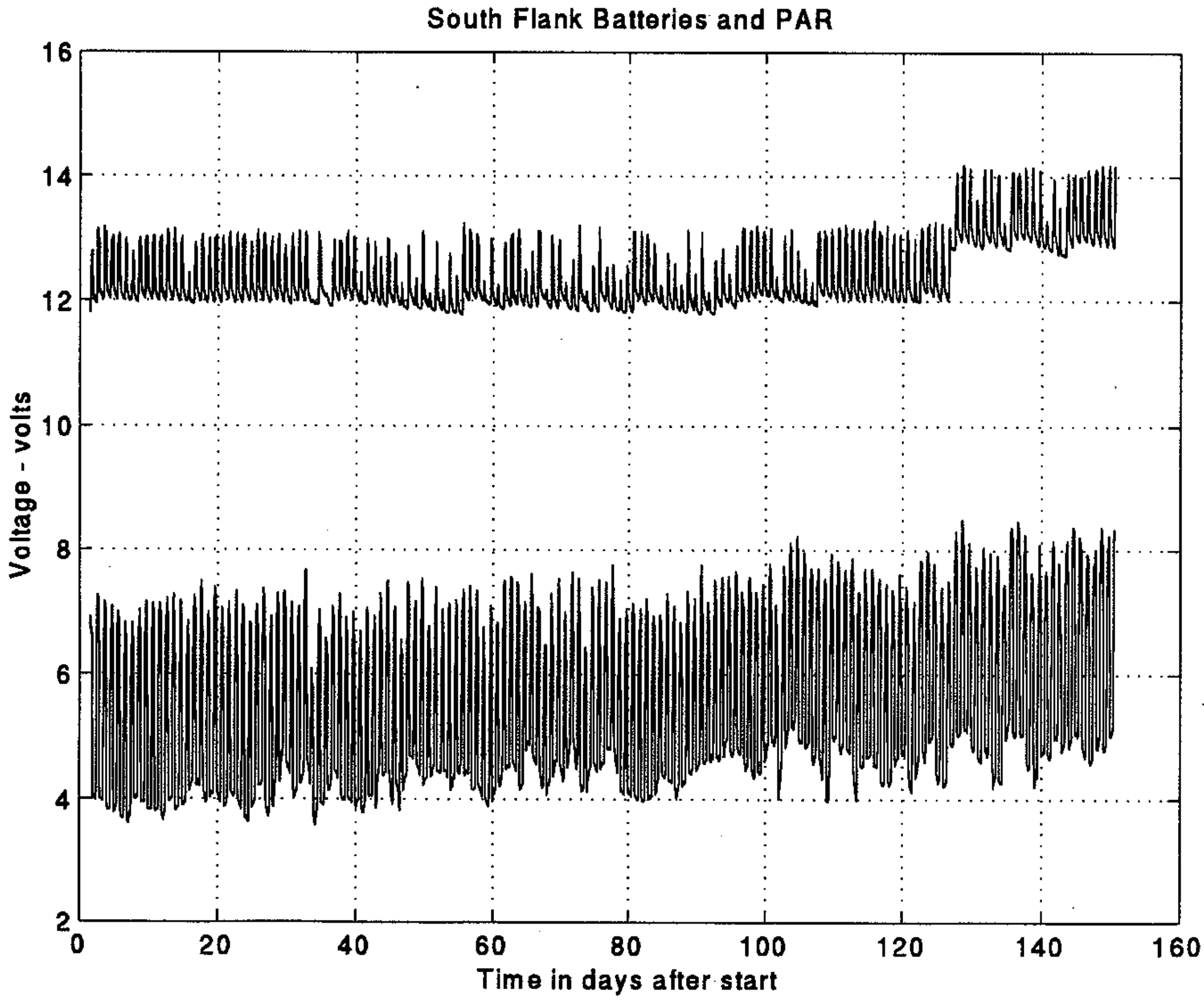

Figure 4. South Flank Moored PAR and Battery voltages. There are three batteries in the system whose voltage is plotted on top of each other at the top. The voltage is very uniform. The PAR sensor times 25 is plotted at the bottom. There is a correlation between the height off the battery charge cycles and the PAR sensor as one would expect.

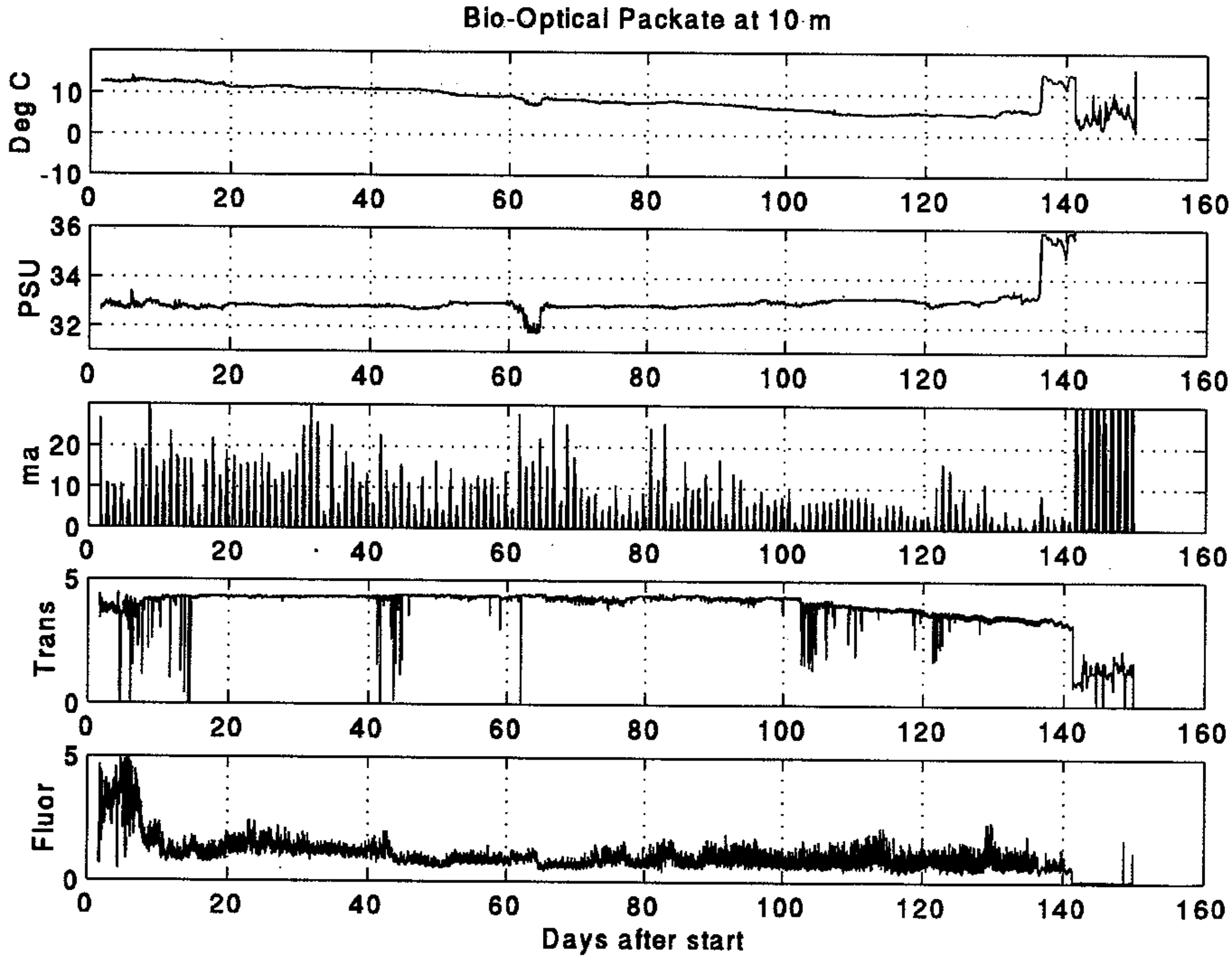

Figure 5. South Flank Moored Bio-optical package at 10 m. The temperature, salinity, PAR, transmissometer and fluorometer data are plotted against start time. The high fluoromeeter reading during the warm core ring event at the start is clearly efficient. Also the transmissometer drift probably due to biofouling is also evident after 100 days. The PAR sensor clearly shows when the package was recovered on the R/V SEWARD JOHNSON. The temperature and salinity agree with the other observations shown in Figures 2 and 3.

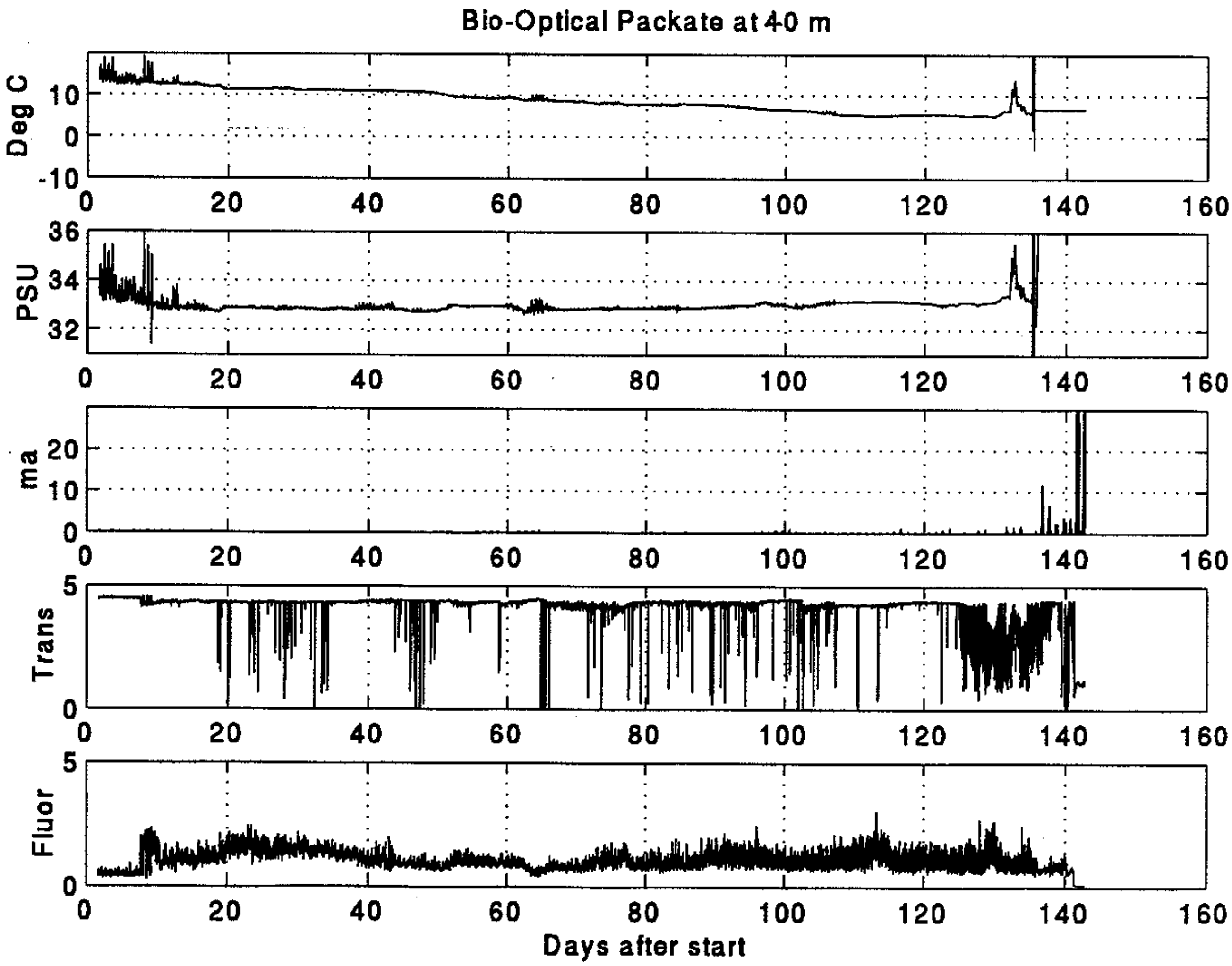

Figure 6. South Flank Moored Bio-optical package at 40 m. The temperature, salinity, PAR, transmissometer and fluorometer data are plotted against start time. The high fluoromeeter reading during the warm core ring event at the start is efficient. The PAR sensor clearly shows when the package was recovered on the R/V SEWARD JOHNSON. The temperature and salinity agree with the other observations shown in Figures 2 and 3.

subsurface float was hauled aboard by hand. The subsurface float and acoustic release were recovered by the crane. Since this was an evaluation mooring, the mooring hardware including the tethers were placed in a box for study back at WHOI, and new hardware and tethers used in the redeployment. Initial inspection of the hardware and elastics showed no adverse effects on the components, and our predictions of long mooring life at the Crest site appear to be good.

When the buoy was recovered, the batteries were indeed low (about 11.5 volts). The system responded when a computer was attached to the command port. When the system power drops below about 8 volts, the Synergetics data system begins to have problems and shuts down. This then reduces the current drain to about 25 ma, so the solar panels could begin to recharge the batteries. As an indication of the low voltage, the sampling program was lost from the controller's EPROM. (This also could indicate further damage to the system by lightening.) The GOES and ARGOS transmitter and Master Controller Module were replaced, and will be sent back to Synergetics for evaluation. In 6 buoy years experience with this data system, no major problems such as we experienced this were with the telemetry were encountered. Why they should fail on this deployment is yet a mystery. In addition to the transmitter, the antenna wire and antenna were replaced. There was indication of corrosion in the antenna cable which may have attenuated the signal. Again the wire is being brought back to WHOI for evaluation. Revised termination and weatherproofing were tried for the redeployment.

The system recorded data in the WHOI constructed PCMCIA backup data recorder. The PCMCIA card has its own backup battery which is good for several years in case of power failure in the main system. The data was dumped to a shipboard computer and analyzed onboard to evaluate the system performance and aid it repair. Figures 7, 8 and 9 show the temperatures, salinity and PAR respectively. The temperature records look very similar to the Southern Flank results (Figure 2). The salinity record appears noisy, probably due to the air bubbles in the surface waters under the buoy. The shift in salinity signal around day 75 is associated with grounding problems with the load cell, which also appeared noisy at this time (Figure 10). The load cell and cables were removed, and sampling software change before deployment 2, so that we would not have a continuing problem . This data indicated that everything was working well until the end of the year, then the load cell began to show a very noisy record. As January progressed, the noise got worse, and finally the system power decreased to the level that the system quit. The backup recording system appeared to work well on both buoys, and will be improved in the future with Flash Cards of larger size which will allow the storage of the 1 minute samples from all sensors for high frequency, internal wave observations.

The mooring tension from the load cell is plotted in Figure 10. The maximum tension appears to be less than 1300 pounds. Strong tidal variations are evident, along with the slower changing wind/current variations. The minimum tension did not go below 100 pounds. A tension of zero would imply that the tethers were slack, and could possibly tangle and be cut on the mooring hardware. The mean tensions (hourly averages) show 500-800 pounds tension, which is in good agreement with our predicted mooring performance. The minimum and maximum tensions are individual samples taken at 1 second intervals during the hour. The high frequency wave component is appears as the standard deviation of the tension, and is typically 50 to 100 pounds, very acceptable.

