Open access • Report • DOI:10.2172/188562

# Acoustic Doppler current profiling from the JGOFS Arabian Sea cruises aboard the RV T.G. THOMPSON: TN043, January 8, 1995--February 4, 1995; TN044, February 8, 1995--February 25, 1995; TN045, March 14, 1995--April 10, 1995; TN046, April 14, 1995--April 29, 1995 — Source link

C.N. Flagg, H.S. Kim, Y. Shi

**Published on:** 01 Sep 1995

BNL-62352



# Acoustic Doppler Current Profiling from the JGOFS Arabian Sea Cruises Aboard the RV T.G. THOMPSON

**TN043, January 8, 1995 - February 4, 1995**

**TN044, February 8, 1995 - February 25, 1995**

**TN045, March 14, 1995 - April 10, 1995**

**TN046, April 14, 1995 - April 29, 1995**

by

Charles N. Flagg, Hyun-Sook Kim and Yan Shi
Oceanographic and Atmospheric Sciences Division
Department of Applied Sciences
Brookhaven National Laboratory
Upton, NY

September 1995

DEPARTMENT OF APPLIED SCIENCE

BROOKHAVEN NATIONAL LABORATORY
UPTON, LONG ISLAND, NEW YORK 11973

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Printed in the United States of America
Available From
National Technical Information Service
U.S. Department of Commerce
5285 Port Royal Road
Springfield, VA 22161

NTIS price codes:
Printed Copy: A06; Microfiche Copy: A01

## Table of Contents

## List of Figures

**Figure 9.** Diagnostic profiles of ensemble averaged a) zonal vertical shear, b) meridional vertical shear, c) vertical velocity, d) error velocity, e) backscatter intensity, f) percent good for underway and on station ADCP data taken along the main JGOFS transect on cruise TN044 (see Figure 6). 22

**List of Tables**

# 1. Introduction

Acoustic Doppler current profiler (ADCP) data from the R/V T.G. THOMPSON is part of the core data for the U.S. JGOFS Arabian Sea project along with hydrographic and nutrient data. Seventeen cruises on the THOMPSON are scheduled to take place between September 1994 and January 1996, Table 1. (The cruises on the THOMPSON are numbered consecutively from the ship's commissioning with the first JOGFS cruise designated TN039.) This is the second in a series of data reports covering the ADCP data from the Arabian Sea JGOFS cruises TN043 through TN046. The first data report presented results from cruises TN039 through TN042 (Flagg and Shi, 1995).

All but the first cruise have been or will be staged from Muscat, Oman. Seven of the cruises, referred to as process cruises, follow the standard cruise track, Figure 1, making hydrographic, chemical and biological measurements. The remainder of the cruises which are for the deployment and retrieval of moored equipment and towing of a SeaSoar take place generally within the region defined by a set track. Each cruise is scheduled for a duration of between two weeks and one month.

ADCP data are being collected on all the JGOFS Arabian Sea cruises using an autonomous data acquisition system developed for ship-of-opportunity cruises. This system, referred to as the AutoADCP, makes it possible to collect the ADCP data without the constant monitoring usually necessary and assures constant data coverage and uniform data quality. The AutoADCP system is an extension of RD Instrument's DAS version 2.48 using enhancements made possible with "user-exit" programs. Because of the AutoADCP system, the JGOFS cruises do not have a person on board dedicated to the ADCP. Rather, the ship's technicians provide general monitoring for hardware and/or software problems and retrieve the data at the end of the cruises. Because of this arrangement the technicians on the THOMPSON have an important and critical role in the success of the JGOFS ADCP data set. The ADCP configurations used for the data collection are the result of experience, consultation with other JGOFS investigators, and testing during the calibration and training cruise, TN039.

This data report presents ADCP results from the second group of four JGOFS cruises, TN043 through TN046, concentrating on the data collection and processing methods. The ADCP data itself reside in a CODAS data base at Brookhaven National Laboratory and is generally available to JGOFS investigators through contact with the authors. The CODAS data base and associated ADCP processing software were developed over a number of years by Eric Firing and his group at the University of Hawaii. The CODAS software is shareware available for PC's or Unix computers and is the single most widely used ADCP processing program for ship mounted units.

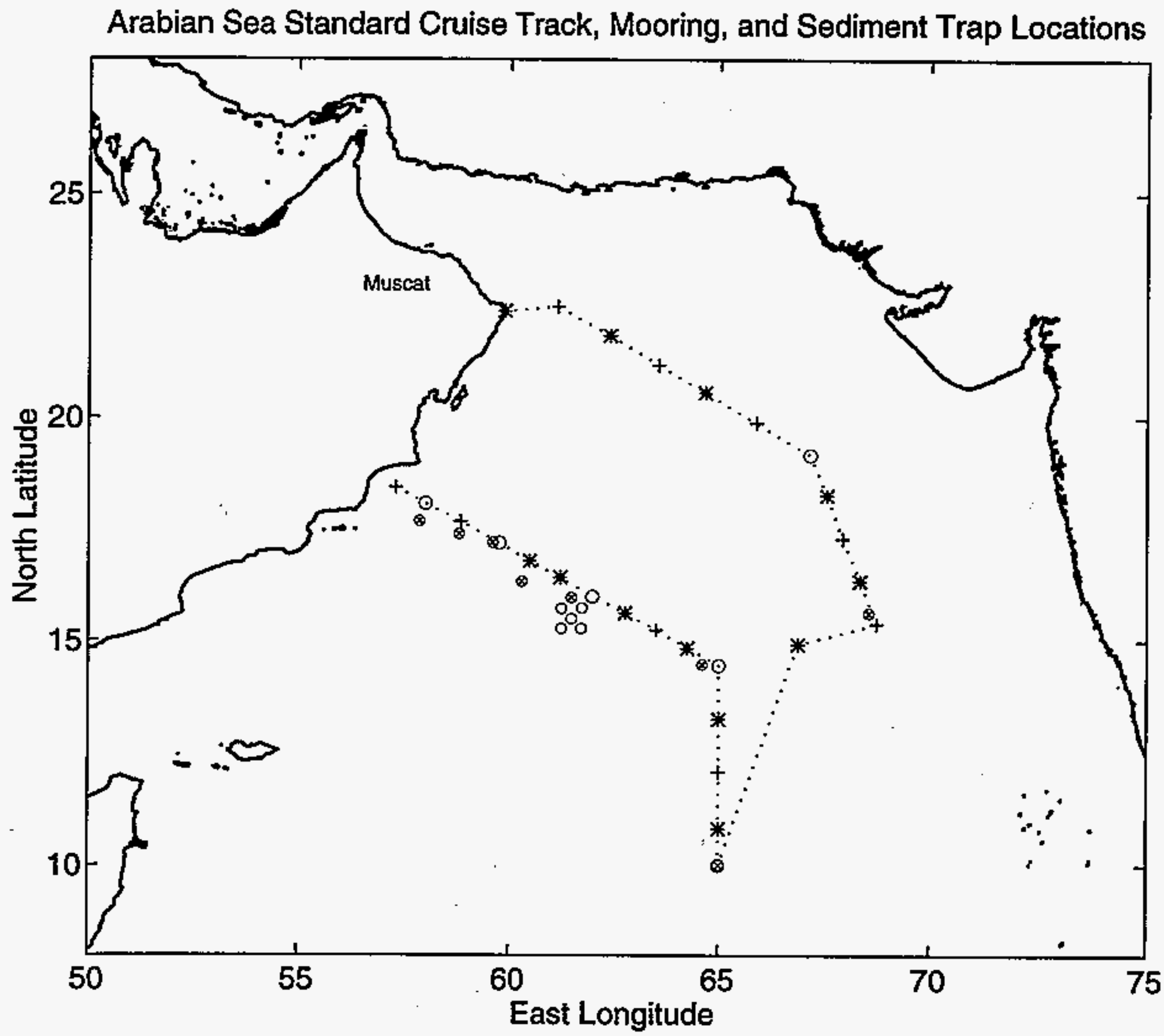



Figure 1: Arabian Sea standard cruise track with the station locations repeating for the process cruises, and an array of current meter moorings: The o, +, and * indicate, respectively, long, intermediate and hydro stations. The symbol o designates sediment trap moorings. The smaller circles centered about 15.5°N, 61.5°E represent the locations of the five long-term moorings.

## 2. ADCP Installation on the R/V THOMPSON

### 2.1 ADCP Hardware

The ADCP used on the R/V T.G. THOMPSON is a 153.6 kHz ADCP, model VM-150, manufactured by RD Instruments of San Diego, CA. The ADCP was sent to RD Instruments for a complete overhaul and calibration in June/July 1994 just prior to the commencement of the JGOFS program. The four-beam concave ADCP transducer, serial number 127, is mounted in a faired transducer pod that protrudes below the hull of the THOMPSON by about two feet such that the depth of the transducer is nominally 5.9 meters (19 feet). The transducer pod eliminates, or at least reduces, the impact of bubble-sweep-down on the ADCP. The transducer is exposed directly to the sea. Experience with this installation during the relatively calm conditions of the first eight cruises indicates that this is an excellent installation producing high quality data at all ship speeds. The impact of high waves on ADCP performance is unknown at present although the ability to produce high quality data is now being tested severely during the JGOFS monsoon cruises. The ADCP deck unit is installed in the THOMPSON's computer lab in a computer rack above a sub-bottom depth sounder. The temperature of the deck unit with the depth sounder operating was measured to be 30° Celsius on TN039. While the computer lab of the THOMPSON is air-conditioned, there are occasional large variations in temperature that may be alter the deck unit's operating environment. The ADCP deck unit is plugged into the ship's uninterruptable power supply where the AC voltage measured at the outlet on TN039 was 117 volts.

On the R/V T.G. THOMPSON, the AutoADCP programs have been installed on two PC computers, both of which are connected by a Pathworks network to virtual disks on a DEC 5000-200 Unix workstation. In September 1994, one of the THOMPSON's PCs (a Delphi 286) was set up to collect the data, while a PC supplied by Brookhaven (a Dell 310) was used for real-time presentation of the results. The AutoADCP programs were installed on both computers so that the data collection could be switched to the Brookhaven PC if the primary PC suffered a failure.

Standard ADCP data is displayed on the THOMPSON's Delphi 286. The presentation consists of 5-minute ensemble averaged profiles of U (zonal) and V (meridional) velocity, AGC (backscatter intensity) and percentage of good pings. In addition to the data gathering performed by the AutoADCP system, another set of programs was written in MATLAB to present ADCP data in real-time. These programs run on the second computer, the Dell 386, and make use of the networked virtual disk that is common with the AutoADCP system to access the most recent pingdata files. The real-time displays include vertical sections of U (zonal) velocity, V (meridional) velocity and range corrected backscatter intensity. The usual setup displays the last 12 hours of ADCP data, updating the display at 15 minute intervals.

## 2.2 AutoADCP Data Acquisition System

ADCP data is being collected on the R/V T.G. THOMPSON throughout the Arabian Sea JGOFS project. To insure that the best possible data is obtained and to minimize interference with other program components, a modification to RD Instrument's data acquisition system for narrow-band ADCPs, DAS 2.48, is used, enabling autonomous operation. This capability was developed previously in a collaboration among Brookhaven National Laboratory, the University of Rhode Island and RD Instruments. The program expands upon the standard DAS's capabilities making it possible to automatically start and stop the collection of the data and to change the configuration of the DAS depending upon the ship's location. The AutoADCP system is also designed to make back-up copies of the pingdata files and provides a means of restarting the system if for any reason the DAS locked-up.

The major component of the system is a "user-exit" program named FLAG.EXE. This program is called up at the end of each ADCP ensemble, determines the ship's position, and compares it with pre-defined regions, Figure 2. When the ship leaves one region for another, the DAS's configuration file is updated, the computer reboots, and starts pinging using the new configuration. Provision has also been made for a watchdog timer and automatic backup of pingdata files each time a file is filled. The utility of the AutoADCP DAS is that ensemble interval, number of bins, bin and pulse size, bottom tracking, and other configuration parameters can be controlled without an on-board operator monitoring the DAS's performance. This makes for a more consistent and robust data set.

In order for the ADCP's data acquisition system to collect the data it is necessary to define the desired system configuration in the file START.CNF. The AutoADCP system determines the appropriate region by comparing the ship's position with the regions defined in the POSITION.DAT file. If necessary, a configuration for the new region is copied into the START.CNF file and the PC is rebooted. Most of the data in the program was obtained using the configuration for the northern Arabian Sea. The ARABSEA.CNF file is shown in Table 2.

In addition, the system includes the WOCE standard enhancements to the DAS with another "user-exit" program, UE4.EXE, which was developed by Eric Firing's group at the University of Hawaii. This program is designed to improve upon some features of RD Instruments' DAS software. The most important element is that UE4 records the position of the ship at either end of the ensemble rather than as the average position during the ensemble. This allows for a more precise computation of the ship's velocity during an ensemble. The UE4 program has been expanded recently so that it now works with Ashtech's GPS attitude sensor that uses phase differential GPS to determine the ship's heading. The Ashtech heading data is not only more accurate than the ship's gyro compass, but also immune to the latitudinal speed and turning errors that degrade gyros. However, because the Ashtech heading data can have gaps, the primary heading information for the ADCP retains the gyro compass. The recorded Ashtech heading data is used on a post-cruise basis to adjust the compass heading as needed.

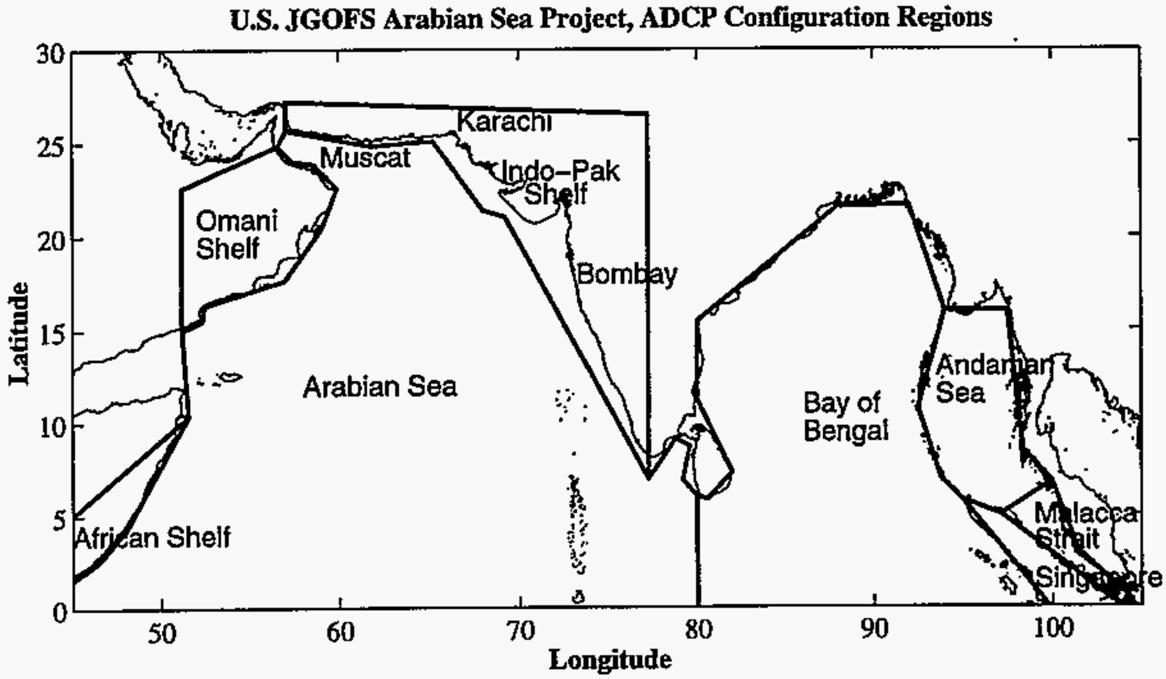



Figure 2: The ADCP regions of the Arabian Sea, Bay of Bengal, and western portion of the Indonesian Archipelago, which dictate control over the operation of the ADCP withconfiguration file. The configuration regions include possible ports of call and the continental shelves as well as the open ocean of the Arabian Sea and Bay of Bengal.

The Ashtech receiver was available for cruise TN044. The unit died on TN045 and has only recently been reinstalled on the THOMPSON for cruise TN049.

A third user-exit program, AGCAVE.EXE, modifies the way the DAS collects acoustic backscattered intensity data. Without the addition of this program, the DAS records the intensity (which used to be called amplitude) data as a single profile composed of the average of all four beams. This degrades the intensity data because without calibration, the individual beams produce slightly different profiles. To address this problem and to allow for post-cruise calibration of the intensity data, AGCAVE was developed. The program forms ensemble averaged profiles for each beam and stores the results separately in the pingdata data file location reserved for "last AGC".

These are the main programs in the Autonomous ADCP DAS system so that it only requires an occasional check to insure that the hardware is still functioning. At the end of each cruise the pingdata files have been copied to a SyQuest removable hard disk and sent to Brookhaven National Laboratory for processing.

### 2.3 Navigation

Navigation information for the THOMPSON was provided by a GPS satellite navigation system. The intent was to use a P-code GPS receiver for the JGOFS cruises. However, permission to use the more accurate system was delayed and the P-code receiver was not used during the first four cruises of the program (Flagg and Shi, 1995). Finally the receiver was made operational in January, 1995 in preparation for cruise TN043 and has been working successfully for cruises TN043 through middle of cruise TN046 (Appendix B). The improvement in the navigation quality due to the P-code receiver is significant and quite obvious during the processing of the ADCP data (see below).

The use of the P-code data was controlled by the UE4 configuration file where the P-code data stream was set as the primary navigation source. The position data from the Ashtech receiver, when it was available, was used as a back up. The UE4 user-exit program reads the navigation data contained in the NEMA "GGA" message at the end of the ensemble and records the result in the "user buffer" area. With the P-code receiver in the system, the laptop computer used to reformat of the "GGA" message during the earlier cruises was no longer used. The UE4 program also maintained the PC clock to within 2 seconds of the GPS time provided in the GGA message.

Relative accuracy of ensemble end-point positions during the first four cruises using the C/A GPS code receiver had an rms value of about 33 meters for both latitude and longitude. Starting with cruise TN043 the THOMPSON was able to use a P-code GPS receiver. This has made a large difference in navigational accuracy. The change in navigational quality is most visible in the initial estimates of the reference layer velocities where there has been a factor of four to five reduction in the short-term variance suggesting a similar reduction in rms short-term position accuracy. During the ADCP data processing the navigation fixes are smoothed (Appendix B) to lessen the effects of the quasi-random navigation errors. With the P-code GPS receiver the required smoothing to produce high quality results is significantly less.

### 2.4 Compass

The primary heading data for the ADCP was provided by the THOMPSON's gyro compass. Both the latitude and speed corrections for the compass were daily/regularly updated by bridge personnel depending upon the ship's activities (Bill Martin, personal communication). When the ship stops on station, the gyro is apparently set to zero. On cruise TN044 the compass was augmented with an Ashtech GPS attitude sensor which provided a data stream that could be used during post processing to reduce errors inherent to gyro compasses. The Ashtech operated only for a day on TN045.

## 3. Data Processing and Analysis

The binary pingdata files from each cruise were processed on a Silicon Graphics Indy workstation using the ship-board ADCP processing programs developed by the ADCP group at the University of Hawaii. These programs consisted of two parts, a set of processing programs and a data base system called CODAS (Common Oceanographic Data Access System) written in C, and a series of MATLAB analysis routines for post-processing and plotting the ADCP velocity and backscatter data. The CODAS routines were augmented to handle the backscatter intensity data in keeping with the methods developed by Flagg and Smith (1985) and Flagg, et al. (1994).

### 3.1 Velocity

The binary pingdata files were first scanned to produce listings of the headers and ADCP configurations for each of the pingdata files and to extract the GPS navigation data contained in the user-buffer area. Using the header listings as a guide to the appropriate ADCP profiles, the ADCP data in the pingdata files were loaded into a separate CODAS data base for each cruise. The editing of the data started with a determination of parameters to flag complete ADCP profiles or portions of profiles. The basic editing parameter was the percent good determined by the ADCP and recorded along with the velocity data. The minimum percent good was set to 30 percent. There were four other editing parameters that were also used: The first was a bottom search criterion that is the difference between the minimum backscatter intensity and a subsequent maximum. Most of the JGOFS Arabian cruise time has been spent in waters considerably deeper than the ADCP's range so this parameter was often ignored. In shallower water bottom tracking was used which also determined the bottom depth and that data was used to edit the ADCP profiles for bottom interference. The second flagging parameter was the error velocity, the difference between the vertical velocity calculated by the transducer pairs. The third parameter was the variance of the vertical velocity over the entire profile. The last editing parameter was the second difference (ie. $\propto \partial^2/\partial z^2$) in the vertical and horizontal velocity components. Collectively, these parameters flag interference from the bottom, from instrumentation suspended from the ship, from large aggregations of fish or scatterers and other, possibly anomalous, behavior.

Each velocity and backscatter profile were examined visually and in light of the flagging parameters. On the whole, the ADCP data from these cruises was very clean. The vertical diel migration of euphausids and mictofids often caused high vertical velocity variances and false bottom indications. Generally, profiles that showed this vertical migration were kept in the data set. One of the more notable features of this data set was the dramatic effect that diel migration had on the range of the ADCP. During daylight hours when the plankton were at depth the ADCP easily reached 350 to 400 meters but during the night when the plankton were in the upper layer the range often decreased to 200 to 250 meters. On cruise TN039, increasing the ADCP's acoustic output power at night by increasing pulse length (to 32 m) did not effect the range to any noticeable degree. Apparently, there were simply no scatterers left behind in the mad rush out of the low-oxygen layer and up into the food (and predator) containing layers.

Calibration of the ADPC's orientation and velocity scaling was accomplished using data collected on a 29 hour run up the Malacca Straits during the calibration and training cruise, TN039, when bottom tracking was enabled. During this time the ship had an average speed of about 13 knots (6.75 m/s) and an average heading of 308°. A least square fit between the ship's track determined from the bottom track velocities and that determined from the GPS positions indicated that the transducer had a rotation offset of 1.53° and an amplitude scale factor of 1.000. Subsequently, the ADCP calibration was checked on another bottom track run along the continental shelf south of Oman during cruise TN039 and using water tracking on cruise TN041. From the three hour run along the Oman shelf where the ship was steaming at 4.4 knots on a heading of 261°, the rotation correction was 1.29° while the scale factor was 1.006. The water tracking calibration from TN041 used about 85 right-angle turns produced during several rectilinear patterns made while the ship was making SeaBeam bottom surveys. The water track calibration resulted in a scale factor of 0.999 and rotation correction of 1.39°. While all the calibration runs yielded similar values, we have used the coefficients from the bottom track run up the Malacca Straits since that section covered a long distance under nearly ideal conditions.

During the second cruise in this series, TN044, Frank Bahr changed the heading offset in the ADCP configuration files from 45° to 43.5° to account for the miss-alignment and improve the real-time output. Thus, the ADCP data from TN043 were rotated 1.53° in the data base while no extra rotation was done for cruises TN045 and TN046.

Cruise TN044 made use of the Ashtech attitude data recorded by the UE4 user-exit program. For each ensemble the UE4 program determines, among other things, the ensemble average difference between the ship's compass and the Ashtech heading based upon approximately one second sampling, recording the result in the user buffer portion of the pingdata files. During processing of the ADCP data, a file is created with the angular differences which are used to rotate the velocity vectors for each ensemble. The mean offset during TN044 between the Ashtech and the ship's compass was -3.17°, ranging from a minimum offset of -1.8° to a maximum of -4.4°. This procedure corrects for the various compass errors but leaves the ADCP angular data relative to new reference frame. It was therefore necessary to determine the angular offset of the Ashtech antennae relative to ADCP using the bottom tracking. Bottom track data from a 7.5 hour run near the end of cruise TN044 along the Omani shelf covering a distance of about 100km, resulted in an angular offset of 3.314°. The data from the cruise were then rotated by this amount. Note that this correction and the mean difference between the compass and the Ashtech are nearly equal and of opposite sign.

Once the ADCP profiles were edited and the velocities scaled and rotated, the navigation data, extracted from the user-buffer, were combined with reference layer velocities to produce smoothed versions of the ship's track and absolute reference layer velocities. In deep water the reference layer spanned bins 5 to 20 (46 to 166 meters) while in the shallower waters of the Oman shelf the reference layer was defined as bins 3 to 8 (30 to 70 meters). The smoothing of the reference layer velocity was done using a Blackman window convolution filter (Bahr, Firing and Songnian, 1989) with a width of one hour. This filter has a half-power point at about 20 minutes corresponding to a distance of about 8 km at 13 knots. The smoothed reference layer velocity was then added to the ship's velocity relative to the reference layer to produce a smoothed version of the total ship's velocity. The displacements calculated from the smoothed ship's velocity were then fit to the position data to yield a smoothed cruise track. The smoothed reference layer velocities and positions were then loaded into the data base. At this point in the processing the velocity data in the CODAS data base was ready to be extracted for plotting and analysis.

### 3.2 Acoustic Backscatter Intensity

Backscatter intensity data, in terms of digital counts from each of the ADCP's four transducers, were loaded into the CODAS data base directly from the pingdata files along with the velocity data. In addition, two blank variables, CALIB_AMP and ZOOP_BIOMASS, were also loaded into the data base to make room for parameters will be calculated later. Calibrating the intensities from each of the beams and combining them to produce a single calibrated intensity profile for each ensemble is the first step in processing backscatter intensity. The calibration procedure is based upon the method outlined in RD Instruments' technical bulletin ADCP-90-04 issued in December 1994 that attempts to determine the absolute value of the volume reverberation, $S_v$, from each depth bin. The calibration equation for $S_v$ for each beam is:

$$S_v = 10\log_{10}\left(\frac{4.47\times10^{-20}\, K_2\, K_s (T_x+273)(10^{K_c(E-E_r)/10}-1)R^2}{c\,L\,K_1\,10^{-2\alpha R/10}}\right), \qquad (1)$$

where the K's are calibration coefficients, c is the speed of sound at the transducer, m/s, L is the pulse length, m, $T_x$ is the transducer temperature, °C, $\alpha$ is the sound absorption coefficient, dB/m, R is the slant range, m, $E_r$ is the intensity reference level, and E is the echo intensity level. Both E and $E_r$ are given in terms of counts. Two of the constants, $K_1$

and $K_2$, are determined by RD Instruments during instrument checkout. $K_1$ is the power sent to the transducer and is given by:

$$K_1 = K_{1c}\left(\frac{1.397\,V_s - 4.27}{37.14}\right)^2, \tag{2}$$

where $V_s$ is the measured rms AC voltage supplied to the deck unit, 117 v, and the values of $K_{1c}$ supplied by RD Instruments for the THOMPSON for beams 1 to 4 are:

| Beam | $K_{1c}$, Watts |
|---|---|
| 1 | 5.424 |
| 2 | 5.647 |
| 3 | 6.609 |
| 4 | 6.172 |

The system noise factors, $K_2$, also supplied by RD Instruments for the THOMPSON for beams 1 to 4 are:

| Beam | $K_2$ |
|---|---|
| 1 | 2.158 |
| 2 | 2.244 |
| 3 | 1.854 |
| 4 | 2.183 |

The conversion factor, $K_c$, from ADCP counts to measured intensity in dB is given by:

$$K_c = 127.3 / (T_e + 273), \tag{3}$$

where $T_e$ is the temperature of the deck unit on the THOMPSON which was 30°C when measured. The reference thermal transducer noise, $E_r$, for the beams is given by:

$$E_r = E_{rc} + (292 + 0.133\,T_e)(1-a) + (27.3 + 0.1\,T_x)(1-b), \tag{4}$$

$$a = \frac{T_e + 273}{T_{ec} + 273}, \quad b = \frac{T_x + 273}{T_{xc} + 273}, \tag{5}$$

where $E_{rc}$ is the measured reference thermal noise and $T_{ec}$ and $T_{xc}$ are the deck unit and transducer temperatures at the time when $E_{rc}$ was measured. For the THOMPSON data the values of $E_{rc}$ for each beam were taken to be the minimum backscatter counts values recorded during the entire first cruise, minus one count to avoid numerical problems with calculating logarithms. $T_{ec}$ was taken to be 30°C while the values of $E_{rc}$ and $T_{xc}$ for the THOMPSON were:

| Beam | $E_{TC}$, counts | $T_{XC}$, °C |
|---|---|---|
| 1 | 12 | 28.4 |
| 2 | 15 | 28.1 |
| 3 | 17 | 28.7 |
| 4 | 16 | 27.2 |

The absorption coefficient is given by Urick (1982) as:

$$\alpha=\left(1.86\times10^{-2}\,S\,f_t\left(\frac{f^2}{f_t^2+f^2}\right)+2.68\times10^{-2}\left(\frac{f^2}{f_t}\right)\right)\left(\frac{1-6.54\times10^{-4}P}{914.4}\right), \tag{6}$$

where P is the pressure in atmospheres, $f$ is the frequency of the ADCP which is 153.6 kHz for the ADCP on the THOMPSON and

$$f_t=21.9\times10^{\left(6-\frac{1520}{(T_x+273)}\right)}. \tag{7}$$

The absorption coefficient for each bin is the average value between the transducer and the bin because the pressure term has a noticeable effect and needs to be included. The transducer temperature is clearly not the correct value except near the transducer itself but at this point we have not attempted to refine this value further by using CTD cast results.

This procedure brings the four acoustic beams into close, but not perfect agreement. Typically over the normal range of variability, the beams might differ by one to two dB. As a result, we have taken an ad-hoc approach to insure that over the length of a section or cruise all the beams will yield the same average backscatter profile. This secondary correction is done using the linear transformation:

$$S_{vc}=a_0+a_1\,S_v, \tag{8}$$

where the scaling and offset factors for each beam relative to the mean profile are determined by least squares.

In the past this has been a straight forward procedure but in the Arabian Sea there was enough biological patchiness that when the ship was on station a single beam occasionally indicated substantially larger concentrations of scatterers than the others. Under these circumstances, scatter plots of a single beam's return versus the average of all four beams showed enough scatter to adversely influence the least square calculations. To distinguish those profiles with large inter-beam variations, we calculated the rms difference of each profile relative to the mean from all four beams. An examination of the time dependence of the rms difference showed that high values were exclusively associated with period when the ship was on station. The reverse was not necessarily the case. From this behavior we surmise that the distribution of plankton and/or fish can be patchy on the scale of one to two hundred meters, the distance the beam spread at a range of one to two hundred meters. Thus, when the ship is still the anomalous scatterers can remain within a beam for a significant portion of an ensemble and increase the recorded backscatter intensity. Figure 3 shows a plot of backscatter intensity differences between beam 1 profiles and beam averaged profiles when the rms intensity differences were greater than 1.5 dB. (This plot was generated before the secondary corrections were applied which leads to a positive mean offset.) The figure shows that the large beam discrepancies are confined to the ADCP's mid-range, between bins 12 and 32. These bins correspond to depths between 114 and 274 meters spanning the thermocline in the Arabian Sea and the depths over which the oxygen concentrations decrease to very small values. It would appear that there are individual large fish, schools of smaller fish, or plankton patches that tend to congregate in and just above the thermocline perhaps waiting to feed on the upward migrating meso-planktonic euphausids and mictophids.

Having determined a plausible explanation for the anomalous intensity values, we were able to edit the profiles and include only those whose rms intensity differences were less than or equal to 1 dB. The secondary correction factors, determined using an edited set of profiles from the calibration and training cruise, TN039, were:

| Beam | $a_0$, dB | $a_1$ |
|---|---|---|
| 1 | -1.6387 | 0.9991 |
| 2 | -0.2789 | 0.9983 |
| 3 | 0.9646 | 0.9954 |
| 4 | -0.0794 | 0.9926 |

During the processing, the ensemble averaged backscatter profiles are combined to form a single profile for each ensemble. For those ensembles where the rms intensity differences relative to the mean are greater than 1 dB, indicating contamination from anomalous scatterer densities, the averaged profiles are set to nulls. A comparison of the a single beam's backscatter results relative to the average from all the beams after secondary correction has been applied, is shown in Figure 4.

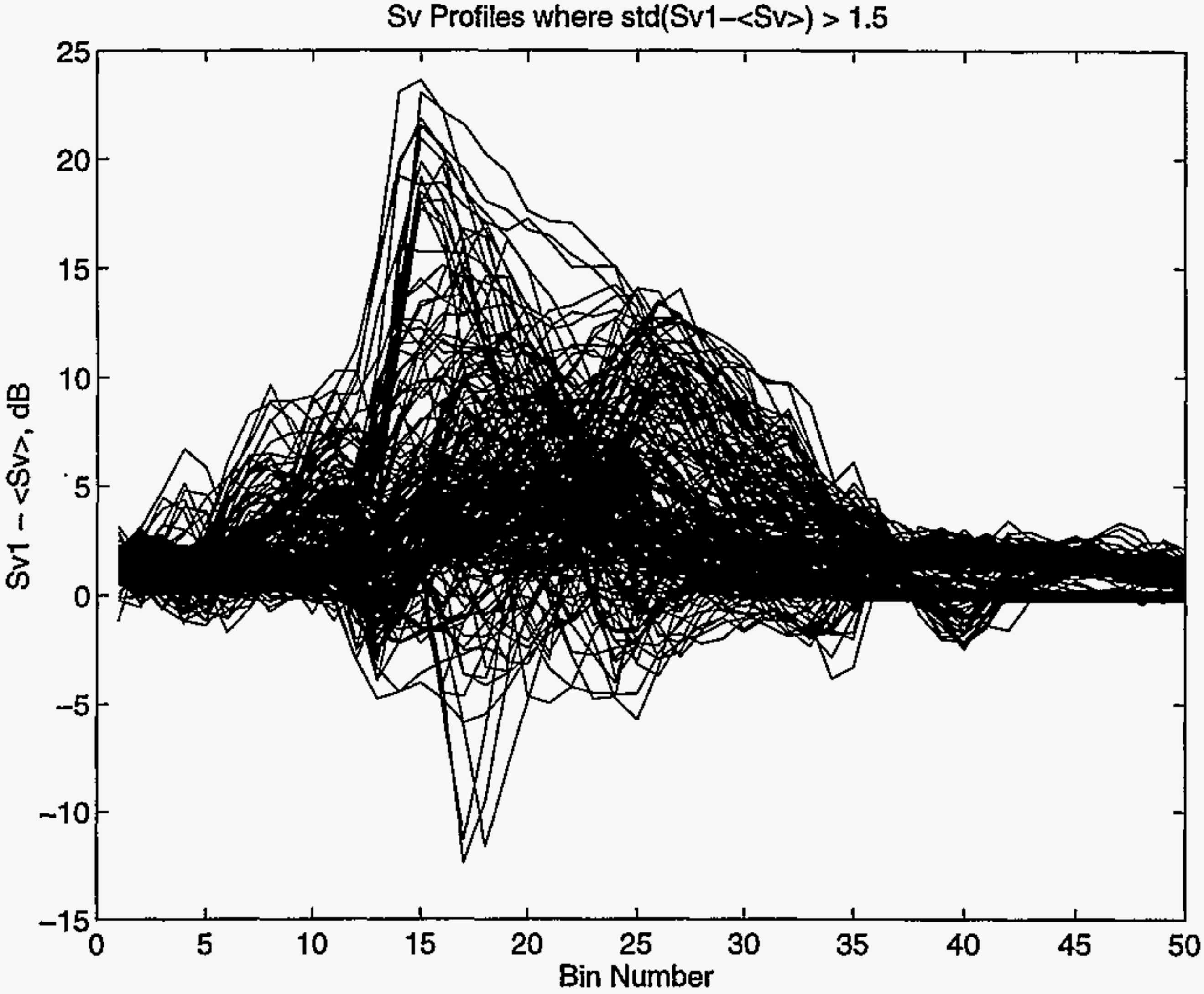



Figure 3: Plot of the difference between the partially calibrated backscatter intensities from Beam #1 and the mean intensities from all four beams when the rms difference was greater than 1.5 dB. The data was taken from cruise TN039. The occurrence of these relatively large differences is restricted to periods when the ship is on station. It appears to reflect inhomogeneities in the small-scale distribution of fish and/or plankton. The bin length is 8 meters and the first bin is centered at a depth of approximately 22 meters.

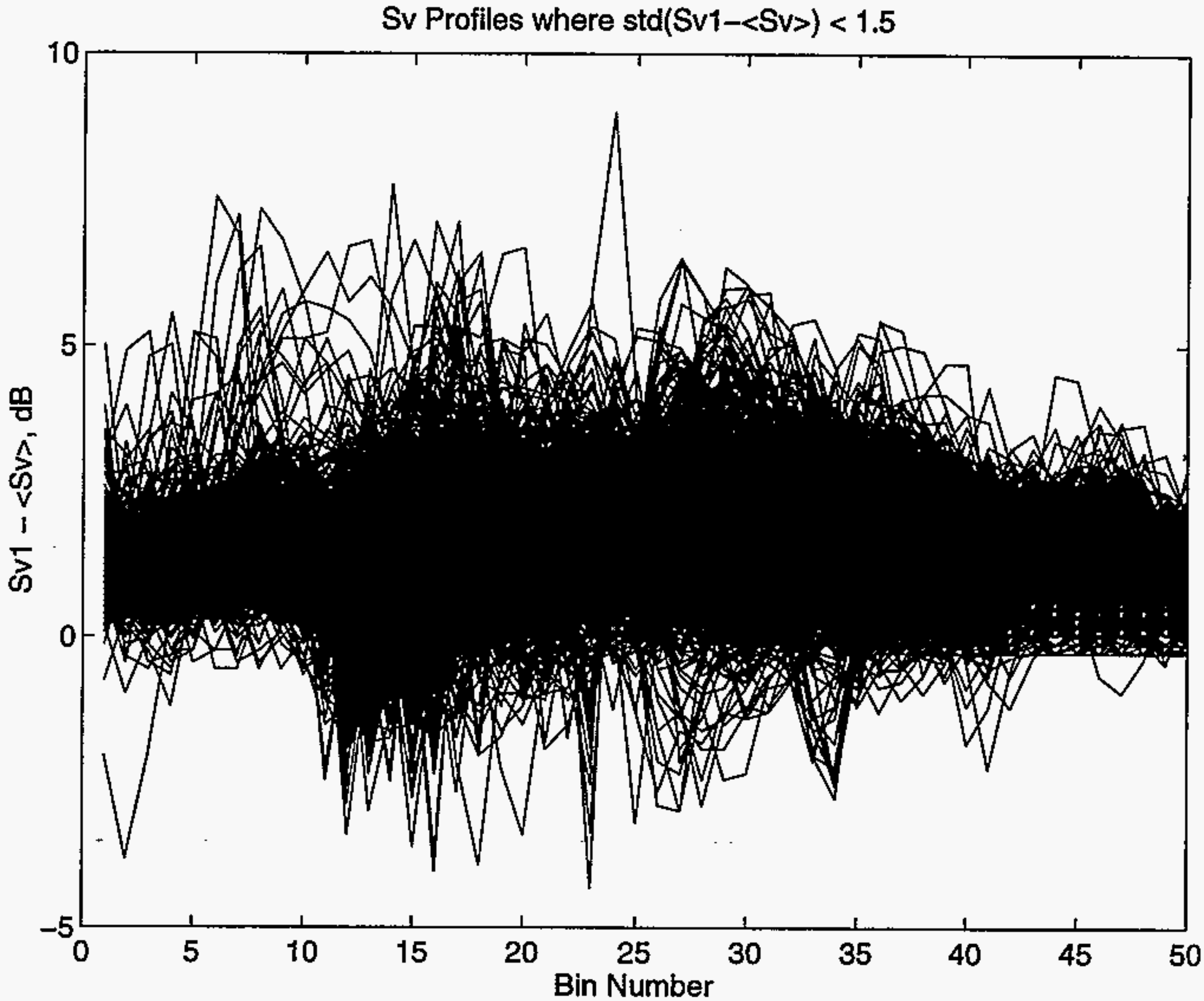



Figure 4: Scatter plot of the alibrated backscatter intensity from Beam #1 versus the average calibrated intensity from all four beams from profiles where the rms differences between the individual beams and the beam-averaged profiles were less than or equal to 1.0 dB.