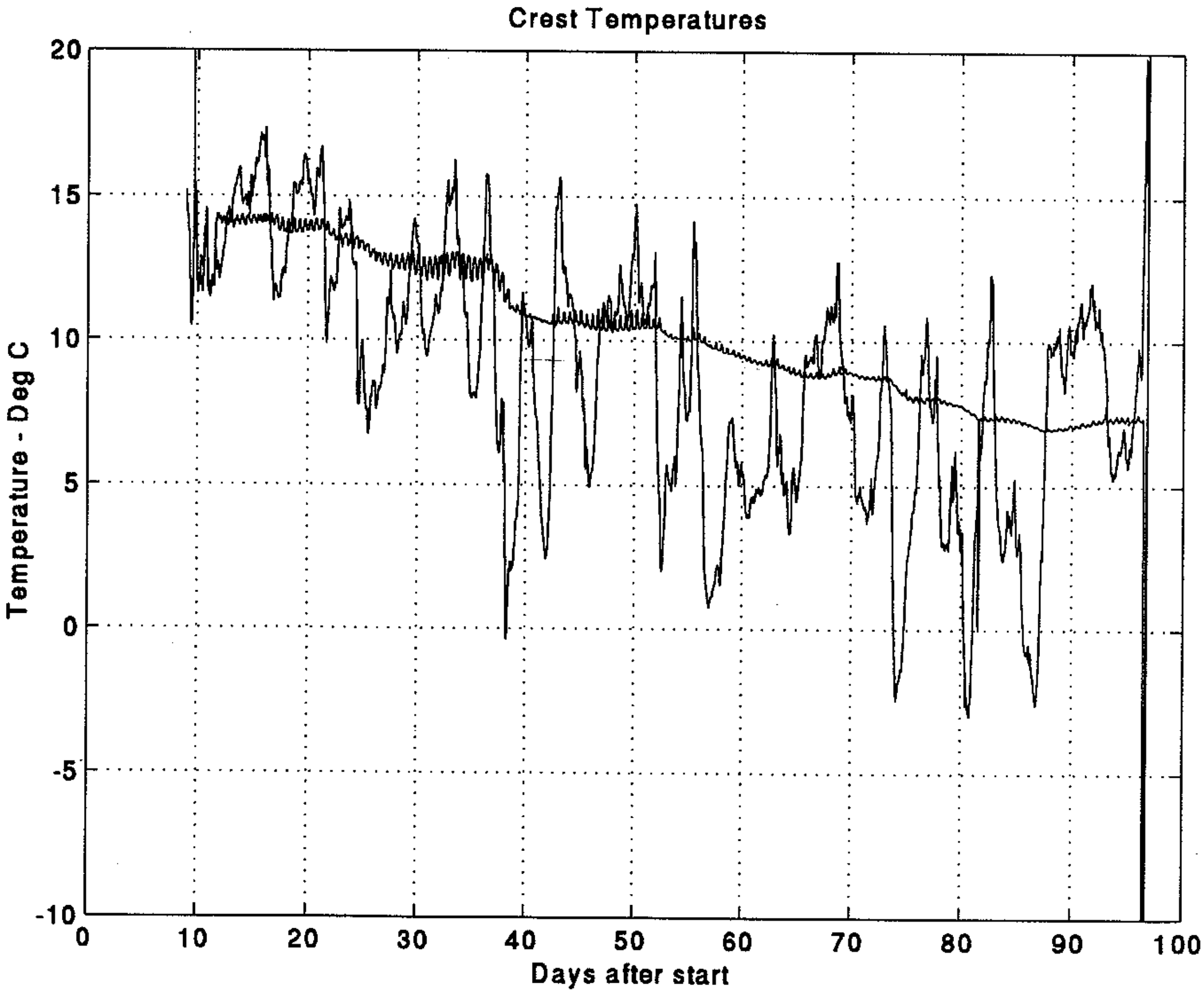

Figure 7. Crest Moored Temperature. The signal with large fluctuations is the air temperature at 3 meters above the water, and the smoother record is the sea surface temperature at 1 meter under the buoy. The tidal signal due to horizontal advection of temperature gradient is evident in the sea surface temperature.

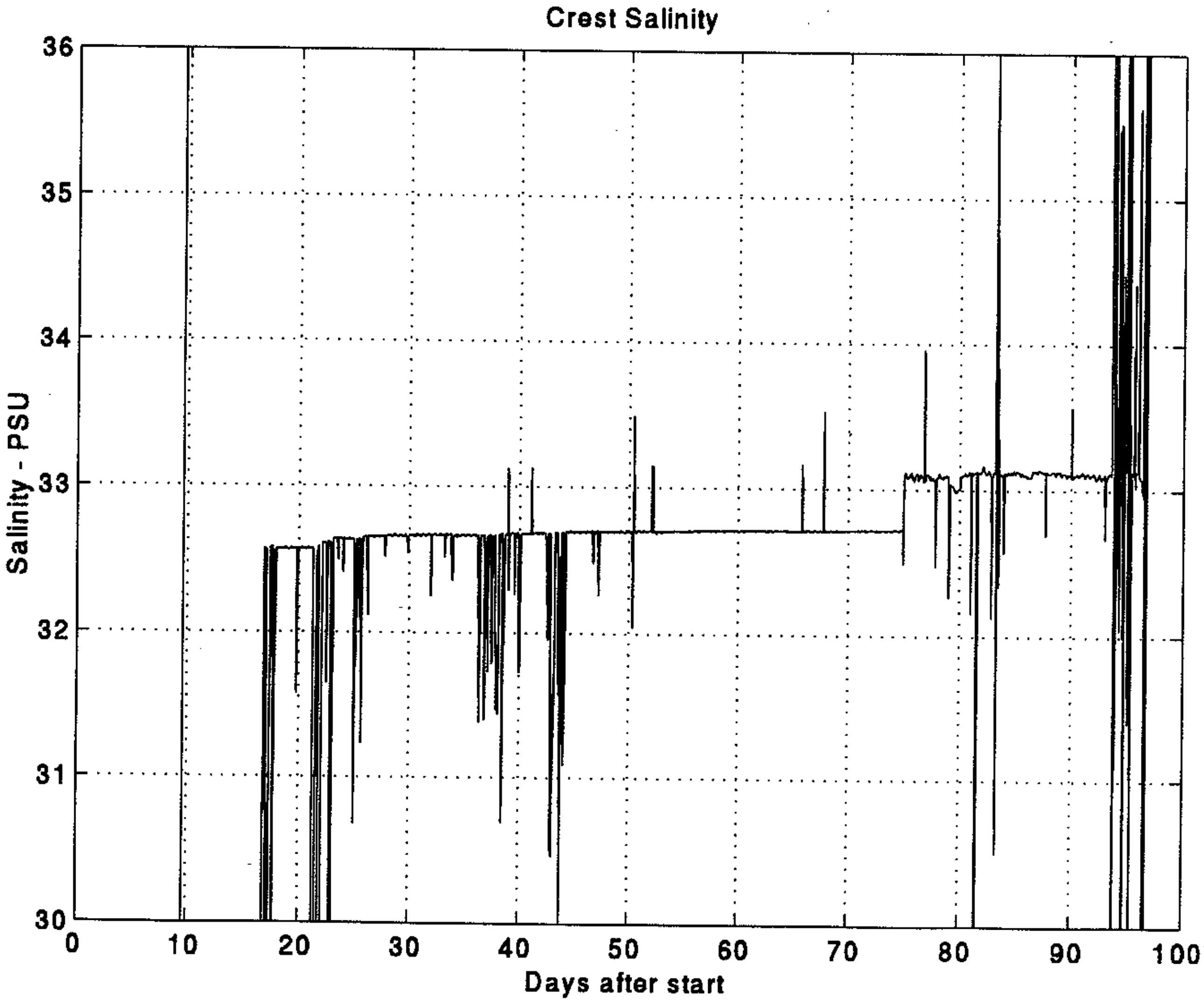

Figure 8. Crest Moored Salinity. The salinity record is contaminated at times by air bubbles which make the negative going spikes in the record. The offset at 75 days is due to a short in the load cell nearly.

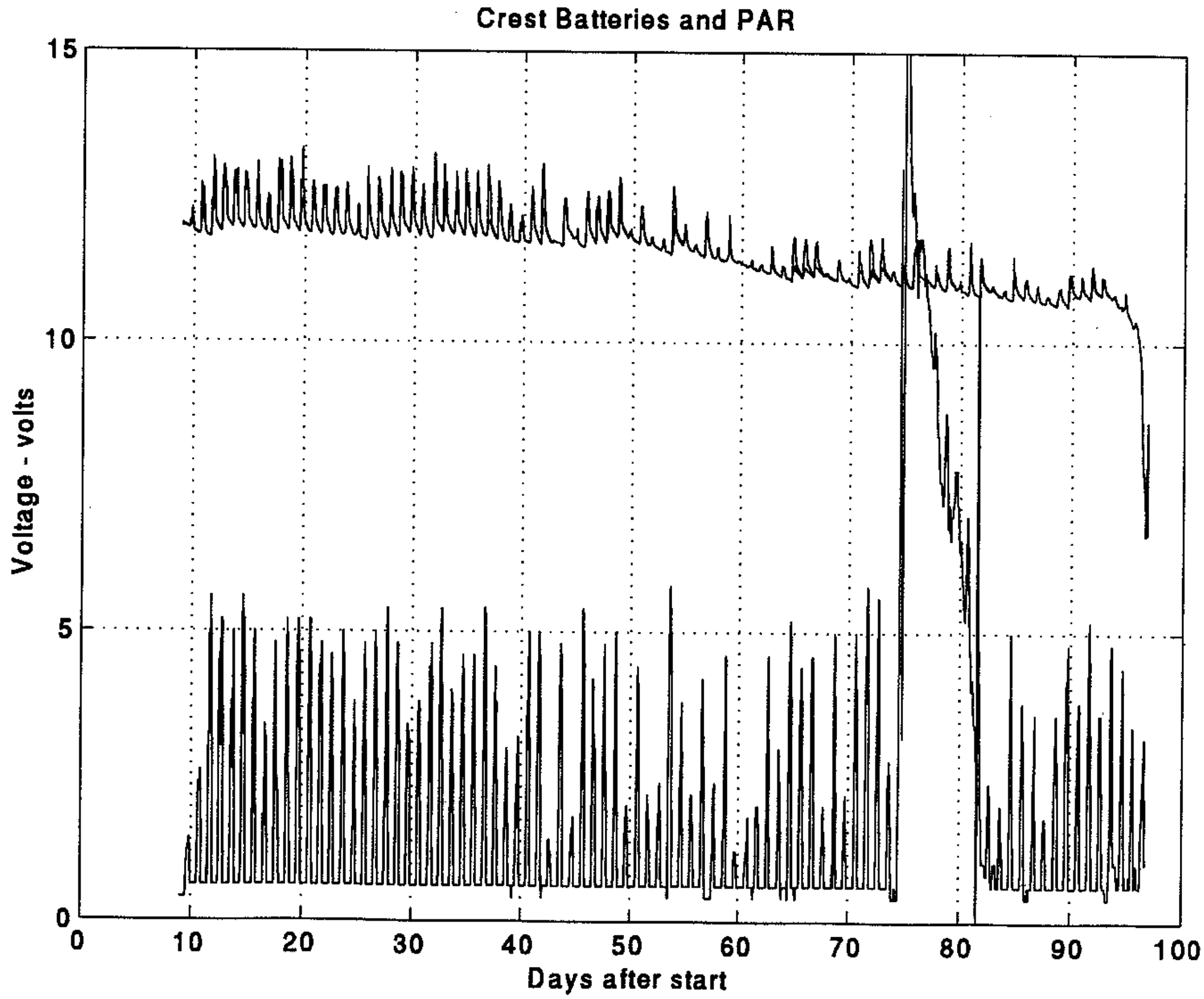

Figure 9. Crest Moored PAR and batteries. The battery voltage shows the slow decay with time and the eventual failure of the system about day 95. The Par sensor indicates less radiation than anticipated after day 40 (mid-December).

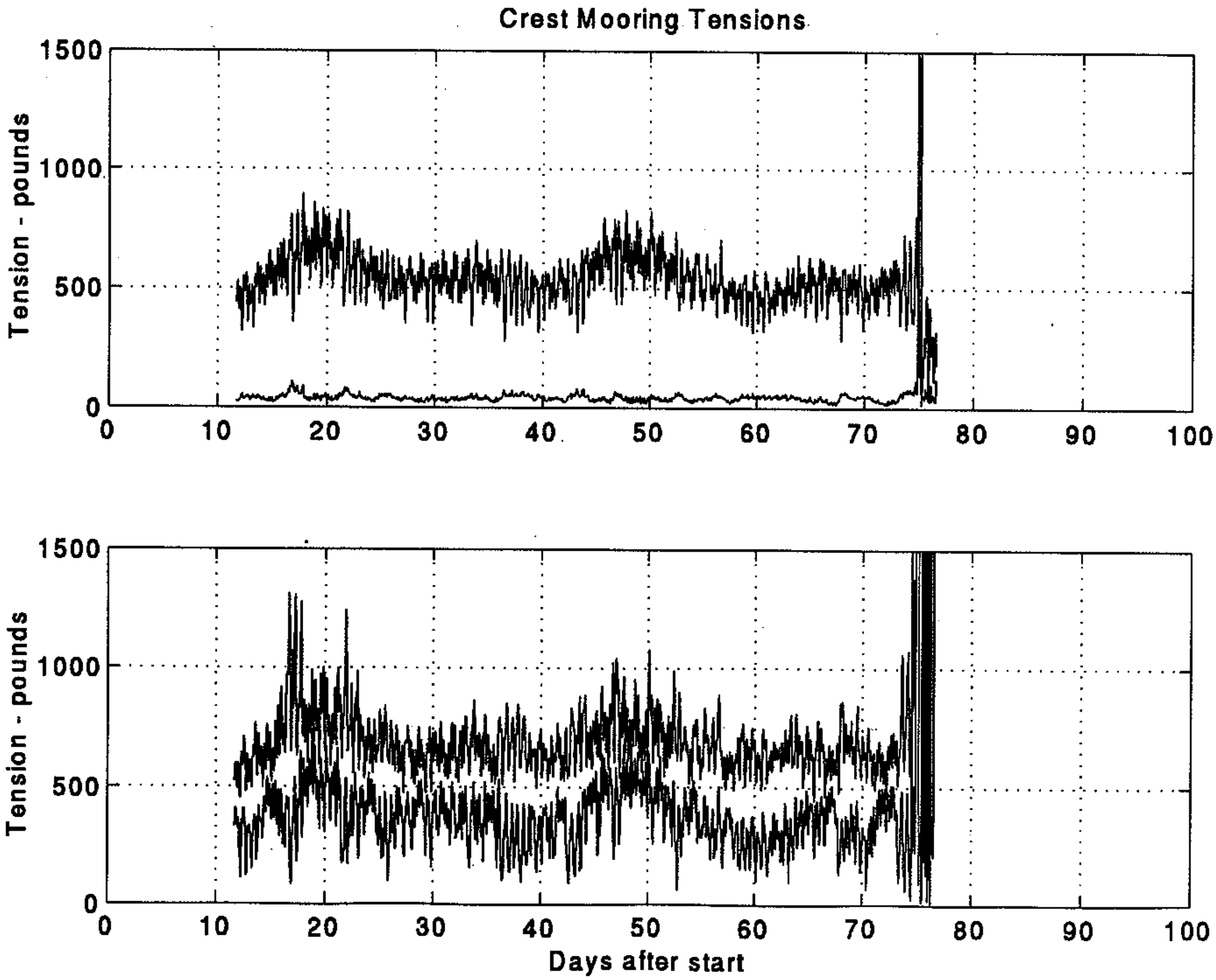

Figure 10. Crest Load Cell Tensions. The hourly mean and standard deviation of the hourly record are plotted on top, and the maximum and minimum tensions during the hour are plotted on the bottom. The minimum tension get down to 100 pounds, but do not go to zero, which would indicated that the tethers were slack, and could tangle and cause failure. Also the maximum tensions do not go above 1300 pounds. (Note that the estimated breaking strength of the 6 tethers used is about 6000 pounds.) The standard deviation of the tension is due to wave activity, and is typically 50 to 100 pounds.

With the new electronics in place, the system was reprogrammed and readied for deployment. After checking the operations with the atmospheric temperature and PAR sensors, the PAR sensor gain was increased by 50. The Sea Bird sea surface temperature sensor worked throughout the recorded record, but had failed by the time of recovery. This sensor and the conductivity sensor were replaced, and the system readied for deployment. (See Table 2 for sensor IDs and location.) The guard lamp appeared to be working on deck well, although it was not working when the buoy was recovered due to low batteries.

The buoy was assembled on deck, tested once and deployed at the same position, (see Table 1). As a check on the water depth, a DataSonics Chirp Sonar profile (Figure 11), was run across the mooring site before deployment. This again showed a flat bottom 40 to 41 meters deep between the sand/gravel ridges. When redeployed, the mooring did not have the load cell, but did have an addition of a bio-optical package (temperature, conductivity, PAR, fluorometer and transmissometer with internal recorder) at 10 m depth. The mooring configuration with the bio-optical package is shown in Figure 12. Telemetry from the ARGOS transmitter received on board the R/V SEWARD JOHNSON after deployment, indicated that the system was working well, and that we were back to collecting oceanographic data. The ARGOS telemetry was again monitored several days later when doing comparative CTD profiles by the buoy, and again the data looked good.

CTD Survey:

Because the weather was too rough to recover buoys on the first day out of Woods Hole, a CTD section was made from the Long-Term Moored Program's Crest site through the South Flank mooring site out to the 100 meter isobath. The profiles were made with a Neil Brown MarkIII CTD with General Oceanics rosette sampler owned and maintained by the University of Miami. The data was processed by the University of Miami's post processing routines, and this data (without salinity correction is shown below). The system also carried a Sea Tech 25 cm pathlength transmissometer and fluorometer as well as a PAR sensor. A Datasonics altimeter allowed the CTD's distance off the bottom to be displayed on the screen for control of the profiles. Water samples were taken 5 meters off the bottom at the bottom of the profile and at 5 meters depth on the up-cast for check on the calibration and operation of the CTD's conductivity sensor. The samples were run on board by the University of Miami's technicians. Profiles were made to about 5 meters off the bottom because of the relatively high seas. The location of these 11 profiles in the section and the moorings are shown in Figure 13 and listed in Table 3.

The temperature and salinity profiles (Figures 14 and 15) show the water column is relatively well mixed from the near surface waters to the bottom at stations 1 through 9 (to about 85 meters depth). (Note that profile 4 is noisy due to instrumental problems and not environmental signal. As a preliminary look, this unedited data is included for completeness.) Stations 10 and 11 show the warmer, saltier north Atlantic water influence near the bottom. Even thought the water column is well mixed over much of the bank, there are horizontal gradients. The warmer, saltier water is seen at the Crest site, and as one moves offshore, the water becomes cooler and fresher. The coldest and freshest water (see Figures 14, 15 and 16) has the T-S characteristics of Gulf of Maine Intermediate water. This may also be seen in the surface temperature from satellite AVHRR data (Figure 17), although there is indication of cold Scotian Shelf water flowing across the Northeast Channel onto the Southern Flank of Georges Bank.

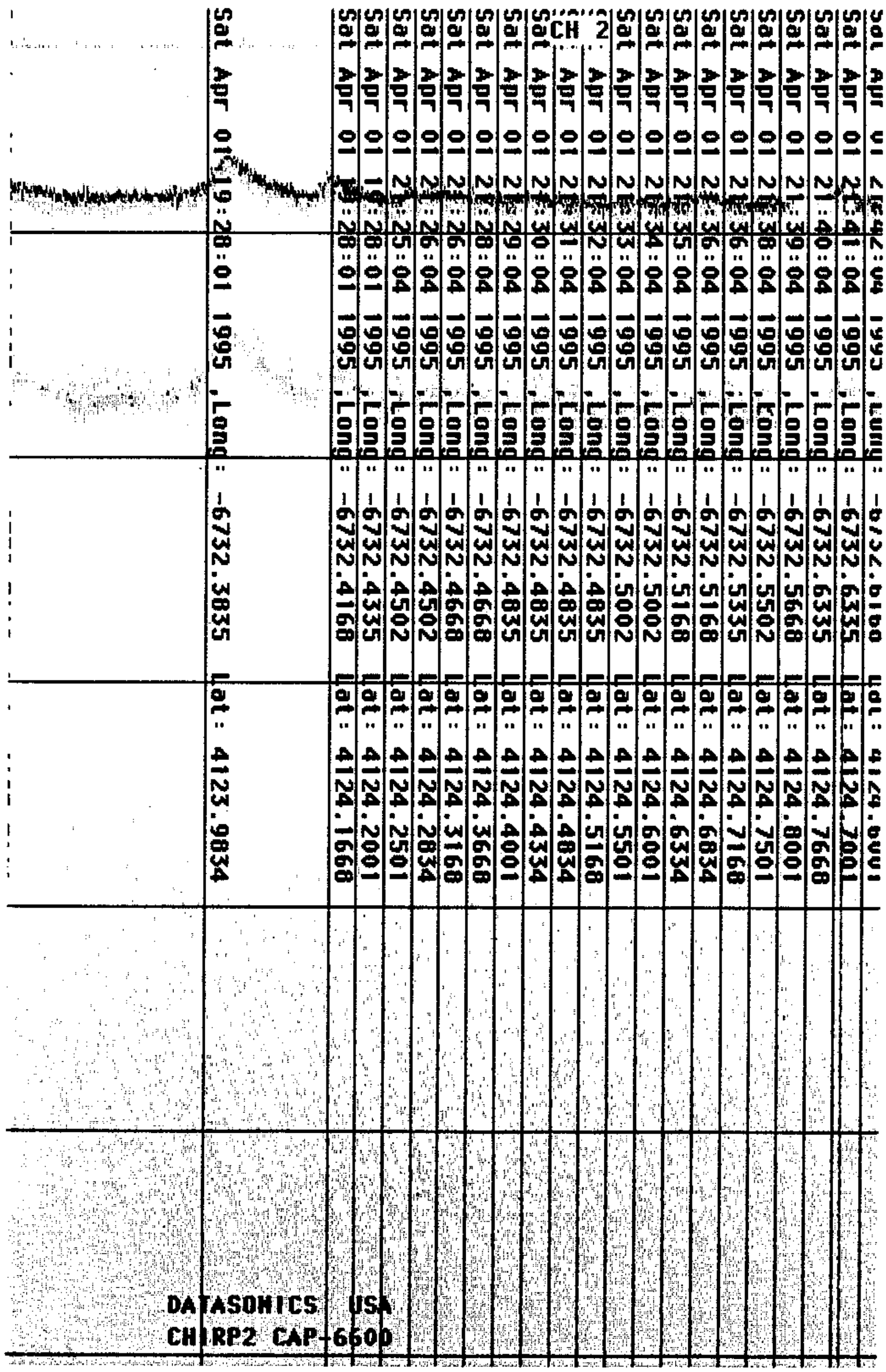

Figure 11. DataSonics Chirp Sonar bathymetry on a South to North section through the Crest mooring site. The flatness of the bottom at the 40 to 41 meter depth between the 10 to 15 meter ridge bathymetry confirms proper mooring site.

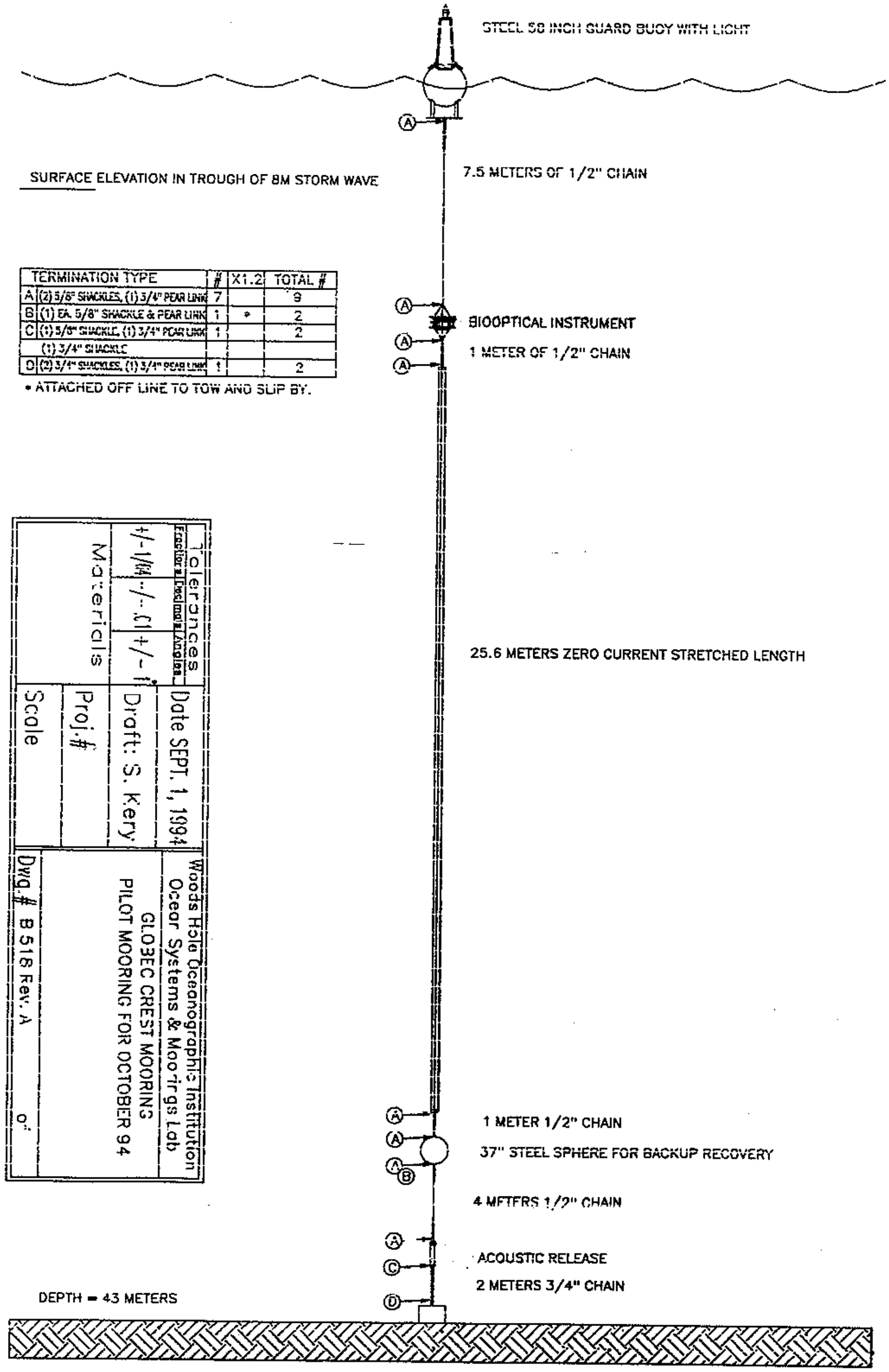

Figure 12. The revised Crest Mooring configuration as deployed on SJ9504. The mooring is the same as used successfully over the winter with the deletion of the load cell and the addition of the bio-optical package at 10 meters.

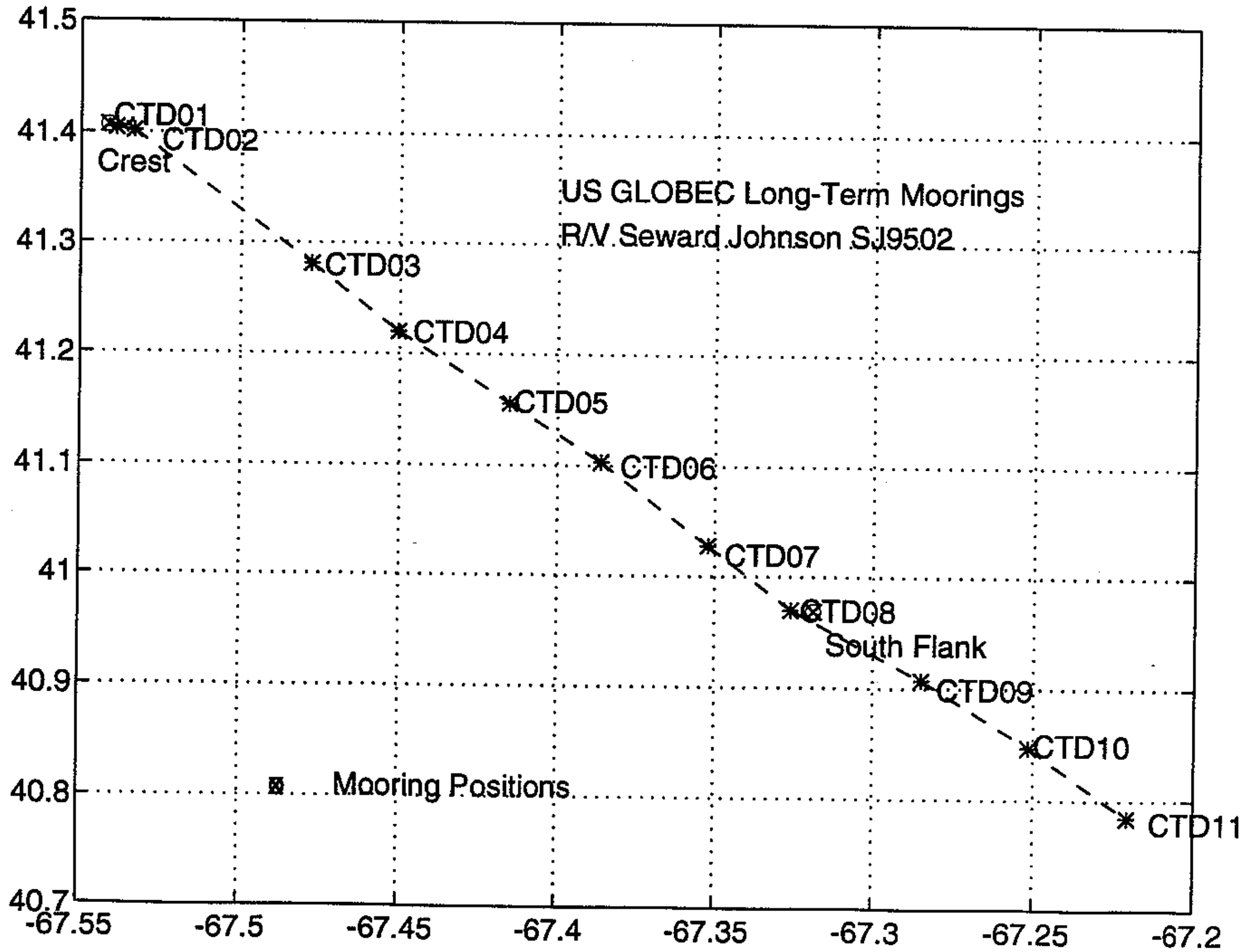

Figure 13. CTD and Mooring Positions from CTDs along the Long-Term Moored Section. The positions of the two moorings are also shown for comparison.