# 4. Data Collection

## 4.1 TN043

This cruise was the first of the JGOFS process cruises and was intended to cover the early part of the northeast monsoon. The ship left Muscat on January 8, 1995, proceeded clockwise around the standard JGOFS cruise track, and returned to Muscat on February 4, 1995, Figure 5. Mike Roman was the chief scientist and Mike Realander was the ship's technician responsible for monitoring the ADCP system. Mike Realander installed the connection between the new P-code GPS receiver and the ADCP's data acquisition system on this cruise, removing the laptop PC that had been acting as an interface with the ship's standard GPS system. The ADCP worked successfully throughout the cruise using the P-code GPS receiver for navigation.

## 4.2 TN044

This cruise was the second of the ONR/NRL SeaSoar cruises. The THOMPSON left Muscat on February 8, 1995 and returned earlier than planned on February 25, 1995 because of problems with one of the Z-drives, Figure 6. Ken Brink was the chief scientist and Bill Martin was the ship's technician responsible for monitoring the ADCP system. The Ashtech GPS attitude unit was installed for the first time on the THOMPSON for this cruise although it took considerable effort on Bill Martin's and Frank Bahr's parts to accomplish this. There was a delay in getting the Ashtech on-line so that the ADCP data with enhanced directional data started February 12, 1995. Bill Martin and Frank Bahr also modified the UE4 configuration file so that the Ashtech data would be properly processed and recorded. In addition, Frank Bahr changed the heading offset in the configuration files to correspond to the offset we had determined earlier from bottom track and water track calibration runs.

## 4.3 TN045

The start of this cruise was delayed because of the problem with the THOMPSON's propulsion system. At the end of TN044 the THOMPSON transited to a shipyard in Abu Dubai passing through the Straits of Hormus. We managed to get the ADCP turned on for at least part of this repair cruise and that data is included with the TN045 data set. Cruise TN045 itself, the second of the JGOFS process cruises, departed Muscat on March 14, 1995, proceeded clockwise around the JGOFS standard cruise track and returned to Muscat on April 10, 1995, Figure 7. John Marra was the chief scientist for this inter-monsoonal cruise while Mike Grogan was the ship's technician responsible for monitoring the ADCP system. The Ashtech unit died after the first day on this cruise and so we reverted to the earlier method for dealing with the heading data.

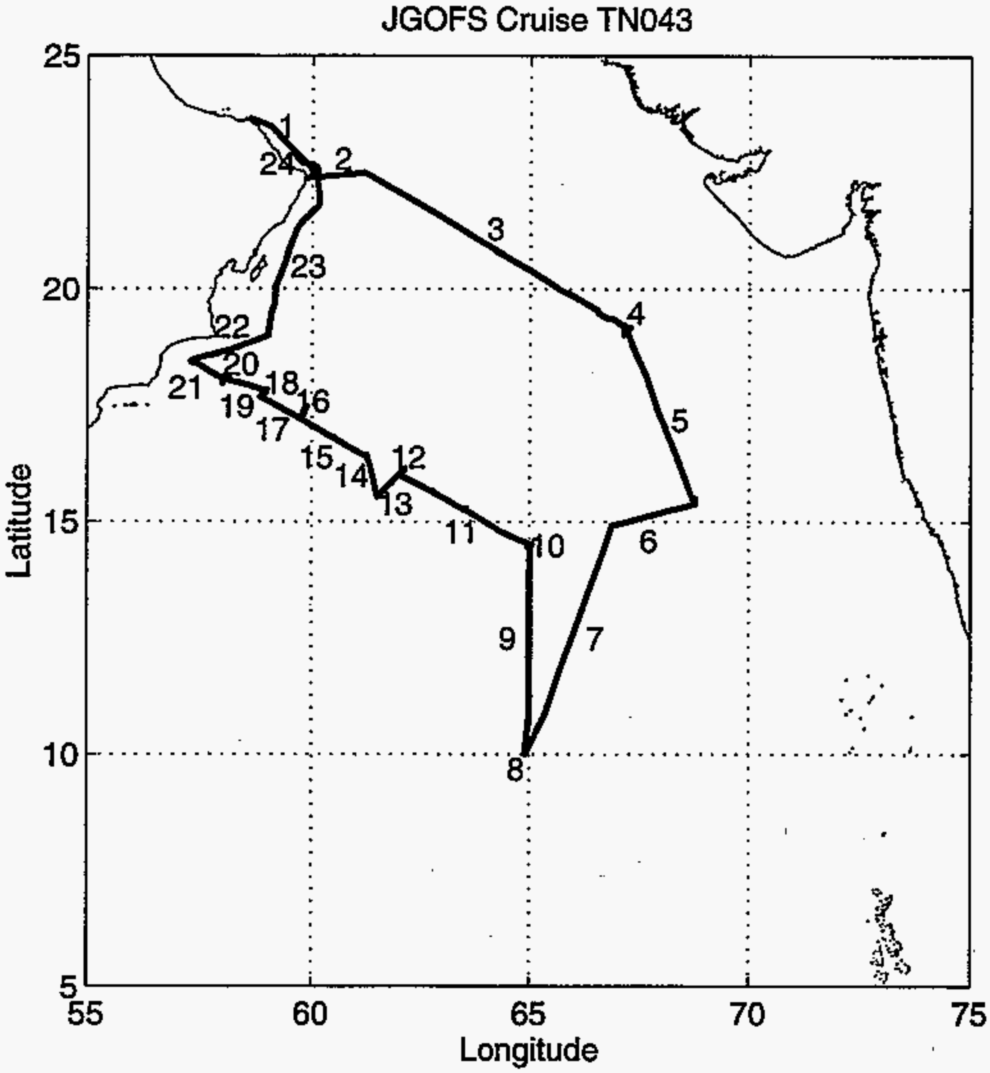



Figure 5: Cruise map of the northeast monsoon JGOFS process cruise, TN043. The RV T.G. Thompson left Muscat on January 8, 1995 and returned on February 4, 1995. Numbers along the track represent sections and stations for vector and contour plottings which are shown in Appendix C. The corresponding positions and the start and end of times are tabulated in Appendix A.

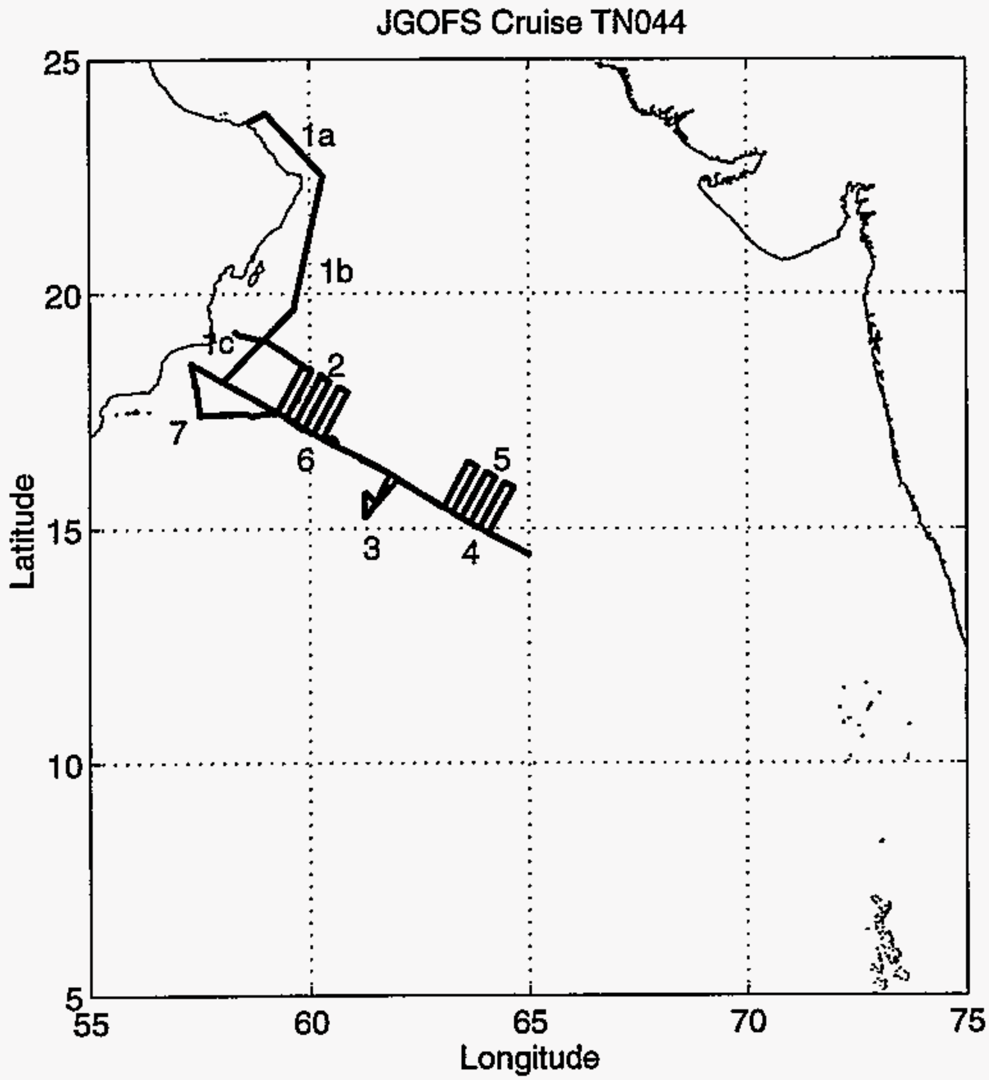



Figure 6: Cruise map of the second ONR/NRL SeaSoar cruise, TN044. The RV T.G. Thompson left Muscat on February 8, 1995 and returned on February 25, 1995. Below is the same as Figure 5.

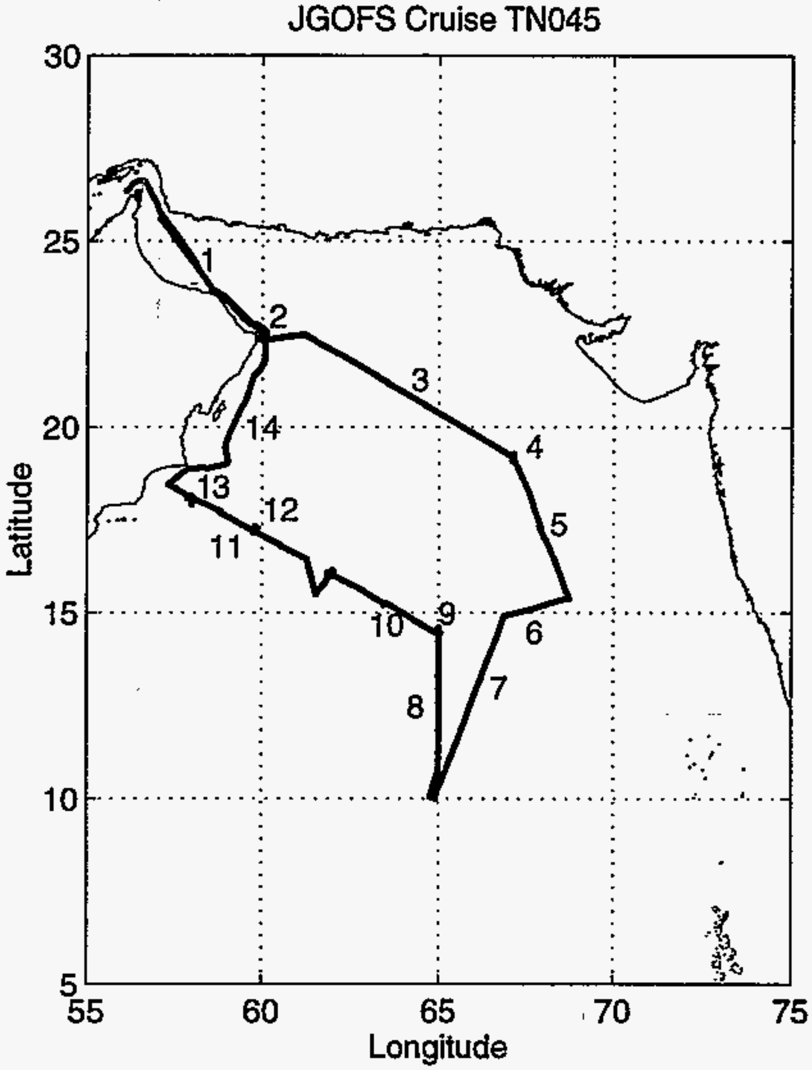



Figure 7: Cruise map of the second ONR/NRL SeaSoar cruise, TN045. Included in this cruise is the deviation to Abu Dubai for repairs between February 28 and April 13, 1995. The RV T.G. Thompson left Muscat for the process cruise itself on March 14 and and returned on April 10, 1995. Below is the same as Figure 5.

### 4.4 TN046

The purpose of cruise TN046 was to recover and redeploy the current meter and surface meteorological array centered at 15° 30'N, 61° 31'E, Figure 8. On the return leg from the mooring site the ship ran northwest toward the coast and then alongshore to the northeast. The THOMPSON left Muscat on April 14 and returned on April 29, 1995 with Bob Weller as chief scientist and Bill Martin as the ship's technician responsible for monitoring the ADCP. The ADCP worked well throughout middle of the cruise using the P-code GPS receiver but without the Ashtech.

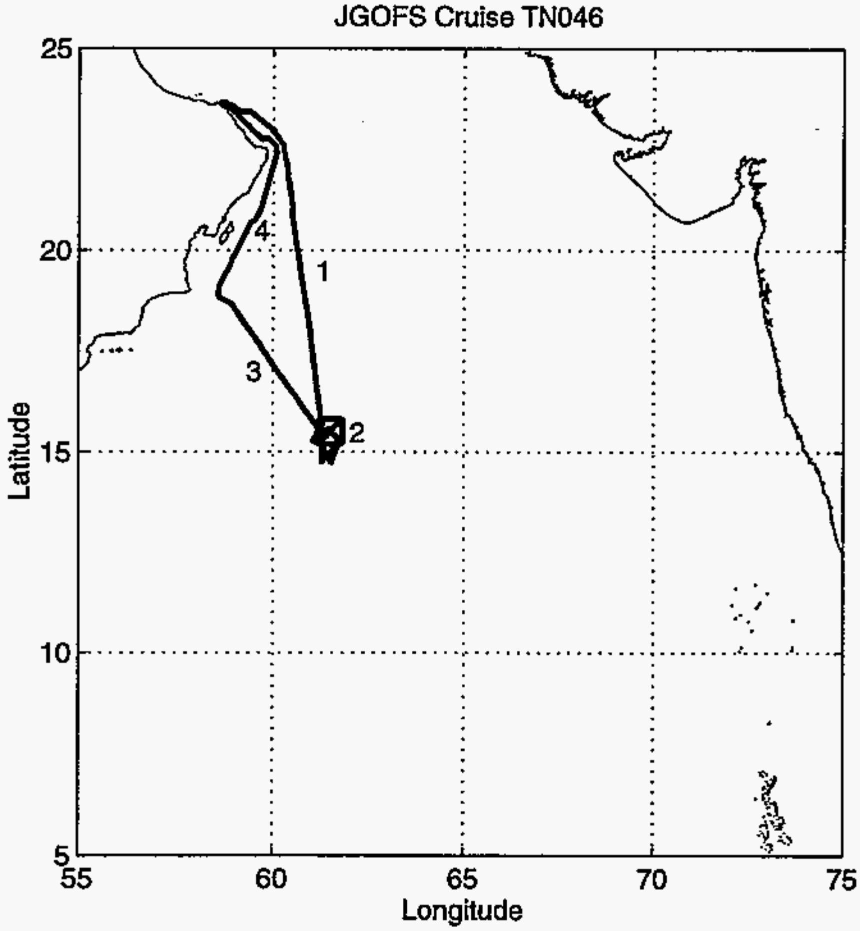



Figure 8: Cruise map of the second ONR/NRL SeaSoar cruise, TN046. The RV T.G. Thompson left Muscat on April 14 and returned on April 29, 1995. Below is the same as Figure 5.

## 5. Profile Quality

In processing the ADCP data, a set of diagnostic products are routinely produced. Typically, the cruise is broken into sections along the track or subsections of special interest. The diagnostic products include separate underway and on station profiles of averages and standard deviations of horizontal velocity shear (first differences), vertical velocity, error velocity, backscatter intensity, and percent good, based upon the ensemble data. In general, analysis of these results show the same acceptable behavior for all the cruises examined so far. Cruise TN044 where both the P-code GPS receiver and Ashtech attitude sensor are available is of special interest because that data set should be of the highest quality possible with current technology. The quality parameters for that cruise, however, do not indicate significant differences, at least in terms of vertical shears and the suite of diagnostic variables, relative to the other cruises.

Illustrating the results of the data quality analyses are plots from TN044 during the period when the THOMPSON took hydrographic stations and steamed along the main JGOFS transect. Along this transect 833 ensembles were extracted while the ship was on-station (< 1.5 m $s^{-1}$) and 401 ensembles while the ship was underway (>5.0 m $s^{-1}$). The weather was calm during the cruise so the results reflect the data processing, geometry of the ADCP's transducers and flow regime generated by the ship itself. (The effect of the heavy weather during the monsoon periods will be assessed from later cruises.) This section is characterized by vigorous currents, up to 0.4 m $s^{-1}$, whose direction varies from southwest to northeast. Both velocity components usually have a shear zone between 100 and 200 m depth although in some places coherent structures extend to 400 m. As on all the other cruises, this transect is characterized by large diel plankton migrations which reduced the ADCP's range from almost 400 meters during the day to 200 to 250 meters during the night.

The first difference vertical shear diagnostics of Figures 9a,b are intended to illustrate those portions of the profile affected by misalignments of the tracking filters possible near the surface, in regions of high shear and in regions of low return signal. However there is relatively small vertical shear in the horizontal velocity components, distributed between 100 and 300 m, it does not seem to cause any filter tracking problems. Despite fluctuations in the ADCP's range due to the diel scatterer migration it does not appear to be any tracking filter induced; notwithstanding noise bias is evident in the deeper bins. Near the surface there is significant shear in the upper couple of bins which is particularly noticeable in the zonal underway data. It would appear that at least some of this is due to flow distortions caused by the ship itself while underway. Other than near the surface, there is very little difference between the mean profiles generated when the ship was underway and those when the ship stopped. The shear standard deviation profiles for both components indicate increase in variability below 200 to 300 m, which coincides with the maximum ranges of night profiles. The percent good criteria used in accepting velocity results ($\geq$ 30 %) eliminates those portions of the profiles which at the extreme range generate this high shear standard deviations. Overall, looking at data from this section and others, it seems that the choice of blanking interval of

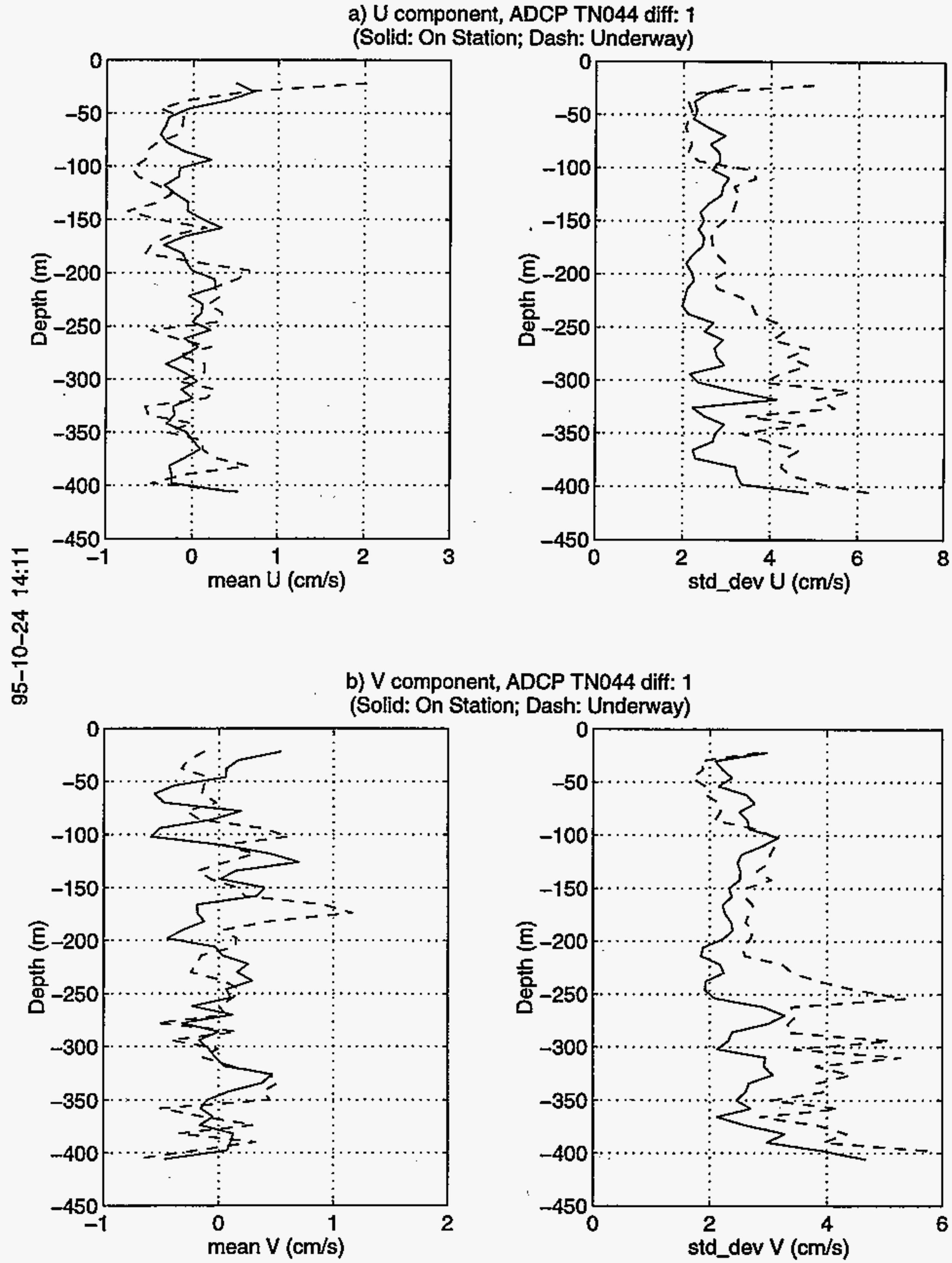
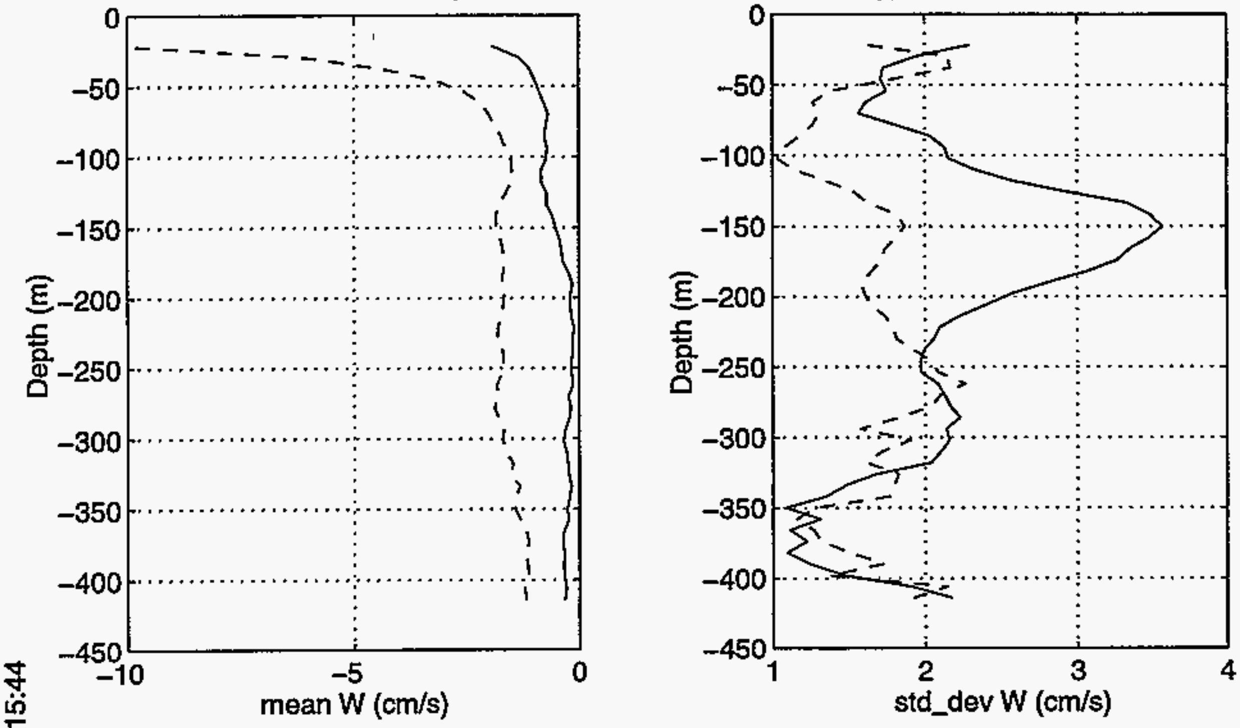


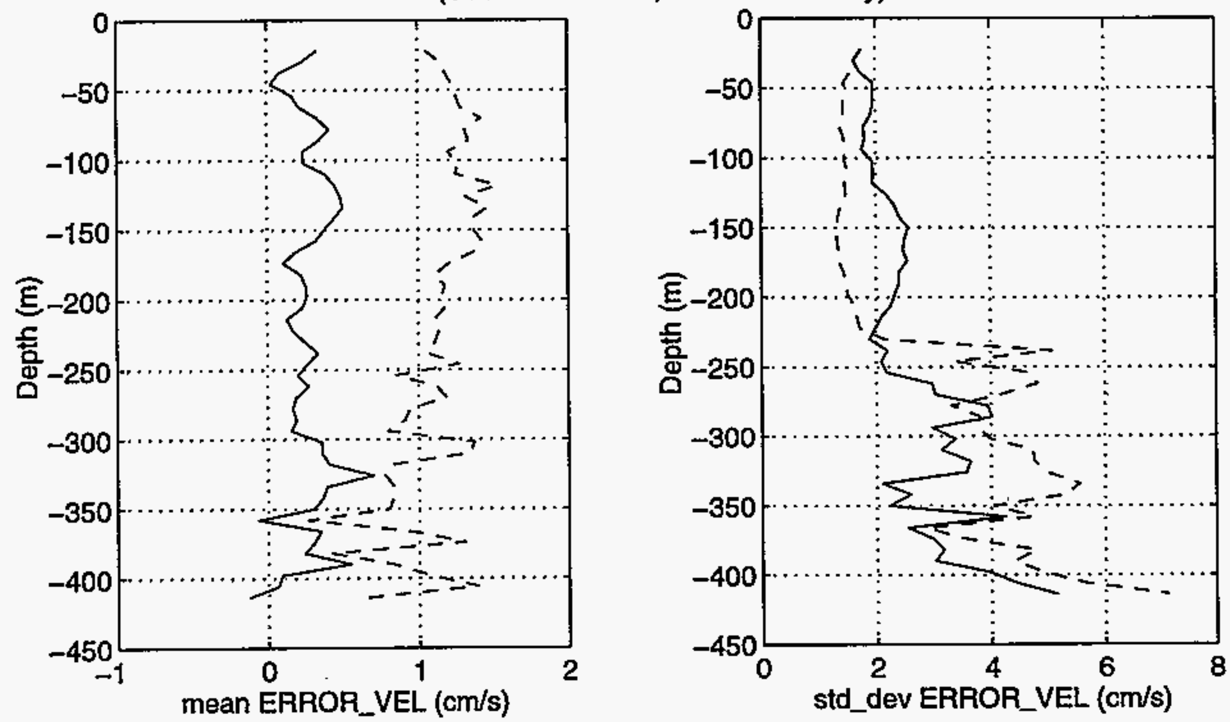

Figure 9: Diagnostic profiles of ensemble averaged a) zonal vertical shear, b) meridional vertical shear, c) vertical velocity, d) error velocity, e) backscatter intensity, f) percent good for underway and on-station ADCP data taken along the main JGOFS transect on cruise TN044 (see FIgure 6).

c) W component, ADCP TN044
(Solid: On Station; Dash: Underway)

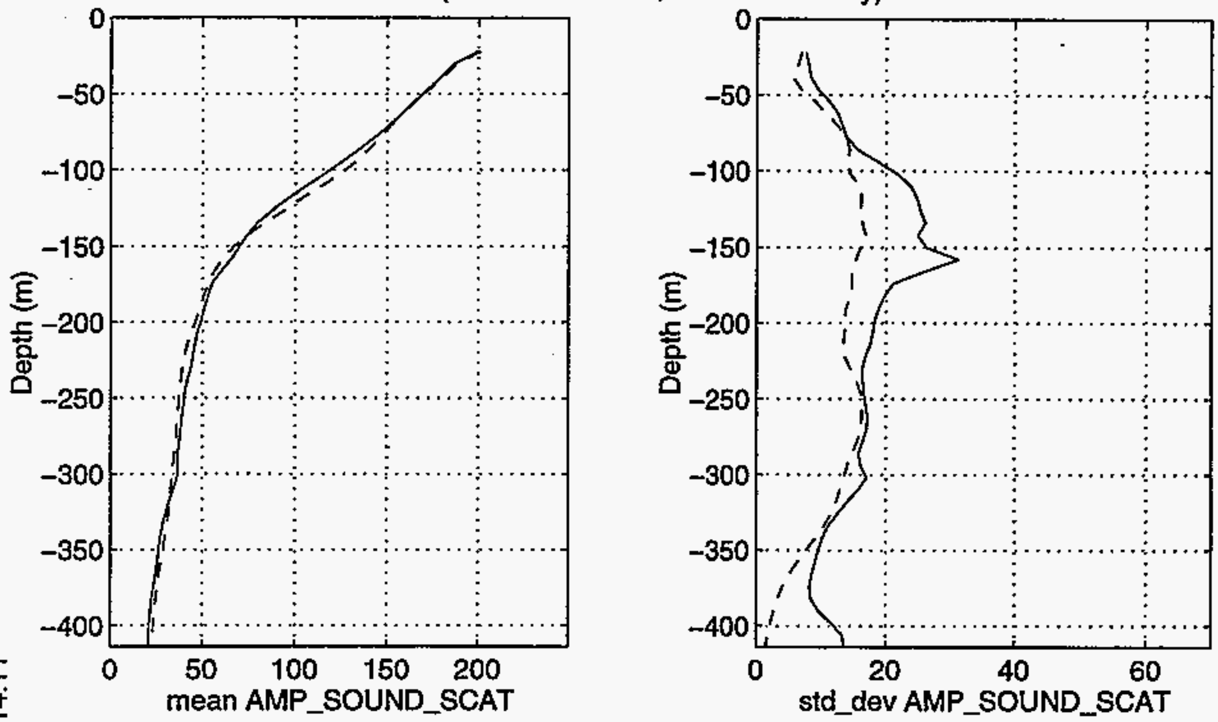



95-10-24 15:44

d) ERROR VELOCITY, ADCP TN044
(Solid: On Station; Dash: Underway)

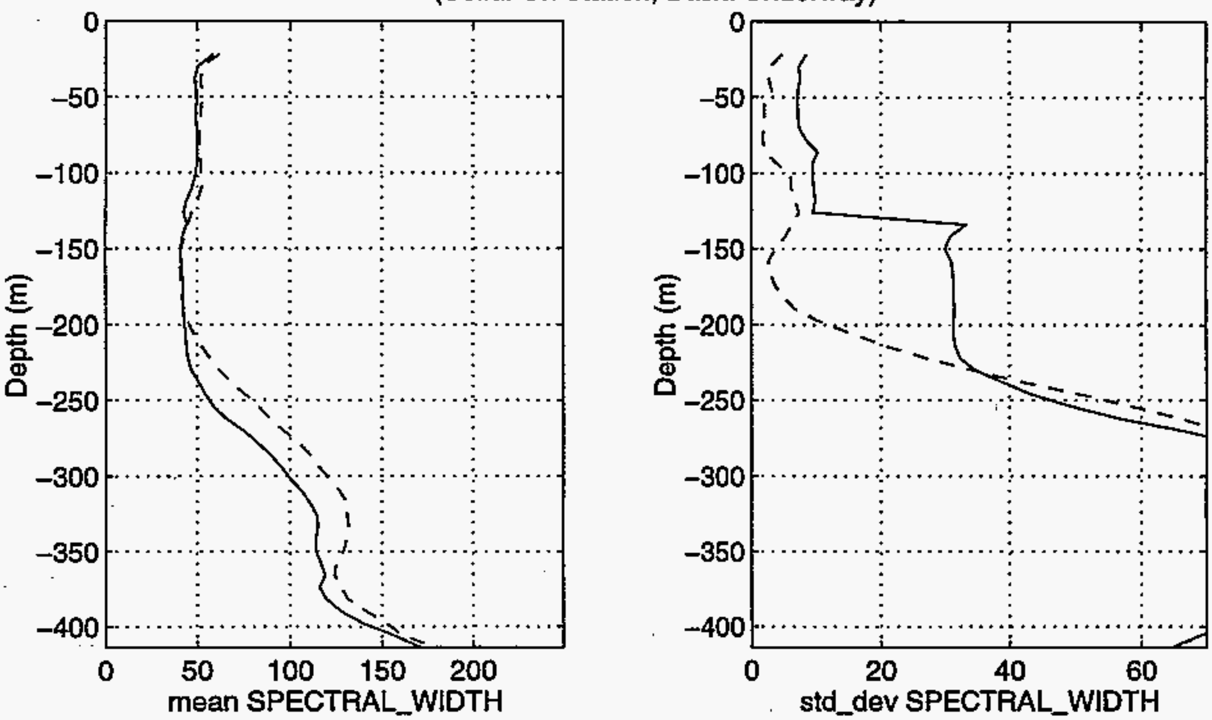


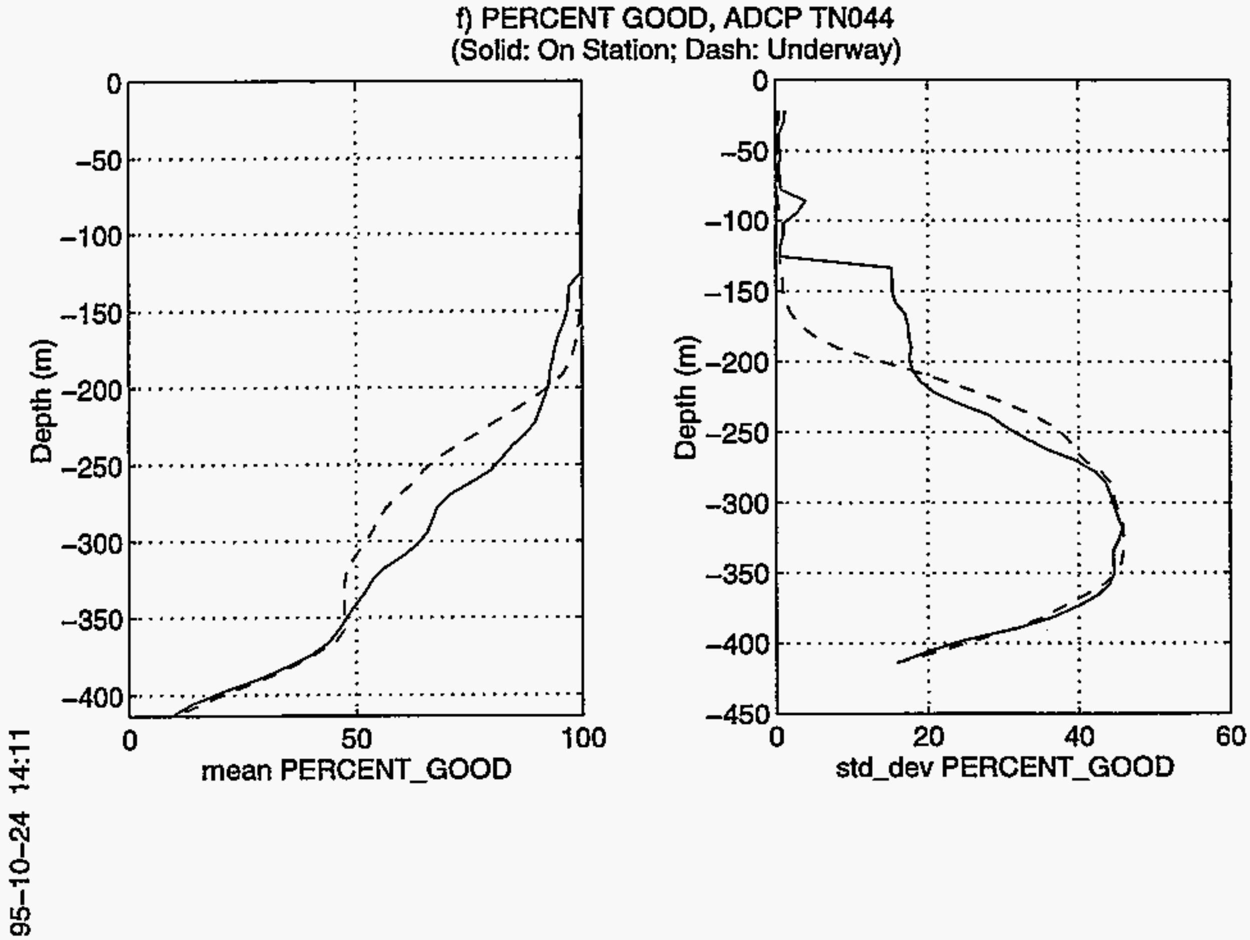
e) AMPLITUDE, ADCP TN044
(Solid: On Station; Dash: Underway)




95-10-24 14:11

SPECTRAL WIDTH, ADCP TN044
(Solid: On Station; Dash: Underway)





f) PERCENT GOOD, ADCP TN044
(Solid: On Station; Dash: Underway)
Depth (m)
0
−50
−100
−150
−200
−250
−300
−350
−400
0
50
100
mean PERCENT_GOOD
Depth (m)
0
−50
−100
−150
−200
−250
−300
−350
−400
−450
0
20
40
60
std_dev PERCENT_GOOD
95−10−24 14:11

4 meters and filter tracking direct command, B009001, are adequate for the THOMPSON's ADCP.

The vertical ,W, and error, E, velocities are expected to be fairly small, and significant deviations would indicate misalignment of the transducers either relative to the vertical or between themselves. The profiles of average underway and on station vertical velocities, Figure 9c, show that below about 75 m they are relatively small, but that there is an increase of about -1.2 cm $s^{-1}$ when the ship was underway. (Due to an error in plotting similar velocity plots in the first Arabian Sea ADCP data report, the vertical velocities are plotted relative to the mean between bins 5 and 20.) An 1 cm $s^{-1}$ average vertical velocity could be caused by a 0.1° angular offset from the vertical which indicates that the THOMPSON runs on a remarkably even keel. The vertical velocity while the ship was underway is large negative in the upper 50 meters, and decreases nearly exponentially with depth. When the ship was on-station the vertical velocity is generally small and negative near the surface. This behavior of the vertical velocity is a common aspect of ship-mounted ADCPs. Although the cause has not been definitely determined, probably it is a result of the flow field about the ship's hull. The standard deviation of the vertical velocity shows significant depth dependence and differences between on station and underway time periods. The reason is unclear although it may reflect day-night differences in the periods covered by the underway and on station data subsets in the presence of diel migration.

The profiles of the error velocity and its standard deviation, Figure 9d, are small and generally constant with depth. The error velocity is the difference between vertical velocity estimates from orthogonal pairs of beams. On the THOMPSON the ADCP is oriented so that the axes defined by the beam pairs are aligned about 45° from the fore and aft ship axis. When the ship is on station the error velocity is nearly zero while it is about 1 cm $s^{-1}$ when the ship is underway.

The average backscatter intensity (aka amplitude) profiles, in terms of digital counts, for both underway and on-station conditions, Figure 9e, shows the usual large decrease with depth. These averaged profiles are not filtered using a percent good criterion and include all ensembles selected for this section. Without range correction, the backscatter intensity profiles accentuate the upper water column. The standard deviation profiles indicate maximum variability between 100 and 300 m reflecting the planktonic diel migration under which a large proportion of the plankton rises from their daytime depths around 300 meters to the upper 100 meters during the night.

The percent good profiles, Figure 9f, indicates that highly reliable data covered the upper two hundred meters, but below that, the range was subject to the effects of diel migration. During the night the effective range of the ADCP in the northern Arabian Sea during these cruises was generally not more than 250 meters. We experimented with doubling the pulse lengths to 32 meters during cruise TN039 to see if we could increase the range during the night without achieving any measurable effect.

## 6. Acknowledgments

We would like to express our appreciation for the assistance of George White, Mike Realander, Bill Martin, Mike Grogran and the THOMPSON's crew in the initial set up the ADCP system and in the continuing data collection. We also got significant help from Eric Firing and Frank Bahr at early stages in the program, especially Frank Bahr who has checked on the AutoADCP system and helped the Ashtech receiver available during his cruises. Eric Firing and Julie Renada were also very helpful during the installation of the CODAS processing system on our Unix computer.

## References

Flagg, C.N. and Y. Shi, 1995. Acoustic Doppler Profiling from the JGOFS Arabian Sea Cruises Aboard the RV T.G. THOMPSON, TN039 through TN042. Brookhaven National Laboratory Data Report, BNL-61633, 153pp.

Flagg, C.N. and S.L. Smith, 1985. On the use of the acoustic Doppler current profiler to measure zooplankton abundance. Deep-Sea Research, 36, 455-474.

Flagg, C.N., C.D. Wirick, S.L. Smith, 1994. The interaction of phytoplankton, zooplankton, and currents from 15 months of continuous data from the Mid-Atlantic Bight. Deep-Sea Research, Part II, 41. 411-436.

Urick, R.J., 1982. *Sound Propogation in the Sea.* Peninsula Publishing, Los Altos, California, 207pp.

**Table 1.** Cruise schedule for the U.S. JGOFS Arabian Sea Project. The bold-faced entries are the cruises covered by this data report.

| Cruise ID | Start Date | End Date | Chief Sci. | Purpose |
|---|---|---|---|---|
| TN039 | 09/20/94 | 10/07/94 | L. Codispoti | Calibration & Training |
| TN040 | 10/11/94 | 10/25/94 | C. Erikson | Mooring Deployment |
| TN041 | 10/28/94 | 11/21/94 | S. Honjo | Sediment Traps & Coring |
| TN042 | 11/28/94 | 12/17/94 | D. Young | SeaSoar Survey #1 |
| **TN043** | **01/08/95** | **02/04/95** | **M. Roman** | **Process Cruise #1** |
| **TN044** | **02/08/95** | **02/25/95** | **K. Brink** | **SeaSoar Survey #2** |
| **TN045** | **03/14/95** | **04/10/95** | **J. Marra** | **Process Cruise #2** |
| **TN046** | **04/14/95** | **04/29/95** | **R. Weller** | **Mooring Turn-Around** |
| TN047 | 05/03/95 | 05/21/95 | J. Dymond | Process Cruise #3 |
| TN048 | 06/21/95 | 07/13/95 | K.Brink | SeaSoar Survey #3 |
| TN049 | 07/17/95 | 08/15/95 | R. Barber | Process Cruise #4 |
| TN050 | 08/17/95 | 09/15/95 | S. Smith | Process Cruise #5 |
| TN051 | 09/18/95 | 10/11/95 | R. Arnone | SeaSoar Survey #4 |
| TN052 | 10/14/95 | 10/25/95 | D. Rudnick | Mooring Retrieval |
| TN053 | 10/28/95 | 11/26/95 | B. Balch | Process Cruise #6 |
| TN054 | 11/29/95 | 12/27/95 | W. Gardner | Process Cruise #7 |
| TN055 | 12/31/95 | 01/19/96 | W. Prell | Sed. Trap Retrieval |

**Table 2.** The listing of the Arabian Sea regional ADCP configuration used for the deep water portion of the U.S. JGOFS Arabian Sea project cruises after the heading offset had been revised to reflect the bottom track calibrations on TN044.

| | |
|---|---|
| AD,SI,HUNDREDTHS | 300.00 Sampling interval |
| AD,NB,WHOLE | 50 Number of Depth Bins |
| AD,BL,WHOLE | 3 Bin Length |
| AD,PL,WHOLE | 16 Pulse Length |
| AD,BK,TENTHS | 4.0 Blank Beyond Transmit |
| AD,PE,WHOLE | 1 Pings Per Ensemble |
| AD,PC,HUNDREDTHS | 1.00 Pulse Cycle Time |
| AD,PG,WHOLE | 25 Percent Pings Good Threshold |
| XX,OD2,WHOLE | 5 [SYSTEM DEFAULT, OD2] |
| XX,TE,HUNDREDTHS | 0.00 [SYSTEM DEFAULT, TE] |
| AD,US,BOOLE | YES Use Direct Commands on StartUp |
| DP,TR,BOOLE | NO Toggle roll compensation |
| DP,TP,BOOLE | NO Toggle Pitch compensation |
| DP,TH,BOOLE | YES Toggle Heading compensation |
| DP,VS,BOOLE | YES Calculate Sound Velocity from TEMP/Salinity |
| DP,UR,BOOLE | YES Use Reference Layer |
| DP,FR,WHOLE | 5 First Bin for reference Layer |
| DP,LR,WHOLE | 20 Last Bin for reference Layer |
| DP,BT,BOOLE | NO Use Bottom Track |
| DP,B3,BOOLE | NO Use 3 Beam Solutions |
| DP,EV,BOOLE | YES Use Error Velocity as Percent Good Criterion |
| DP,ME,TENTHS | 250.0 Max. Error Velocity for Valid Data (cm/sec) |
| DR,RD,BOOLE | YES Recording on disk |
| DR,RX,BOOLE | YES Record N/S (FORE/AFT) Vel. |
| DR,RY,BOOLE | YES Record E/W (FORT/STBD) Vel. |
| DR,RZ,BOOLE | YES Record vertical vel. |
| DR,RE,BOOLE | YES Record error Good |
| DR,RB,BOOLE | NO Bytes of user prog. buffer |
| DR,RP,BOOLE | YES Record Percent good |
| DR,RA,BOOLE | YES Record average AGC/Bin |
| DR,RN,BOOLE | YES Record Ancillary data |
| DR,AP,BOOLE | YES Auto-ping on start-up |
| XX,LDR,TRI | 3 [SYSTEM DEFAULT, LDR] |
| XX,RB2,WHOLE | 192 [SYSTEM DEFAULT, RB2] |
| DR,RC,BOOLE | NO Record CTD data |
| XX,FB,WHOLE | 1 [SYSTEM DEFAULT, FB] |
| XX,PU,BOOLE | NO [SYSTEM DEFAULT, PU] |
| GC,TG,TRI | 1 DISPLAY (NO/GRAPH/TAB) |
| GC,ZV,WHOLE | 4 ZERO VELOCITY REFERENCE (S/B/M/L) |
| GC,VL,WHOLE | -200 LOWEST VELOCITY ON GRAPH |
| CG,VH,WHOLE | 200 HIGHEST VELOCITY ON GRAPH |
| GC,DL,WHOLE | 0 LOWEST DEPTHS ON GRAPH |

| | |
|---|---|
| GC,DH,WHOLE | 200 HIGHEST DEPTHS ON GRAPH |
| GC,SW,BOOLE | YES SET DEPTHS WINDOW TO INCLUDE ALL BINS |
| GC,MP,WHOLE | 25 MINIMUM PERCENT GOOD TO PLOT |
| SG,PNS,BOOLE | YES PLOT NORTH/SOUTH VEL. |
| SG,PEW,BOOLE | YES PLOT EAST/WEST VEL. |
| SG,PVT,BOOLE | NO PLOT VERTICAL VEL. |
| SG,PEV,BOOLE | NO PLOT ERROR VEL. |
| SG,PPE,BOOLE | NO PLOT PERCENT ERROR |
| SG,PMD,BOOLE | NO PLOT MAG AND DIR |
| SG,PSW,BOOLE | NO PLOT AVERAGE SP. W. |
| SG,PAV,BOOLE | YES PLOT AVERAGE AGC. |
| SG,PPG,BOOLE | YES PLOT PERCENT GOOD |
| SG,PD1,BOOLE | NO PLOT DOPPLER 1 |
| SG,PD2,BOOLE | NO PLOT DOPPLER 2 |
| SG,PD3,BOOLE | NO PLOT DOPPLER 3 |
| SG,PD4,BOOLE | NO PLOT DOPPLER 4 |
| SG,PW1,BOOLE | NO PLOT SP. W. 1 |
| SG,PW2,BOOLE | NO PLOT SP. W. 2 |
| SG,PW3,BOOLE | NO PLOT SP. W. 3 |
| SG,PW4,BOOLE | NO PLOT SP. W. 4 |
| SG,PA1,BOOLE | NO PLOT AGC 1 |
| SG,PA2,BOOLE | NO PLOT AGC 2 |
| SG,PA3,BOOLE | NO PLOT AGC 3 |
| SG,PA4,BOOLE | NO PLOT AGC 4 |
| SG,PP3,BOOLE | NO PLOT 3-BEAM SOLUTION |
| SS,OD,WHOLE | 0 OffSet for Depth |
| SS,OH,TENTHS | 43.5 OffSet for Heading |
| SS,OP,TENTHS | 0.0 OffSet for Pitch |
| SS,ZR,TENTHS | 0.0 OffSet for Roll |
| SS,OT,HUNDREDTHS | 45.00 OffSet FOR temp |
| SS,ST,HUNDREDTHS | 50.00 Scale for Temp |
| SS,SL,HUNDREDTHS | 36.00 Salinity (PPT) |
| SS,UD,BOOLE | YES Toggle UP/DOWN |
| SS,CV,BOOLE | NO Toggle concave/Convex transducerhead |
| SS,MA,TENTHS | 30.0 Mounting angle for transducers. |
| SS,SS,HUNDREDTHS | 1500.00 Speed of Sound (m/sec) |
| XX,GP,BOOLE | YES [SYSTEM DEFAULT, GP] |
| XX,DD,TENTHS | 1.0 [SYSTEM DEFAULT, DD] |
| XX,PT,BOOLE | NO [SYSTEM DEFAULT, PT] |
| XX,TU,TRI | 2 [SYSTEM DEFAULT, TU] |
| TB,FP,WHOLE | 1 FIRST BINS TO PRINT |
| TB,LP,WHOLE | 64 LAST BIN TO PRINT |
| TB,SK,WHOLE | 6 SKIP INTERVAL BETWEEN BINS |
| TB,DT,BOOLE | YES DIAGNOSTIC TAB MODE |
| DU,TD,BOOLE | NO TOGGLE USE OF DUMMY DATA |

| | |
|---|---|
| XX,PN,WHOLE | 0 [SYSTEM DEFAULT, PN] |
| DR,SD,WHOLE | 4 Second recording drive |
| DR,PD,WHOLE | 3 First recording drive (1=A:,2=B: ... ) |
| DP,PX,BOOLE | NO Profiler does XYZE transform |
| SS,LC,TENTHS | 5.0 Limit of Knots change |
| SS,NW,TENTHS | 0.5 Weight of new knots of value |
| GC,GM,TRI | 2 GRAPHICS CONTROL 0=LO RES, 1=HI RES, |
| 2=ENHANCED | |
| AD,PS,BOOLE | NO YES=SERIAL/NO=PARALLEL Profiler Link |
| XX,LNN,BOOLE | YES [SYSTEM DEFAULT, LNN] |
| XX,BM,BOOLE | YES [SYSTEM DEFAULT, BM] |
| XX,RSD,BOOLE | NO RECORD STANDARD DEVIATION OF |
| VELOCITIES PER BIN | |
| XX,DRV,WHOLE | 0 [SYSTEM DEFAULT, DRV] |
| XX,PBD,WHOLE | 3 [SYSTEM DEFAULT, PBD] |
| TB,RS,BOOLE | NO SHOW RHPT STATISTIC |
| UX,EE,BOOLE | YES ENABLE EXIT TO EXTERNAL PROGRAM |
| SS,VSC,TRI | 0 Velocity scale adjustment |
| AD,DM,BOOLE | NO USE DMA |
| TB,SC,BOOLE | NO SHOW CTD DATA |
| AD,CW,BOOLE | YES Collect spectral width |
| DR,RW,BOOLE | YES Record average SP.W./Bin |
| DR,RRD,BOOLE | NO Record last raw dopplers |
| DR,RRA,BOOLE | YES Record last raw AGC |
| DR,RRW,BOOLE | NO Record last SP.W. |
| DR,R3,BOOLE | NO Record average 3-Beam solutions |
| DR,RBS,BOOLE | YES Record beam statistic |
| XX,STD,BOOLE | NO [SYSTEM DEFAULT, STD] |
| LR,HB,HUNDREDTHS | 0.00 Heading Bias |
| SL,1,ARRAY5 | 0 1 8 NONE 19200 PROFILER |
| SL,2,ARRAY5 | 0 1 8 NONE 1200 LORAN RECEIVER |
| SL,3,ARRAY5 | 0 1 8 NONE 1200 REMOTE DISPLAY |
| SL,4,ARRAY5 | 0 1 8 NONE 1200 ENSEMBLE OUTPUT |
| SL,5,ARRAY5 | 0 1 8 NONE 1200 AUX 1 |
| SL,6,ARRAY5 | 0 1 8 NONE 1200 AUX 2 |
| DU,1,ARRAY6 | 100.00 100.00 60.00 0.00 0.00 YES D1 |
| DU,2,ARRAY6 | -100.00 -100.00 60.00 0.00 0.00 YES D2 |
| DU,3,ARRAY6 | 200.00 200.00 60.00 0.00 0.00 YES D3 |
| DU,4,ARRAY6 | -200.00 -200.00 60.00 0.00 0.00 YES D4 |
| DU,5,ARRAY6 | 200.00 19.00 60.00 0.00 0.00 YES AGC |
| DU,6,ARRAY6 | 0.00 0.00 60.00 0.00 0.00 NO SP. W. |
| DU,7,ARRAY6 | 0.00 0.00 60.00 0.00 0.00 NO ROLL |
| DU,8,ARRAY6 | 0.00 0.00 60.00 0.00 0.00 NO PITCH |
| DU,9,ARRAY6 | 0.00 0.00 60.00 0.00 0.00 NO HEADING |
| DU,10,ARRAY6 | 0.00 0.00 60.00 0.00 0.00 NO |
| TEMPERATURE | |

```
DC,1,SPECIAL  "FH00001" MACRO  1
DC,2,SPECIAL  "CF64" MACRO  2
DC,3,SPECIAL  "E0004020099" MACRO  3
DC,4,SPECIAL  "B009001" MACRO  4
CI,1,SPECIAL "Arabian Sea" CRUISE ID GOES HERE
LR,1,SPECIAL " " LORAN FILE NAME GOES HERE
```

## Appendix A. List of Sections

Each cruise is divided into sections and stations to form either nearly linear transects or coverage over some localized area. In the following, we list the start date, stop date, and the begining and end positions of each of the sections (the sections and stations are illustrated in each cruise track, Section 4). The current vectors plots, zonal and meridonal velocity contour plots, and backscatter intensity contour plots shown in the following sections are all based upon the listed section segments.

## Section List for TN043

| Sect # | Start Date | Start Time | Year-Day | Lat °N | Long °E | End Date | End Time | Year-Day | Lat °N | Long °E |
|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 95/01/08 | 04:31:34 | 7.189 | 23.648 | 58.625 | 95/01/08 | 14:22:21 | 7.599 | 22.422 | 59.985 |
| 2 | 95/01/08 | 14:22:21 | 7.599 | 22.403 | 59.984 | 95/01/09 | 04:47:05 | 8.199 | 22.484 | 61.184 |
| 3 | 95/01/09 | 04:47:05 | 8.199 | 22.484 | 61.183 | 95/01/11 | 21:21:36 | 10.890 | 19.167 | 67.166 |
| 4 | 95/01/11 | 21:21:36 | 10.890 | 19.166 | 67.166 | 95/01/13 | 15:07:12 | 12.630 | 19.170 | 67.165 |
| 5 | 95/01/13 | 15:07:12 | 12.630 | 19.167 | 67.166 | 95/01/15 | 11:57:04 | 14.498 | 15.491 | 68.764 |
| 6 | 95/01/15 | 11:57:04 | 14.490 | 15.493 | 68.764 | 95/01/16 | 05:57:04 | 15.248 | 14.907 | 66.873 |
| 7 | 95/01/16 | 05:57:04 | 15.240 | 14.904 | 66.873 | 95/01/17 | 07:55:12 | 16.330 | 10.005 | 64.904 |
| 8 | 95/01/17 | 07:55:12 | 16.330 | 10.005 | 64.904 | 95/01/18 | 21:07:12 | 17.880 | 10.001 | 64.898 |
| 9 | 95/01/18 | 21:07:12 | 17.880 | 10.001 | 64.898 | 95/01/20 | 10:48:00 | 19.450 | 14.444 | 65.000 |
| 10 | 95/01/20 | 10:48:00 | 19.450 | 14.449 | 65.000 | 95/01/22 | 00:57:36 | 21.040 | 14.541 | 64.970 |
| 11 | 95/01/22 | 00:57:36 | 21.040 | 14.541 | 64.970 | 95/01/23 | 12:14:24 | 22.510 | 15.990 | 62.043 |
| 12 | 95/01/23 | 12:14:24 | 22.510 | 15.990 | 62.043 | 95/01/25 | 12:14:24 | 24.510 | 15.997 | 61.987 |
| 13 | 95/01/25 | 12:14:24 | 24.510 | 15.997 | 61.987 | 95/01/25 | 18:25:14 | 24.768 | 15.563 | 61.497 |
| 14 | 95/01/25 | 18:25:14 | 24.760 | 15.563 | 61.497 | 95/01/26 | 04:45:16 | 25.198 | 16.416 | 61.232 |
| 15 | 95/01/26 | 04:45:16 | 25.190 | 16.416 | 61.232 | 95/01/26 | 18:57:36 | 25.790 | 17.200 | 59.767 |
| 16 | 95/01/26 | 18:57:36 | 25.790 | 17.200 | 59.767 | 95/01/28 | 09:07:12 | 27.380 | 17.202 | 59.767 |
| 17 | 95/01/28 | 09:07:12 | 27.380 | 17.202 | 59.767 | 95/01/28 | 14:24:00 | 27.600 | 17.675 | 58.868 |
| 18 | 95/01/28 | 14:24:00 | 27.600 | 17.675 | 58.868 | 95/01/29 | 10:19:12 | 28.430 | 17.791 | 58.980 |
| 19 | 95/01/29 | 10:19:12 | 28.430 | 17.791 | 58.980 | 95/01/29 | 15:36:00 | 28.650 | 18.097 | 58.035 |
| 20 | 95/01/29 | 15:36:00 | 28.650 | 18.097 | 58.035 | 95/01/31 | 09:21:36 | 30.390 | 18.079 | 57.996 |
| 21 | 95/01/31 | 09:21:36 | 30.390 | 18.079 | 57.996 | 95/01/31 | 23:59:57 | 31.000 | 18.453 | 57.299 |
| 22 | 95/01/31 | 23:59:57 | 31.000 | 18.453 | 57.299 | 95/02/01 | 14:20:43 | 31.598 | 18.999 | 59.005 |
| 23 | 95/02/01 | 14:20:43 | 31.590 | 18.999 | 59.005 | 95/02/03 | 04:47:34 | 33.200 | 22.233 | 60.126 |
| 24 | 95/02/03 | 04:47:34 | 33.200 | 22.233 | 60.126 | 95/02/04 | 17:50:00 | 34.743 | 23.231 | 59.146 |

## Section List for TN044

| Sect # | Start Date | Start Time | Year-Day | Lat °N | Long °E | End Date | End Time | Year-Day | Lat °N | Long °E |
|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 95/02/08 | 04:40:31 | 38.195 | 23.650 | 58.615 | 95/02/10 | 12:59:40 | 40.541 | 18.132 | 58.011 |
| 1a | 95/02/08 | 04:40:31 | 38.195 | 23.650 | 58.615 | 95/02/09 | 01:19:12 | 39.055 | 22.456 | 60.209 |
| 1b | 95/02/09 | 01:23:31 | 39.058 | 22.444 | 60.287 | 95/02/09 | 22:09:07 | 39.923 | 19.601 | 59.562 |
| 1c | 95/02/09 | 22:13:26 | 39.926 | 19.593 | 59.554 | 95/02/10 | 12:59:40 | 40.541 | 18.132 | 58.011 |
| 2 | 95/02/10 | 22:24:41 | 40.934 | 17.474 | 59.254 | 95/02/13 | 10:47:46 | 43.449 | 16.942 | 60.423 |
| 3 | 95/02/14 | 00:00:11 | 44.000 | 16.289 | 61.586 | 95/02/15 | 01:10:11 | 45.049 | 16.036 | 62.005 |
| 4 | 95/02/15 | 01:15:11 | 45.052 | 16.036 | 62.005 | 95/02/15 | 23:58:22 | 45.999 | 14.451 | 65.001 |
| 5 | 95/02/16 | 12:03:22 | 46.502 | 14.905 | 64.102 | 95/02/18 | 23:58:01 | 48.999 | 15.472 | 63.091 |
| 6 | 95/02/19 | 00:03:02 | 49.002 | 15.463 | 63.086 | 95/02/21 | 04:01:47 | 51.168 | 18.480 | 57.301 |
| 7 | 95/02/21 | 04:06:54 | 51.171 | 18.463 | 57.305 | 95/02/25 | 17:29:59 | 55.729 | 19.189 | 58.284 |
| **Outbound SW Transects** | | | | | | | | | | |
| **Outbound SW Transect_a** | | | | | | | | | | |
| | 95/02/10 | 13:04:39 | 40.545 | 18.124 | 58.024 | 95/02/10 | 22:24:41 | 40.934 | 17.474 | 59.254 |
| | 95/02/11 | 16:24:38 | 41.684 | 17.368 | 59.461 | 95/02/11 | 17:54:39 | 41.746 | 17.259 | 59.659 |
| | 95/02/12 | 14:49:40 | 42.618 | 17.158 | 59.877 | 95/02/12 | 16:14:39 | 42.677 | 17.041 | 60.077 |
| | 95/02/13 | 09:42:47 | 43.405 | 16.992 | 60.323 | 95/02/14 | 01:50:11 | 44.077 | 16.160 | 61.826 |
| **Outbound SW Transect_b** | | | | | | | | | | |
| | 95/02/15 | 01:40:11 | 45.070 | 16.039 | 62.008 | 95/02/16 | 00:58:21 | 46.040 | 14.453 | 65.001 |
| **Inbound SW Transects** | | | | | | | | | | |
| **Inbound SW Transect_a** | | | | | | | | | | |
| | 95/02/16 | 01:08:32 | 46.047 | 14.453 | 65.001 | 95/02/16 | 11:58:21 | 46.499 | 14.895 | 64.101 |
| | 95/02/17 | 06:18:22 | 47.263 | 15.010 | 63.891 | 95/02/17 | 08:08:21 | 47.339 | 15.117 | 63.693 |
| | 95/02/18 | 03:08:22 | 48.131 | 15.228 | 63.489 | 95/02/18 | 04:53:03 | 48.204 | 15.338 | 63.283 |
| **Inbound SW Transect_b** | | | | | | | | | | |
| | 95/02/19 | 00:13:01 | 49.009 | 15.445 | 63.074 | 95/02/21 | 03:46:54 | 51.158 | 18.510 | 57.294 |

## Section List for TN045

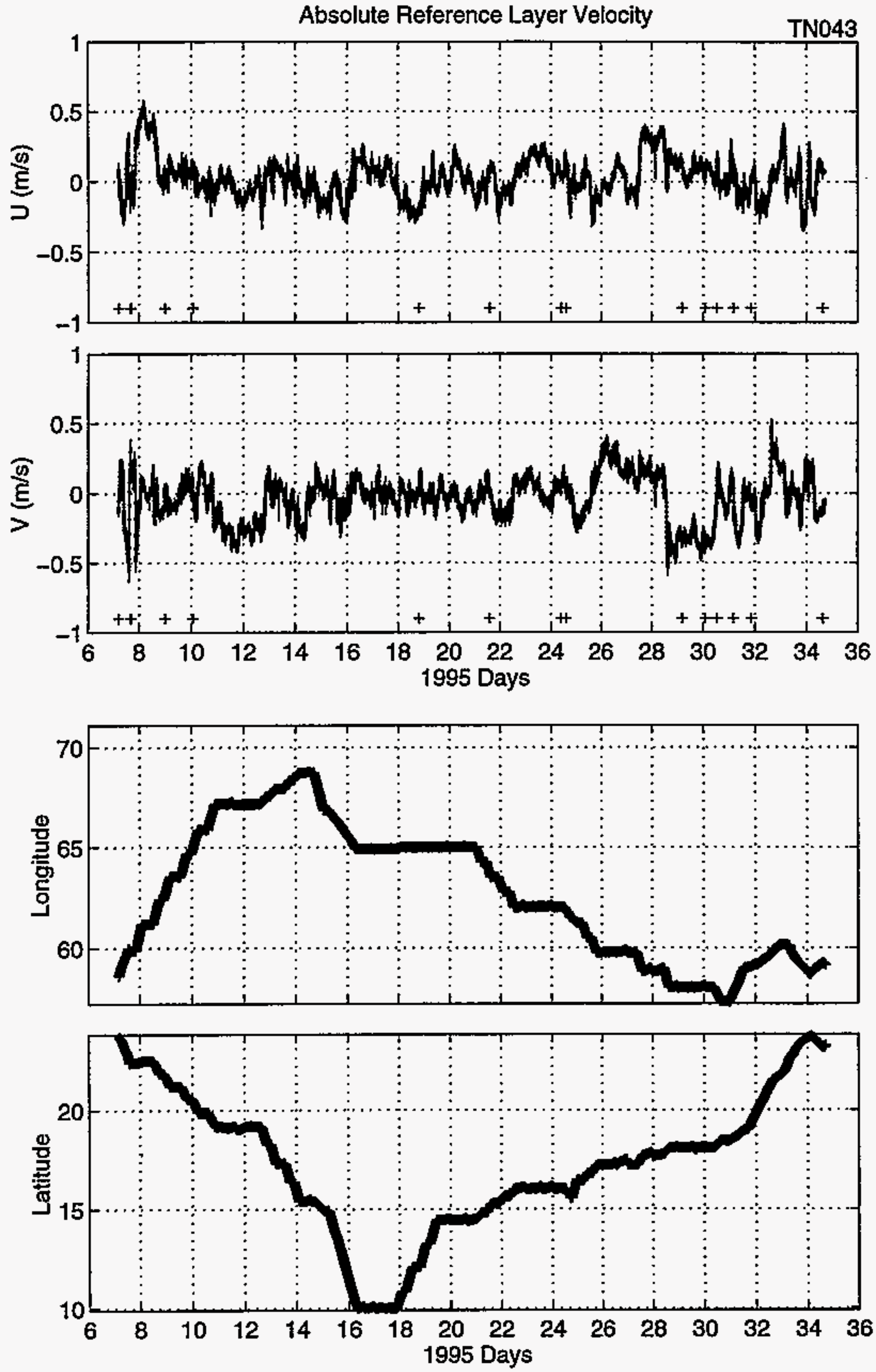
| Sect # | Start Date | Start Time | Year-Day | Lat °N | Long °E | End Date | End Time | Year-Day | Lat °N | Long °E |
|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 95/02/28 | 02:44:08 | 58.134 | 23.686 | 58.626 | 95/03/15 | 00:05:03 | 73.004 | 22.348 | 59.954 |
| 2 | 95/03/15 | 00:10:02 | 73.007 | 22.350 | 59.974 | 95/03/15 | 06:15:02 | 73.260 | 22.487 | 61.181 |
| 3 | 95/03/15 | 06:20:02 | 73.264 | 22.484 | 61.184 | 95/03/18 | 07:10:02 | 76.299 | 19.167 | 67.166 |
| 4 | 95/03/18 | 07:15:03 | 76.302 | 19.167 | 67.166 | 95/03/19 | 19:10:02 | 77.799 | 19.158 | 67.137 |
| 5 | 95/03/19 | 19:15:03 | 77.802 | 19.158 | 67.137 | 95/03/21 | 11:55:02 | 79.497 | 15.380 | 68.738 |
| 6 | 95/03/21 | 12:00:02 | 79.500 | 15.381 | 68.737 | 95/03/22 | 04:45:02 | 80.198 | 14.906 | 66.870 |
| 7 | 95/03/22 | 04:50:02 | 80.201 | 14.889 | 66.864 | 95/03/23 | 05:00:02 | 81.208 | 10.109 | 64.927 |
| 8 | 95/03/23 | 05:05:03 | 81.211 | 10.106 | 64.926 | 95/03/26 | 09:35:03 | 84.399 | 14.460 | 64.988 |
| 9 | 95/03/26 | 09:40:02 | 84.403 | 14.461 | 64.986 | 95/03/28 | 05:55:01 | 86.247 | 14.455 | 64.933 |
| 10 | 95/03/28 | 06:00:02 | 86.250 | 14.456 | 64.930 | 95/03/30 | 06:00:02 | 88.250 | 16.001 | 61.985 |
| 11 | 95/03/30 | 05:00:03 | 88.208 | 16.000 | 61.992 | 95/04/07 | 12:35:21 | 96.525 | 18.245 | 57.691 |
| 12 | 95/04/02 | 06:03:14 | 91.252 | 17.201 | 59.763 | 95/04/04 | 16:46:21 | 93.699 | 17.244 | 59.682 |
| 13 | 95/04/05 | 19:16:22 | 94.803 | 18.085 | 58.038 | 95/04/07 | 12:35:21 | 96.525 | 18.245 | 57.691 |
| 14 | 95/04/07 | 16:50:28 | 96.702 | 18.445 | 57.309 | 95/04/10 | 04:17:02 | 99.178 | 23.656 | 58.582 |

## Section List for TN046

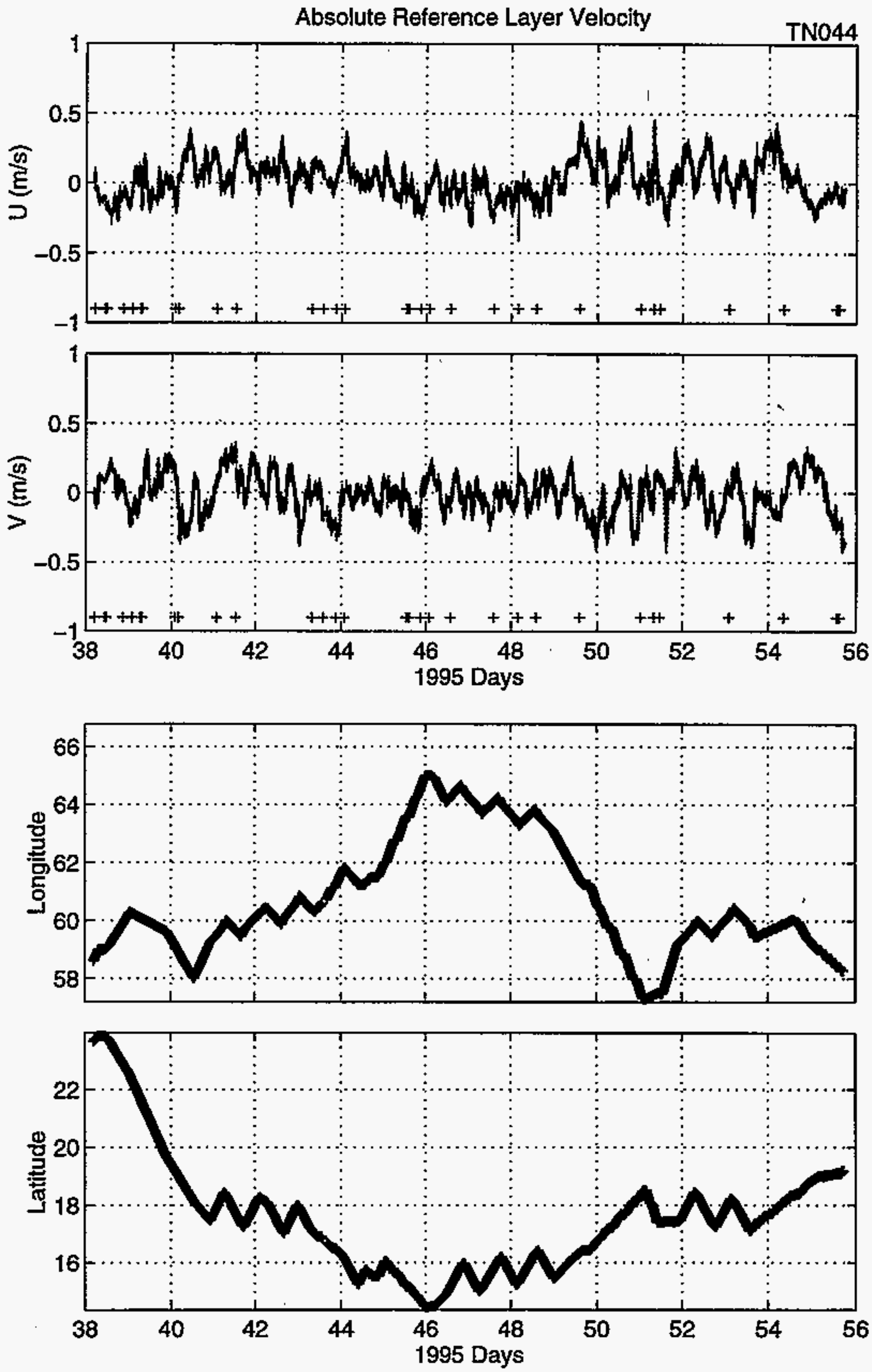
| Sect # | Start Date | Start Time | Year-Day | Lat °N | Long °E | End Date | End Time | Year-Day | Lat °N | Long °E |
|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 95/04/14 | 03:59:38 | 103.166 | 23.643 | 58.626 | 95/04/16 | 02:26:05 | 105.101 | 15.725 | 61.278 |
| 1a | 95/04/14 | 03:59:38 | 103.166 | 23.643 | 58.626 | 95/04/14 | 17:45:36 | 103.740 | 22.394 | 60.286 |
| 1b | 95/04/14 | 17:59:38 | 103.750 | 22.338 | 60.295 | 95/04/16 | 00:11:04 | 105.008 | 16.067 | 61.218 |
| 2 | 95/04/16 | 02:31:05 | 105.105 | 15.725 | 61.279 | 95/04/26 | 15:35:49 | 115.650 | 15.656 | 61.129 |
| 3 | 95/04/26 | 15:40:48 | 115.653 | 15.670 | 61.118 | 95/04/27 | 14:20:49 | 116.598 | 18.850 | 58.580 |
| 4 | 95/04/27 | 14:25:49 | 116.601 | 18.862 | 58.580 | 95/04/29 | 02:10:48 | 118.091 | 23.665 | 58.685 |

## Appendix B. Reference Layer Velocities

This section shows the zonal and meridional reference layer velocities together with the cruise tracks in terms of latitude/longitude time plots for each cruise

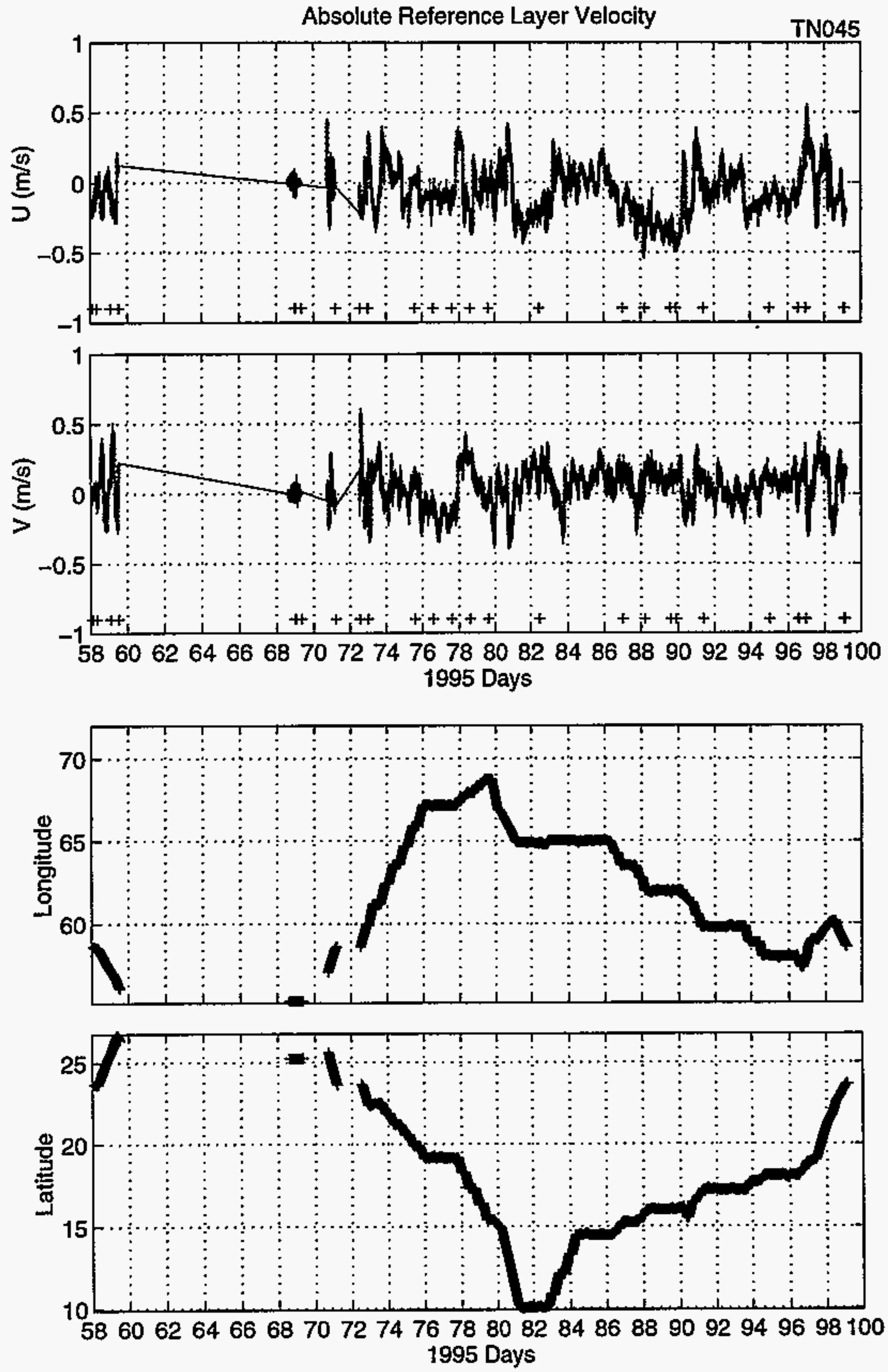

Absolute Reference Layer Velocity
TN043
U (m/s)
V (m/s)
1995 Days
Longitude
Latitude
1995 Days