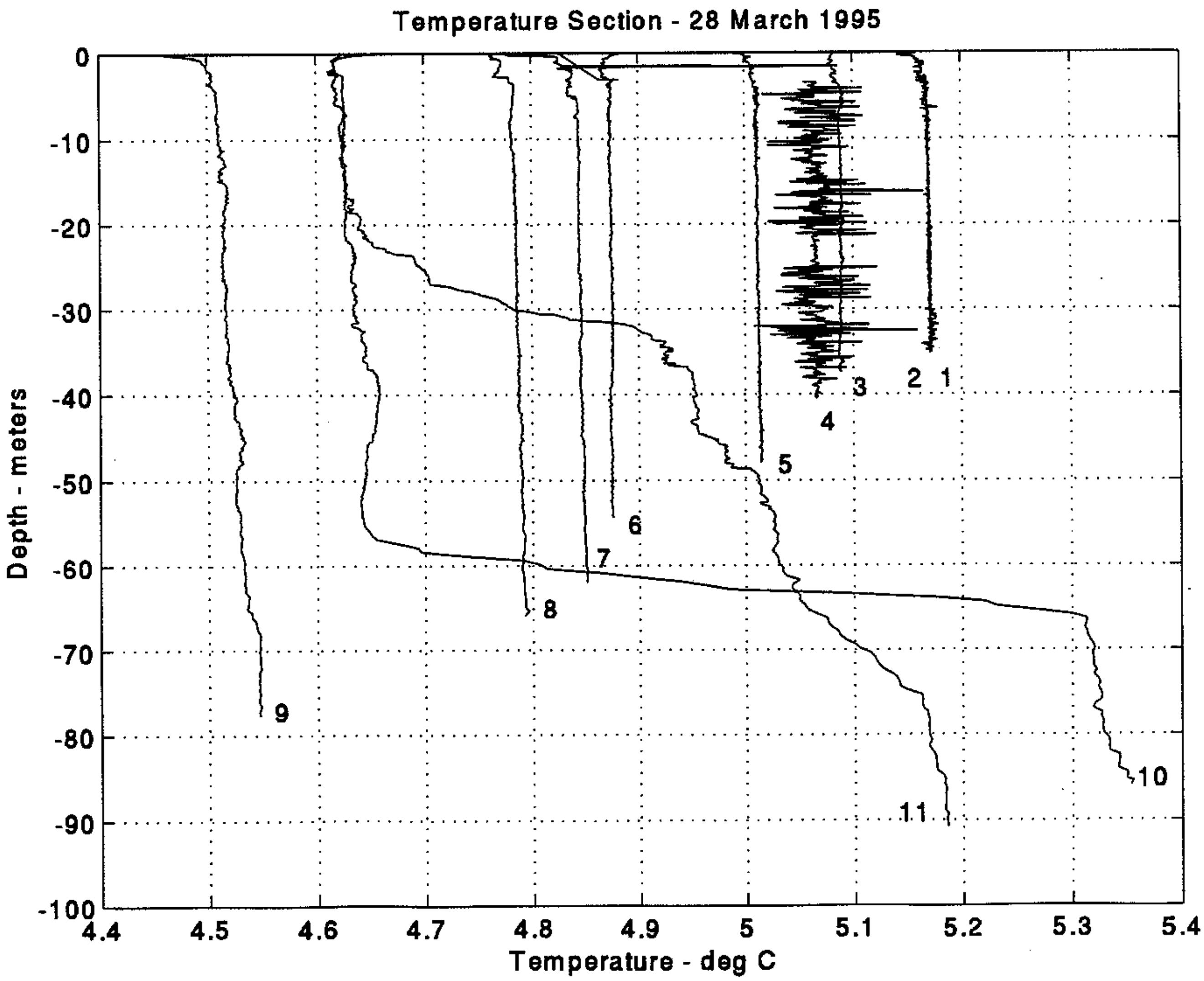

Figure 14. Long-Term Moored Section Temperature from 11 unedited and uncorrected profiles taken at positions shown in Figure 13.

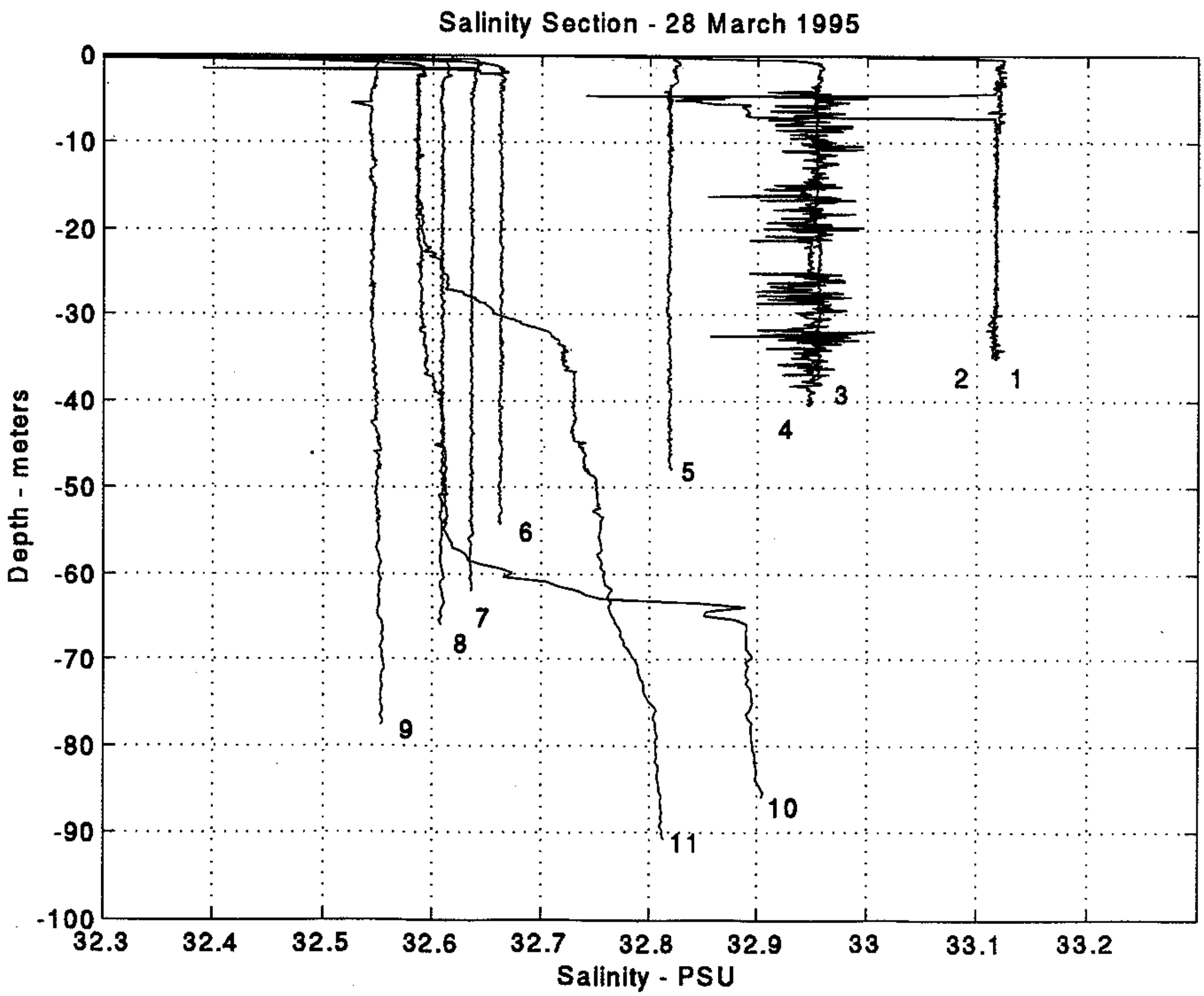

Figure 15. Long-Term Moored Salinity from 11 unedited and uncorrected profiles taken at positions shown in Figure 13.

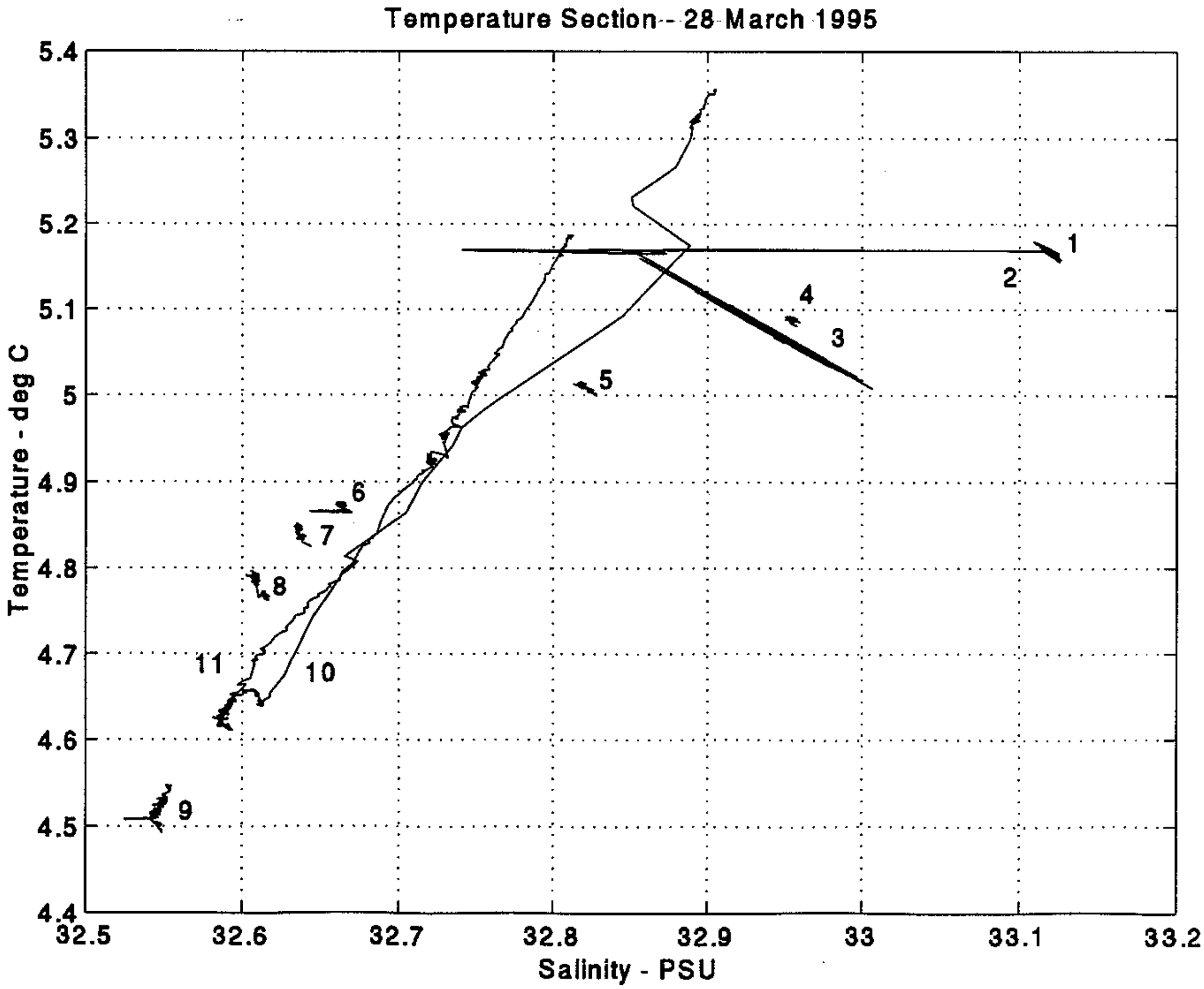

Figure 16. Long-Term Moored Section T-S (Temperature versus Salinity) from 11 unedited and uncorrected profiles shown in Figure 13.

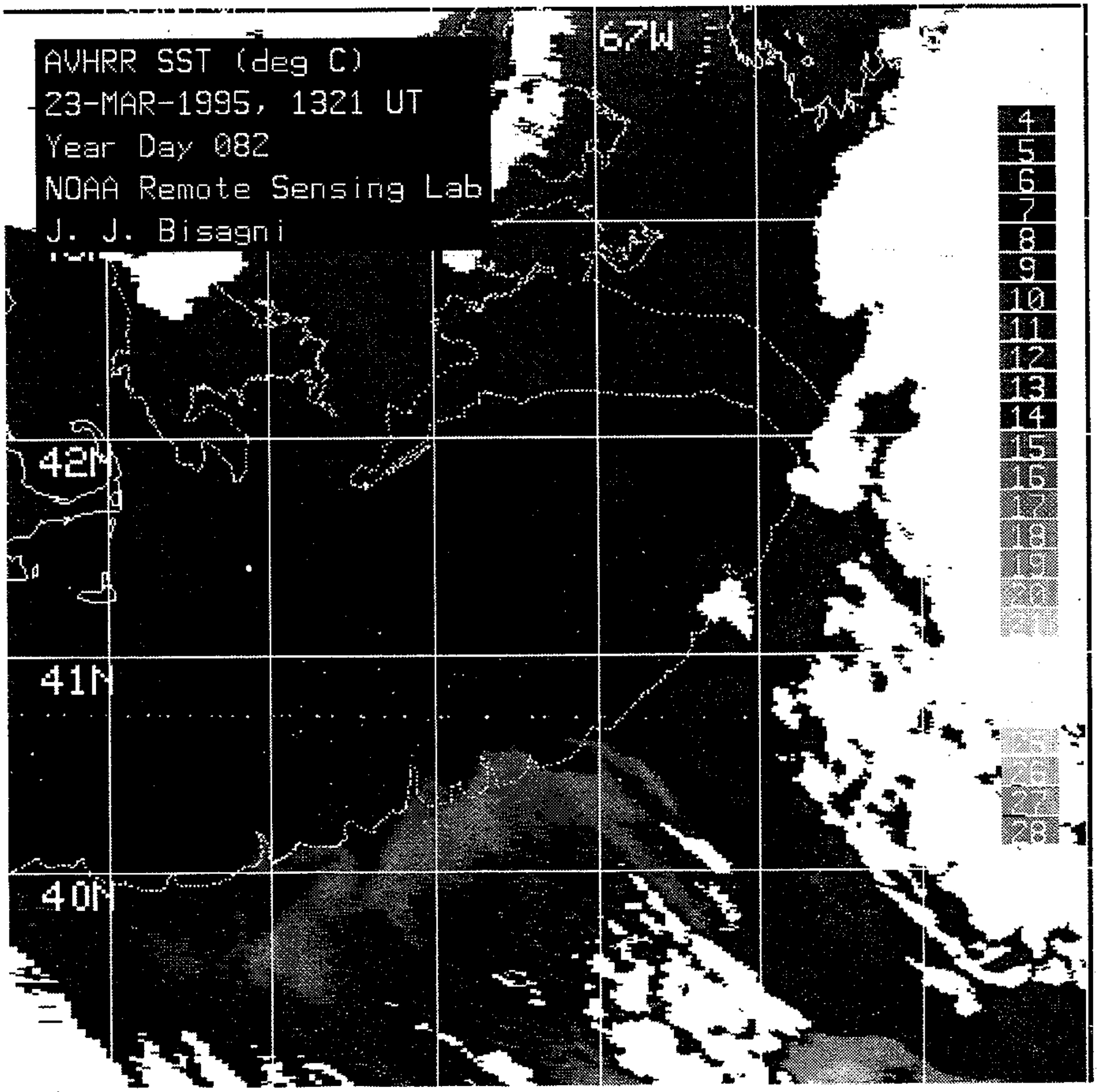

Figure 17. AVHRR satellite sea surface temperature map for the GLOBEC region courtesy of Jim Bisagni, NOAA/Narragansett for 23 March 1995 shows the relatively warmer water on Georges Bank and the cooler water on the southern flank, indicating a possible origin in Scotian Shelf water.

The transmissometer profiles (Figure 18) records showed very little vertical structure, while the fluorometer profiles (Figure 19) showed many sharp spikes. Although we were suspicious of this structure, the Miami technicians checked the CTD's A/D, the cables, and the output of two different fluorometers with dye, and everything checked OK. Therefore, these signals are probably real, but with nature of the well mixed water, the layers of high fluroescence appear anomalous. The PAR profiles (Figure 20) showed attenuation with depth, and no signal at night. They were not compared with shipboard radiation, but the data would normally be used for *in-situ* calibration of the PAR sensors on the moored bio-optical packages.

Several days after the Crest mooring was deployed, a series of profiles was made next to the buoy. (See Figure 21) These profiles show the well mixed temperature and salinity of the earlier profiles, but a much higher mean fluorometer level, perhaps indicative of increased biological activity in the calm few days after the storm just before the Main Line CTD Section was started. There is little obvious correlation in the vertical structure of the fluorometer and transmissometer signals.

Underway Ship's Data:

In addition to the CTD profiles, underway data was collected during the cruise, and archived for later analysis. Sea Bird sea surface temperature and salinity data were collected along with air temperature, relative humidity, atmospheric pressure and wind speed and direction. IMET sensors have been placed on the SEWARD JOHNSON, but were not operational during this cruise. Navigational data including ships speed, heading, GPS and Differential GPS (good to the tip of Georges Bank) positions and depth were also recorded. Two shipboard ADCPs were run throughout most of the cruise. A standard 150 kHz narrowband ADCP reached to the bottom at all times and ran in bottom track mode. A 600 Hz Broadband ADCP did not reach the bottom at the BIOMAPER survey site. The ADCP data will be turned over to Drs J. Candela and C. Flagg for processing and analysis as part of the GLOBEC data set. However, due to acoustic interference, the ADCPs and Chirp fathometer were turned off during the side scan surveys.

South Flank Guard buoy check and service

In order to ascertain that we could maintain guard buoys for a full year on Georges Bank without servicing, the moorings were constructed for one year, but one was retrieved and checked after 6 months. Since only one of the buoys had a working guard light, the other was recovered. This light appeared flooded, but because of the wind, swell and currents were running in different directions, we managed to pull the buoy under the boat during recovery operations. This should have run down the battery in the short time before the light was unplugged, even though the water covered the terminals on the flasher unit. Therefore, we believe the light was flooded by slow leakage during the winter, and the battery slowly discharged. The ride under the ship did little damage to the buoy (bending the top antenna guard which is not used), and appeared to do none to the ship. The buoy was pulled aboard, and the chain mooring and anchor recovered by pulling up 25 foot sections on the crane and stopping it off at the rail with a chain grab each time. This operation had been done many times before during CODE with no problems by this WHOI crew, but all were uncomfortable with this recovery operation on the R/V SEWARD JOHNSON for some reason. We will plan to use the TSE winch to recover the mooring through the A-frame on the stern of the R/V ENDEAVOR in the fall.

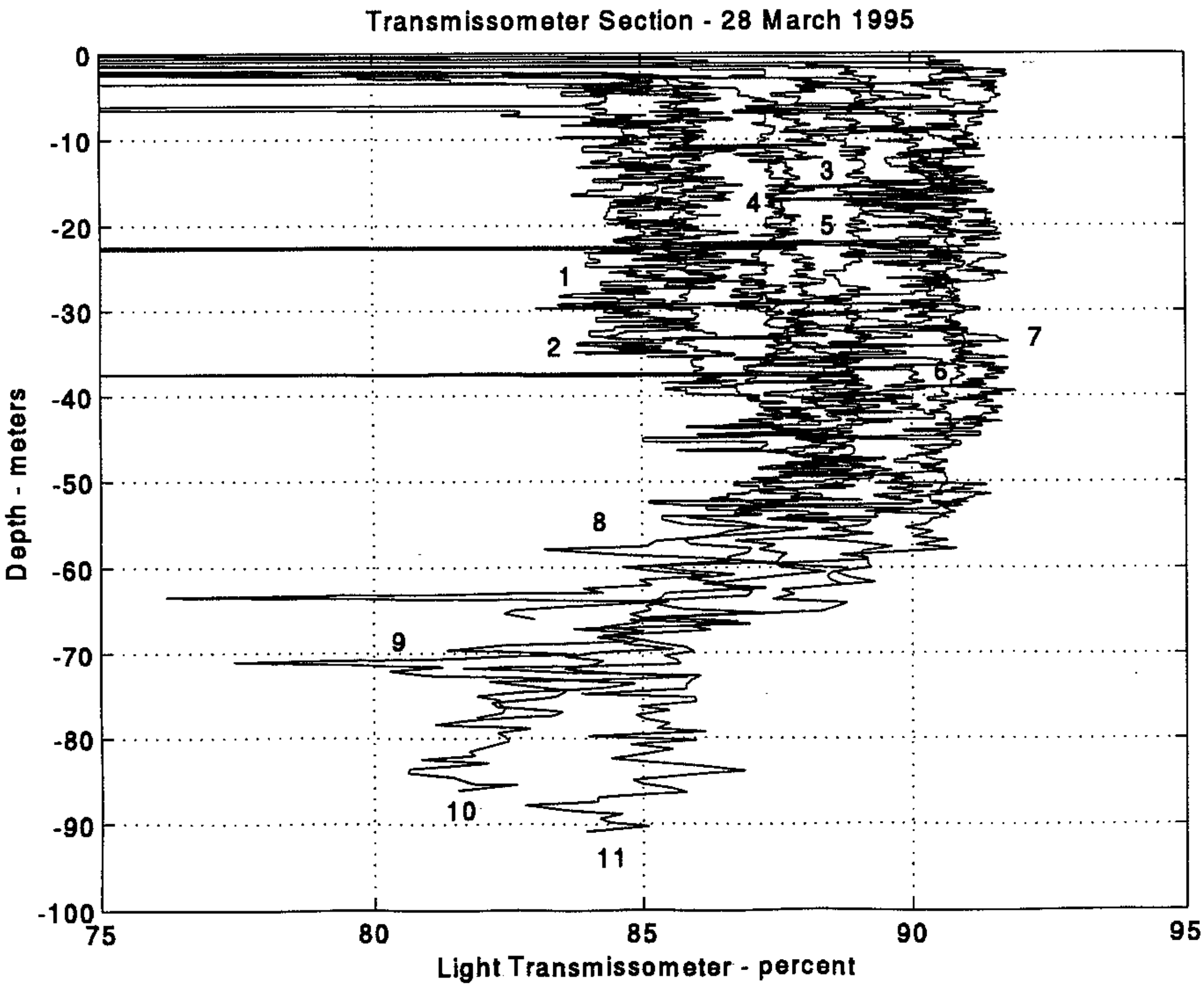

Figure 18. Long-Term Moored Section Transmissometer from 11 unedited and uncorrected profiles taken at positions shown in Figure 13.

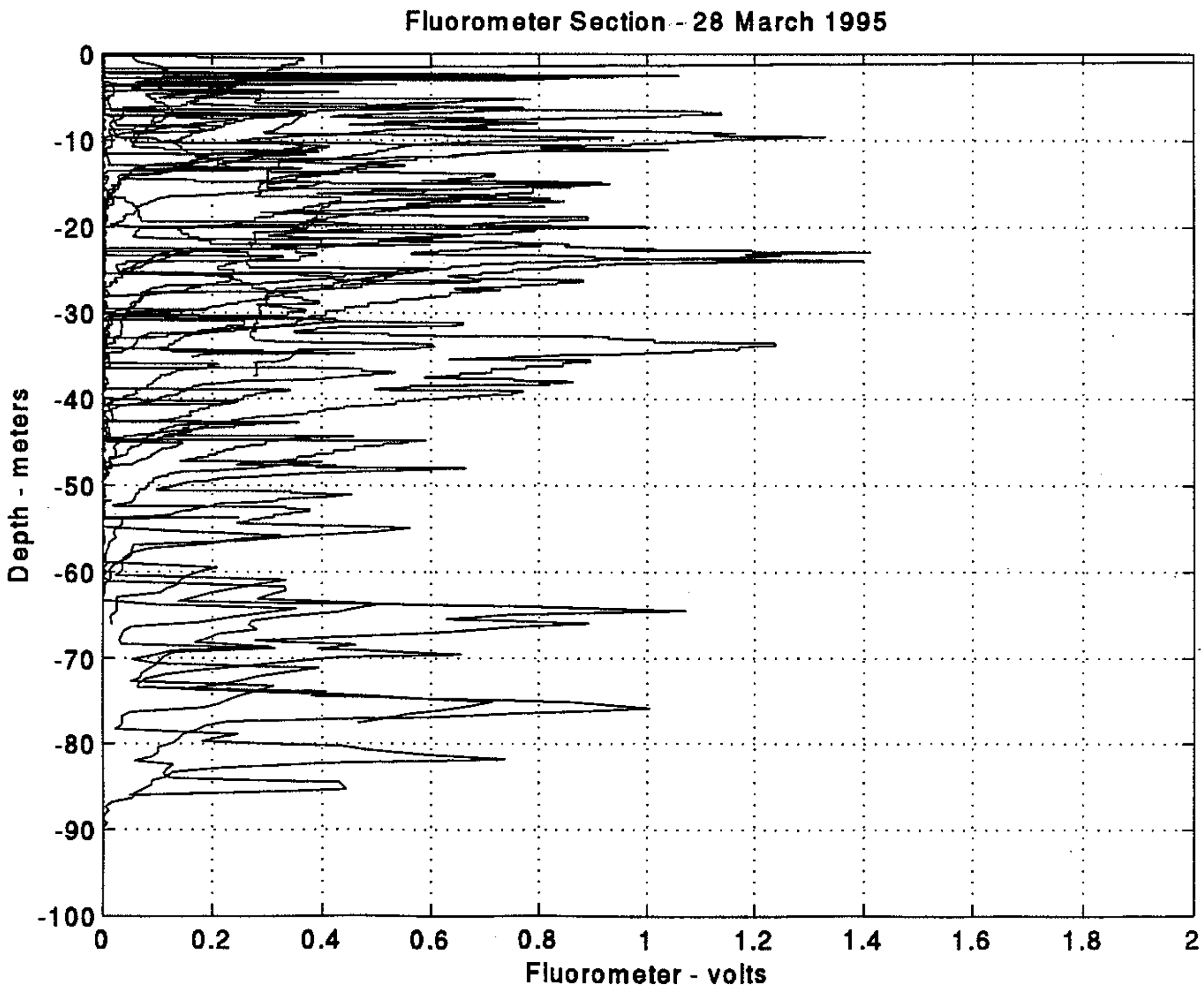

Figure 19. Long-Term Moored Section Fluorometer from 11 unedited and uncorrected profiles taken at positions shown in Figure 13.