95– 2–24 14: 2

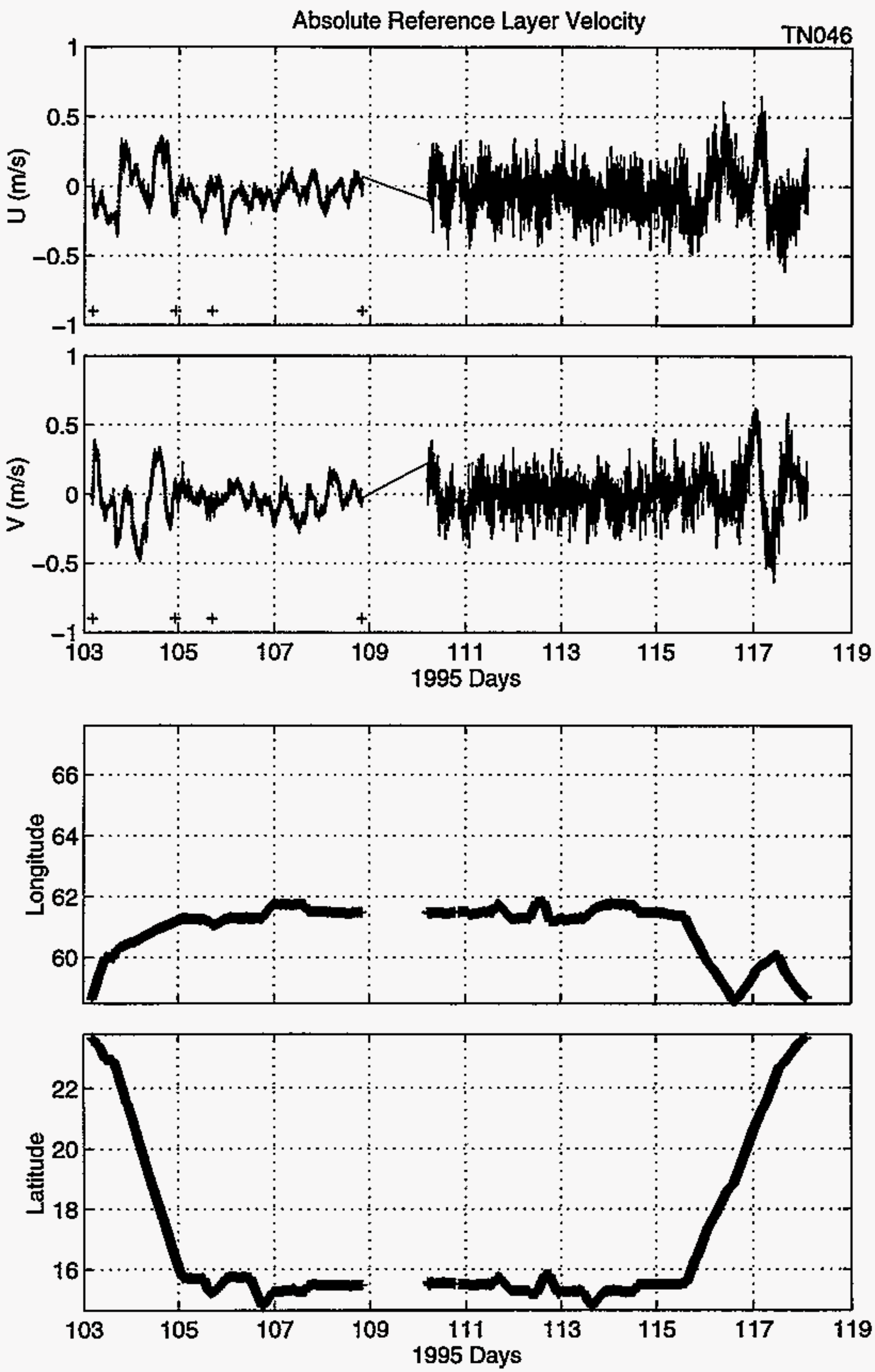


Absolute Reference Layer Velocity
TN044
U (m/s)
V (m/s)
1995 Days
Longitude
Latitude
1995 Days


95- 4-28 13:5


Absolute Reference Layer Velocity
TN045
U (m/s)
V (m/s)
1995 Days
Longitude
Latitude
1995 Days

95- 9- 6 11:49



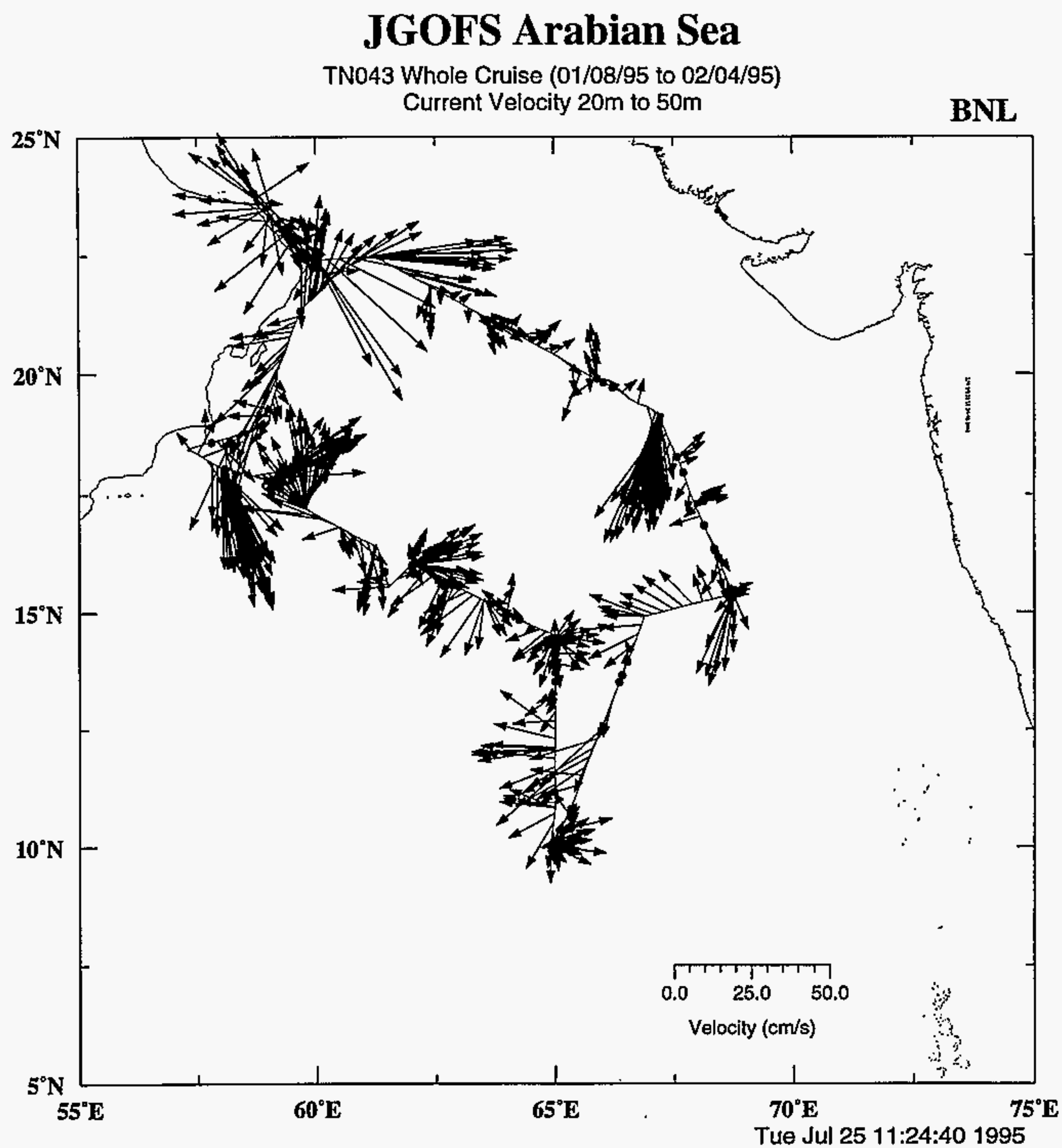
Absolute Reference Layer Velocity
TN046
U (m/s)
V (m/s)
1995 Days
Longitude
Latitude
1995 Days


95– 9– 6 10:44

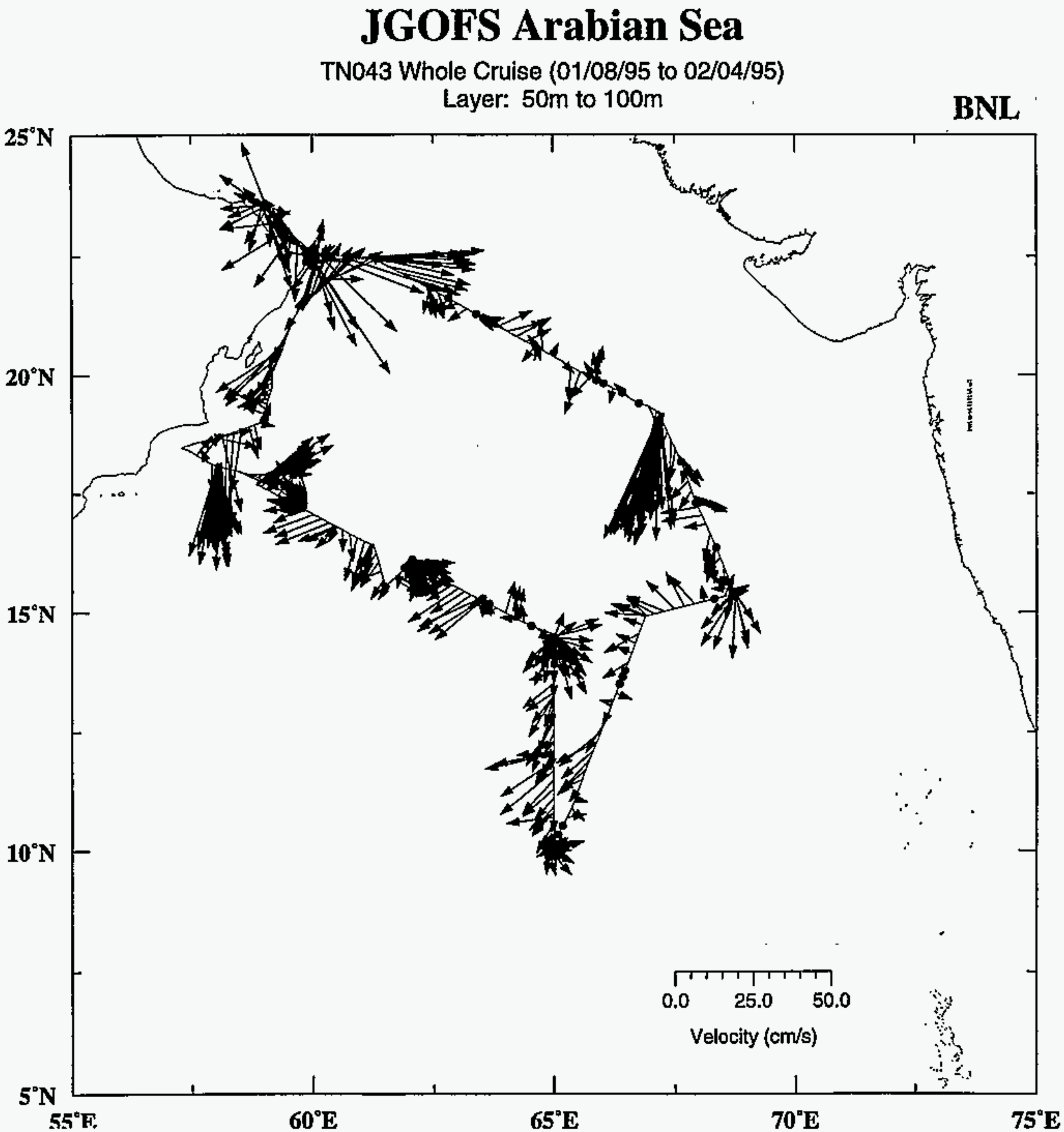
## Appendix C. Vector Plots and Contoured Sections

Vector plots along sections of the cruises, as indicated in Appendix A, are shown as well as contoured zonal and meridional velocities. The vector plots include currents averaged in layers 20-50m, 50-100m, 100-200m, 200-300m, and 300-400m where the data is available.

# TN043

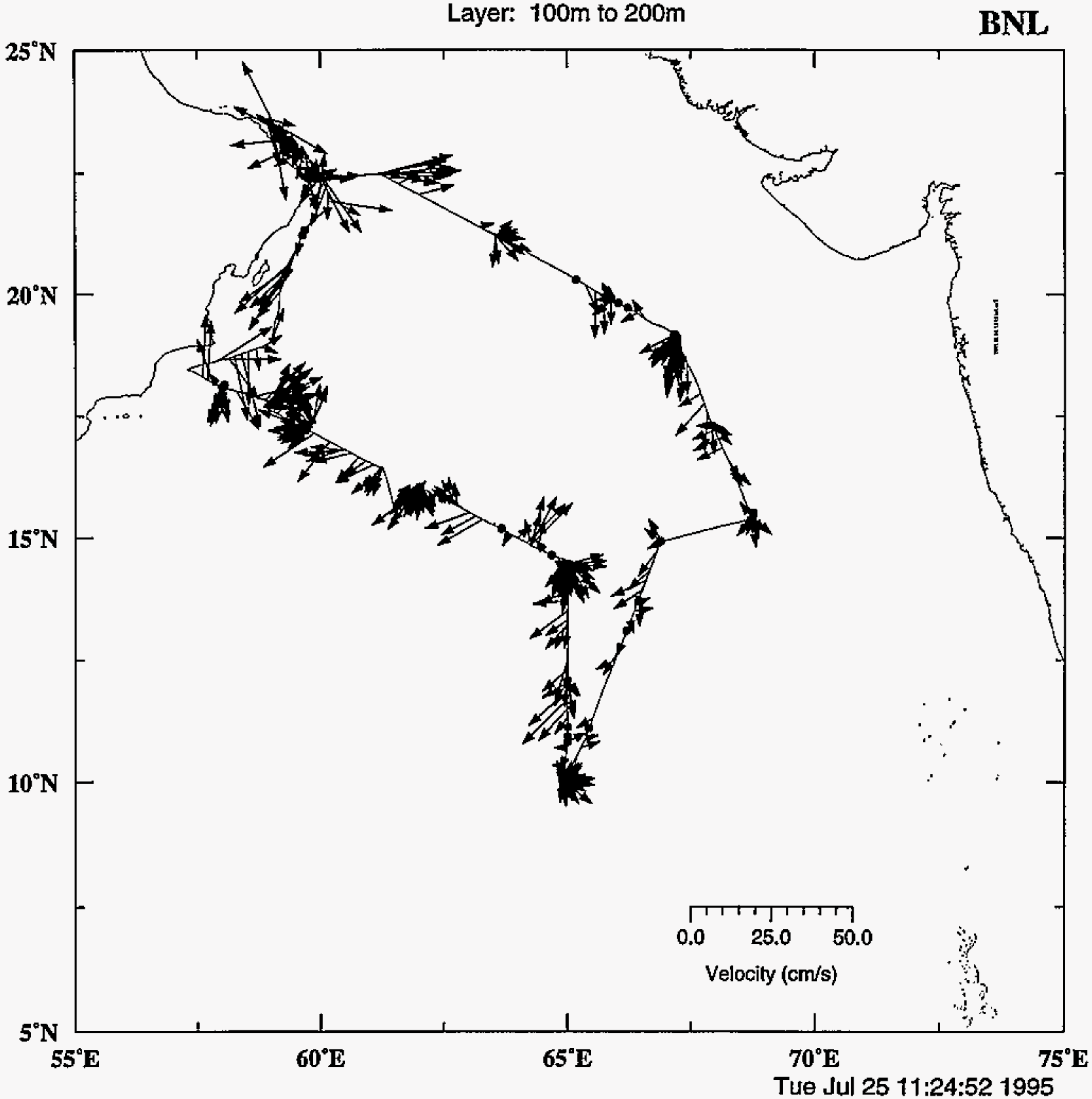


JGOFS Arabian Sea
TN043 Whole Cruise (01/08/95 to 02/04/95)
Current Velocity 20m to 50m
BNL
25°N
20°N
15°N
10°N
5°N
55°E
60°E
65°E
70°E
75°E
0.0
25.0
50.0
Velocity (cm/s)
Tue Jul 25 11:24:40 1995


JGOFS Arabian Sea
TN043 Whole Cruise (01/08/95 to 02/04/95)
Layer: 50m to 100m
BNL
25°N
20°N
15°N
10°N
5°N
55°E
60°E
65°E
70°E
75°E
0.0
25.0
50.0
Velocity (cm/s)

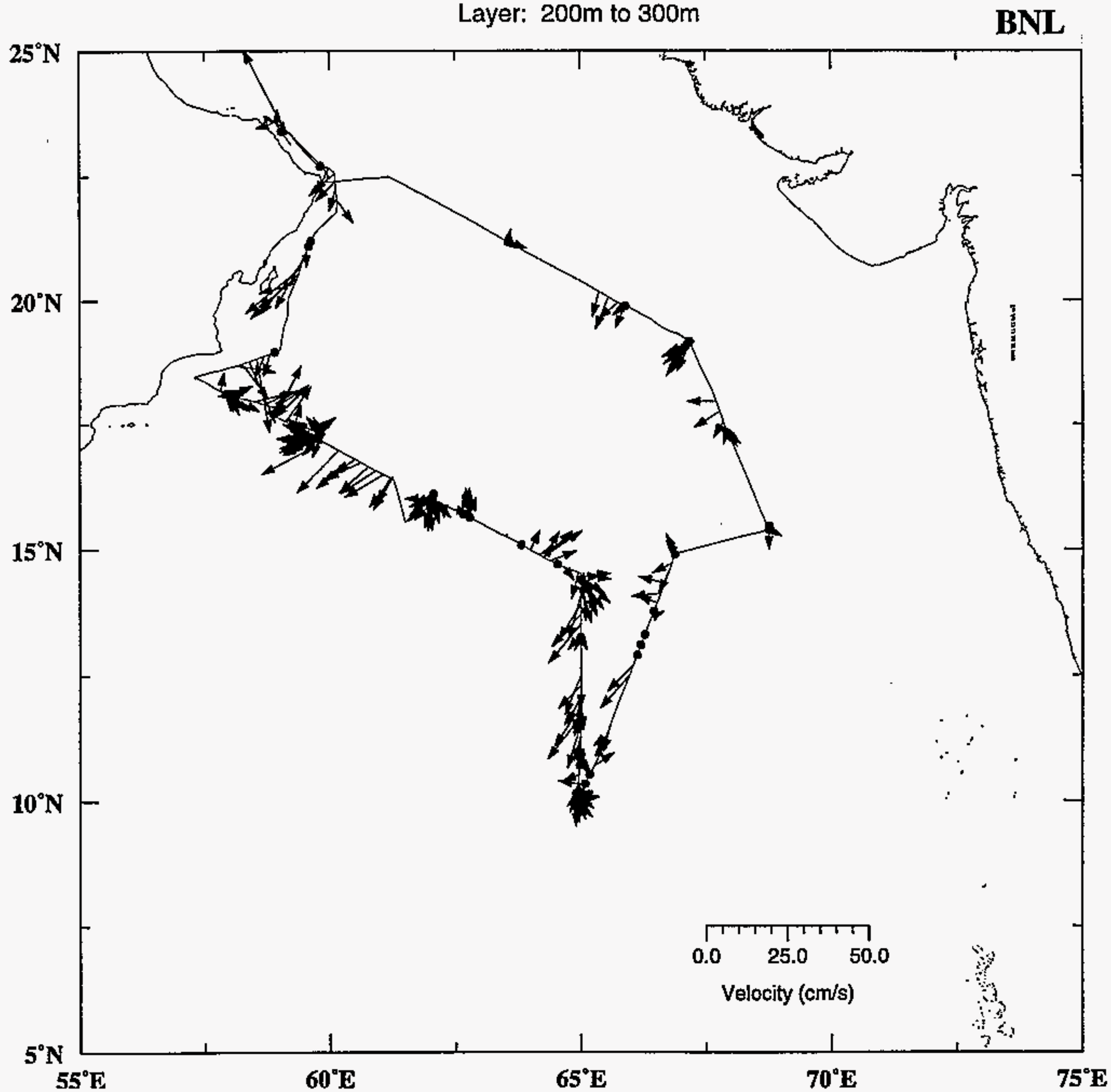
# JGOFS Arabian Sea

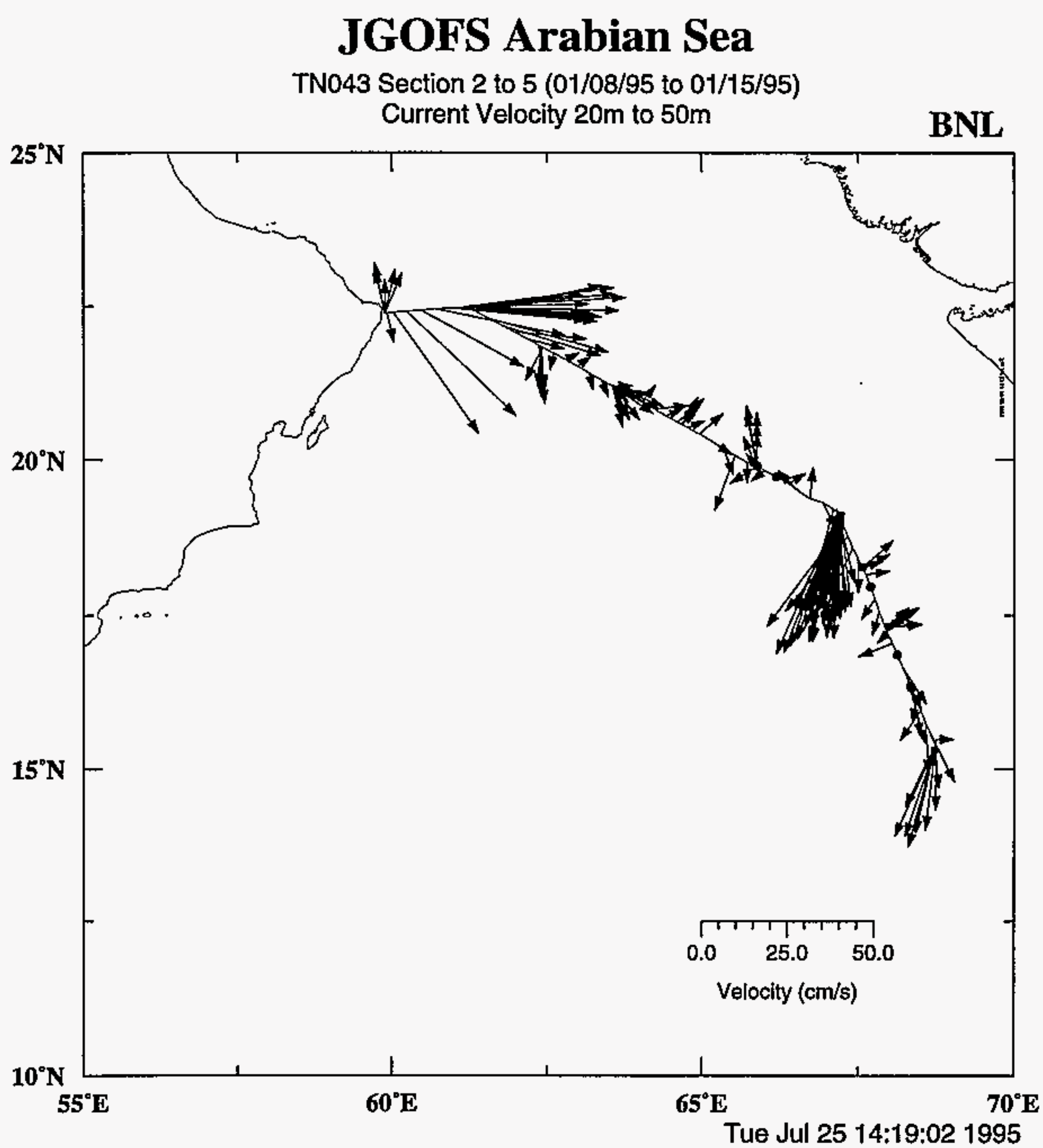
TN043 Whole Cruise (01/08/95 to 02/04/95)
Layer: 100m to 200m

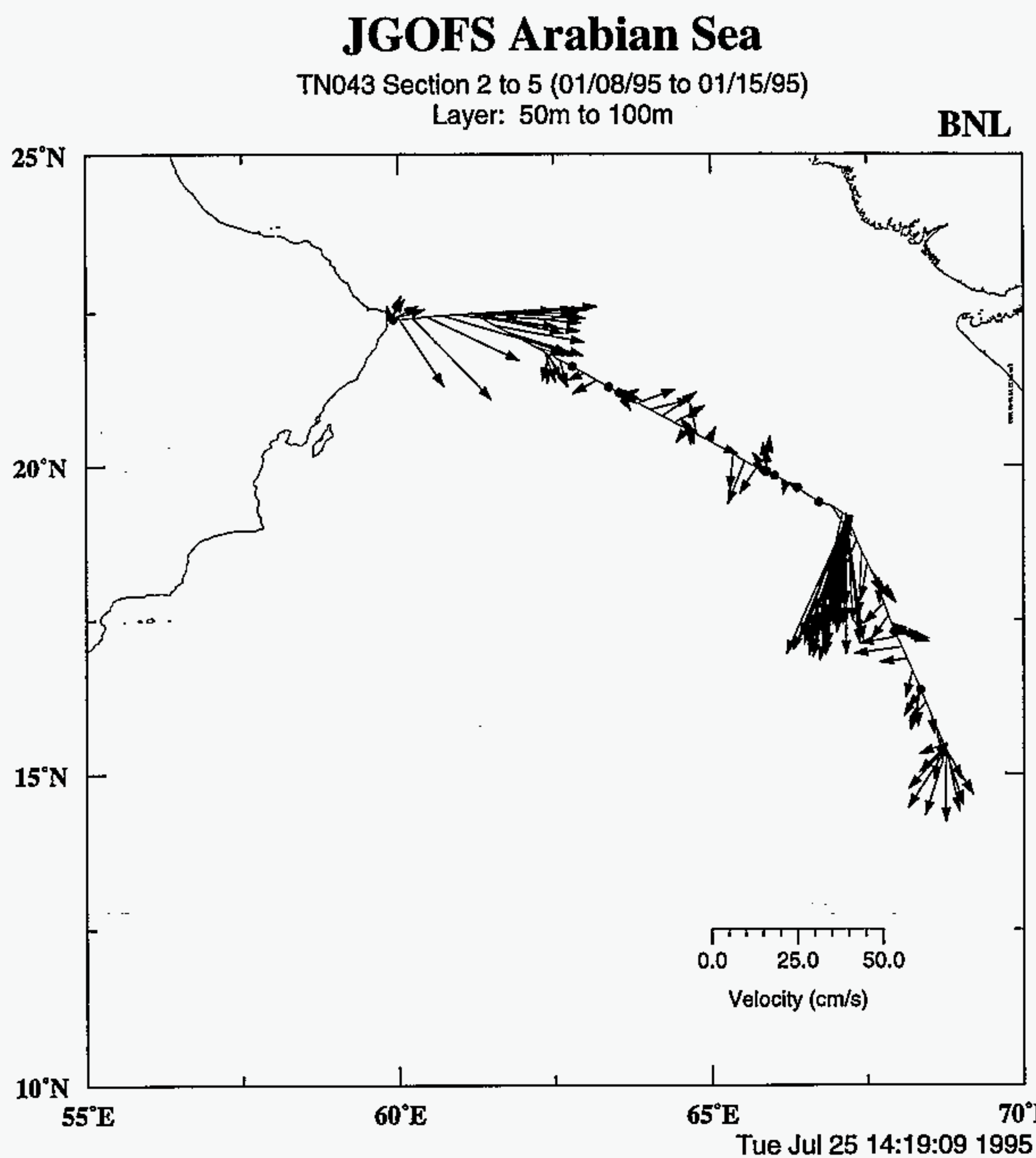


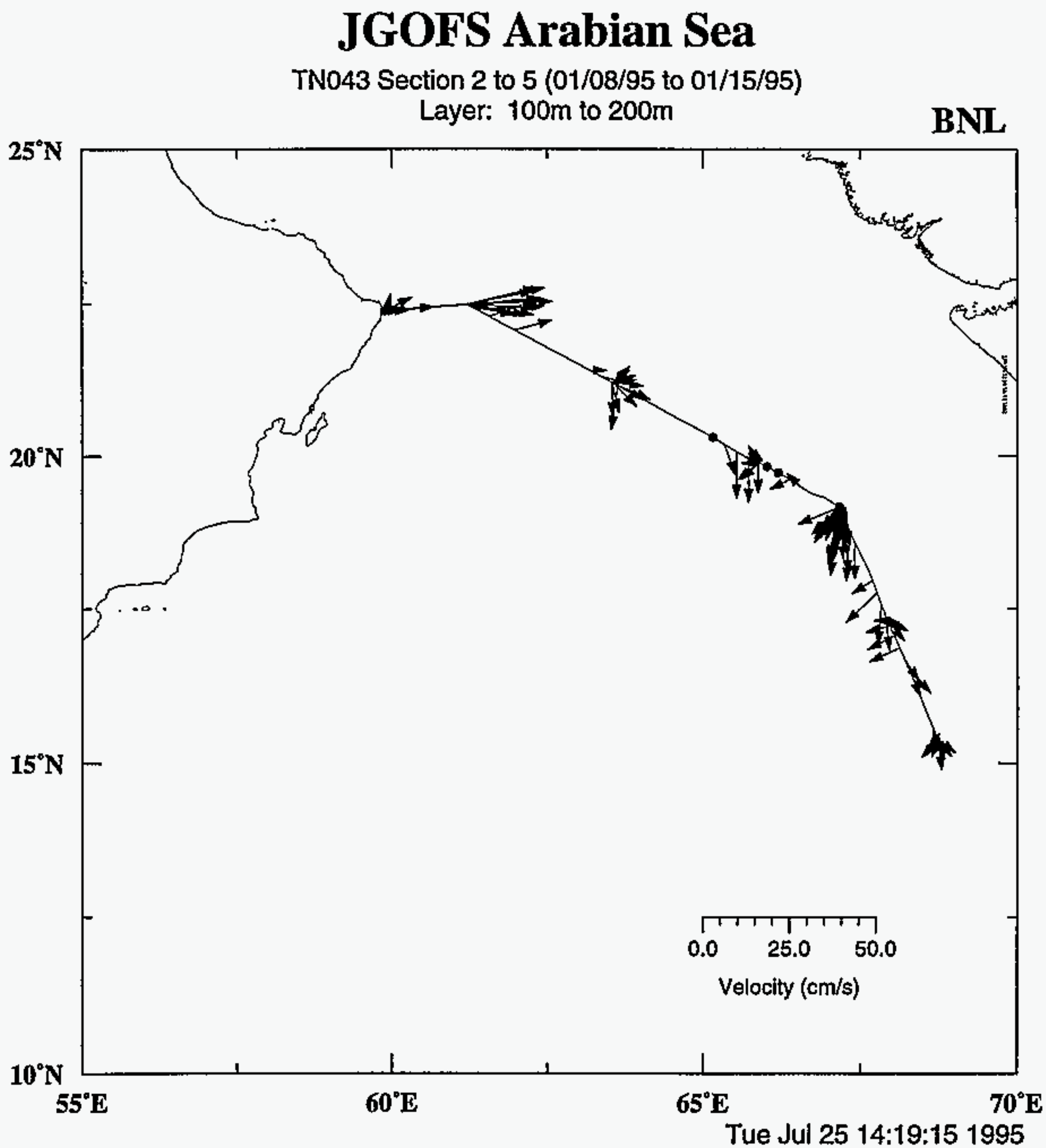
# JGOFS Arabian Sea

TN043 Whole Cruise (01/08/95 to 02/04/95)
Layer: 200m to 300m



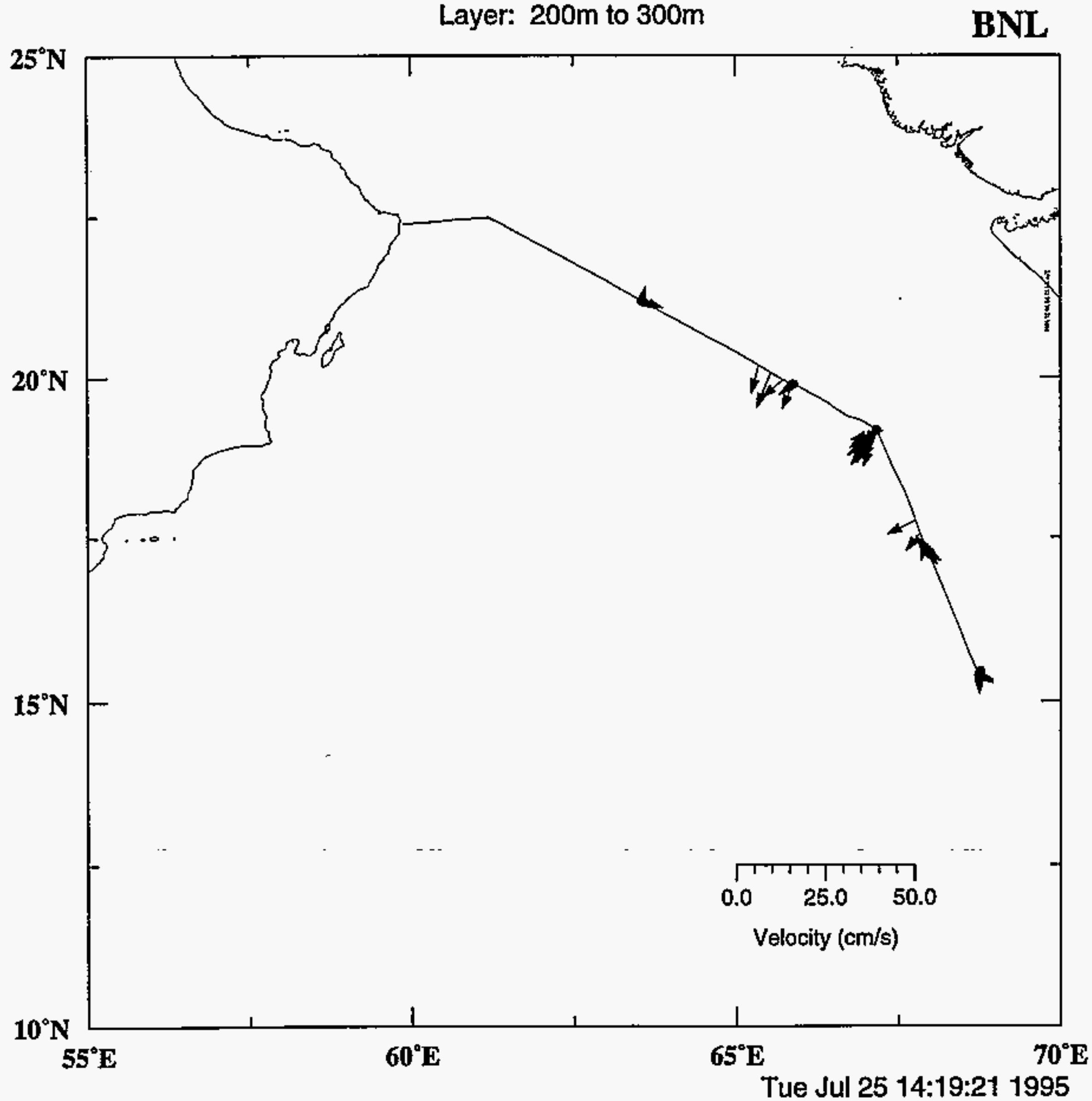

JGOFS Arabian Sea
TN043 Section 2 to 5 (01/08/95 to 01/15/95)
Current Velocity 20m to 50m
BNL
25°N
20°N
15°N
10°N
55°E
60°E
65°E
70°E
0.0
25.0
50.0
Velocity (cm/s)
Tue Jul 25 14:19:02 1995


JGOFS Arabian Sea
TN043 Section 2 to 5 (01/08/95 to 01/15/95)
Layer: 50m to 100m
BNL
25°N
20°N
15°N
10°N
55°E
60°E
65°E
70°E
0.0
25.0
50.0
Velocity (cm/s)
Tue Jul 25 14:19:09 1995


JGOFS Arabian Sea
TN043 Section 2 to 5 (01/08/95 to 01/15/95)
Layer: 100m to 200m
BNL
25°N
20°N
15°N
10°N
55°E
60°E
65°E
70°E
0.0
25.0
50.0
Velocity (cm/s)
Tue Jul 25 14:19:15 1995