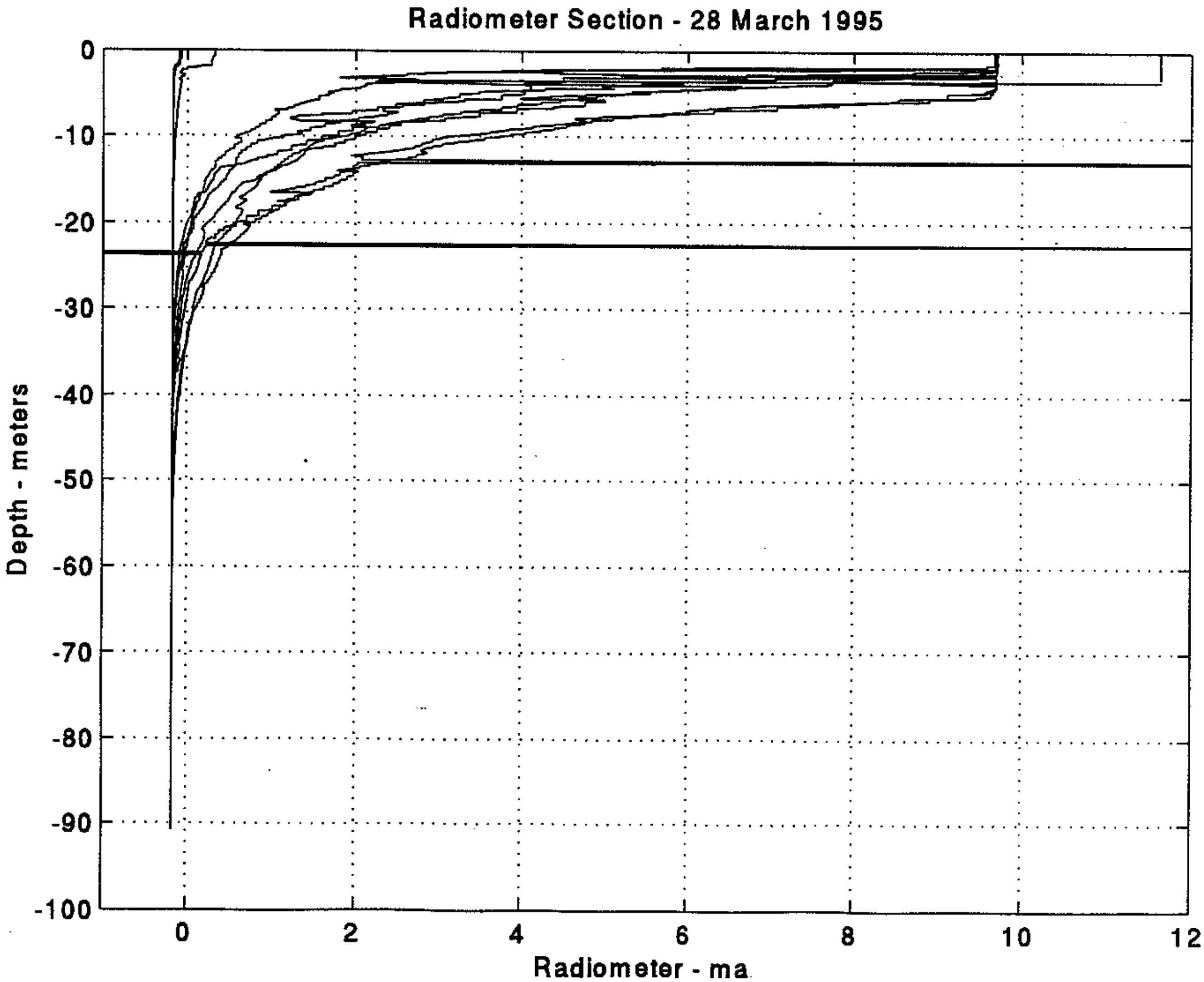

Figure 20. Long-Term Moored Section Photosynthetically Active Radiation (PAR) from 11 unedited and uncorrected profiles taken at positions shown in Figure 13.

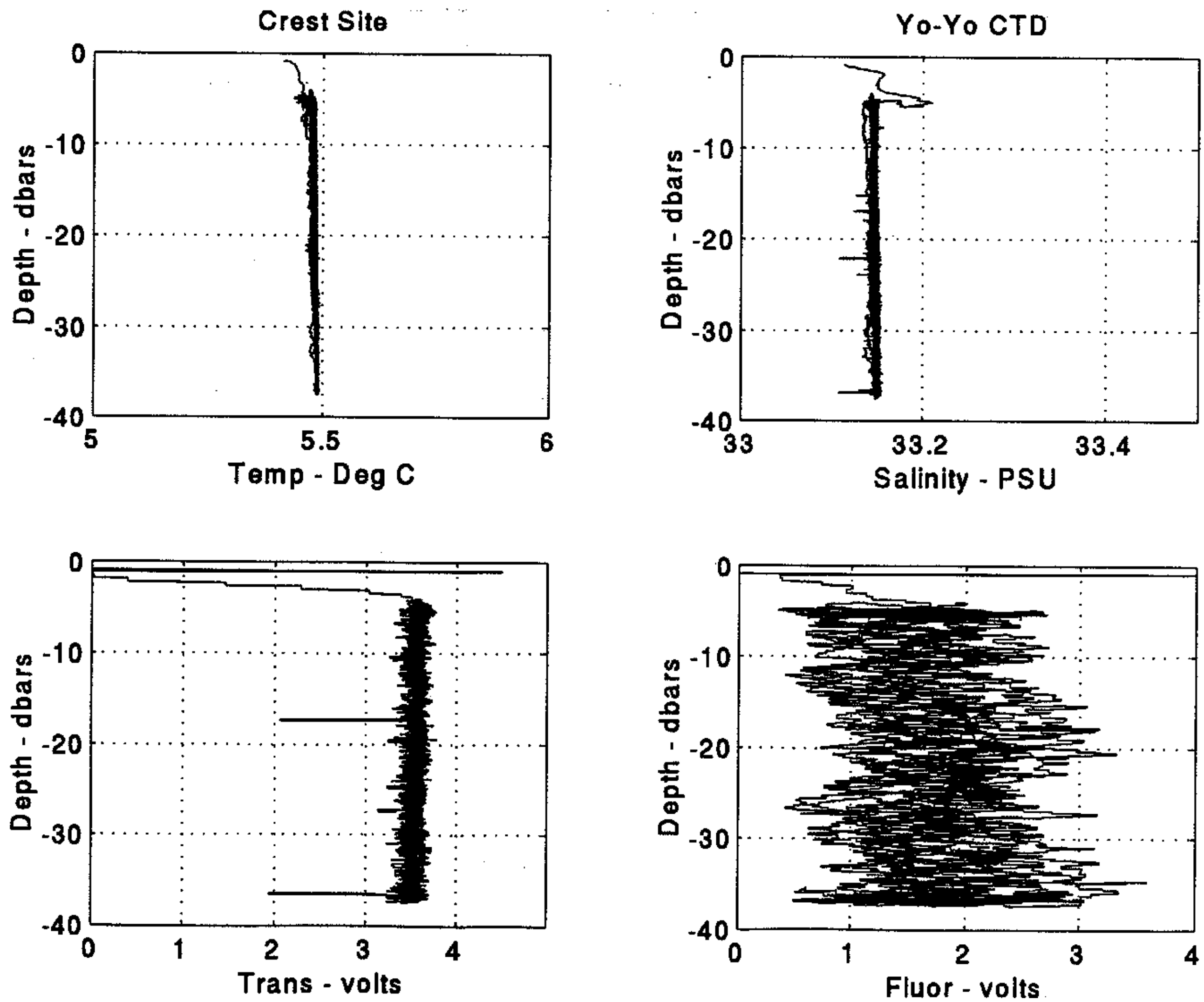

Figure 21. Crest Mooring Site CTD yo-yo. Six profiles were made beside the Crest Mooring in a 15 minute time span without removing the CTD from the water. The results will be used as an initial *in-situ* calibration of the bio-optical sensors.

The light on the recovered guard buoy was flooded, and the was battery low. The battery and light will be replaced and the buoy readied for deployment in the fall 1995. Examination of the mooring components, showed that the mooring chain was in excellent condition, and the shackles out of the mud were also like new. The bottom part of the mooring from the anchor to well off the bottom was made up of short sections of 3/4" chain, and the shackles in this region showed some wear around the nuts. However the cotterpins were still in good shape and the moorings should survive a full year.

Bottom ADCP/PT Turnaround

To profile the water column velocity field at the Southern Flank Site, a 300 kHz RD Instruments ADCP was mounted in a bottom, trawl proof frame. The ADCP was gimbaled in the frame with a locking mechanism which after a few hours would release a pin which would lock the gimbals from further movement. To make the package smaller, the ADCP was purchased with the smallest internal battery pack, and additional batteries were carried in a separate pressure case. Also, to measure the depth of the ADCP and obtain bottom tidal records, a Sea Data Model 635-11 busting pressure recorder was placed in the same battery case with a Paroscientific pressure sensor. The system was configured to measure the pressure with a Paroscientific pressure sensor, the temperature of the Paroscientific pressure sensor, the pressure case end cap temperature and the conductivity with a Sea Bird conductivity sensor. However, due to power requirements and size constraints of the battery packs for the pressure, conductivity sensors and the ADCP, the conductivity sensor was left off, and the ADCP sampling program reduced to 10 minute averages every half hour.

The system was release from the bottom by an acoustic command which dropped a lead anchor, and the package floated to the surface on the buoyancy of six 17" Benthos glass balls. In addition, the acoustic release was set to release a group of plastic net balls which would bring a line to the surface to pull the system out of any sand that might have collected and jammed the anchor release mechanism. However, the system came up with the plastic net ball mounting frame firmly jammed in the trawl-proof frame. There was clear evidence of trawl wire running over the frame which probably jammed this backup release mechanism. Thus, the trawl proof frame did prevent the instrument from being fished up, but did disable the backup recovery mechanism. A retaining bar was added to prevent this same problem from happening in the future.

The data was dumped from the ADCP, and onboard tests indicated 12 MB of data dumped, but a quick look at the BBLIST program from RDI indicated that only a few days of data existed. Not having the software or time to figure this out. the old ADCP was thereby removed from the frame, and a backup unit installed that had run for months in the laboratory without problems. The ADCP will be sent back to RDI for evaluation of the data return and failure.

Because of the problems with the ADCP, we are considering placing the ADCP just under the buoy in the mooring line in a downward looking mode, and powering the ADCP with batteries in the buoy. The pressure case on the buoy is large enough that ADCP batteries can be carried for any conceivable sampling program. In addition, the RS232 data line from the ADCP can be interfaced with the telemetry system so we can telemeter back a subset of the data to assure us that the ADCP is functioning properly. We had planned to do this with acoustic telemetry from the bottom to the surface, but now believe that the buoy mounted configuration would lead to little degradation in data quality, and the buoy mounted configuration would increase the sampling and monitoring capability at no increase in cost.

The bottom pressure instrument also appeared to stop after a few days. This appeared to be due to the burst sampling method used having an electronic problem on one of the boards that was not caught in precruise testing. This same problem reduced data return from STRESS III deployment on the recorders to be deployed at the NE Peak of Georges Bank next fall. After this failure, we started a thorough chip by chip testing program designed to catch any electronics problems. The instrument deployed in GLOBEC had run for over one month in the laboratory without problems. Then on the day before loading ship, the system hung up with a high current drain in the conductivity counter board. With no replacement boards, available, this was removed and not repaired. We thought that this would fix the problem, so the failure was a surprise. The burst control boards were replaced and the instrument was tested at an accelerated sampling program during the turnaround days without the burst sampling feature enabled with no problems. Therefore, for the second deployment, the burst feature was disabled, and more testing will be done to ascertain the nature of the systematic problem before the fall 1995 deployment. If the ADCP were placed on the mooring, then a simplified frame holding only the bottom pressure temperature and conductivity sensors would be deployed. This would mean we could cut back the guard buoys to only one with each instrumented, with nearly the same safety, and save again.

BIOMAPER Search and Recovery Operations

In preparation for retrieving the BIOMAPER, a Klein Side Scan sonar unit and winch were placed on the R/V SEWARD JOHNSON. Also a line handling spool and hook were attached to WHOI's ROV to retrieve the instrument package. After mooring retrieval operations were complete, and while mooring servicing was being accomplished, survey of the BIOMAPER loss site was conducted. Unfortunately, the side scan wire was caught in the ship's screw and cut early in the survey operations. However, the cable and side scan was dragged for and retrieved. The cable was then attached to the chain from the recovered Guard mooring, to act as a depressor weight and protection. Sidescan records were then made of the area, and several potential targets identified. The records were brought back to WHOI for further analysis and selecting the most potential sites for ROV retrieval of BIOMAPER. A detailed discussion of the survey operation is contained in Appendix 2: BIOMAPER Survey and Recovery Operations.

Table 1: GLOBEC Mooring Positions
Long-Term Moored Program
Deployment 2

Mooring or Instrument	Buoy Marked	Deployed - Date & Time	North Latitude (Deg - Min)	West Longitude (deg - Min)	Depth (m)
Guard #1	A (steel)	27 October 94 1333 UTC	40 58.124	67 18.987	76
Guard #2	Surlyn Foam	1 April 1995 1355 UTC	40 58.07	67 19.18	76
South Flank Science		to be deployed end of April 95			76
ADCP/BP	no surface expression	1 April 1995 1528 UTC	40 58.073	67 19.060	76
Crest Science Mooring	B (steel)	1 April 1995 2326 UTC	41 24.461	67 32.538	41

R/V Seward Johnson, GLOBEC SJ9504 Service Cruise

Table 3: CTD Station Sheet
Globec Long-Term Moored Program
Deployment 2

Cast Number	Station and Mumber	Date	Start Time (UTC)	Latitude	Longitude	Water Depth (m)	Time Bottle Trip	ON Deck Time (UTC)	End Latitude	End Longitude
CTD01	ML02-Crest	03/28/95	1351	41 24.240	67 32.346	38	1358	1401		
CTD02	ML02-Crest	03/28/95	1411	41 24.084	67 32.010	40	1424			
CTD03	ML03	03/28/95	1628	41 16.86	67 28.68	40	1629	1633		
CTD04	ML04	03/28/95	1748	41 13.20	67 27.03	46	1750	1755		
CTD05	ML05	03/28/95	1914	41 09.33	67 24.92	54	1915			
CTD06	ML06	03/28/95	2033	41 06.19	67 23.17	60	2036	2039	41 06.14	67 23.34
CTD07	ML07	03/28/95	2138	41 01.68	67 21.13	67	2140	2143	41 01.63	67 21.25
CTD08	ML08 -S Flank	03/28/95	2247	40 58.18	67 19.56	76	2249	2254	40 58.14	67 19.65
CTD09	ML09	03/29/95	0028	40 54.45	67 17.09	83	0031	0035	40 54.39	67 17.15
CTD10	ML10	03/29/95	0126	40 50.81	67 15.09	90	0129	0134	40 50.75	67 15.17
CTD11	ML11	03/29/95	0219	40 47.07	67 13.25	95	0223	0228	40 46.98	67 13.31
CTD12	ML02 - Crest	04/04/95	0110	41 24.29	67 32.73	40	yo-yo	0128		

R/V Seward Johnson, GLOBEC SJ9504 Service Cruise

Appendix 1:
Long-Term Moored Program Cruise Log

Monday - 27 March 1995

EST
1730 - Depart WHOI dock for Crest Site
1900 - General boat drill and discussion in Ships Lounge
2000 - Operations pretty well secured for night
144 nm from WHOI to Crest Site or about 12 hours steaming
ETA 0700-0800 in morning at Crest Site
Winds North 10 kts, seas moderate

Tuesday - 28 March 1995

EST
0800 - At Crest site, Crest Buoy there and riding seas nicely
Winds and Seas up, NOAA weather reports 12' seas today and 7' tomorrow.
No one comfortable with recovery operations in this sea.
Start Main Line CTD section through Crest and South Flank moorings
Starting at Crest buoy, our Main Line station 2.
0852 - CTD01 at ML2 station by Crest Buoy.
0911 - CTD02 two time yo-yo at Crest Buoy
0940 - CTD secure and steaming to ML3. Looking at spiky fluorometer.
Chip states that they checked out the CTD A/D and it is good, and they did a calibration with two fluorometers and dye, and they agreed. Also we discovered a problem with the postprocessing routine setup parameters which caused the processing to drop the first 12 meters of the profile. The data was present in in the acquired data file, so it was just lost in the processing. Problem was wrong parameter interpretation in processing setup. Everything finally OK.
1128 - CTD03 at ML3 station
Weather (wind and seas) quieting! Plan on recovering buoys tomorrow.
1348 - CTD04 at ML4 station
1414 - CTD05 at ML5 station
1533 - CTD06 at ML6 station
1638 - CTD07 at ML7 station
1747 - CTD08 at ML8 station by South Flank Buoys, both there
1928 - CTD09 at ML9 station
2026 - CTD10 at ML10 station
2119 - CTD11 at ML10 station, skip station ML12 as troops dead tired.
2145 - Ending operations for day and steaming back to crest site @ 6 kts.

Wednesday - 29 March 1995

0630 - At Crest buoy, winds 20-25, whitecaps, seas 6' or so
Tides against wind, currents about 85 cm/sec northgoing
0755 - Hydrophone over, enable release, range 155 meters
0757 - Command Release, confirmed fire
subsurface ball sighted at surface
Buoy recovered and set on deck and secured
mooring hardware and elastic tethers pulled aboard by hand
crane used to recover subsurface flotation and acoustic release
Mooring hardware looks in good shape
Elastic tethers disconnected from buoy and subsurface float and placed in

box on 01 level for transport to WHOI for evaluation.
Buoy tower removed and buoy secured by port rail out of the way
Limited crane reach hinders buoy operations on the R/V SEWARD JOHNSON.
Electronics can moved into wet lab for work and repair

0830 - Deck secure and moving to South Flank station
Examination of Crest Buoy:

Brown algae on damping plate, temperature and conductivity sensors and load cell. Slight green, stringy algae growth around water line. Rust staining on tower and buoy out of water. Marked corrosion around end cap of electronics case. Also corrosion at base where electronics case bolts to tower. Junction between aluminum top and steel bottom of tower appears to be corroded. Never seen this much corrosion before in the Gulf of Maine or Massachusetts Bay after 13 months. Antenna lead looks OK. Air temperature and PAR sensors look OK, but a nut was not tightened on the radiation shield, but appears to be jammed. The tower shows signs of being hit, with the top aluminum part showing some bending and cracked aluminum welds. All four solar panels looked OK, and they were checked for no load output in bright sun. It is normally above 20 volts, and three panels checked out fine, but the fourth was only 16 volts output, and it was replaced by a spare. The battery with the system on deck read 11.606 v.

1000 - A computer was attached to the TDS 2020 computer and it was still working fine
2111 data records of data were dumped to the notebook PC on deck
data dumped to files CREST.DMP and CREST2.DMP.
Because of ship's speed, a wave soaked scientists and computer on deck
Dried off computer, and extended cable so we could work from inside the wet lab
Dumped 96 days of 150 days of deployment.
System died when we stopped receiving telemetry transmissions.
Synergetics system alive, but had lost program from EEPROM.
Reloading program and system appears to work fine
Power down system, and ready to bring into lab for work
Tower unbolted from buoy, and set up on deck .
Buoy moved to port rail in standing position to clear deck for guard buoy

1230 - at South Flank site, two guard buoys in site.
1246 - Enable ADCP acoustic release, range 440 meters
1247 - Command release, acknowledgment, range 516 meters
1250 - Floats on surface, whole package intact with orange line floats
1300 - Main hook on ships crane is broken. Changing to another hook
1317 - Crane repaired and ready to start recovery
1325 - ADCP safely recovered and secured on deck

Battery case and ADCP case show no corrosion. Zincs on cases look like new. Zincs on frame largely gone, but frame looks clean of corrosion. Light coating of biological hair on everything. Orange balls tipped toward release so they jammed between the upper and lower frame bars. Need a strong kick to remove. We need to put in some kind of blocking mechanism so this doesn't happen again. The zincs were completely gone from the acoustic release. No corrosion products were seen, but the zincs should have lasted several years. Minor corrosion on aluminum frame of ADCP counterweight. Signs of stainless crevice corrosion on nuts, washers and bolts. Sea urchin, starfish, fish eggs. etc. on the bottom frame. Some were preserved by Wiebe for later analysis. Trawl wire scratches along one leg of the tripod showed that there was some fishing activity which might have caused some serious problem for a standard frame, but just slipped over the trawl proof frame. This wire probably jammed the plastic float package. ADCP frame secured by the rail outside the wet lab to allow us to connect to it and talk from inside.

1452 - approaching Guard Buoy "C" for recovery operations
1456 - Bull Rope hooked into buoy. Due to ship's drift, buoy pulled under ship and line released. Buoy appeared on the other side of ship in one piece, ship still running.
1505 - Making a pass at buoy, decide need to use grapnel to get rope, couldn't manage.
1510 - Another pass at buoy, and Kent used grapnel to snag bull rope and tag on buoy.
1515 - Buoy secured on deck.
1518 - Hooked crane onto chain,
1520 - Mooring chain broken off buoy
Pulling chain shot by shot. Only get about 25 feel on one lift. Chain grab on snubber line over rail makes unsettling noises as rail moves with weight. Would like to have been able to remove rail like we did on R/V WECOMA, OCEANUS and ENDEAVOR. Operation uncomfortable for all on deck.
1555 - Anchor secured on deck by starboard rail by ADCP.
Deck being secured,
Reviewing Guard Mooring Hardware:
Shackles and links at anchor in excellent shape, no real wear
6' 3/4 chain in good shape
sling link and shackles fine
6 ' 3/4" chain in good shape
sling link and shackles fine
6 ' 3/4" chain in good shape
sling link and shackles fine
6 ' 3/4" chain in good shape
sling link OK, shackles with loose nuts, showing wear , good cotter keys.
6' chain in good shape
sling link, shackles in excellent shape
little biofouliing on chain
lots of 1/2" chain
shackles in excellent condition
top of mooring in great shape.
Hardware should last another year, except shackles in 3/4 inch chain in mud
Should use shingle shot of 3/4" chain at the bottom to avoid problems
When deck secured, steam overnight at slow speed to BIOMAPER site

Thursday - 30 March 1995

BIOMAPER survey, cut sidescan as starting survey
dragging operations for sidescan
working analyzing Crest and South Flank mooring data
reworking tower, corrosion appears to be due to drilling through aluminum and steel without cleaning out the debris, which then shorted the aluminum to steel, and the salt spray completed the path to cause the tower corrosion. Parts scraped and wire brushed, damage does not look sever, and should have no problem redeploying. Parts sprayed with cold zinc paint for protection.
Electronics pressure case corrosion around outside lip, does not extend into o-ring area
Some condensate appears inside the electronics can,
Batteries "A" and "B" 11.565 and 11.461 v respectively, batteries removed.
Replacing components in Crest buoy
2 New batteries fully charged - marked GLOBEC "G" and "H"
New GOES, ARGOS, MCM, ribbon cable, antenna and antenna cable

New Sea Surface Temperature sensor
Remove wiring for Load Cell
Remove bottom PT and battery pressure case from ADCP frame
Bottom pressure case appears clean, and zinc in good shape
Bottom pressure sensor batteries down to 4.5 volts and system stopped
System comes up OK on power supply, current drain 4.85 ma.
ADCP Batteries:
Battery 1 - 56.50 v
Battery 2 - 56.51 v
Battery 3 - 56.50 v
No Schottky diodes in battery circuit, put in 5821s
Change acoustic releases as Kent not happy with release pins on current unit
Sean reworking gimbal and locking pins - pins appeared to work on deployment one
read data from PT recorder and check current drains
batteries down, but current drain fine
no problems seen with system operations
replace burst control cards
do overnight accelerated test without bursting function
20:19:00 UTC start overnight test at 128 samples per hour
Reading data from ADCP on deck. System dumped 12 MB of data, but program says data ends 4 Nov. 1994.

Friday - 31 March 1995

Seas calm, sight swell, slight rain and drizzle
dragging operations for sidescan continuing
Testing Crest air temperature and PAR
AT=2.906v, PAR=0.333, not what expect
Remake "CREST2.USE on notebook
Trace noisy PAR to ribbon cable, replace
Air temperature still 2.906 v now
Par now back to 3 to 4 mv
Set gain on PAR sensor digitizer channel to 50, and getting numbers like 183
Load and save CREST2.USE in EEPROM
Decided to replace ADCP with spare unit serial 1271
Laboratory unit ran for > month without problems
Internal RDI battery in pressure case, cleaned and closed
12:29:30 stopped recording PT system
last record written #A1C
At 12:18:46 wrote #A08 = 2568 = 20.6 hours which is right to 1 second
PTC recorder looks good, full memory is 51000 record.
at 16 samples per hour, should get 17,300 in 6 months
turn bursting feature off and get average pressure only at 3 3/4 minute intervals
1230 - Wiebe and company retrieved sidescan!!!
14:58:07.5 EST - Zero time on pressure, reset pressed
this is 19:58:07.5 UTC 31 March 1995.
15:28:07.5 - wrote sample # 40H OK
15:43:07.5 - wrote sample # 60H OK
15:58:07.5 - wrote sample # 80H OK
1715 - Assembly of ADCP, putting frame on anchor
1745 - Shifting buoys on deck, guard buoy by Port rail, Crest buoy to cradle
1750 - Surlyn Foam Guard buoy and anchor on stern of Johnson
21:46:00 - Start ADCP overnight test with deployment parameters
steam overnight to South Flank site

phone conversation from R/V ENDEAVOR on reduced sampling by Crest and Southern Flank moorings since not they are not in place. Will do simple sample there.

Saturday - 01 April 1995

0545 - on station, South Flank
Seas 3 to 4' winds 9 kts, overcast
Three WHOI stickers on ADP, battery pressure case and frame
Guard buoy there, and bridge reported light working fine
ADCP still running
0600 - rigging deck in preparation for Guard Buoy launch
working on ADCP
06:56:03 - ADCP wrote on schedule
07:00:00 - 12:00:00 UTC ADCP started
can hear ADCP as sharp ticks on Radio Shack inductive phone pickup
07:10:01 - wrote sample which ADCP says starts at 5F04010C0001
PMEL temperature pods attached to rope mounts
3239 @ 1 m depth on bottom of buoy
3241 @ 10 m depth just above break in chain
3248 @ 20 m depth
3258 @ about 50 m depth (within 2 m)
0820 - Start turn for launch - set range and bearing to existing buoy at 0.12 nm at 070°T
0821 - chain over rail to keep buoy upright
0825 - Buoy over stern
0826 - Buoy in water upside down, paying out more chain
buoy finally rights itself
0845 - Anchor ready for launch
0855 - Anchor deployed
Buoy A - 40° 58.11' N x 67° 19.00' W
Foam Guard Buoy - 40° 58.07' N x 67° 19.18'W
0915 - Moving buoy anchor into position on fantail
0955 - Testing ADCP acoustic release
1015 - Release tests OK, readying for deployment
1025 - Attaching ADCP/BP to crane with quick release, 0.2 nm to site
1027 - ADCP over the side, holding at water level
1028 - ADCP released at surface, free falling to bottom
40° 58.073' N x 67° 19.060' W
1042 - Trackpoint Navigation shows ADCP is 142 m at 72°, right between buoys
Cleanup deck and start steaming for Crest site
1100 - Crest electronics off bench onto floor, voltage regulator board damaged
Repaired board, and checked electronics, appears to be OK
Drop across Solar Panel diodes = 0.367 v
Drop across Solar Panels and Regulator = 0.5 v
Battery #1 = 13.58v, Battery #2 = 13.49 v
Voltage at electronics = 13.45 v
Check shunt regulators, both shunt at 14.7 v OK
Test GOES transmission
Status => 22 to 35 deg C
power out = 46 to 48 db, A39 says 47.1 db - OK
voltage = 12.5 to 13v after transmission, A37 = 12.60
System appears to be OK, package up in pressure case
1500 - Electronics can on deck
1613 - Tower being assembled on deck, start PDR survey through site
1627 - bottom 39.6 m and flat

1629 - bottom 40.7 m at site
1632 - bottom 40.6 0.1 nm beyond site on heading 360°T
1655 - Attaching tower to buoy
1715 - Cables attached to electronics
SST - 7 kHz and SSC - 2700 Hz - OK
1728 - ARGOS
Average air temperature - 3418, min = 3396, max = 3486, std = 14
PAR = 485, std = 9
SST = negative
SSC = negative
Bat1 = 12.978, Bat2 = 12.966
1734 - PCMCIA recorder dumped
recorder set "Work" and working, appears to be waking every 3 seconds
1755 - start system
reset with A1 TEST.A
system off and running
depth 41.3 to 40.6 meters
1810 - Buoy ready for deployment
1826 - Buoy launched
1830 - Biooptics package deployed over stern
1837 - Subsurface float over stern, towing into position
1904 - Anchor deployed
41° 24.42' N x 67° 32.53' W
all mooring crew crash, transit to BIOMAPER survey site

Sunday - 02 April 1995

work on cruise report, buoy data and rest up
BIOMAPER people survey from deck
redo cable and test

Monday - 03 April 1995

BIOMAPER survey
work on bio-optical data normalization and software
sort out deck boxes and pack deck for offloading on Tues
1436 - Complete sidescan operations and start for Crest site
2100 - CTD yo-yo series by Crest Mooring
2110 - start CTD Yo-Yo
2128 - end CTD Yo-Yo
2138 - CTD Secure
Monitoring ARGOS - saved in log CTD12.log
2148 - Buoy Position
41° 24.461' N x 67° 32.538' W
Continue to WHOI

Tuesday - 04 April 1995

0915 - Arrive WHOI dock
Offload ship

Appendix 2: BIOMAPER survey and recovery operations

Report by Peter H. Wiebe, Mark Benfield, Duncan McGehee, Tom Crook, Dave Lavolvo

We left port about 1730 on the 27th after a day of loading the ship and testing the various pieces of equipment. This cruise had two objectives. The first and highest priority was to service the GLOBEC Georges Bank Moorings on the top of the Bank and on the Southern Flank. The second was to recover BIOMAPER from its watery resting spot. BIOMAPER was lost in the early hours of 16 February 95 when the towing warp parted just as we were about to bring the vehicle on board. We were seeking to avoid the gale force wind and waves that were beginning to affect our operations on the R/V ENDEAVER broad-scale cruise, but instead succumbed to them.

Based on analysis of the GPS data (acquired up to a few minutes before BIOMAPER was lost) and the ship's GPS and bathymetry sonar along-track data (recorded before and after the loss), we concluded that BIOMAPER rests in 125 - 140 m of water. A search box about 200 m wide and 500 m long represents the location within which the vehicle most likely rests.

Tuesday: We did a CTD transect between top of Bank and Southern Flank because it was too rough to pick up the moorings. We steamed back to the top of the Bank to wait for morning and better seas.

Wednesday: We retrieved the moorings both on the top of the Bank and at the Southern Flank and then steamed for the BIOMAPER site.