# JGOFS Arabian Sea

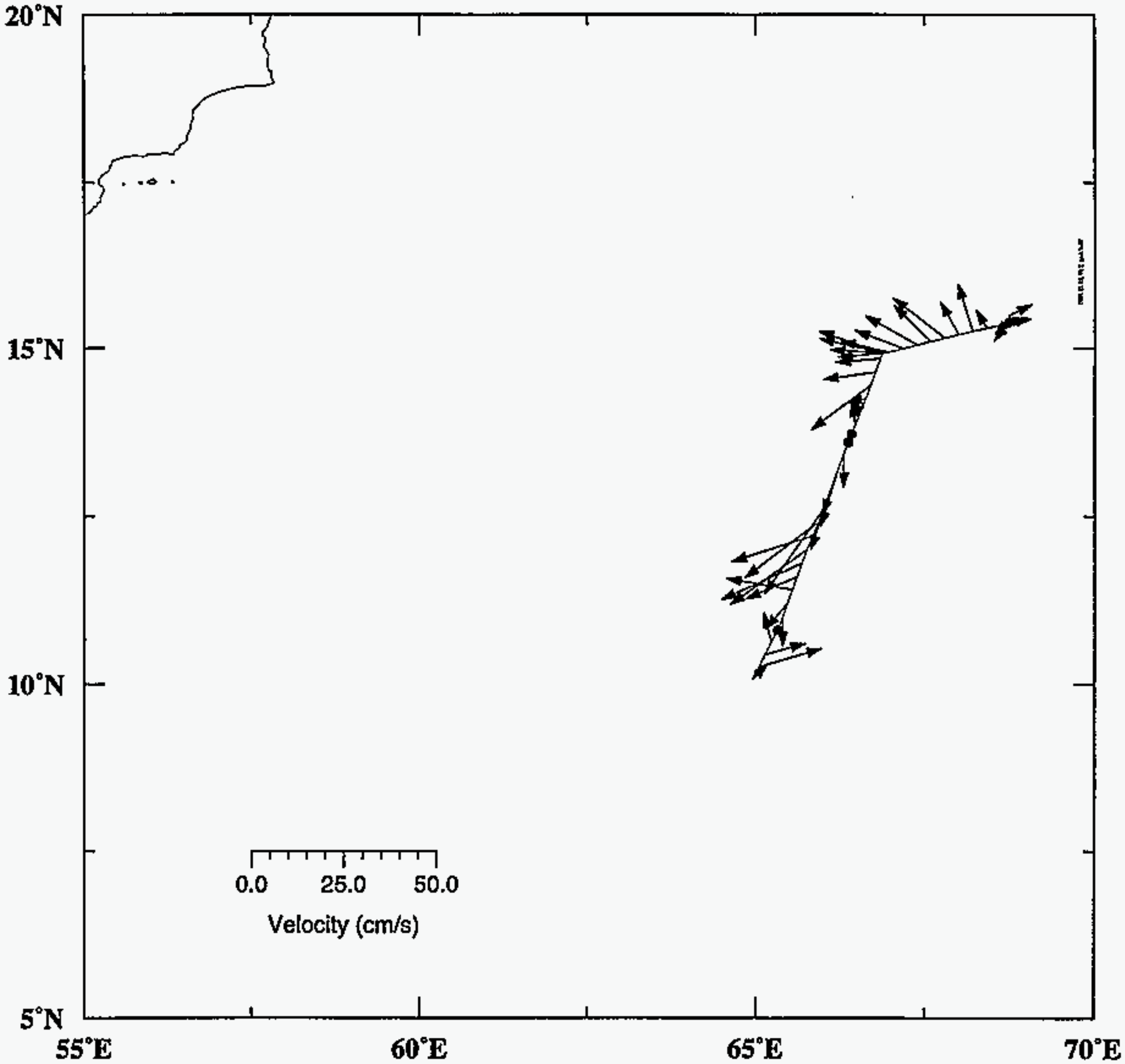
TN043 Section 2 to 5 (01/08/95 to 01/15/95)
Layer: 200m to 300m



# JGOFS Arabian Sea

TN043 Section 6 to 7 (01/15/95 to 01/17/95)
Current Velocity 20m to 50m

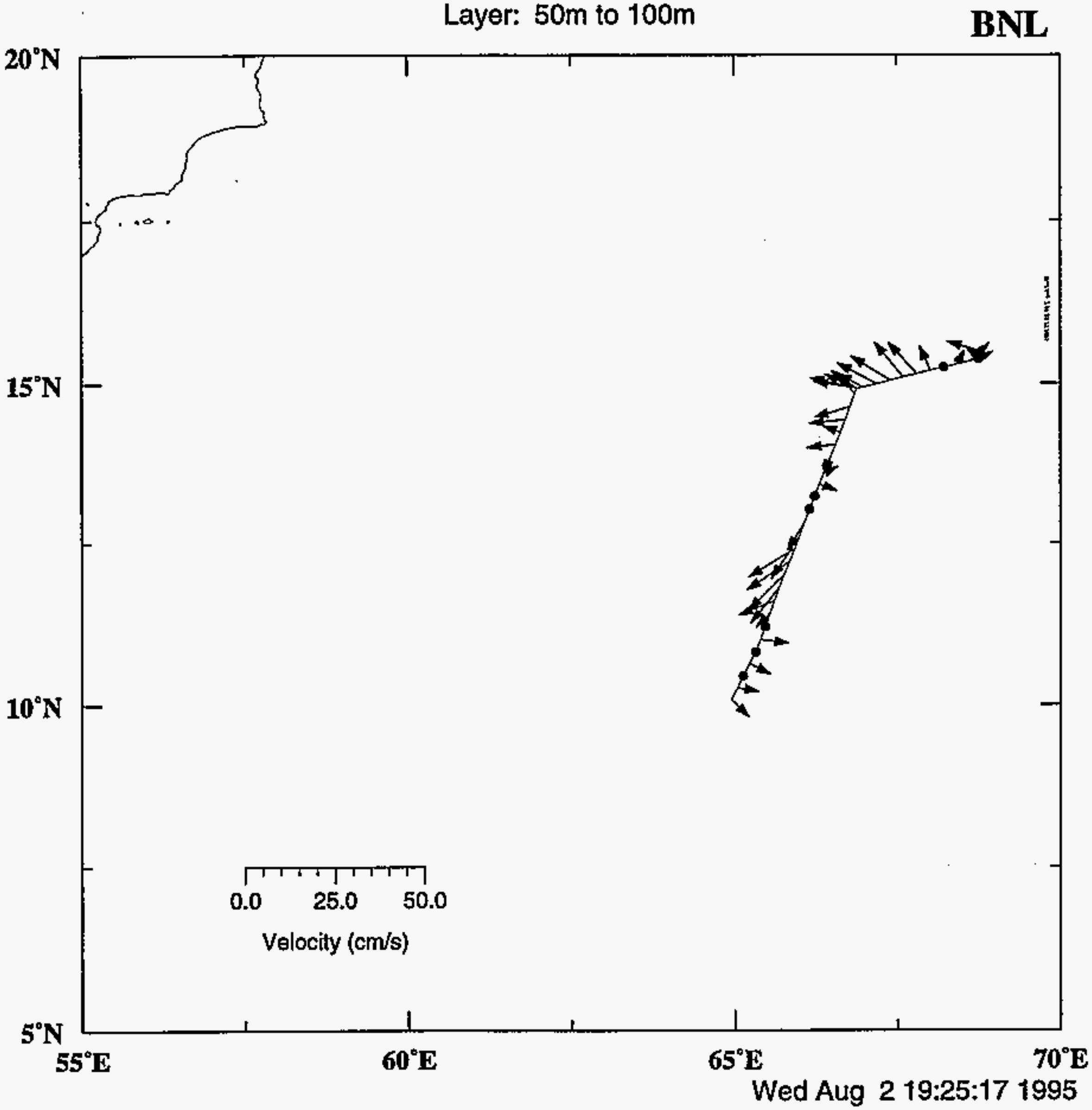
BNL




Wed Aug 2 19:25:12 1995

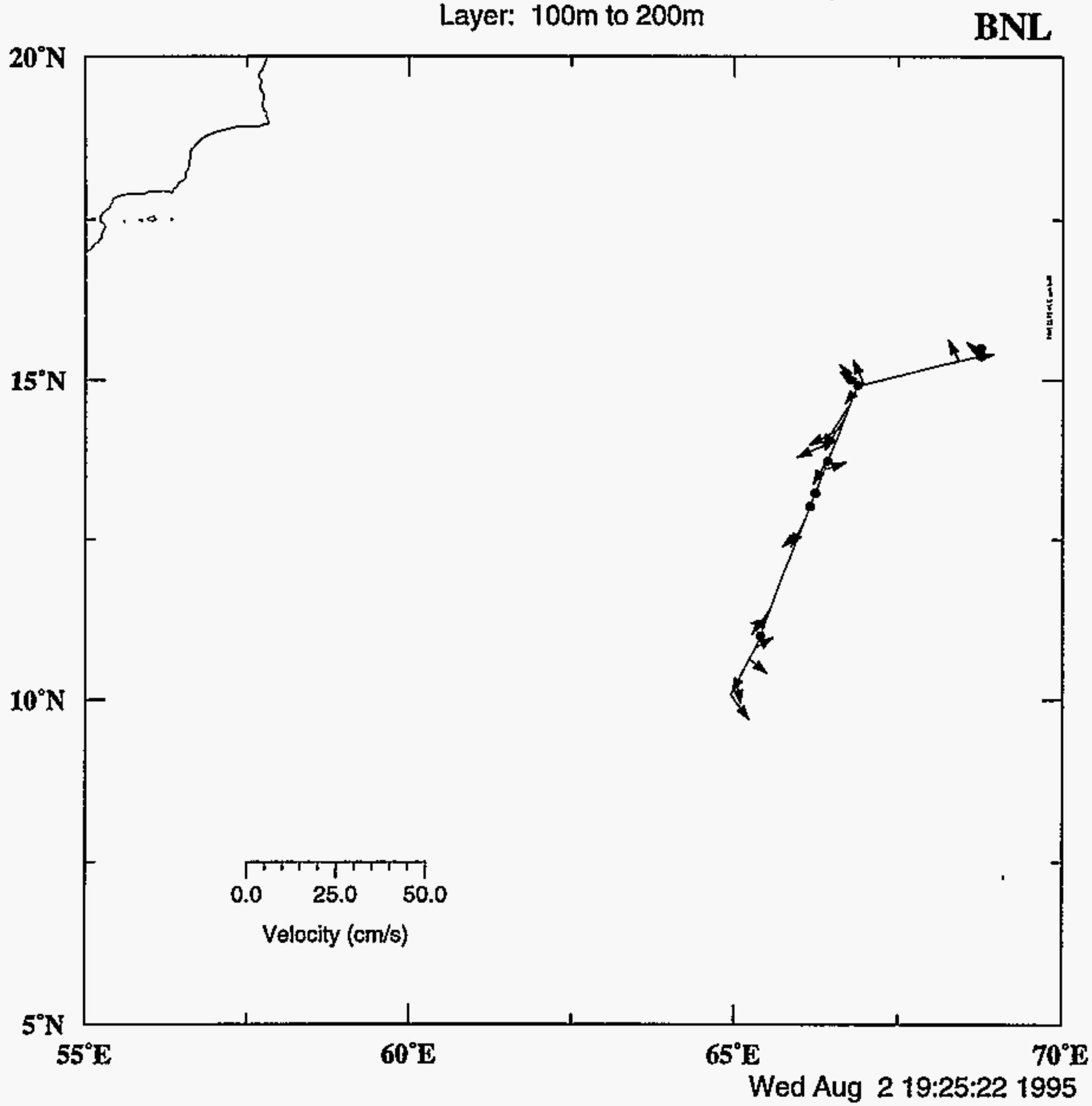
# JGOFS Arabian Sea

TN043 Section 6 to 7 (01/15/95 to 01/17/95)
Layer: 50m to 100m



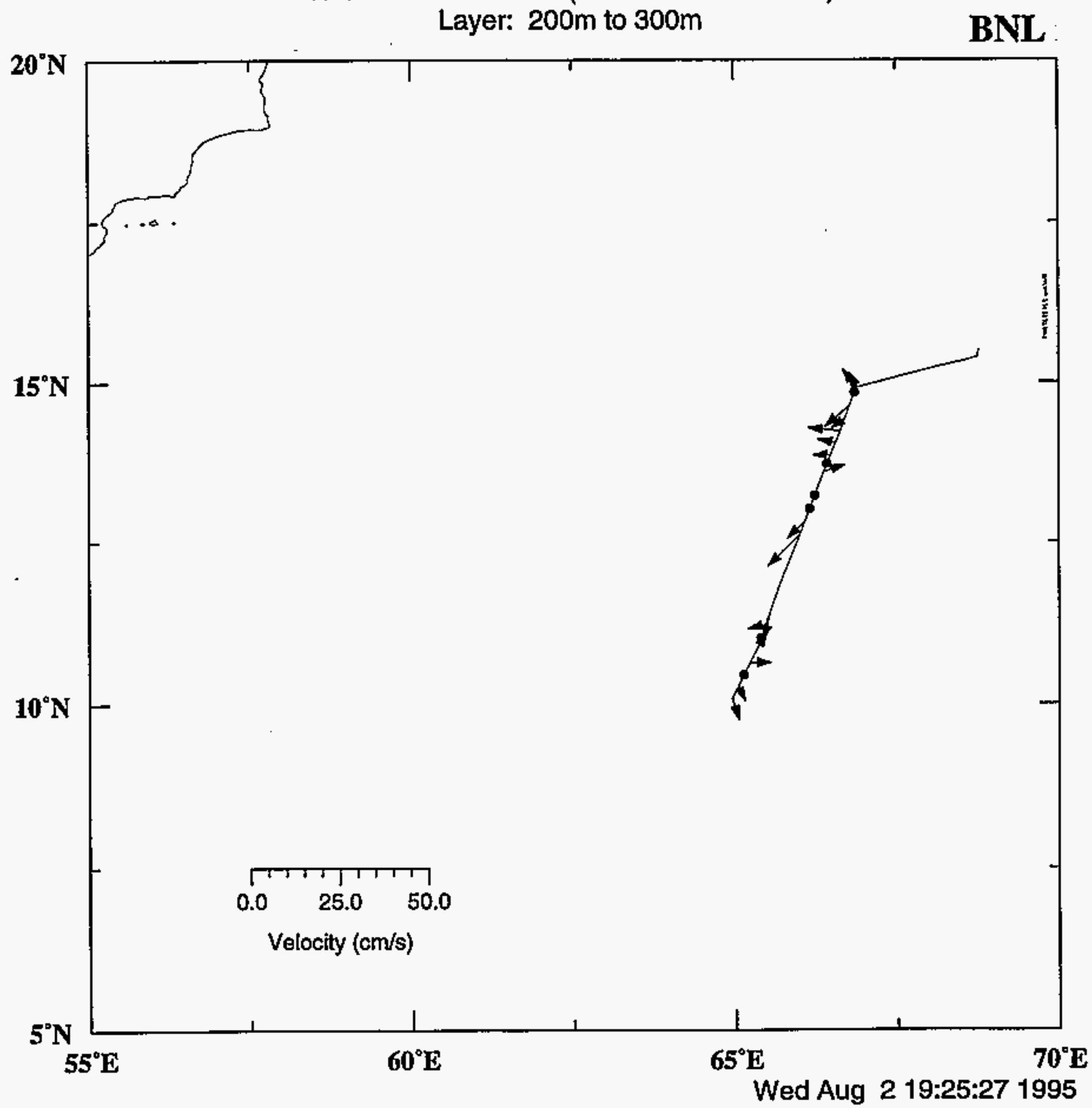
# JGOFS Arabian Sea

TN043 Section 6 to 7 (01/15/95 to 01/17/95)
Layer: 100m to 200m



# JGOFS Arabian Sea

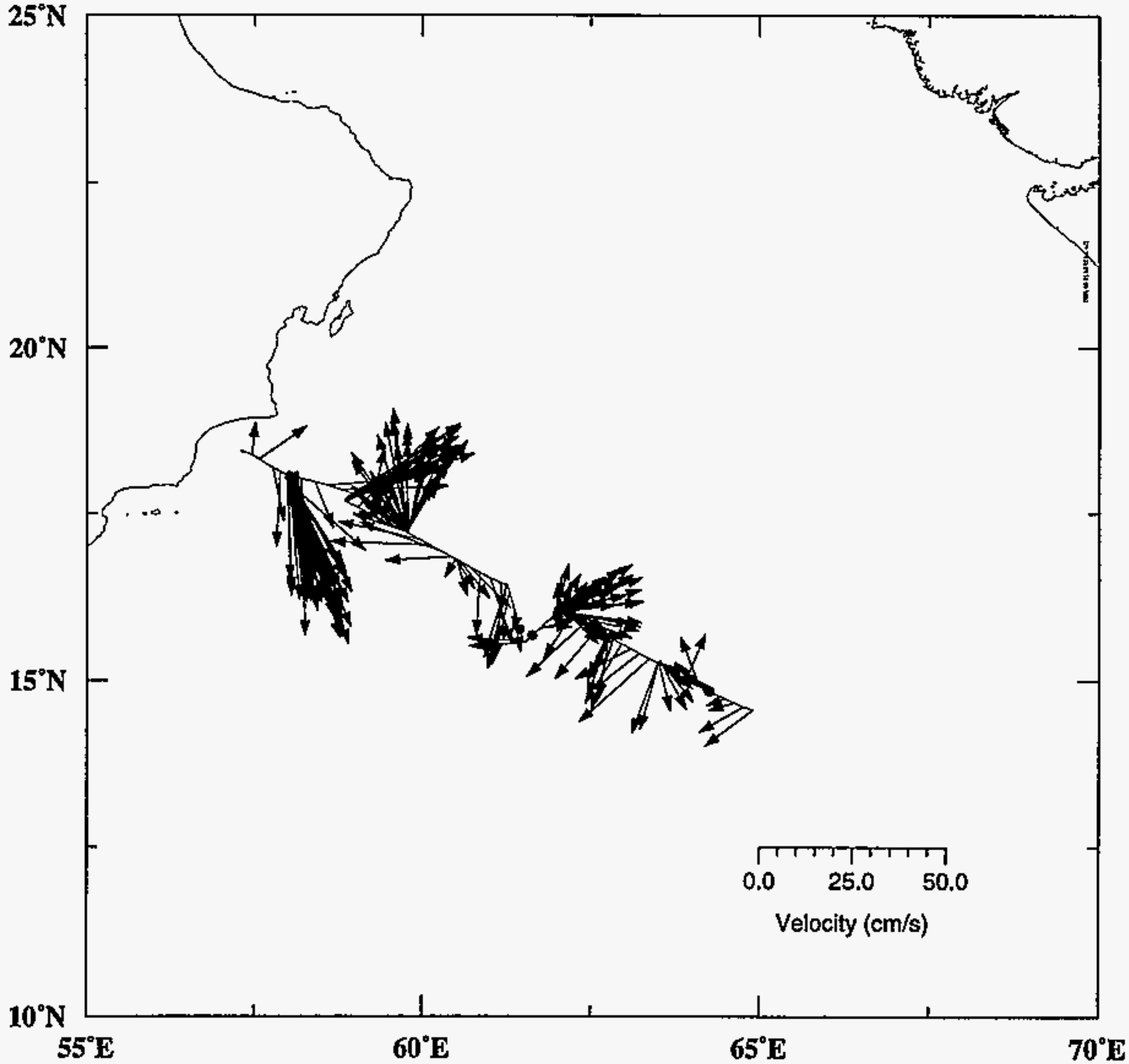
TN043 Section 6 to 7 (01/15/95 to 01/17/95)
Layer: 200m to 300m



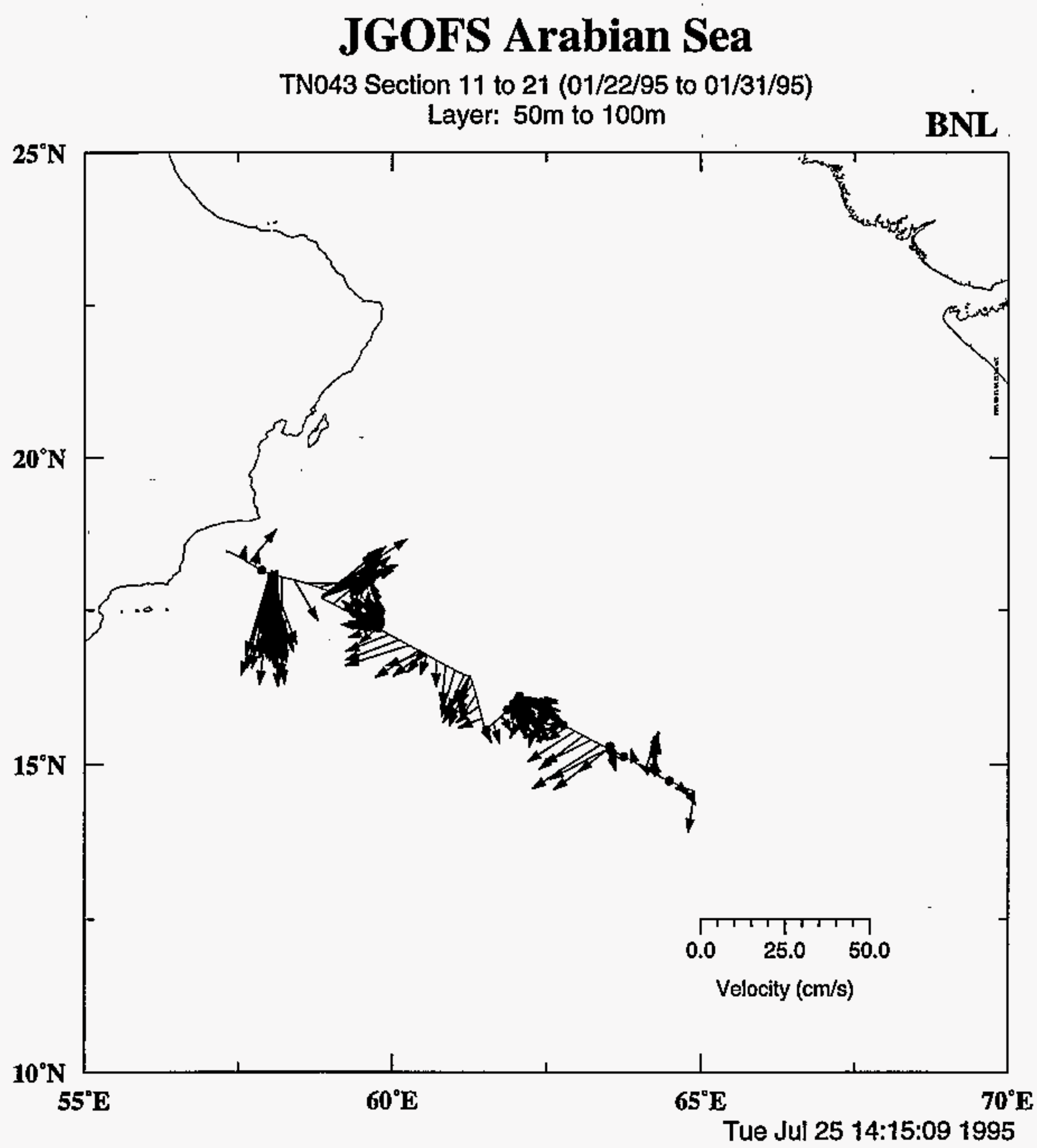
# JGOFS Arabian Sea

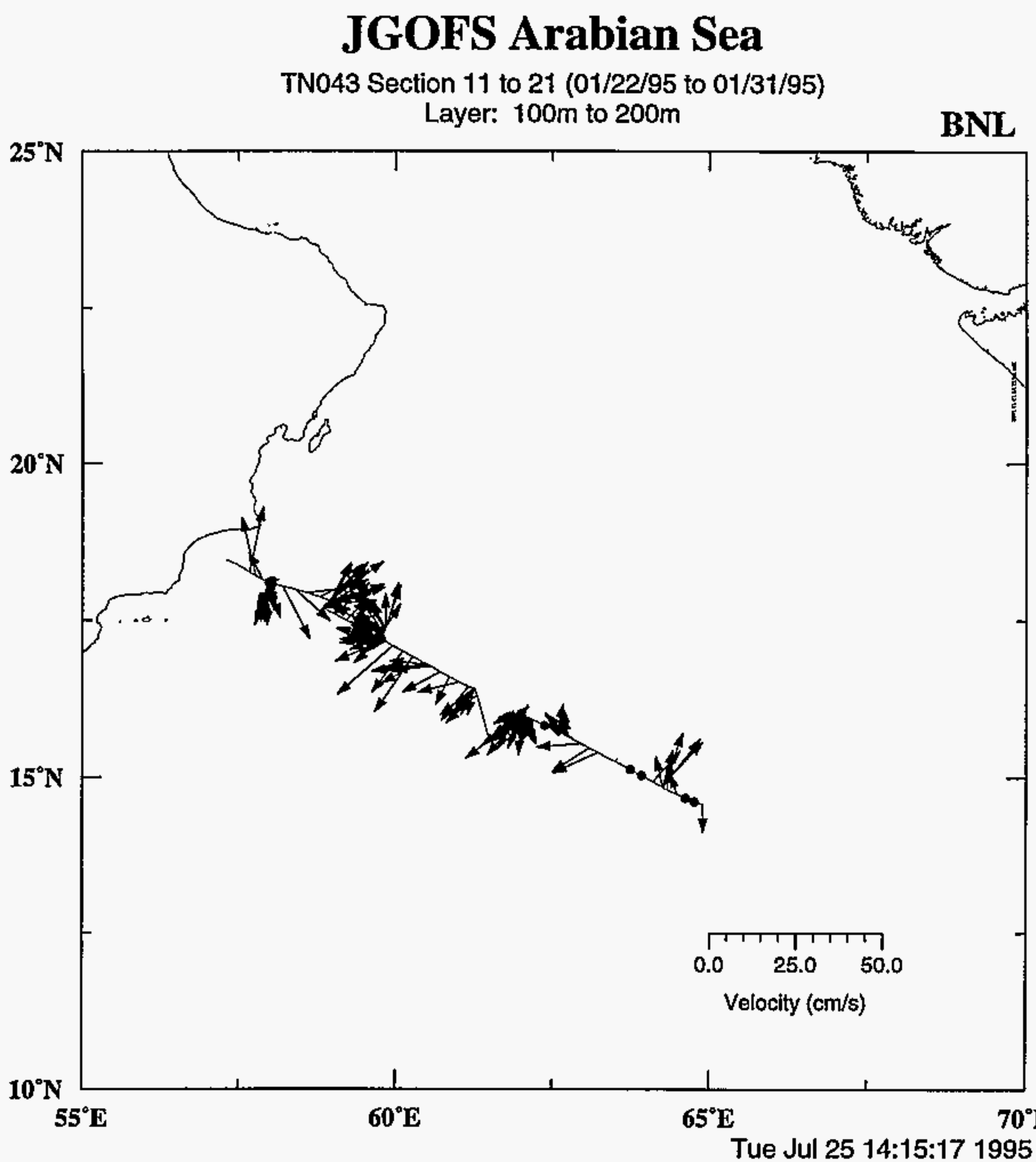
TN043 Section 11 to 21 (01/22/95 to 01/31/95)
Current Velocity 20m to 50m

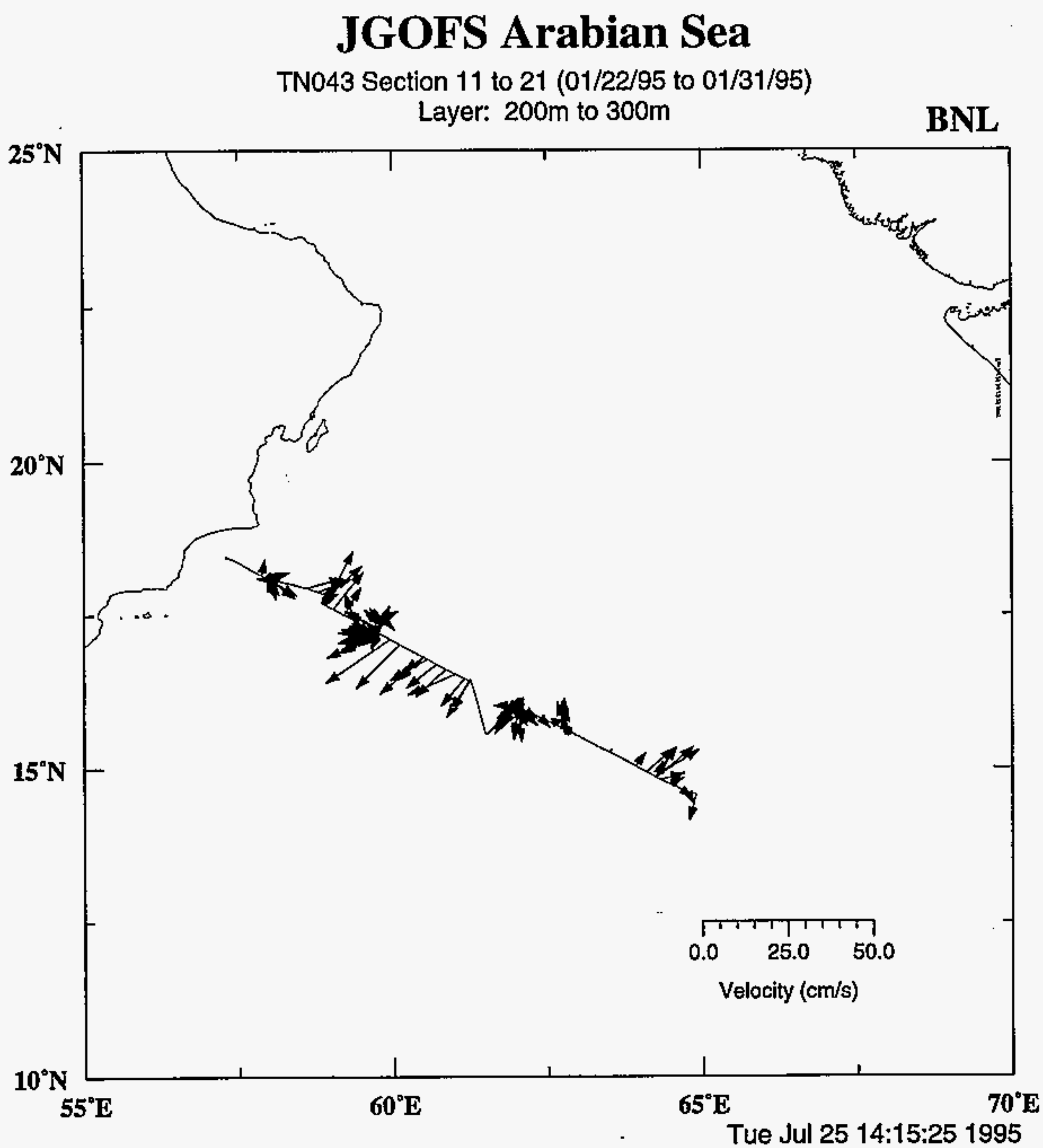
BNL

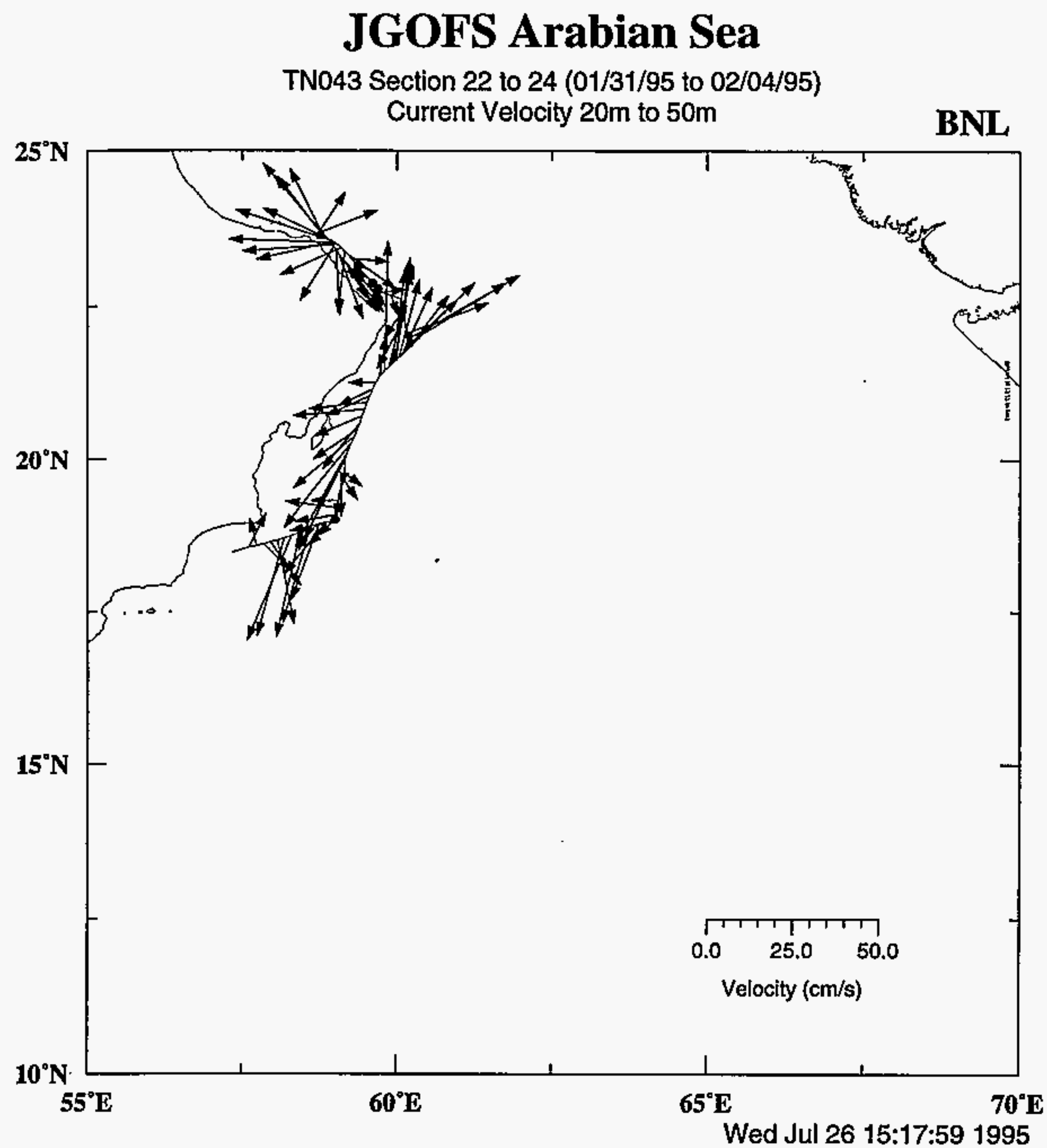



Tue Jul 25 14:15:03 1995


JGOFS Arabian Sea
TN043 Section 11 to 21 (01/22/95 to 01/31/95)
Layer: 50m to 100m
BNL
25°N
20°N
15°N
10°N
55°E
60°E
65°E
70°E
0.0
25.0
50.0
Velocity (cm/s)
Tue Jul 25 14:15:09 1995

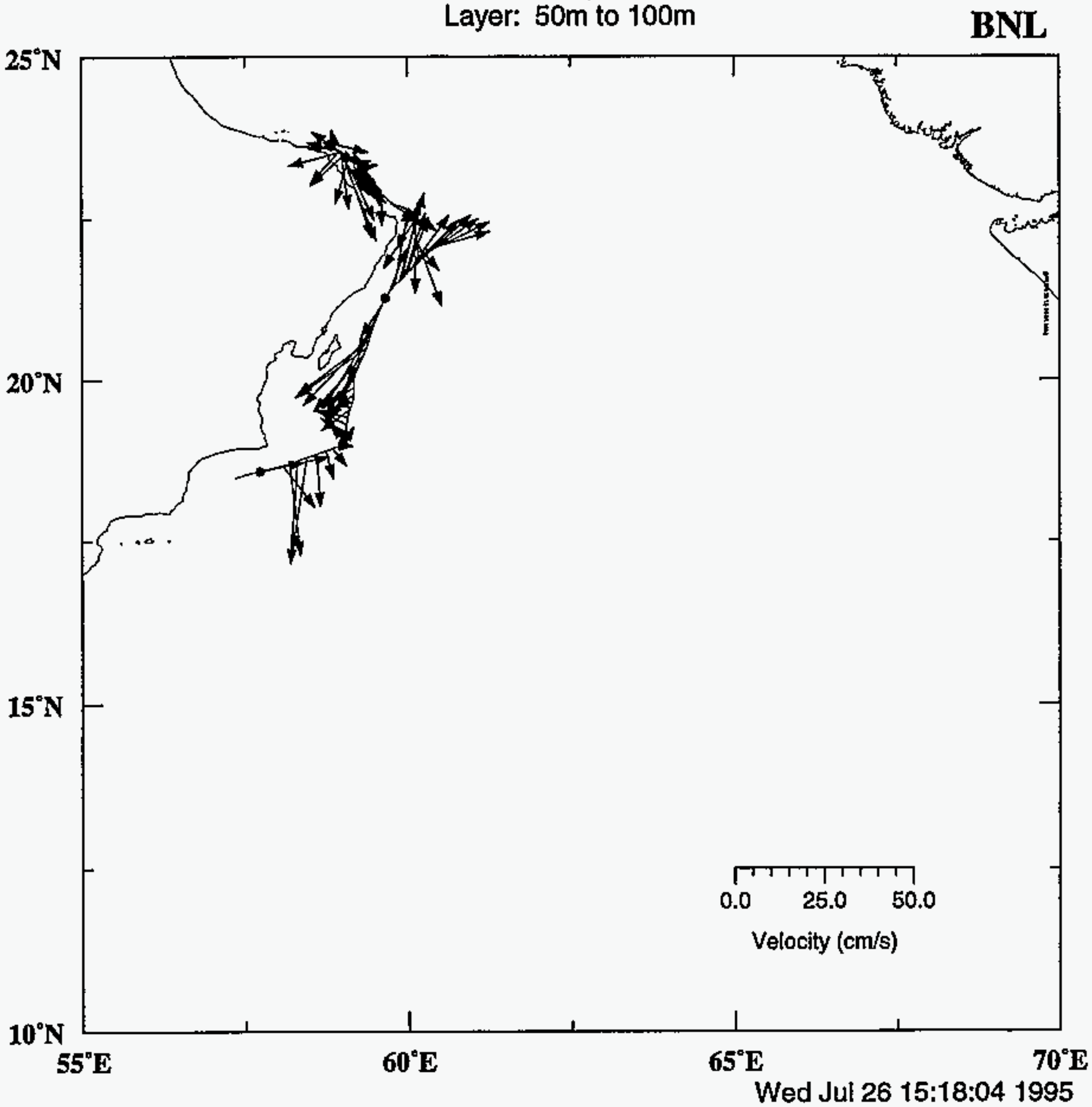

JGOFS Arabian Sea
TN043 Section 11 to 21 (01/22/95 to 01/31/95)
Layer: 100m to 200m
BNL
25°N
20°N
15°N
10°N
55°E
60°E
65°E
70°E
0.0
25.0
50.0
Velocity (cm/s)
Tue Jul 25 14:15:17 1995

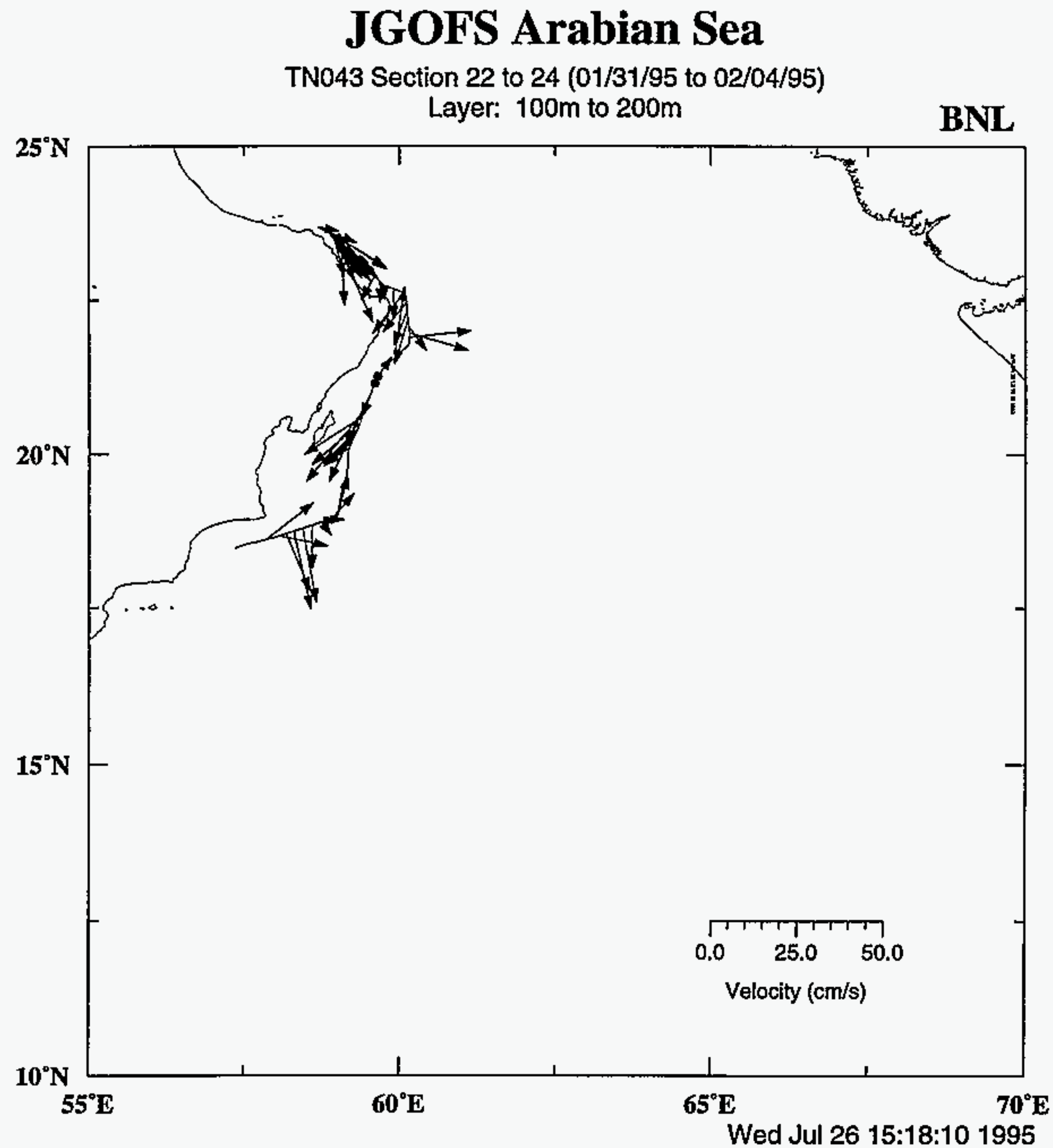

JGOFS Arabian Sea
TN043 Section 11 to 21 (01/22/95 to 01/31/95)
Layer: 200m to 300m
BNL
25°N
20°N
15°N
10°N
55°E
60°E
65°E
70°E
0.0
25.0
50.0
Velocity (cm/s)
Tue Jul 25 14:15:25 1995


JGOFS Arabian Sea
TN043 Section 22 to 24 (01/31/95 to 02/04/95)
Current Velocity 20m to 50m
BNL
25°N
20°N
15°N
10°N
55°E
60°E
65°E
70°E
0.0
25.0
50.0
Velocity (cm/s)
Wed Jul 26 15:17:59 1995

# JGOFS Arabian Sea

TN043 Section 22 to 24 (01/31/95 to 02/04/95)
Layer: 50m to 100m

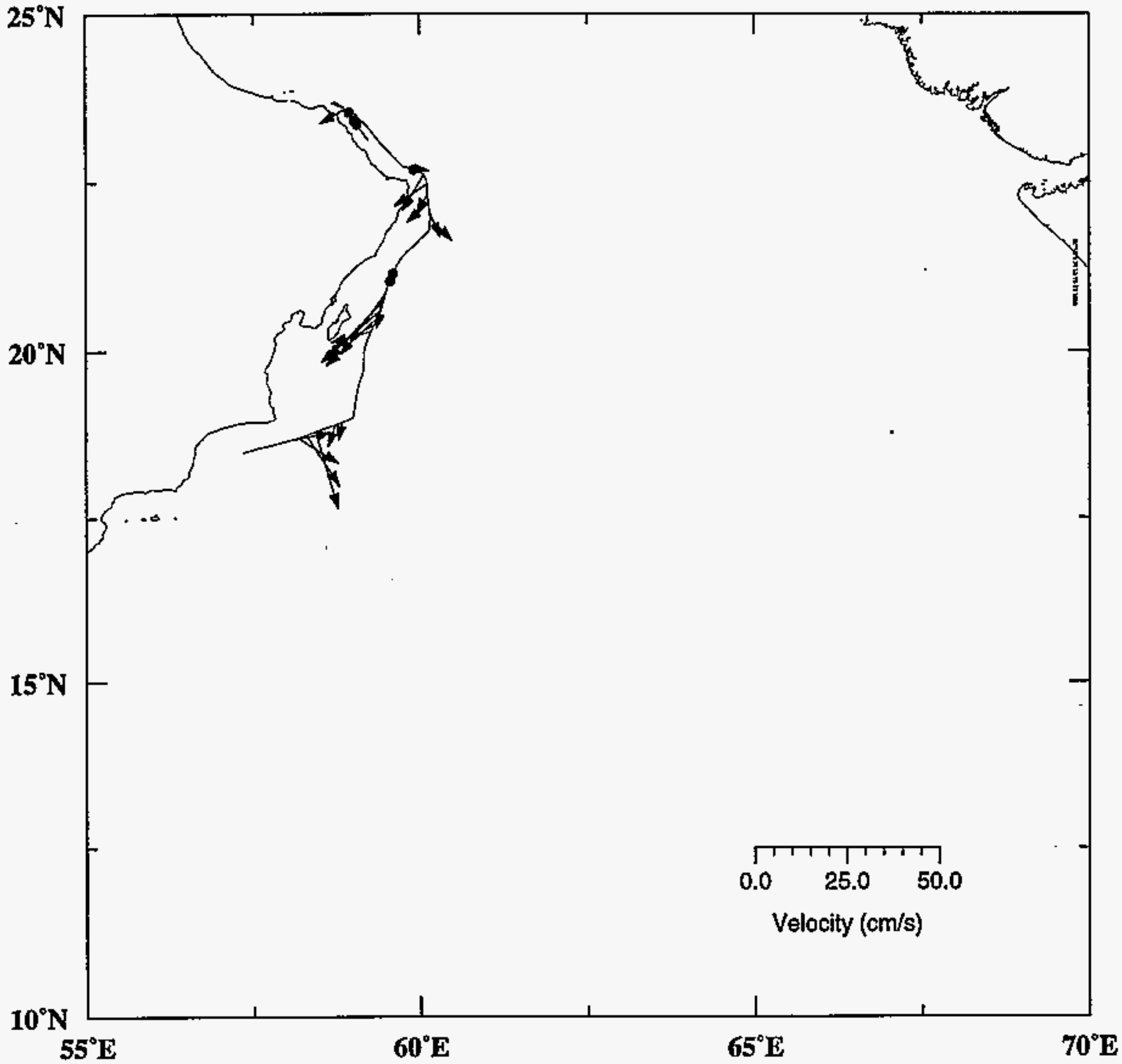



JGOFS Arabian Sea
TN043 Section 22 to 24 (01/31/95 to 02/04/95)
Layer: 100m to 200m
BNL
25°N
20°N
15°N
10°N
55°E
60°E
65°E
70°E
0.0
25.0
50.0
Velocity (cm/s)
Wed Jul 26 15:18:10 1995

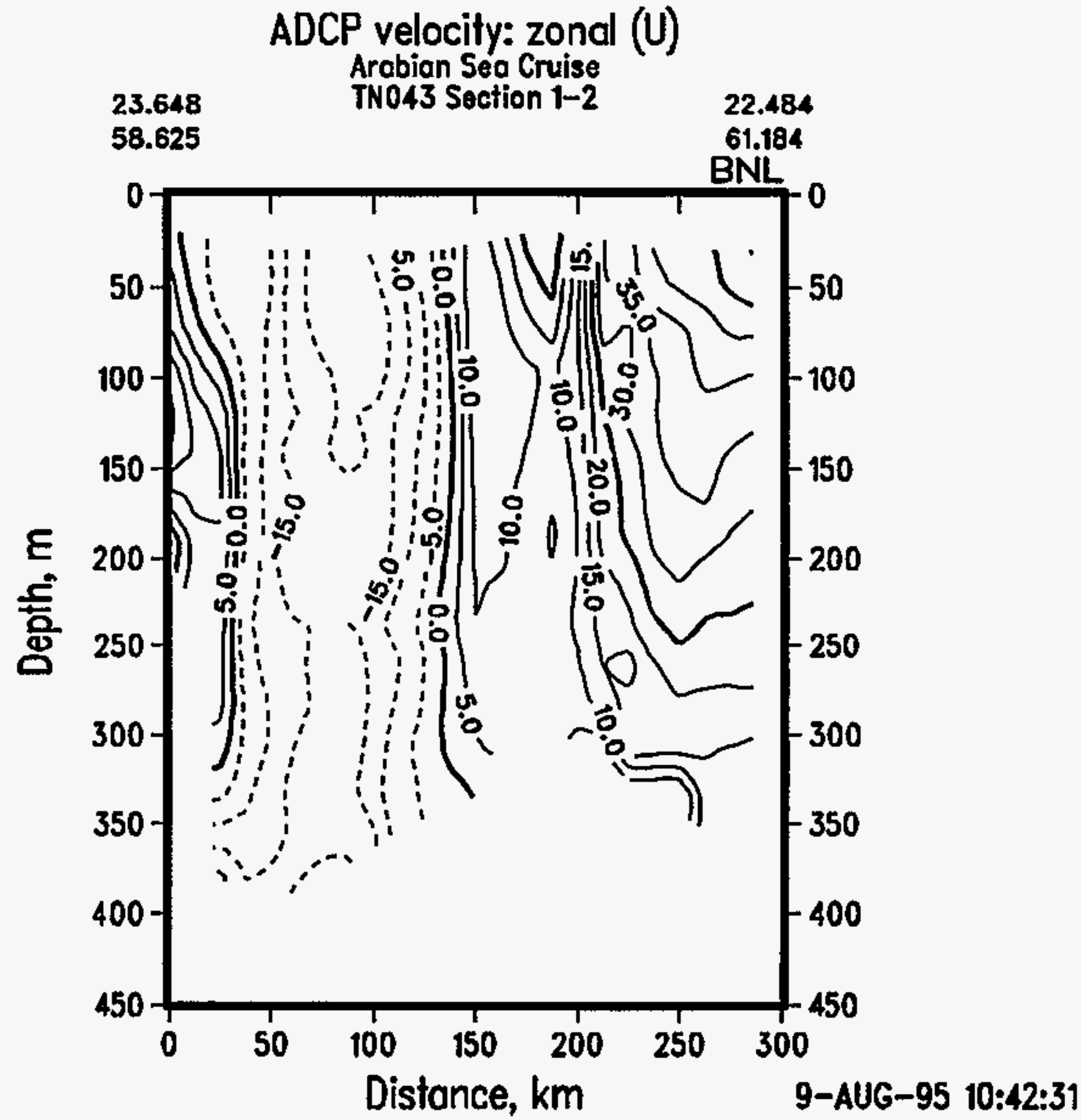
# JGOFS Arabian Sea

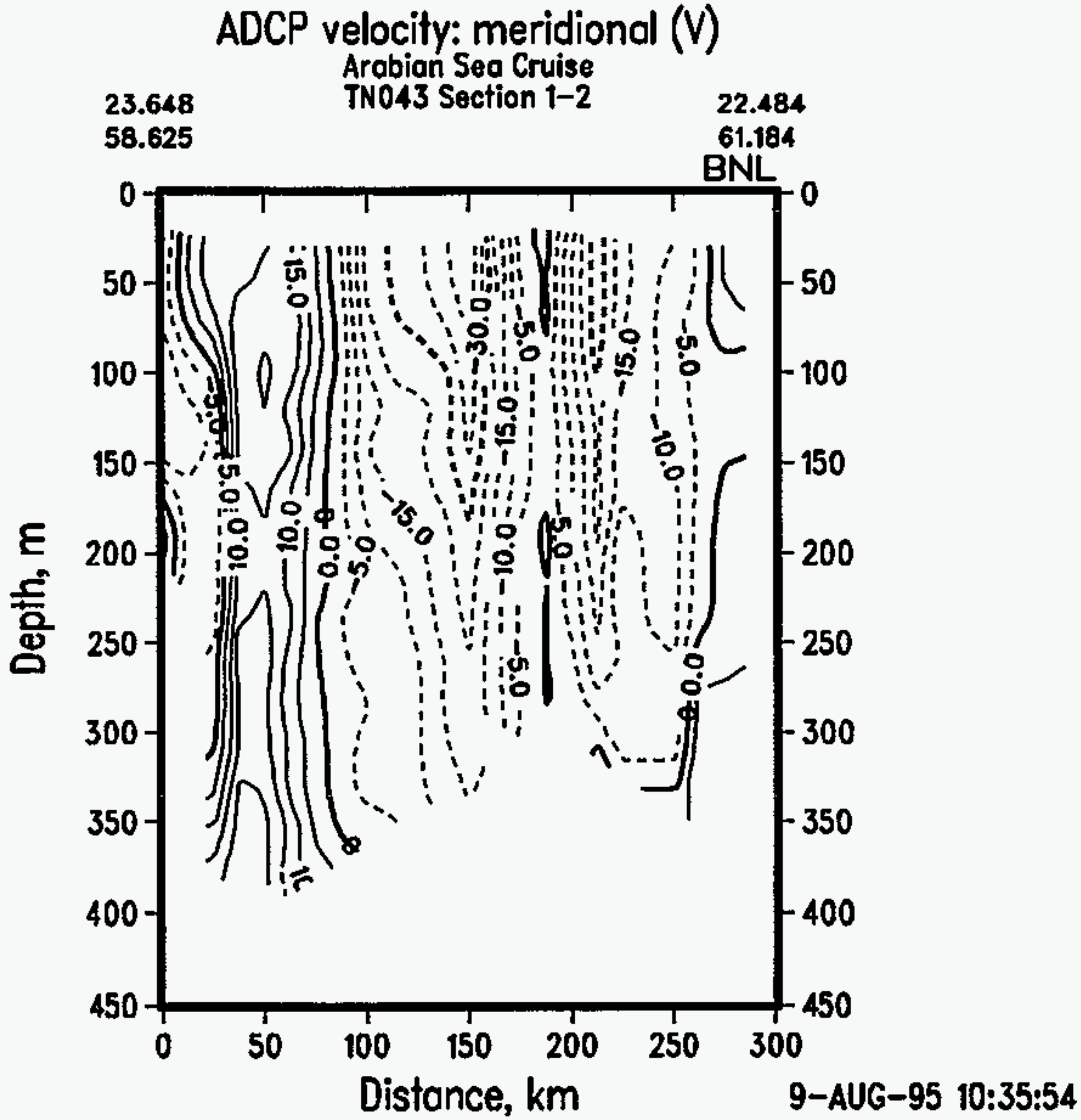
TN043 Section 22 to 24 (01/31/95 to 02/04/95)
Layer: 200m to 300m

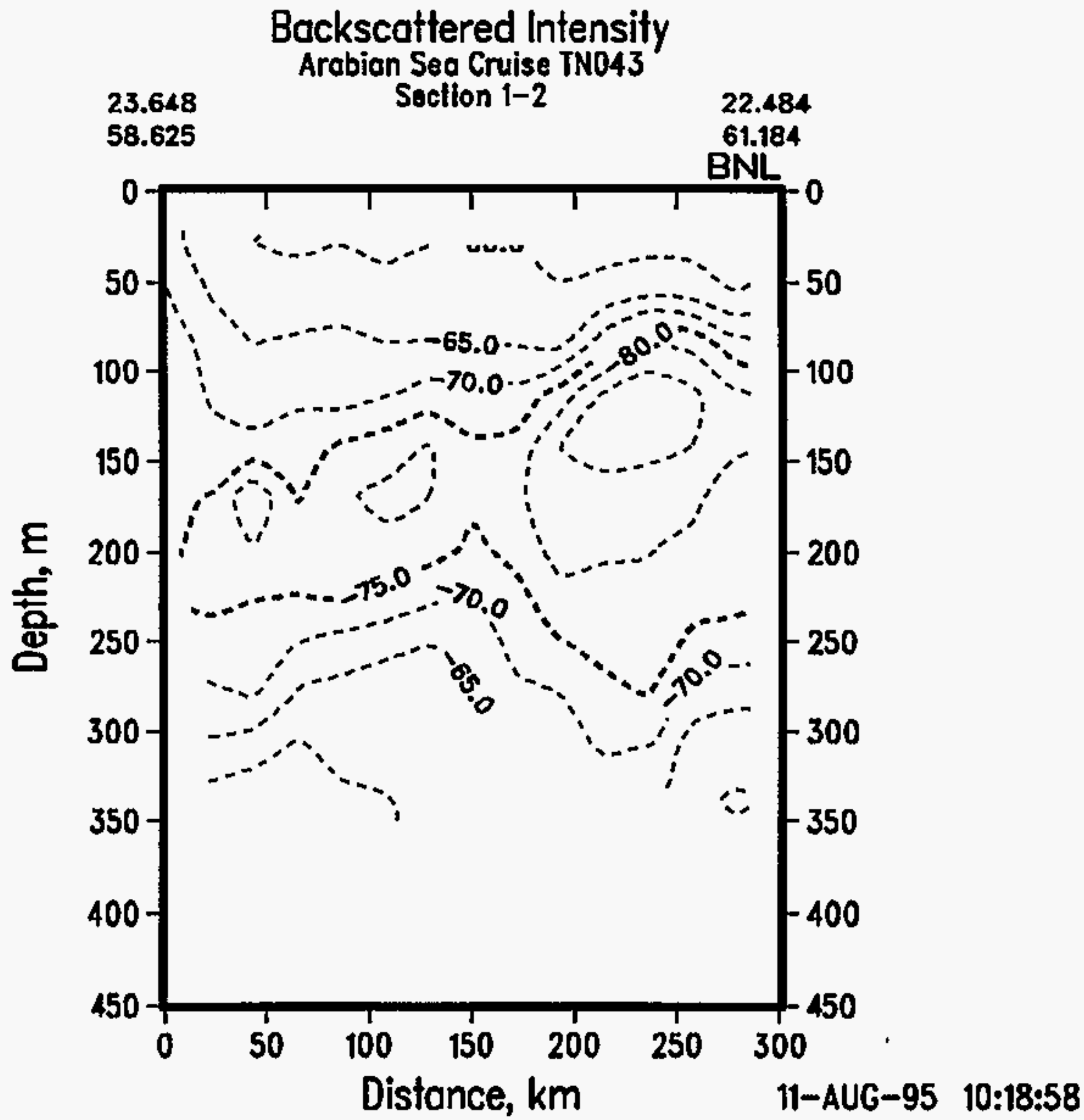
BNL



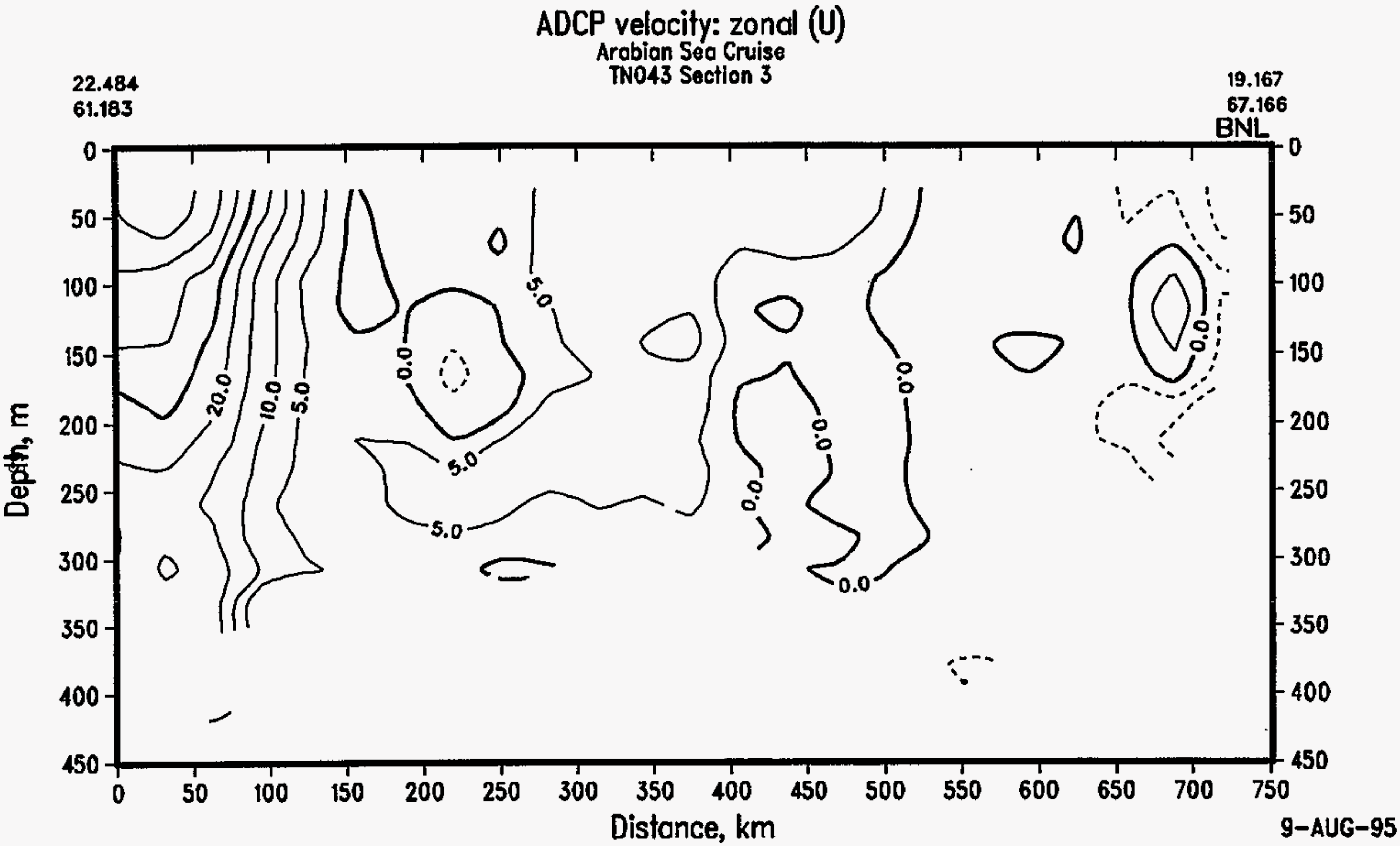

Wed Jul 26 15:18:15 1995


ADCP velocity: zonal (U)
Arabian Sea Cruise
TN043 Section 1-2
23.648
58.625
22.484
61.184
BNL
Depth, m
Distance, km
9-AUG-95 10:42:31
0
50
100
150
200
250
300
350
400
450
0
50
100
150
200
250
300
35.0
30.0
20.0
15.0
10.0
5.0
0.0
-5.0
-15.0
15.

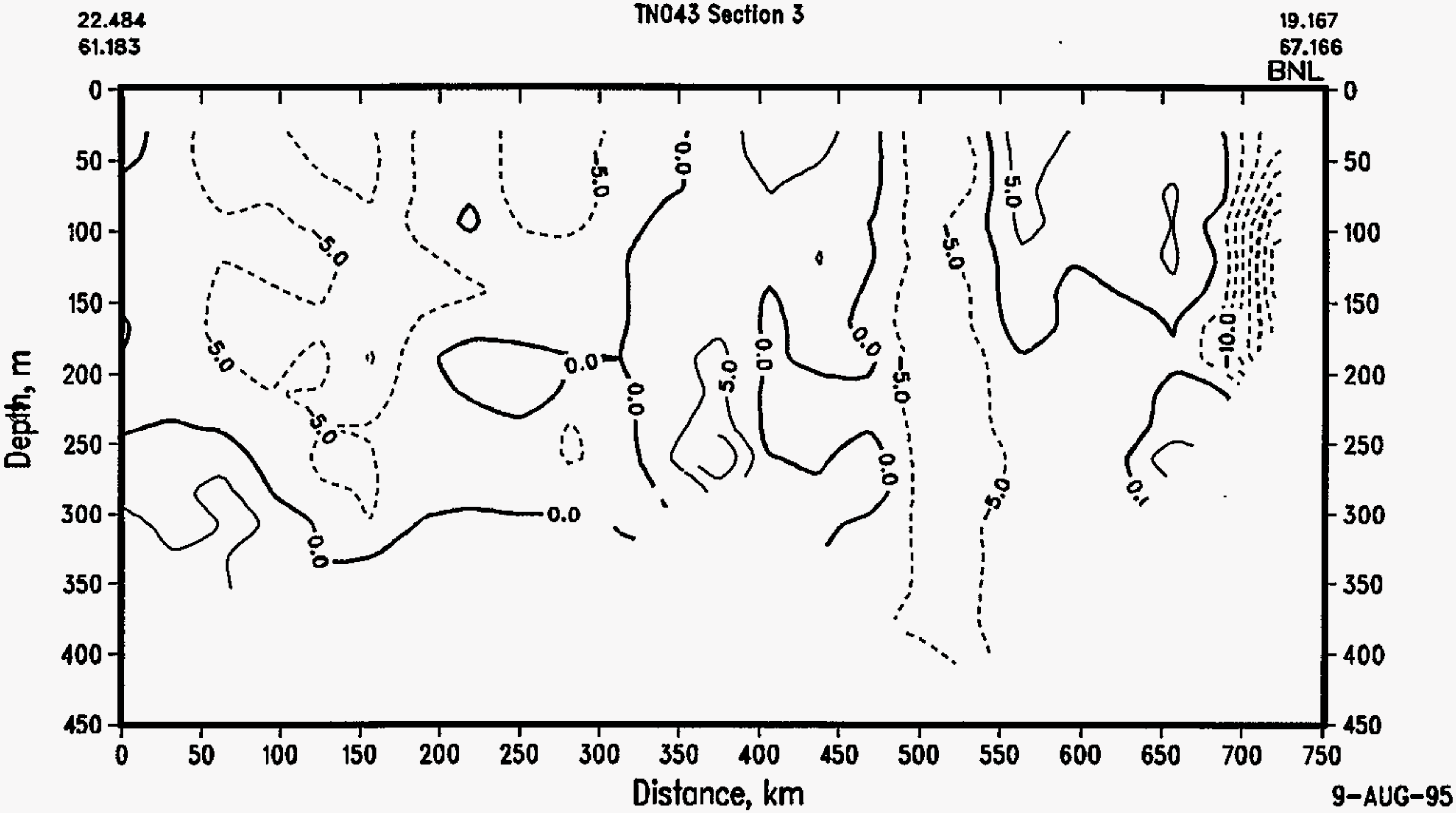

ADCP velocity: meridional (V)
Arabian Sea Cruise
TN043 Section 1-2
23.648
58.625
22.484
61.184
BNL
Depth, m
Distance, km
9-AUG-95 10:35:54

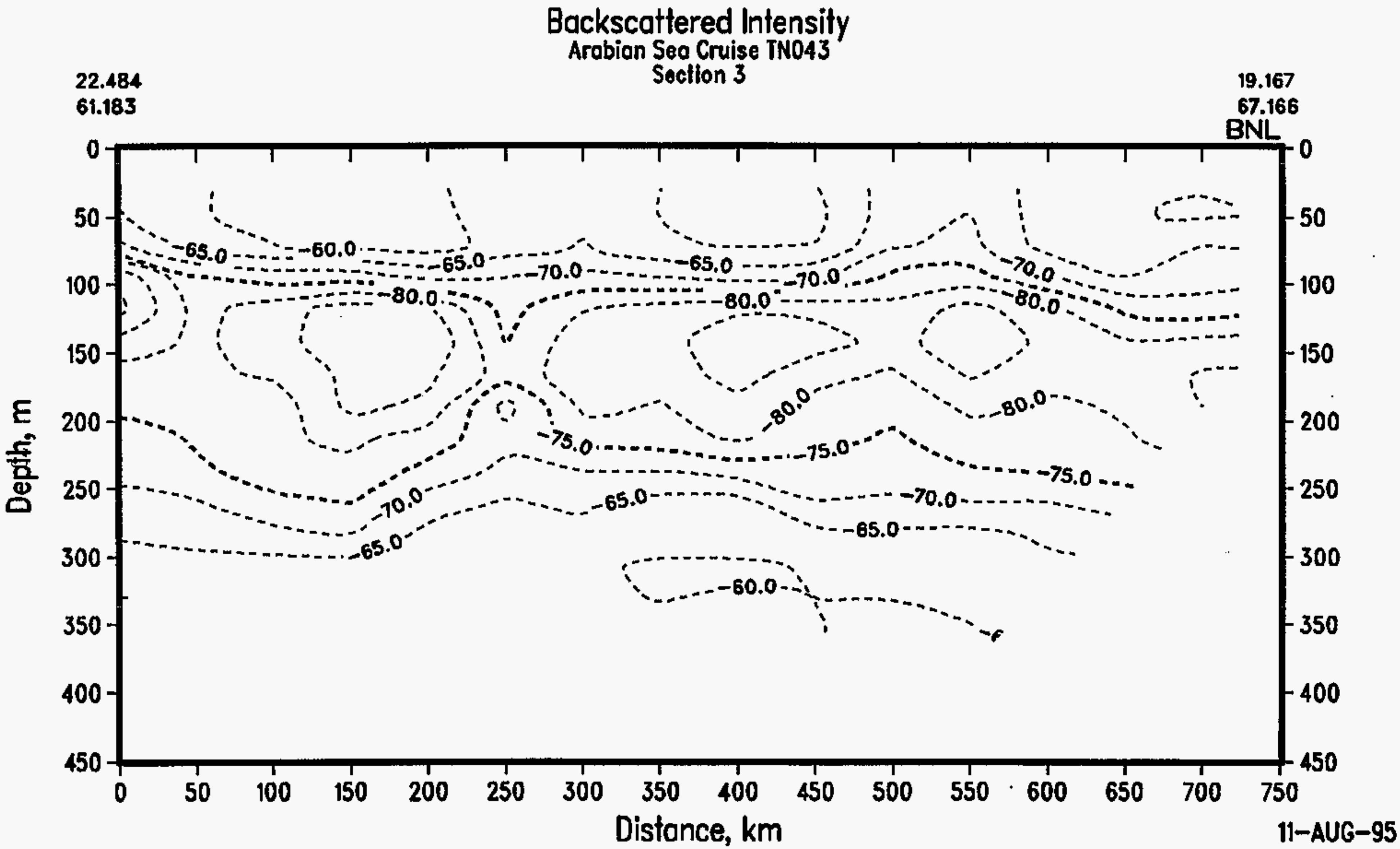


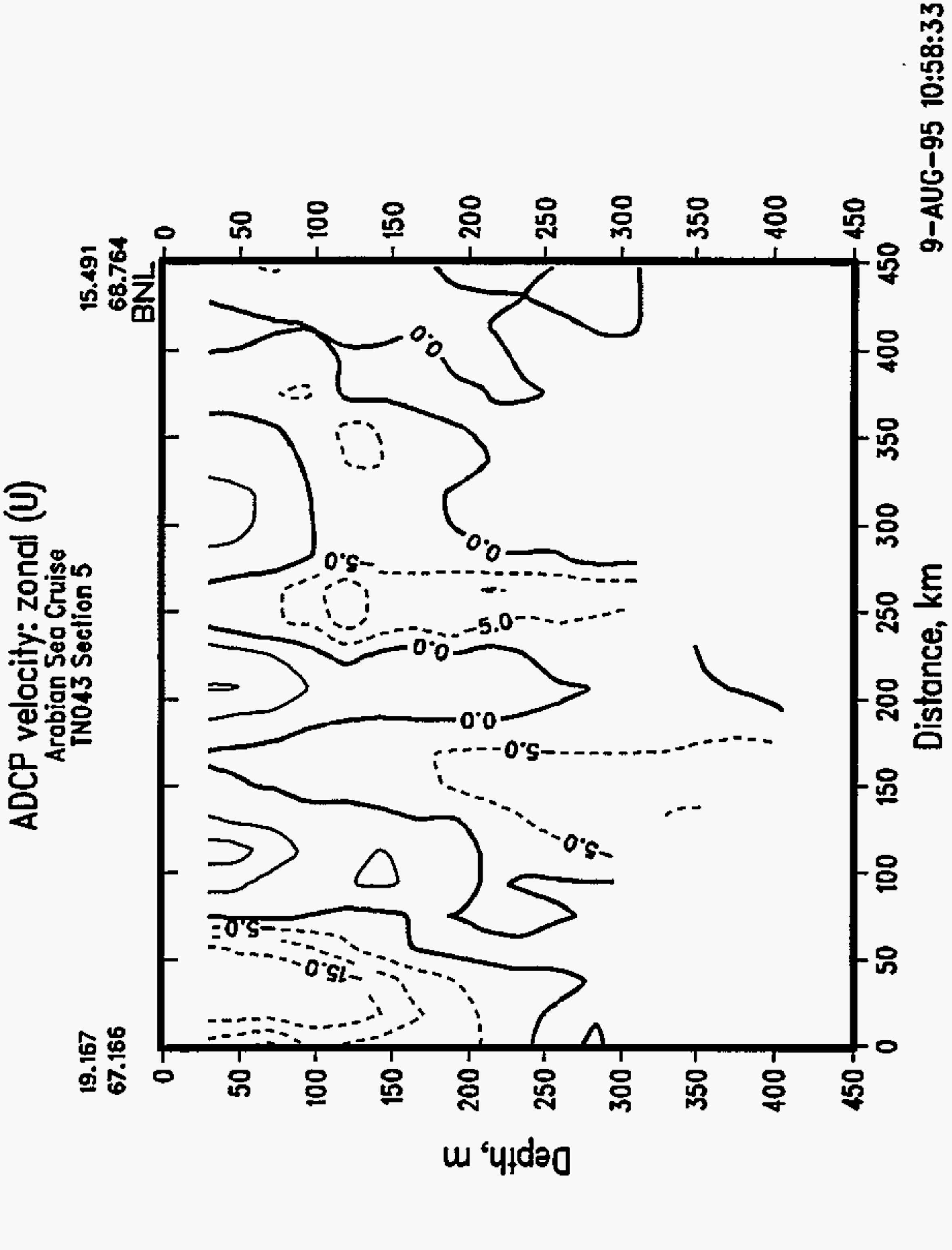
Backscattered Intensity
Arabian Sea Cruise TN043
Section 1-2
23.648
58.625
22.484
61.184
BNL
Depth, m
Distance, km
-65.0
-70.0
-80.0
-75.0
-70.0
-65.0
-70.0
11-AUG-95 10:18:58

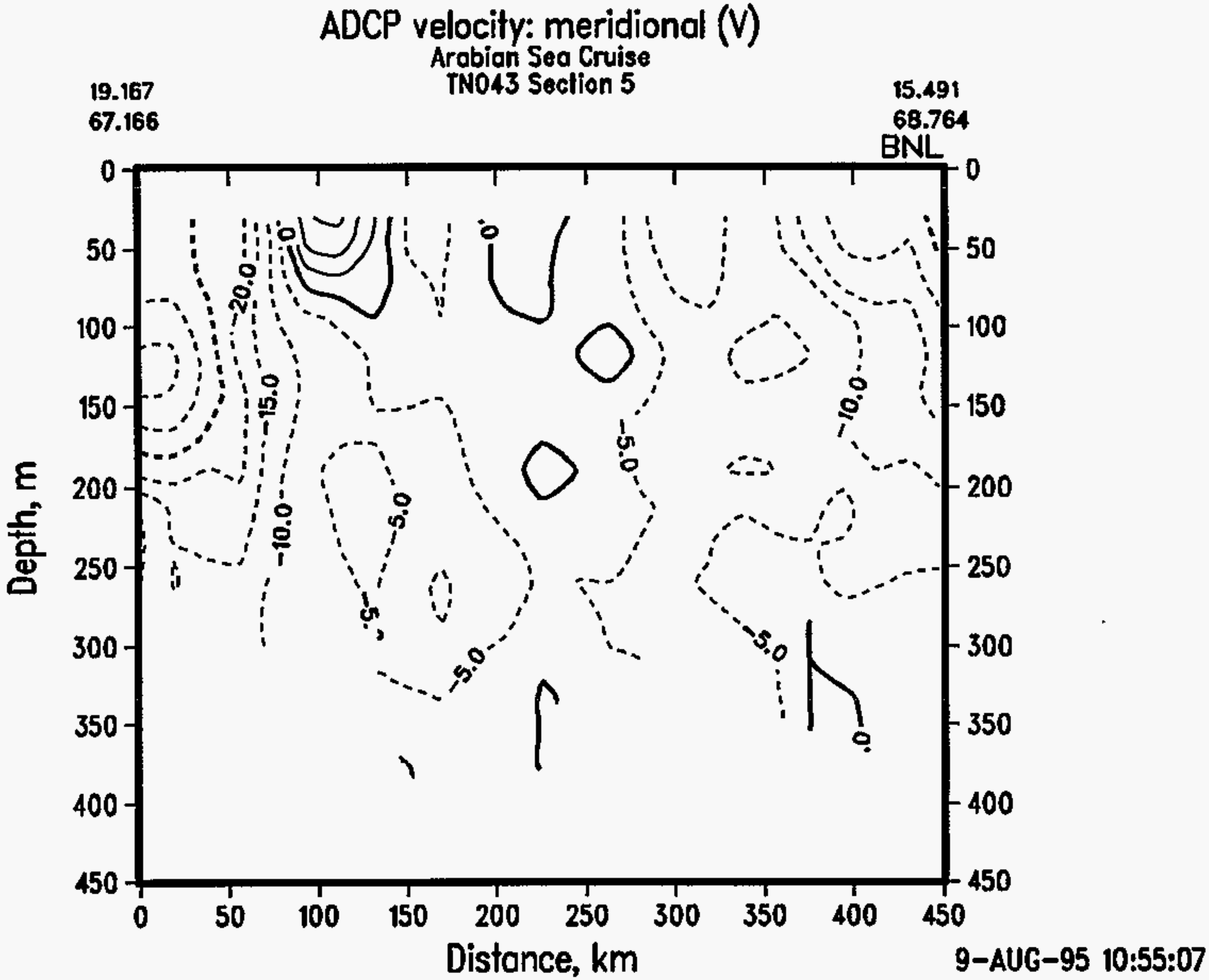

ADCP velocity: zonal (U)
Arabian Sea Cruise
TN043 Section 3
22.484
61.183
19.167
67.166
BNL
Depth, m
Distance, km
20.0
10.0
5.0
0.0
9-AUG-95