Thursday: We started early. Wake-up calls were set for 0430 so we could start the setup for the Klein side scan work by 0500 or so. There were very light winds and the sea was nearly calm. It was a very nice morning to start this work. By 0630 we had rigged the cable from the Hunted winch and had gotten the Klein system into the water. By about 0700 we had the system positioned about 20 meters above the bottom and had begun the first run. The course was approximately 135° which was the same path as the ENDEAVOR was on when BIOMAPER bit the dust. Initial returns from the 500 kHz sonar looked promising; subtle differences in the topography of this flat bottom area were clearly evident on the echogram. While most of the group was looking at the side-scan record in the main lab on the port side of the vessel, the bridge made a course correction by turning to port. The towing wire went under the stern and a couple of loud "Cachunks" came from the stern area as the wire was cut by the propeller. Peter Wiebe ran out onto the deck to see what had happened and found the towing wire hanging limply from the sheave mounted high on the side A-frame. He immediately went inside to say what had happened and to ask that an immediate fix on the ship's position be obtained, so that we would know where it went down; this was (41° 31.97N; 65° 59.3207W). Our initial impression was that the wire had been severed by the prop leading to the immediate loss of the system. Returns from the acoustic transponder attached to the tow wire near the fish indicated that the missing gear was actually ~340 m southwest of the initial accident site (41° 31.8519N; 65° 59.5114W). Apparently, the wire had fouled on the propeller and drifted with the ship before dropping to the bottom.

The incredible had happened. In almost the same location where disaster had struck BIOMAPER, the Klein had suffered a similar fate! It was sitting in 135 m of water. We were devastated and it took some time before we started to think about what to do next. We had one advantage over the loss of BIOMAPER: there was a transponder on the side-scan sonar system and we could use the ship's track point system to locate the system very accurately (within a few meters) on the sea floor. We discussed the idea of grappling for the tow wire. About 200 m of cable was out when the wire was severed, so this was laying on the sea floor. But we had lost the cable we had intended to use for Side Scan and ROV operations and no other winch was on board with cable to use for a grappling operation. On reflection, however, Captain Dan Swartz, made a major decision - we could use the Kevlar submarine rescue line (some 5000 feet long with a 40000 lb+ breaking strength). But the winch holding the Kevlar line was broken (a problem with the hydraulics) and could only be operated in one direction. Jim Irish volunteered the use of the TSE winch which he brought along to work with the moorings and within a few minutes the decision was made to spool the Kevlar onto the TSE winch. Irish's crew, Kent Bradshaw, Sean Kerry, and Pat O'Mally quickly and effeciently made the necessary hook-ups and then ran the equipment. The process of spooling the Kevlar from one winch to the other took about 2 hours. The Kevlar line was longer than anticipated and the TSE drum was filled to capacity by the time the bitter end was reached. There was barely enough room for an additional 70+ m of 1/2" and 3/4" chain which was attached to the end of the Kevlar to provide sufficient weight to get the line to the bottom. A very large grappling hook that Dave Simoneau had provided was attached to the end of the chain.

About 1030, we were in a position to start grappling. Our initial strategy was to lay out long lengths of chain and line on the bottom while maneuvering the ship in circles around the transponder, which was clearly marking the place on the sea floor where the Klein system lay. In addition to circles, we tried long straight pulls over the transponder. Neither strategy proved effective.

About noon we decided to change the strategy. We pulled in the line to where the chain started and hose clamped a second transponder on the Kevlar in the region of the eye splice. We then put out only enough line so that the chain would drag on the bottom and the transponder would be about 15 meters above the bottom. This turned out to be about 30 turns on the TSE winch drum (we could only estimate how much wire was deployed by counting turns (1 turn ~ 4.5 m) because there was no metering wheel). We now had two targets that could be tracked by the ship's track point system, which allowed us to fly the grappling wire over the lost transponder and fish.

The new strategy was to no avail; we made tow pass after tow pass with the transponder on the wire passing within a meter or two of and on the same bearing as the transponder on the Klein system. We approached from a number of different angles, but only one course (030 into the prevailing current of about 1.5 to 2.5 knots) allowed us much control. We worked until about 2130, before giving up for the night.

Friday: We planned to start the grappling operation again after breakfast (0745). A couple of the crew, after watching us, decided we needed additional grapnels on the chain. During the night, Skip, and Tony (members of the ships crew), had put together a spreader bar with additional grapnels and we put that on the chain above the large grapnel and commenced again to try to snag the Klein system. Over and over, we ran the ship and the chain over the transponder, but there was no hint that we had grazed or moved the Klein system from its resting place. Again we tried a variety of bearings in making approaches, but all came up with naught.

At noon, Gray came up to relieve the Captain and took over running a course that had been started by the captain. We watched the track point system display the ship's approach to the transponder and its passage right over the top of it (within a couple of meters) and then watched the transponder at the top of the chain which was ~100 meters behind the track point transducer pass right over the transponder on the bottom. As the chain then passed over that spot on the bottom, we watched the distance between the two transponders widen to the magic distance of ~80 m after which, if we snagged the Klein, the distance would not change. If it continued to widen, we had missed once again. As in the past, the distance continued to widen and after a 120 m or so, we gave up on that pass and after setting the course for the next one, Wiebe went down to eat lunch.

He had barely started his lunch when Tom Crook called over the intercom system and said that the track point distance between the two transponders was staying constant in spite of our continued movement away from the Klein's resting place. We quickly prepared to bring the line back in and see if a miraculous recovery had indeed taken place. The Kevlar line and chain were wound up on the TSE winch and as the grappling bar became visible, we could see nothing attached not could we see anything on the big hook some 2 or 3 meters below the surface. We were going to lower the grapnel for another try when suddenly it was apparent that a cable was streaming down away from the big grapnel. We quickly disconnected the shackles attaching the cross bar with the set of grapnels to the chain and hauled the remaining chain to the surface. The wire was solidly ensnared in two prongs of the grapnel. We brought the grapnel to the edge of the fan-tail and quickly put two cable grabbers on both ends of the snagged cable to prevent either end from slipping away. Then we brought the grapnel onto the deck. We discovered that one end of the cable could be pulled in by hand, but the other, which had the 200+ lb weight on, had to be winched in. We made an eye in the cable with 2 cable clamps and then used the TSE winch to wind the wire, the weight, transponder, and the side scan sonar with only the tail fin missing on board by 1300.

What incredible luck to have recovered them! Perhaps the more miraculous discovery was that the system still worked. Tom announced that he had brought a spare cable that could be used at 100 kHz. As the euphoria of the recovery of this piece of gear wore off, we went back to work on the primary mission - locating and recovering BIOMAPER. By late afternoon a refit system was together and we tried to use it off the stern without a depressor weight. To get as much cable length as possible, the recorder was located in the Compressor Room as far aft as possible. We worked through the evening, but failed to obtain good images of the bottom. The altitude of the fish was too high and other acoustic systems were putting noise into the graphical display.

We quit about 2100 hrs, so that the ship could commence steaming to the mooring sites for work the next day.

Saturday: This day was devoted to deploying the buoys at the southern mooring site and top of the Bank. We were able to test the Klein to see what we could see with the fish closer to the bottom. We were working in about 60 m of water with the fish about 15 m below the surface. We got good enough results to make us want to go back to the BIOMAPER site and try again to locate it.

Sunday: We arrived at the site about 0600, This time we used a different configuration for deploying the fish. To gain maximum depth, given the short length of cable, we put the mooring chain (~100 m) used two days ago back on the TSE winch and then attached the 200 lb weight to the end of it. The side-scan sonar was streamed behind the end of the chain, just above the weight, with about 5 m or so free, and then the rest of the sonar cable was deployed in tandem with the chain. Plastic tie-wraps and electrical tape were used to attached the sonar cable to the chain every 5 to 10 meters. When fully deployed and steaming at 2 knots, the fish reached a depth of about 80 to 85 m which meant that it was about 55 to 60 meters above the bottom. This was far from optimal (we were using the 250 m scale and the rule of thumb is that the depth of the fish should be 10% to 15% of the scale range or in this case 25 to 25 m). In spite of this, by 0730, we had initiated a search pattern and we were starting to acquire side-scan data. We made 9 major passes over the boxed area where we believe BIOMAPER is located and in the process covered a much wider area. Motion of the ship and the very high distance of the fish off the bottom made for poor recordings and no target was observed that looked man-made (i.e. produced a sharp intense return with a shadow behind it). As we watched the sonar images appear, hour after hour, we began to appreciate how small the target might appear on the plots we were making. In fact, of the 360 pings produced every 2 minutes, at 2 knots, only 9 might echo back from BIOMAPER if we passed by broad-side to the towed body (3 m length & 1 m/sec speed * 3 pings/sec). The size of the returns on the echo gram would be very small indeed and because of the very high angle there would be little shadowing produced.

By noon, it was apparent that we were not close enough to the bottom to get a good record of the bottom of to see targets the size of BIOMAPER on the bottom. We continued to make passes over the search box both from the southwest to northeast into the prevailing current and from the southeast to northwest or reverse along the path of the Endeavor when BIOMAPER was lost in order to cover the area completely. It was also apparent that most of the search time was being spent in maneuvering the ship outside the search box to get set to make these passes. Thus, it was taking a lot of time to get complete side-scan coverage of the search box, in spite of its small size. By mid-afternoon, we had about covered all of the area and were attempting to make a pass right down the middle of the length of the search box. The winds had picked up out of the northwest and the current was sufficient to make it impossible to go less than 2.5 to 3 knots, so we stopped the operation.

What we needed was to have the fish much closer to the bottom. During the morning and early afternoon, we had been discussing the possibility of resurrecting a piece of the 1/2" cable that had been cut by the prop and then recovered. The idea was to make it into an extension that could be added to the bottom of the current chain/electrical conducting cable combo. Our inability to tow effectively during the mid-afternoon made this option imperative if we were to continue the search. A piece of the 1/2" cable about 60 m long was selected. A fundamental decision had to be made about whether to continue using the 100 kHz channel or to switch to the 500 kHz channel. Only one channel could be operated at a time because the wire did not have enough conductors. We decided to continue using the 100 kHz channel, because of the experience already gained in looking at its records and because of the uncertainty about the functionality of the 500 kHz after the loss and recovery of the fish. We were also uncertain about how well we would be able to control the depth of the fish and the 500 kHz system needed to be closer to the bottom than the 100 kHz system. Tom Crook and Dave Lavolvo set about to splice in the underwater connectors needed at both ends. This was a time consuming process because each of the eight wires had to be traced and the right pins on the connectors had to aligned with the cable wires. Once the connectors and wires were matched and temporarily put together, the system had to be checked for continuity and the fish hooked up to test to see if it was operating properly. Only then could the making of water tight splices begin. In the process of disassembling the existing cable harness used to connect the fish to the electrical cable, Crook and Lavolvo discovered there was water in at least one of the underwater splices. The whole process took the two of them about 4 hours.

While Crook and Lavolvo were making the cable extension, Mark Benfield, Duncan McGehee, and Wiebe were processing the data from the day's side-scan runs. We got the navigation data from the ships log (which is written to files at 1 minute intervals in 4 hour long time blocks). Wiebe worked on getting these data into a form that would allow us to plot the side-scan tracklines while McGehee and Benfield got data from the side-scan records about target time, size, distance away from the fish, etc. By early evening we had our tracklines plotted and were able to specify the location in our search box of the possible BIOMAPER sightings. What we were looking for were places where more than one sighting occurred on the different tracklines. The poor quality of the side-scan recordings and the lack of really strong sightings made this more of an exercise than a realistic appraisal of the where BIOMAPER might rest.

About 2100 hours, the work was complete and we had an additional 60 m of conducting cable to add to the approximately 110 m long spare cable. Another 1 1/2 hours were spent setting the newly configured system up on the deck ready for deployment,. To attach the fish to the 1/2" wire and to connect this wire to the chain/cable combo, we used Killam's grips (This is a kind of Chinese finger - a meter-long piece of braided polyester line that has an eye to which a shackle can be attached and 4 long flat straps that are wound, one at a time, around the wire in alternating opposite directions. The end of the grip is secured with tape.).

Although we were anxious to get back into the water and re-start the search, we realized that we had been going since early morning and it would be better to rest and get an early start in the morning.

Monday: We had planned to get up at 0430 and be in the water and surveying by 0530, but daylight savings time got us. The clocks were changed forward at 0100, but few knew this change was coming. Wake-up calls were issued as if we were still on the eastern standard time and so we lost an hour.

Deployment started about 0630. The A-frame was positioned so that the sheave was just aft of the fan-tail with the 200 lb weight and end of the chain to which it was attached sitting on the deck. By hand, we first put the fish into the water and let the !/2" cable out. Then, the A-frame was moved outboard and the TSE winch was used to deploy the chain and conducting wire. At 5 to 10 m intervals, Benfield and McGehee used tie-wraps and electrical tape to secure the conducting cable to the chain. By 0700, we were on our first run. We were able to put the system as close to the bottom as we needed and were getting much better records. Still, there was a lot of distortion in the record due to ship heave in many of the runs. We elected to use the 250 m range and needed to have the fish flying between 25 and 35 m above the bottom. A few minutes later, we decided to switch to the 150 m range and fly the fish even closer to the bottom. This we were able to accomplish most of the time. Over the course of the morning, we had covered much of the Northwestern end of the search box and part of the southeastern section. We scrutinized each emerging side-scan run looking for hard (black) objects and associated shadows that might be BIOMAPER. On some runs, targets were observed and marked; on others no targets were seen.

We had to keep an eagle eye on the depth of the fish especially, in the turns, to make sure that it did not sink down and run into the bottom. Whenever it looked as though the fish was getting too close, we asked for increased speed and also used the winch to pull in some chain and conducting wire.

By early afternoon, we had covered most the area with the 150 m range and had a number of possible sightings. We still had not managed to get a run straight up the center of the long axis of the search box. While we were lining up to attempt this run, the ship made a particularly tight turn and the fish started to head for the bottom. The bridge was informed and an urgent request for increased ship speed issued. At the same time, we started hauling in on the chain/cable combo. In spite of our efforts, the altitude of the fish went to zero for about 10 to 15 second and then lifted off the bottom. With great relief, we saw that the system was still producing good side-scan images of the bottom and continued on with the work along the intended course.

One area of special interest was where we thought we had seen a target in about the same place on more than one pass was in the northern end of the search box. So for the last pass, we decided to set the scanning range to 100 m to see if we could get better resolution on the previously observed targets. Unfortunately, nothing of immediate significance stood out.

At 1400 hours, time had run out and we needed to steam back to the top of the Bank for additional CTD work before returning to port. We hauled the system back on board and dissembled the gear. By 1500 hours we were headed for the top of the Bank.

The rest of the afternoon and evening was spent working on processing the data and examining the side-scan sonar records. Plots of the positions of each of the tracklines and the possible sightings were made. Several sightings did overlap and require additional study to see how well they actually overlap.

Several oceanographic elements worked both for us and against us in this search. The weather worked in our favor. The seas were moderate and the winds were mostly less than 10 to 15 kts during the periods of the side-scan work. On the other hand, the prevailing current was out of the northeast and was usually about 2 knots and made ship handling along most tracklines very difficult. The ship could not hold position over a point on the bottom better than to within 60 to 100 m, which was not good enough for ROV operations. Hence, we were not able to deploy the ROV for either sector scanning sonar surveys of particular locations or for pick up of BIOMAPER had we determined its probable location sooner.

While we have returned from this cruise without an exact position of BIOMAPER, we have several excellent prospective locations which can be the start of a future search with a more powerful ROV or the JSL DSRV.