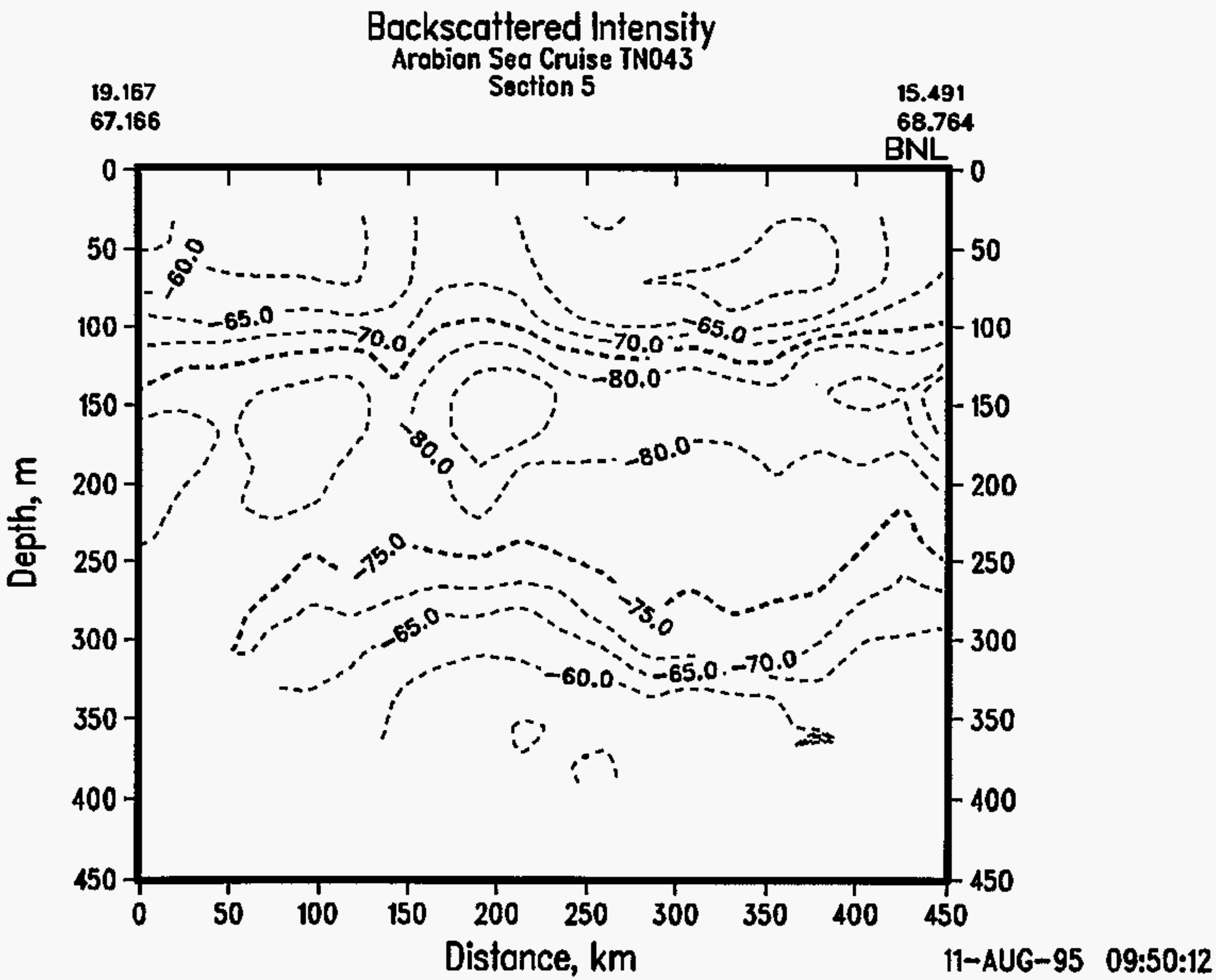
ADCP velocity: meridional (V)
Arabian Sea Cruise
TN043 Section 3

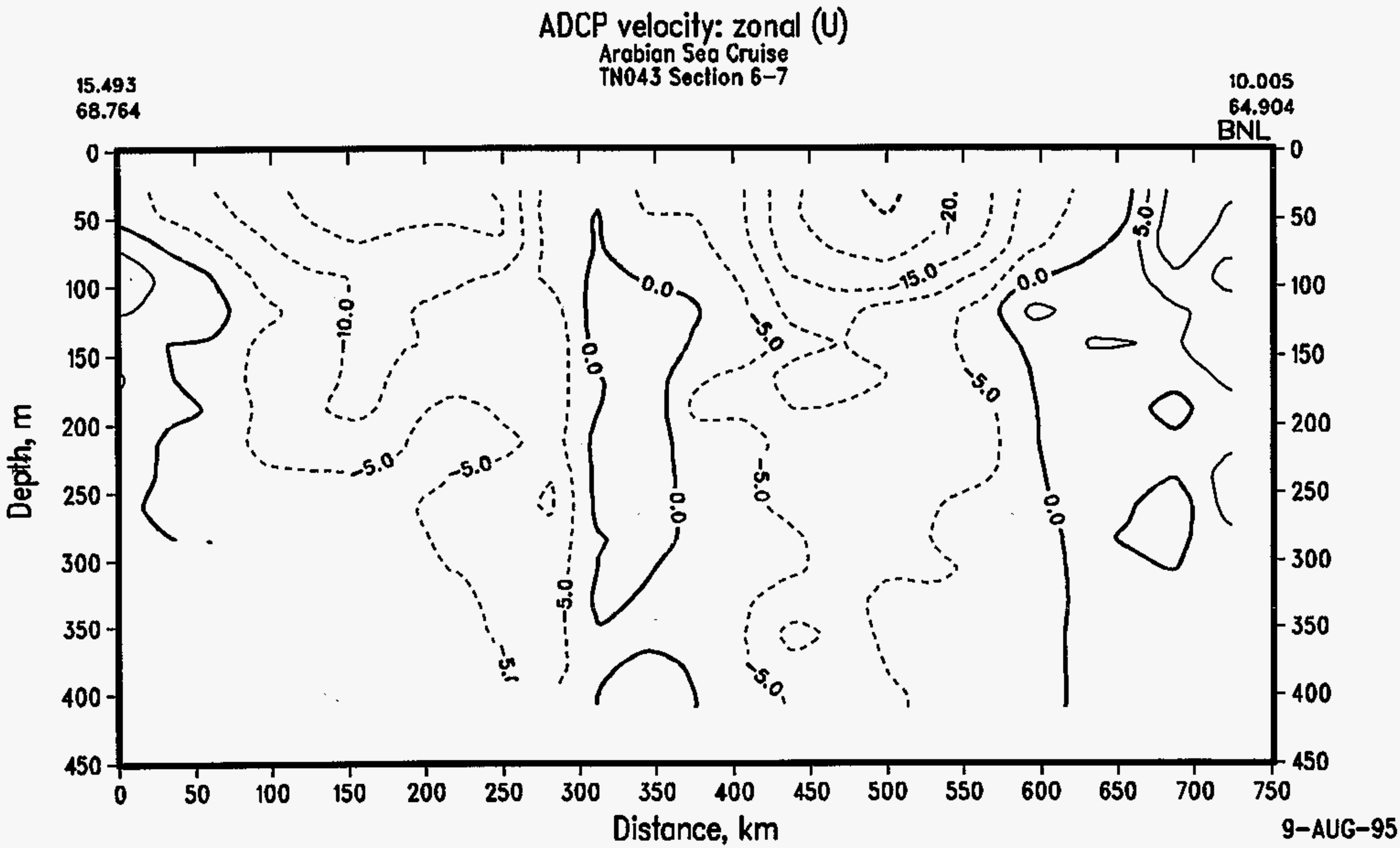



Backscattered Intensity
Arabian Sea Cruise TN043
Section 3
22.484
61.183
19.167
67.166
BNL
Depth, m
Distance, km
0
50
100
150
200
250
300
350
400
450
500
550
600
650
700
750
-60.0
-65.0
-70.0
-75.0
-80.0
11-AUG-95

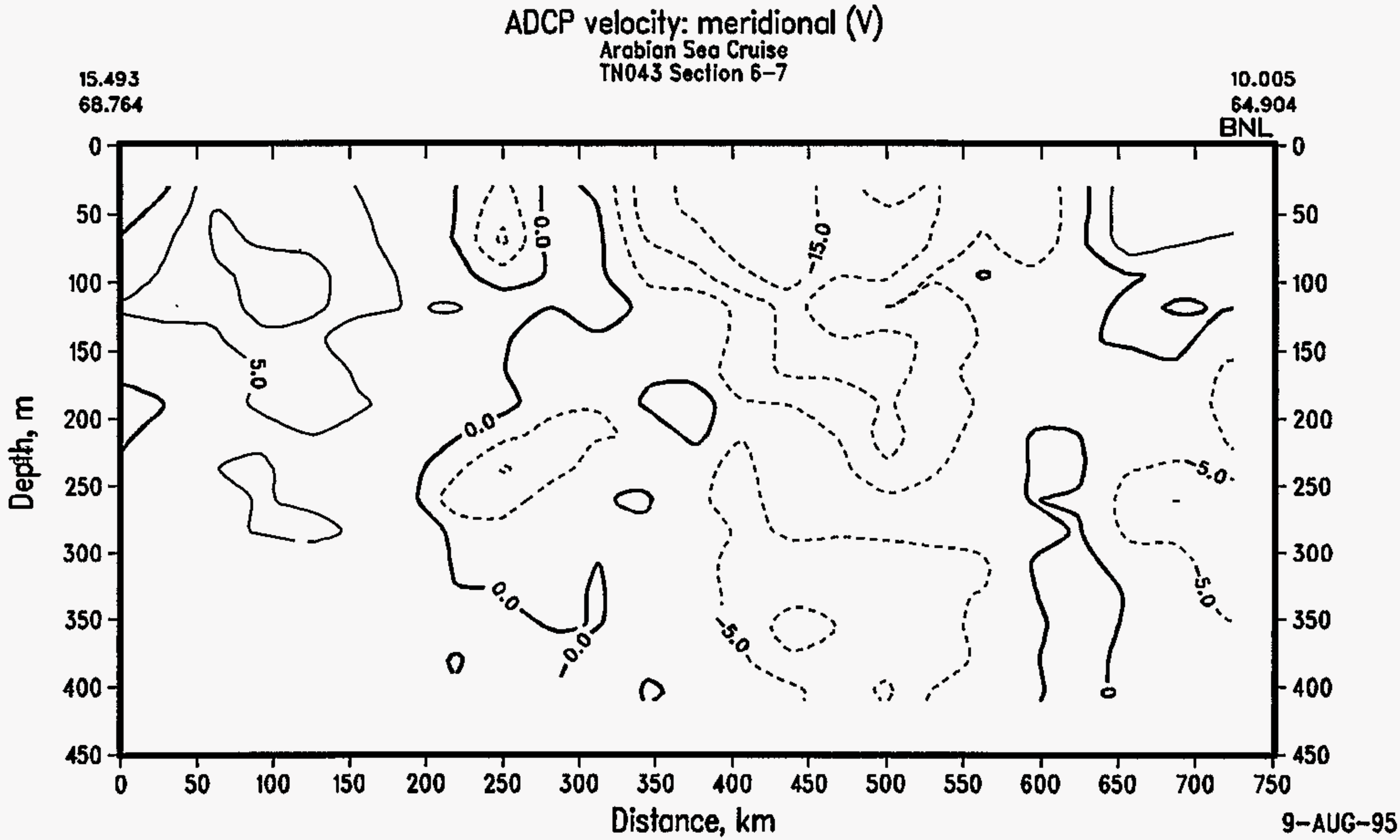

ADCP velocity: zonal (U)
Arabian Sea Cruise
TN043 Section 5
19.167
67.166
15.491
68.764
BNL
Depth, m
Distance, km
0.0
-5.0
5.0
-15.0
9-AUG-95 10:58:33

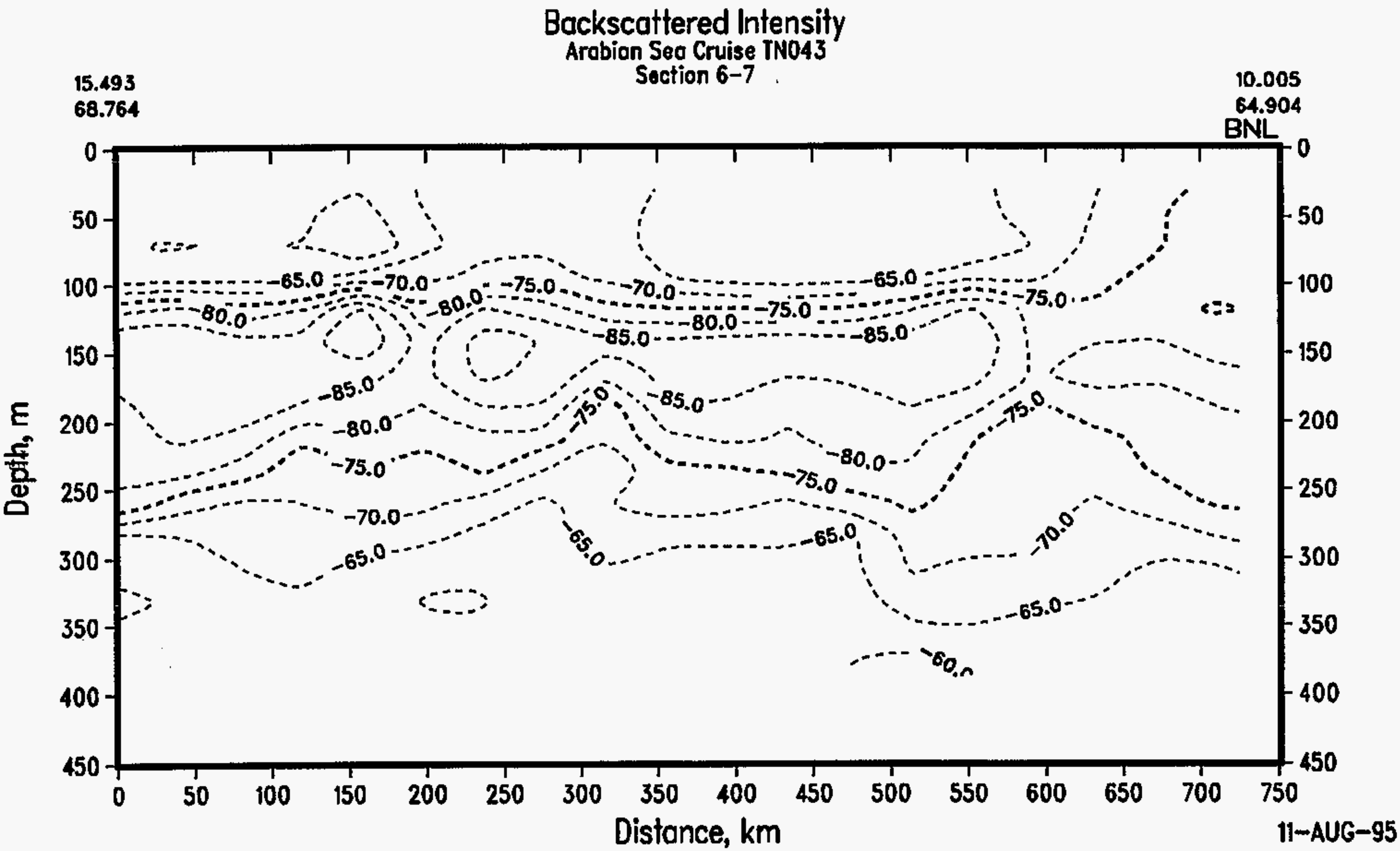

ADCP velocity: meridional (V)
Arabian Sea Cruise
TN043 Section 5
19.167
67.166
15.491
68.764
BNL
Depth, m
Distance, km
9-AUG-95 10:55:07


Backscattered Intensity
Arabian Sea Cruise TN043
Section 5
19.167
67.166
15.491
68.764
BNL
Depth, m
Distance, km
-60.0
-65.0
-70.0
-80.0
-75.0
11-AUG-95 09:50:12

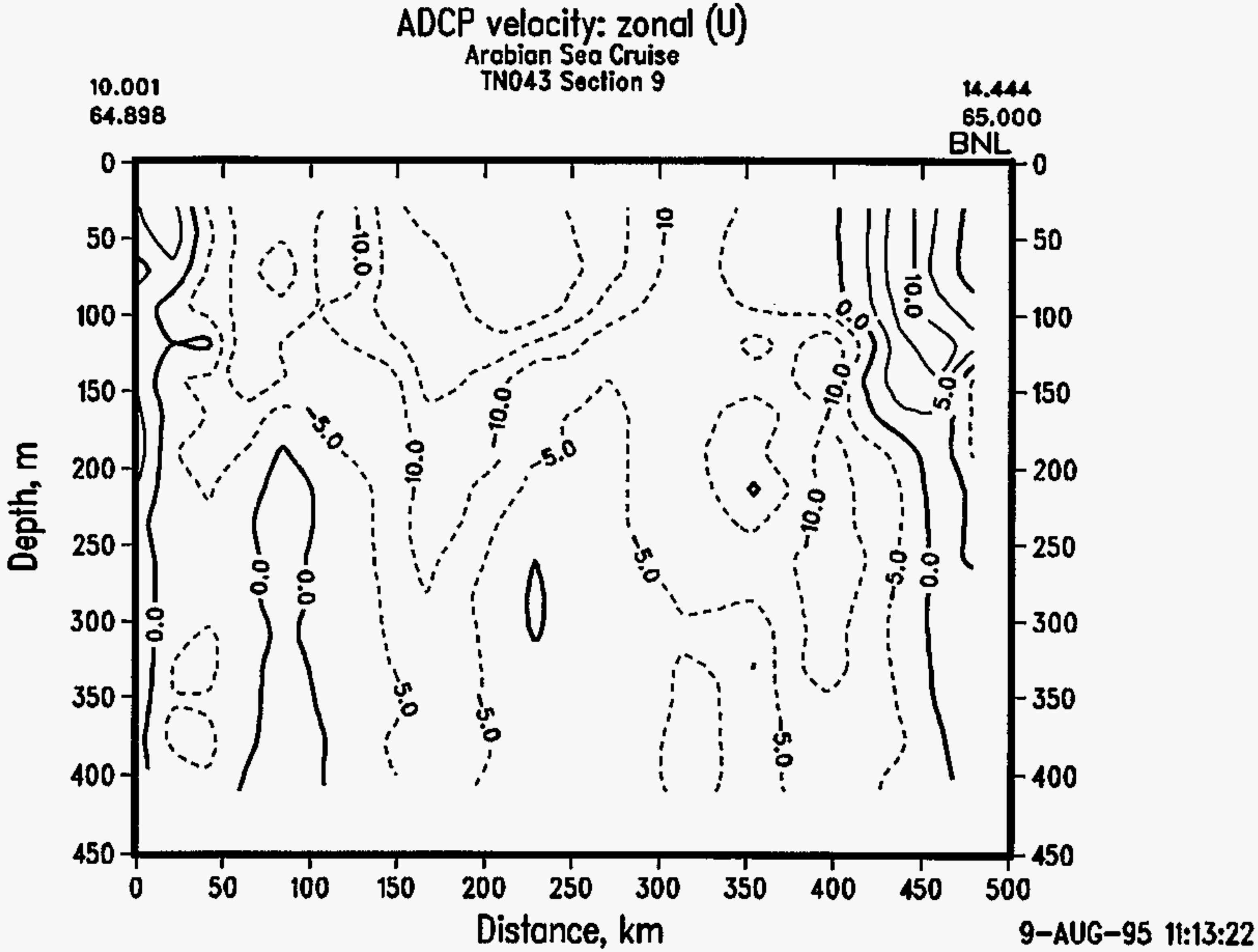


ADCP velocity: zonal (U)
Arabian Sea Cruise
TN043 Section 6-7
15.493
68.764
10.005
64.904
BNL
Depth, m
Distance, km
9-AUG-95
0
50
100
150
200
250
300
350
400
450
500
550
600
650
700
750
-10.0
-5.0
0.0
-15.0
-20.
5.0

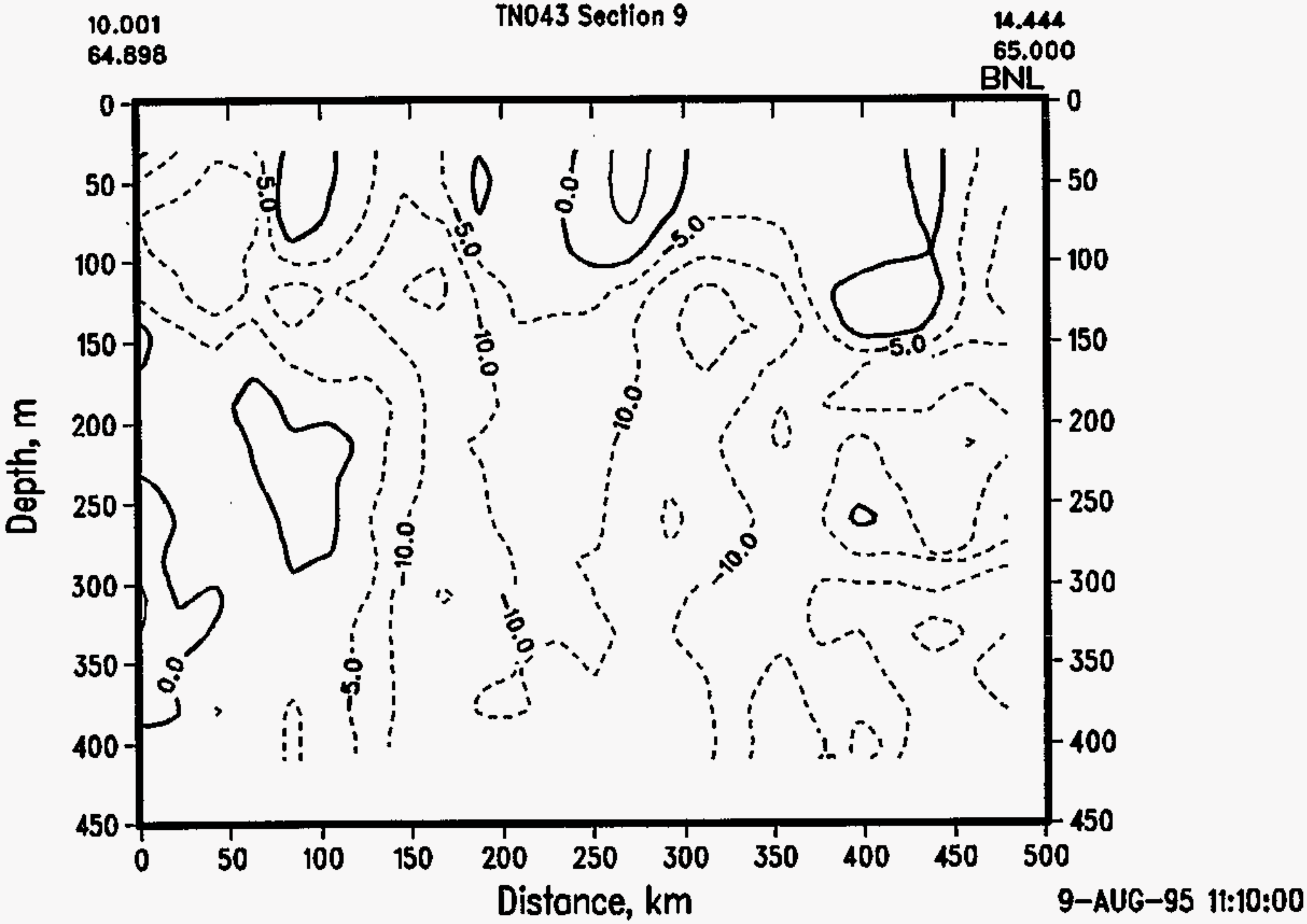

ADCP velocity: meridional (V)
Arabian Sea Cruise
TN043 Section 6-7
15.493
68.764
10.005
64.904
BNL
Depth, m
Distance, km
9-AUG-95
0 50 100 150 200 250 300 350 400 450
0 50 100 150 200 250 300 350 400 450 500 550 600 650 700 750
5.0
0.0
-15.0
-5.0
-0.0



Backscattered Intensity
Arabian Sea Cruise TN043
Section 6-7
15.493
68.764
10.005
64.904
BNL
Depth, m
Distance, km
11-AUG-95

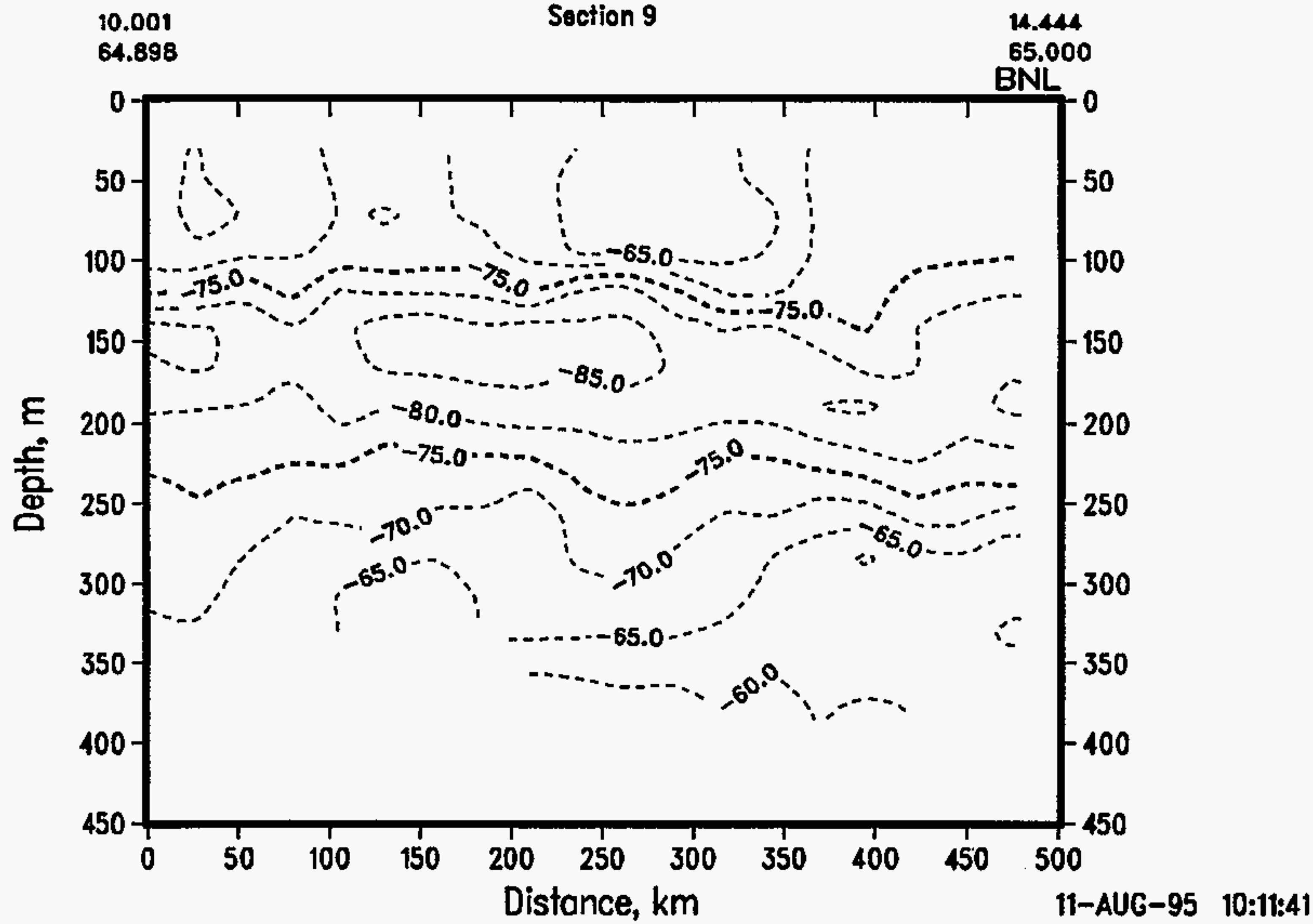

ADCP velocity: zonal (U)
Arabian Sea Cruise
TN043 Section 9
10.001
64.898
14.444
65.000
BNL
Depth, m
Distance, km
9-AUG-95 11:13:22

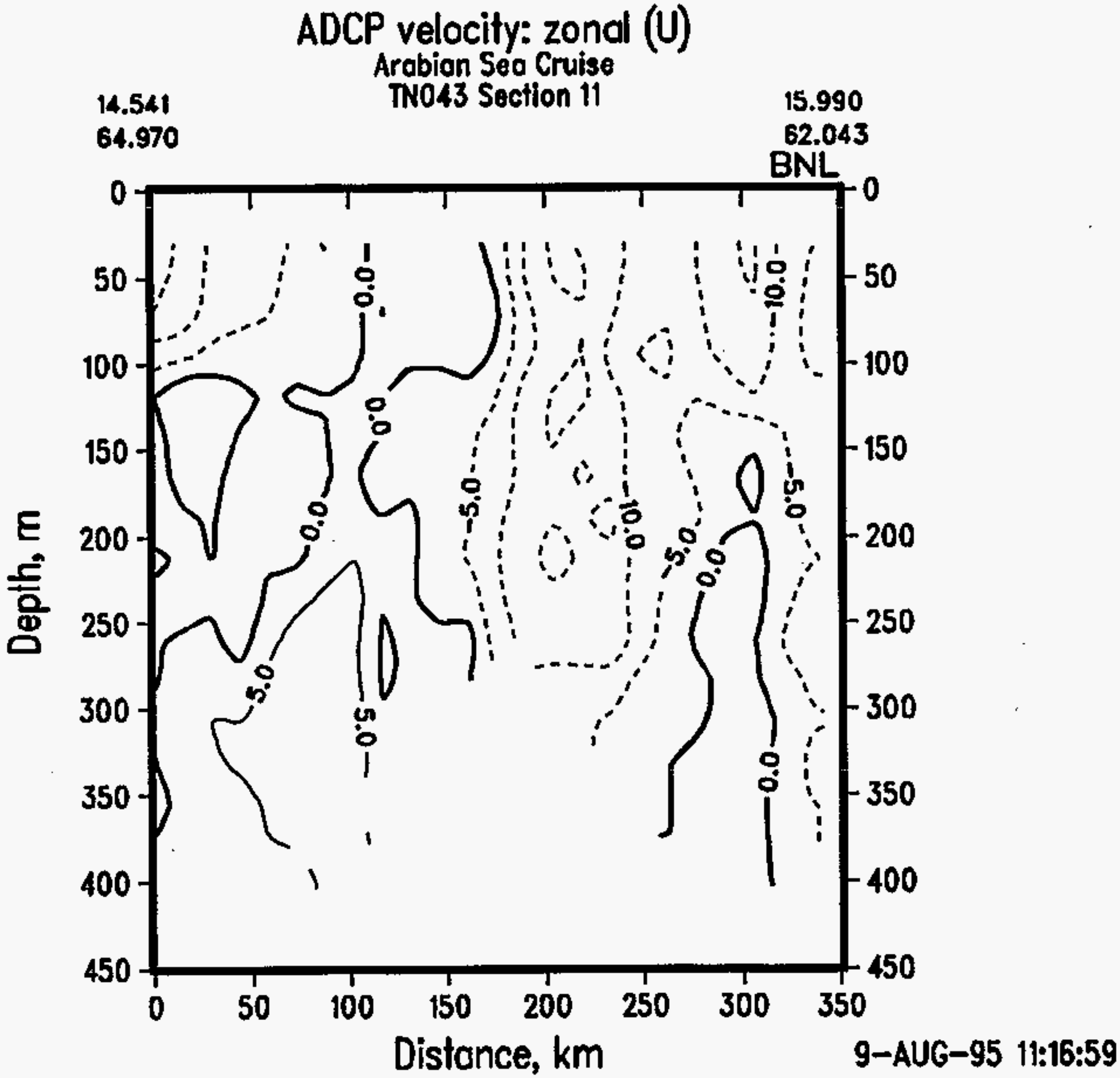
ADCP velocity: meridional (V)
Arabian Sea Cruise
TN043 Section 9



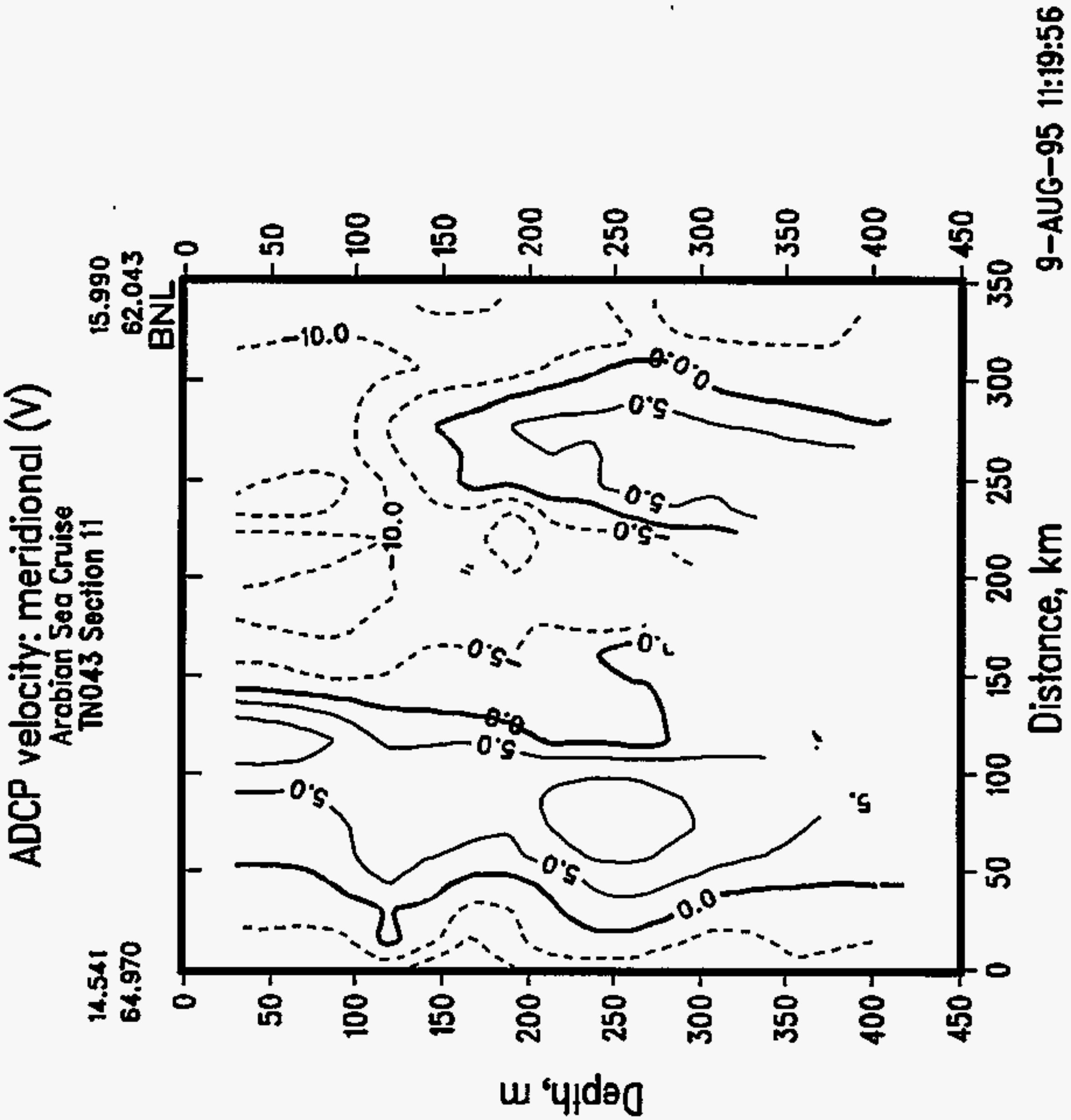
# Backscattered Intensity

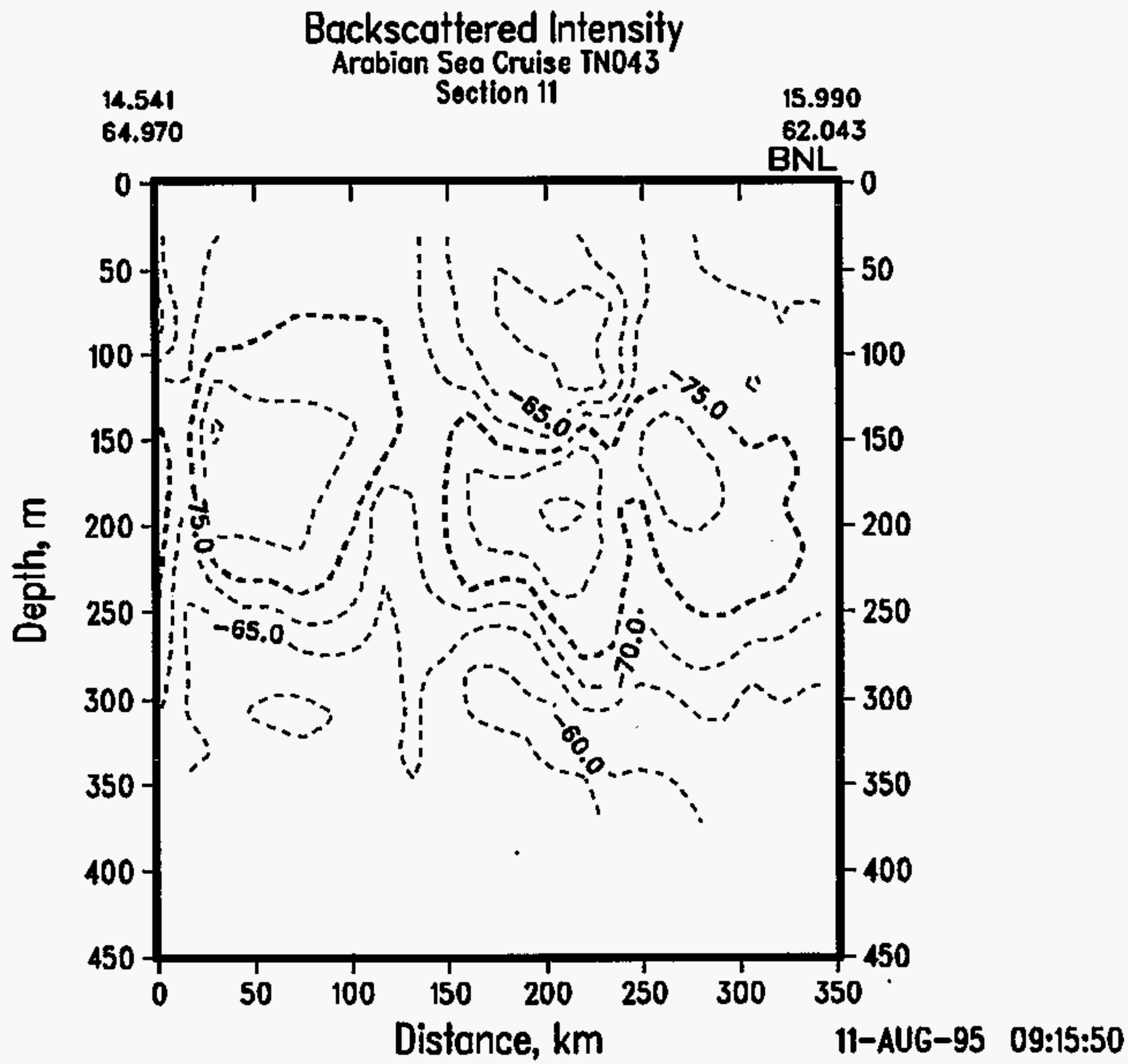
Arabian Sea Cruise TN043
Section 9

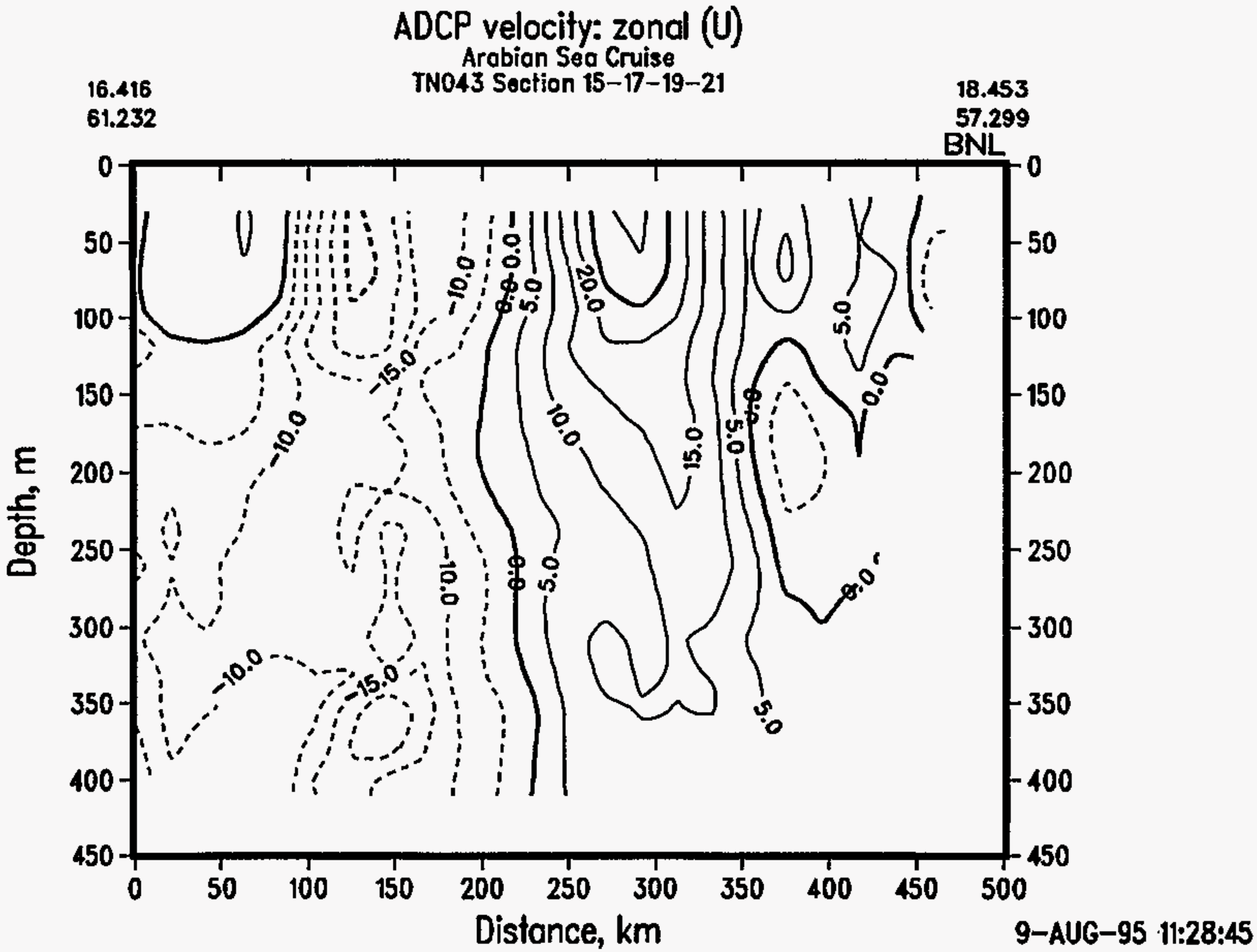


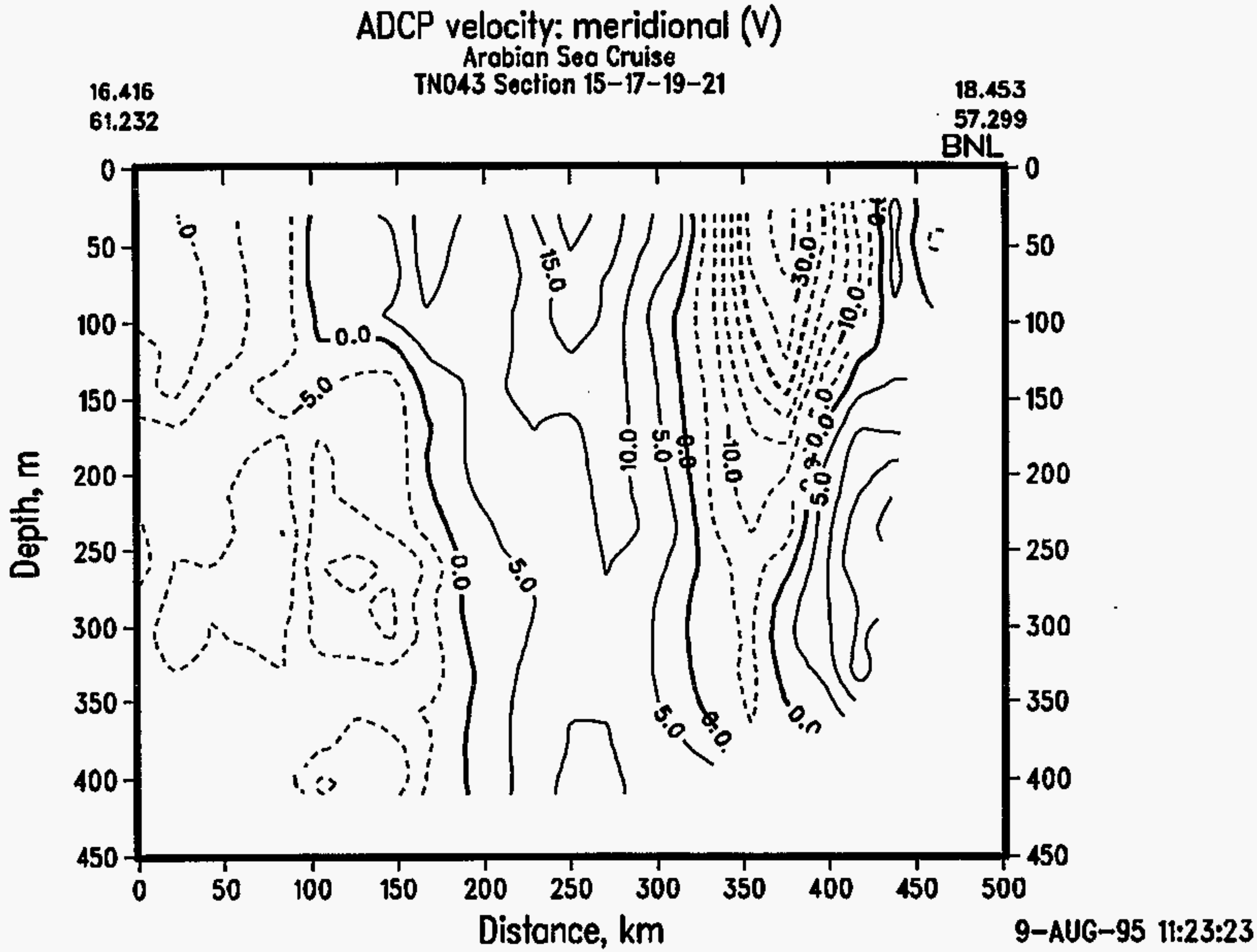


ADCP velocity: zonal (U)
Arabian Sea Cruise
TN043 Section 11
14.541
64.970
15.990
62.043
BNL
Depth, m
Distance, km
0
50
100
150
200
250
300
350
400
450
0
50
100
150
200
250
300
350
0.0
-5.0
-10.0
5.0
9-AUG-95 11:16:59

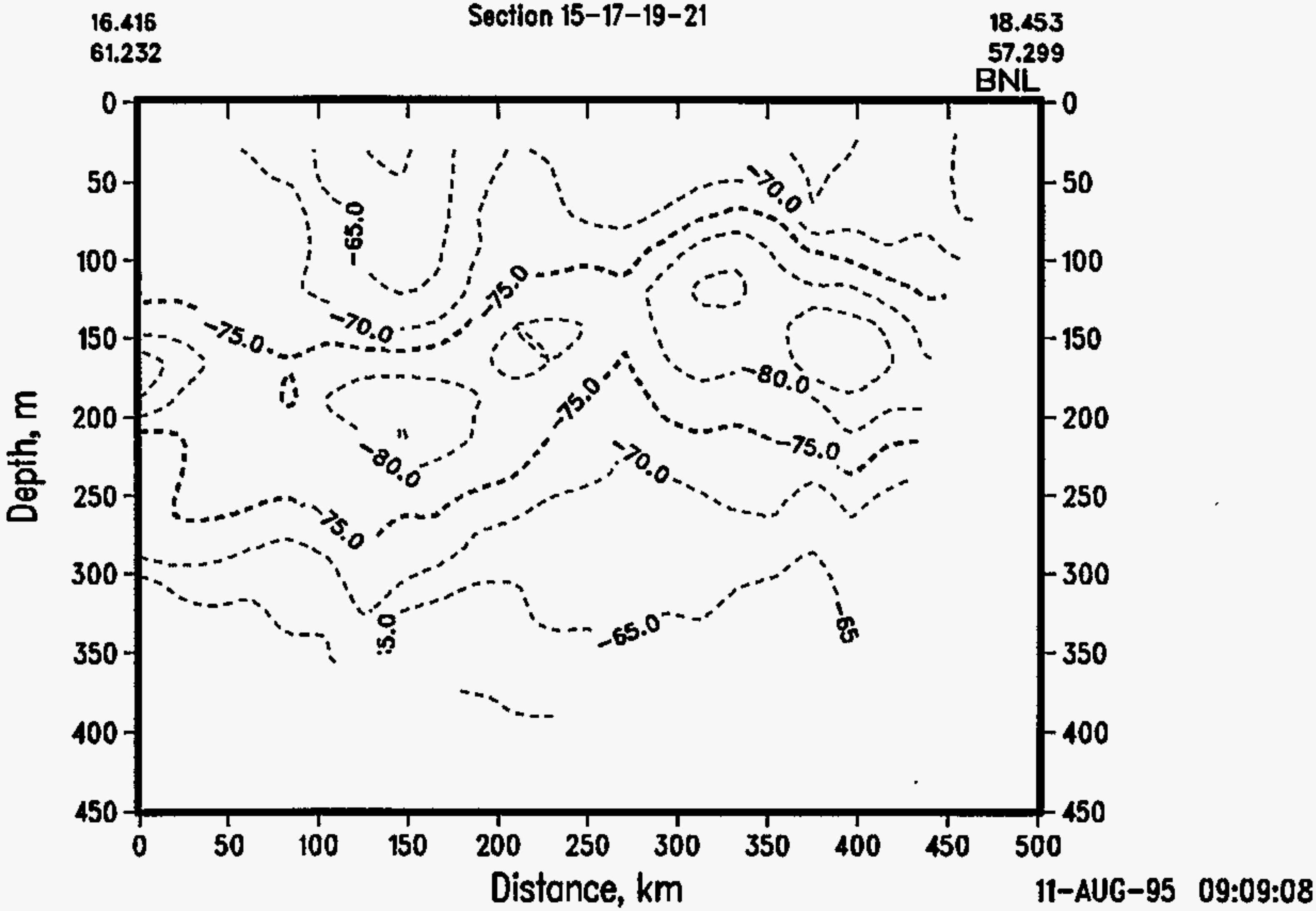

ADCP velocity: meridional (V)
Arabian Sea Cruise
TN043 Section 11
14.541
64.970
15.990
62.043
BNL
Depth, m
Distance, km
9-AUG-95 11:19:56

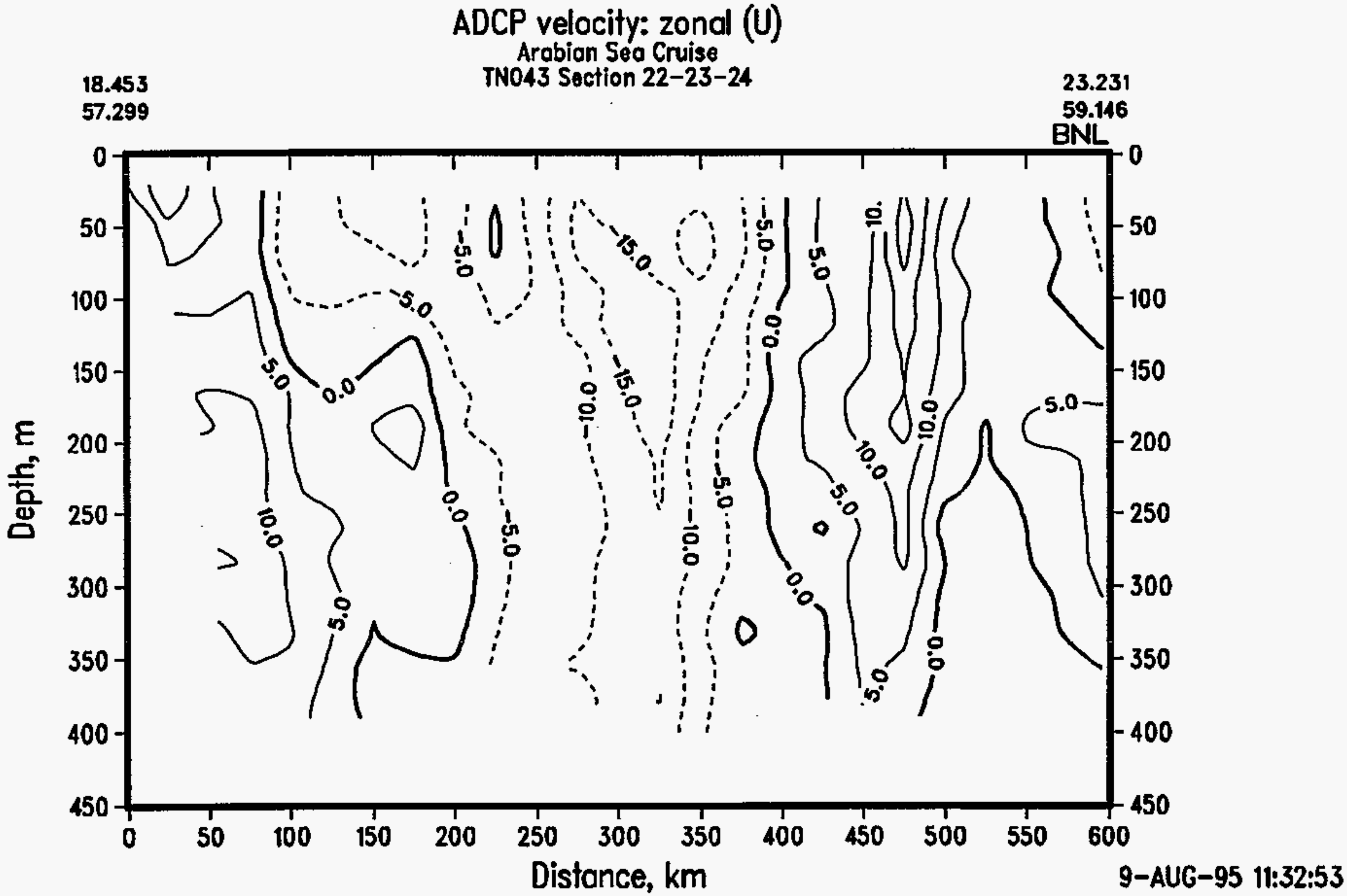

Backscattered Intensity
Arabian Sea Cruise TN043
Section 11
14.541
64.970
15.990
62.043
BNL
Depth, m
Distance, km
-75.0
-65.0
-70.0
-60.0
11-AUG-95 09:15:50

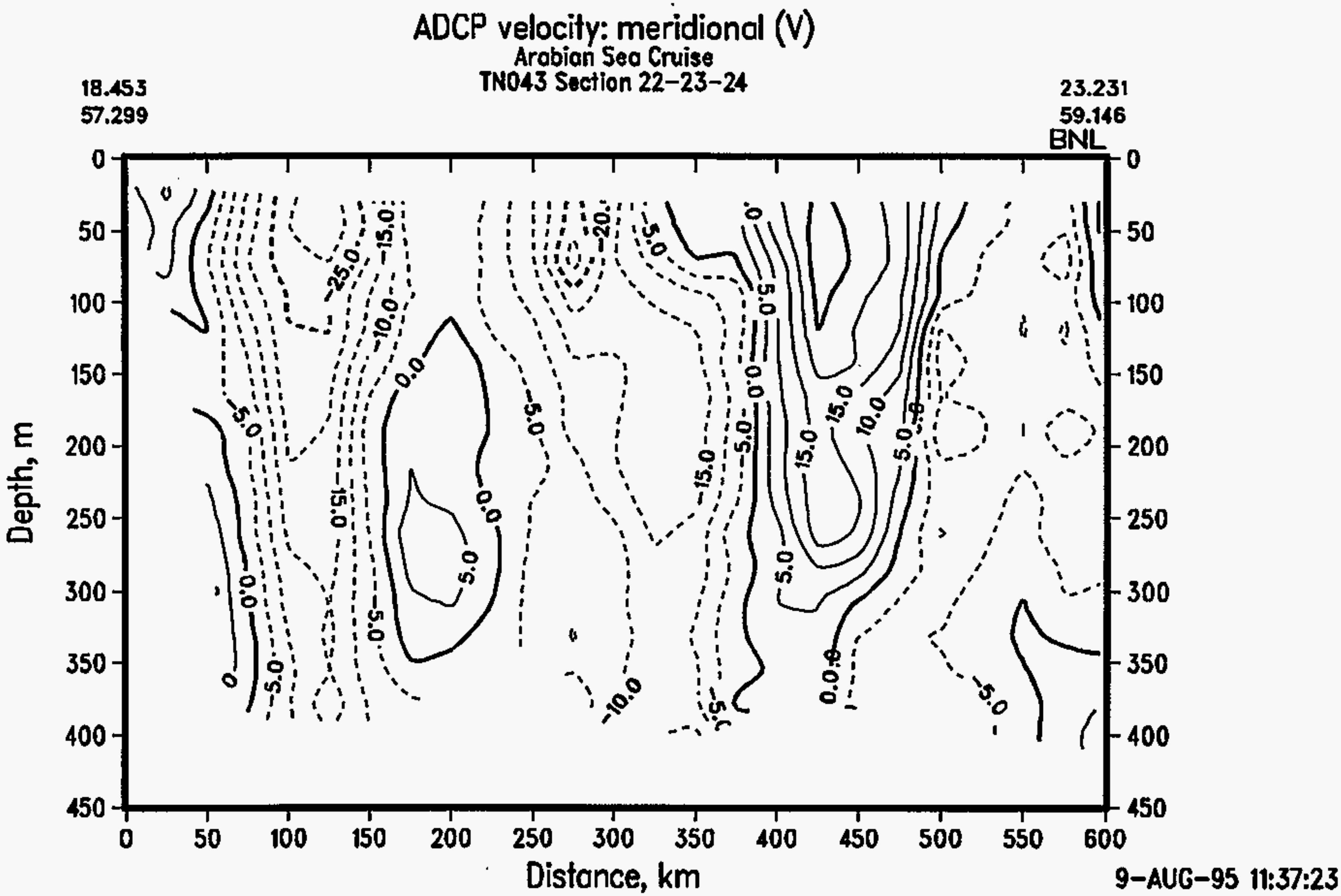

ADCP velocity: zonal (U)
Arabian Sea Cruise
TN043 Section 15-17-19-21
16.416
61.232
18.453
57.299
BNL
Depth, m
Distance, km
9-AUG-95 11:28:45

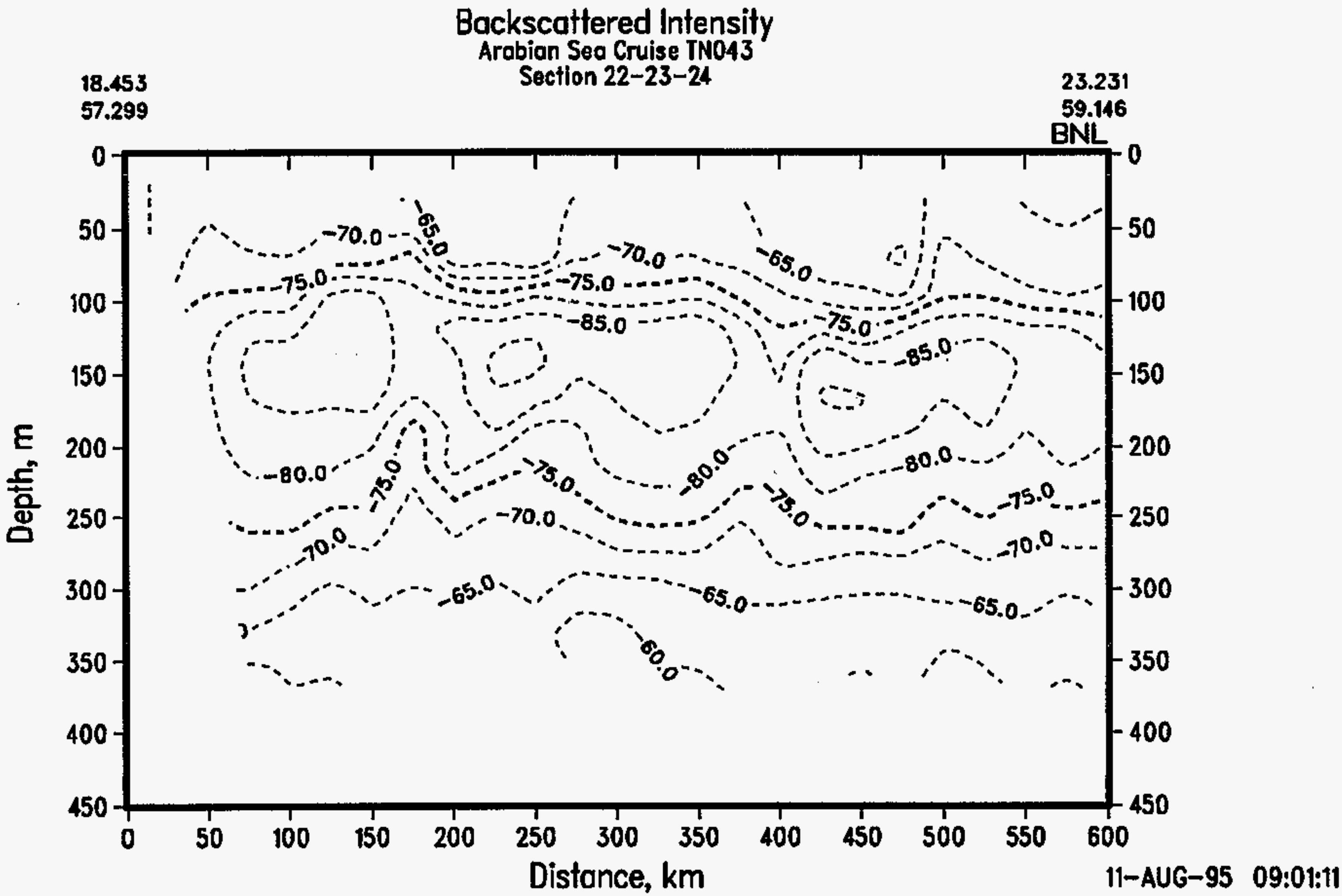

ADCP velocity: meridional (V)
Arabian Sea Cruise
TN043 Section 15-17-19-21
16.416
61.232
18.453
57.299
BNL
Depth, m
Distance, km
9-AUG-95 11:23:23

Backscattered Intensity
Arabian Sea Cruise TN043
Section 15-17-19-21




ADCP velocity: zonal (U)
Arabian Sea Cruise
TN043 Section 22-23-24
18.453
57.299
23.231
59.146
BNL
Depth, m
Distance, km
9-AUG-95 11:32:53

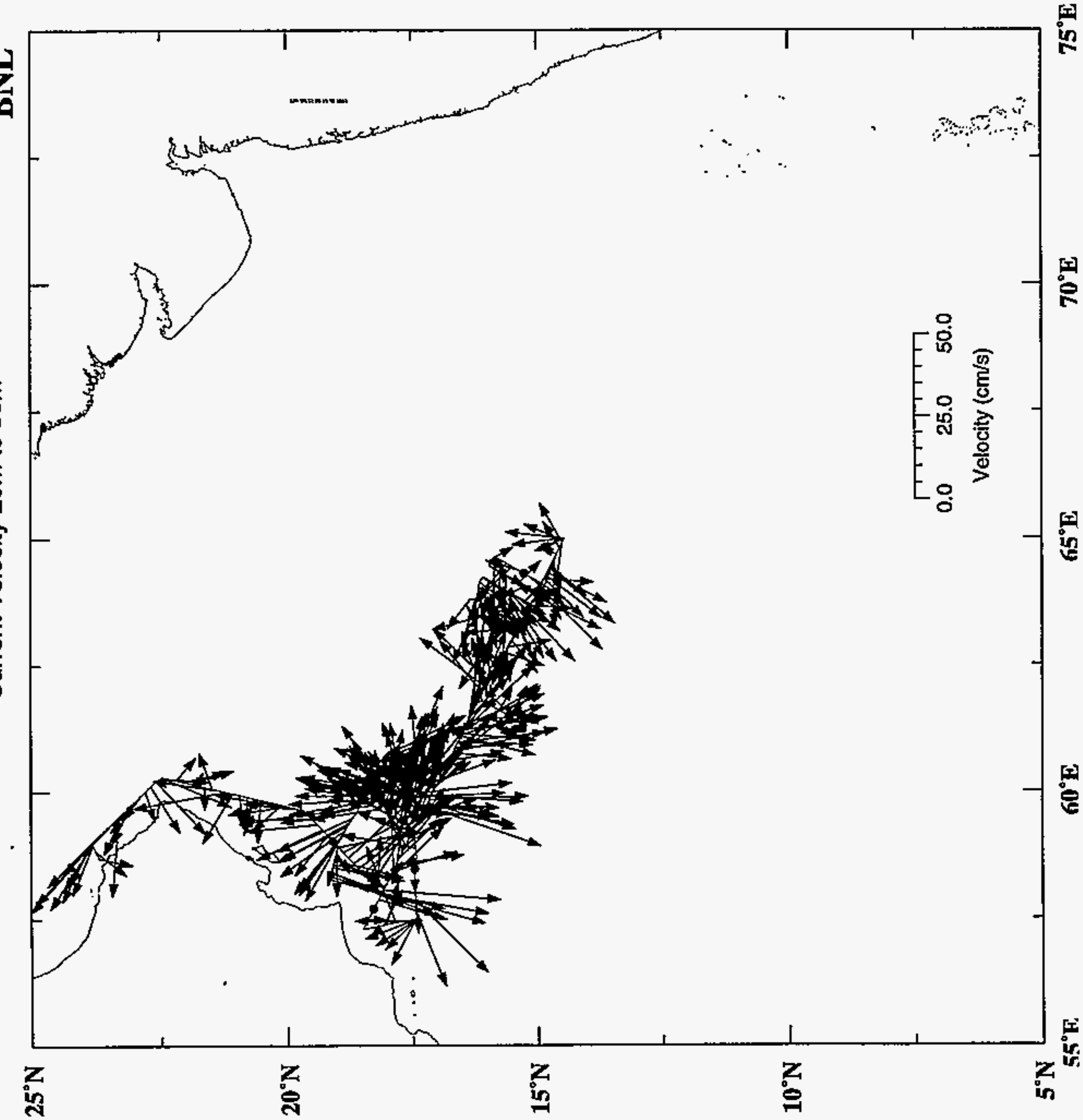

ADCP velocity: meridional (V)
Arabian Sea Cruise
TN043 Section 22-23-24
18.453
57.299
23.231
59.146
BNL
Depth, m
Distance, km
0
50
100
150
200
250
300
350
400
450
500
550
600
-25.0
-20.
-15.0
-10.0
-5.0
0.0
5.0
10.0
15.0
9-AUG-95 11:37:23

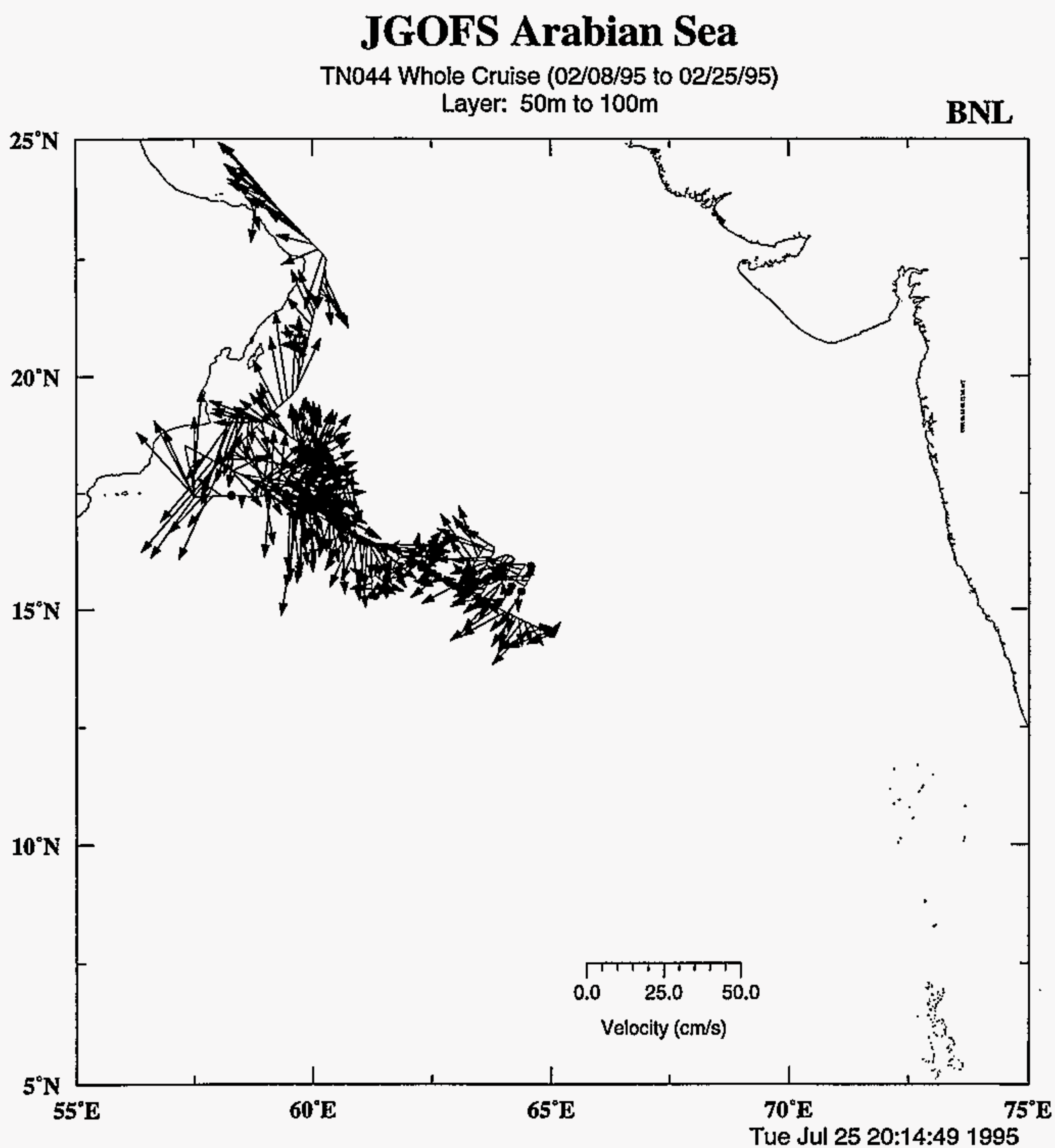

Backscattered Intensity
Arabian Sea Cruise TN043
Section 22-23-24
18.453
57.299
23.231
59.146
BNL
Depth, m
Distance, km
-70.0
-65.0
-75.0
-85.0
-80.0
-60.0
11-AUG-95 09:01:11

# TN044

# JGOFS Arabian Sea

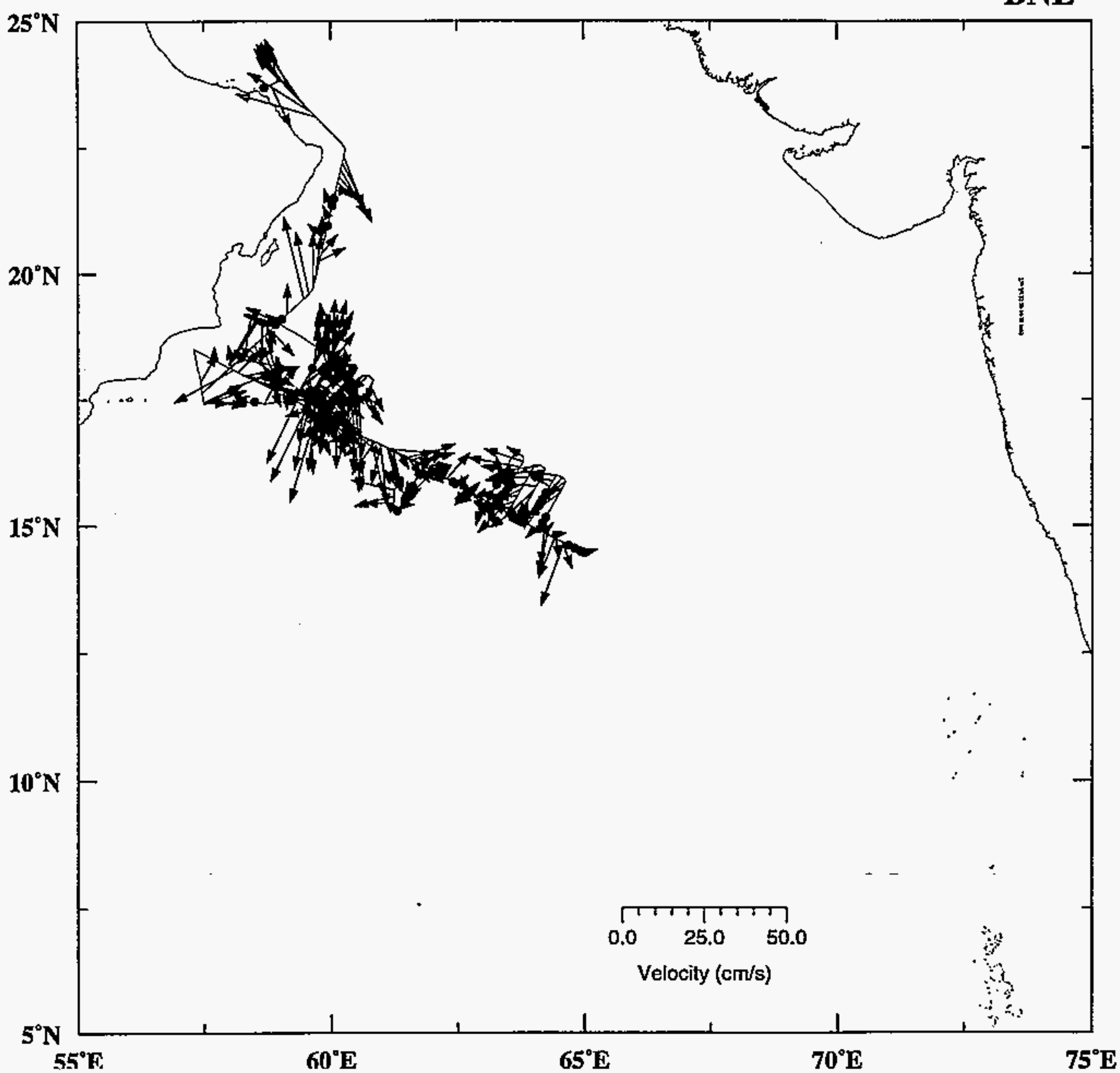
TN044 Whole Cruise (02/08/95 to 02/25/95)
Current Velocity 20m to 50m

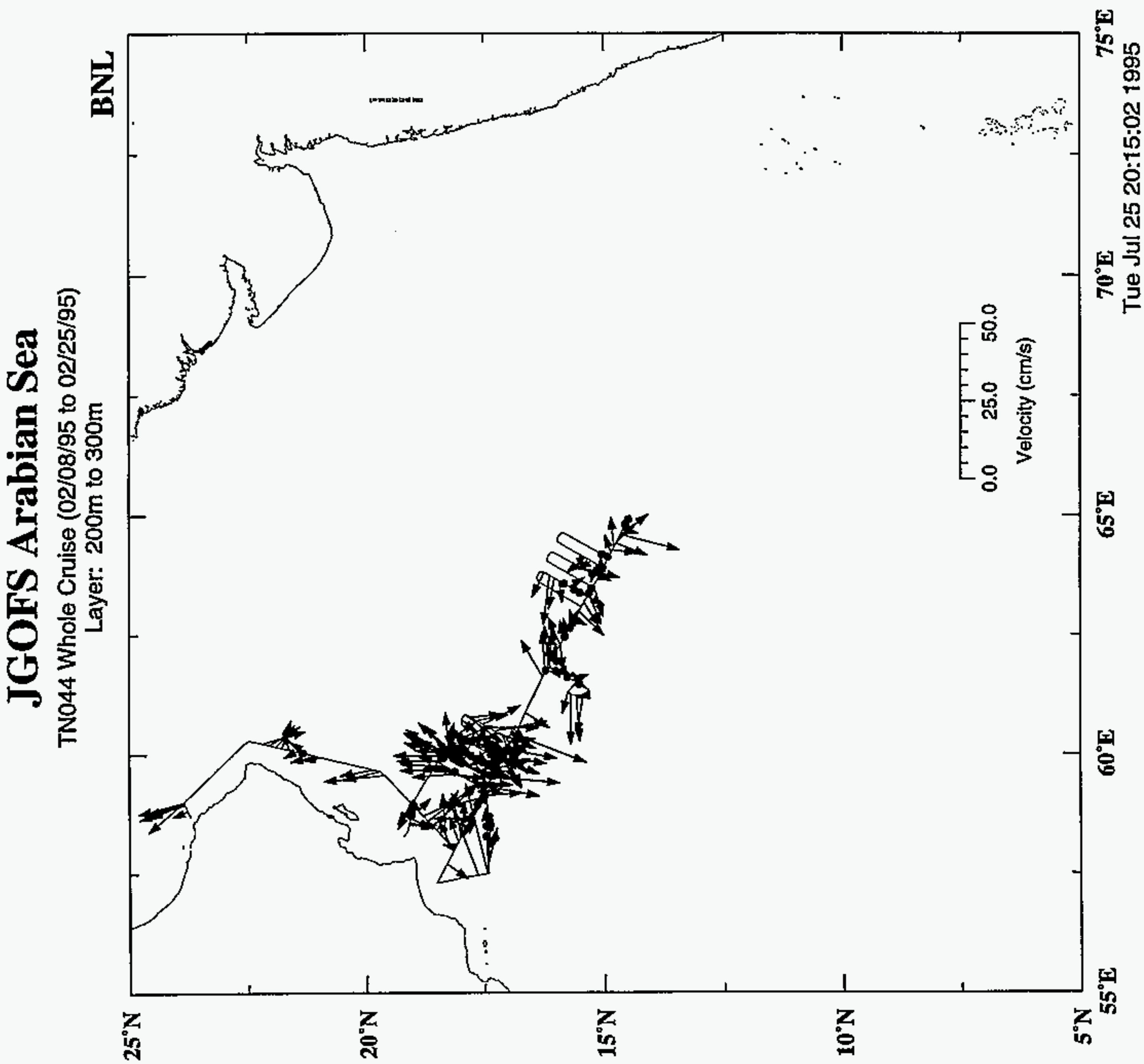



JGOFS Arabian Sea
TN044 Whole Cruise (02/08/95 to 02/25/95)
Layer: 50m to 100m
BNL
25°N
20°N
15°N
10°N
5°N
55°E
60°E
65°E
70°E
75°E
0.0
25.0
50.0
Velocity (cm/s)
Tue Jul 25 20:14:49 1995

## JGOFS Arabian Sea

TN044 Whole Cruise (02/08/95 to 02/25/95)
Layer: 100m to 200m

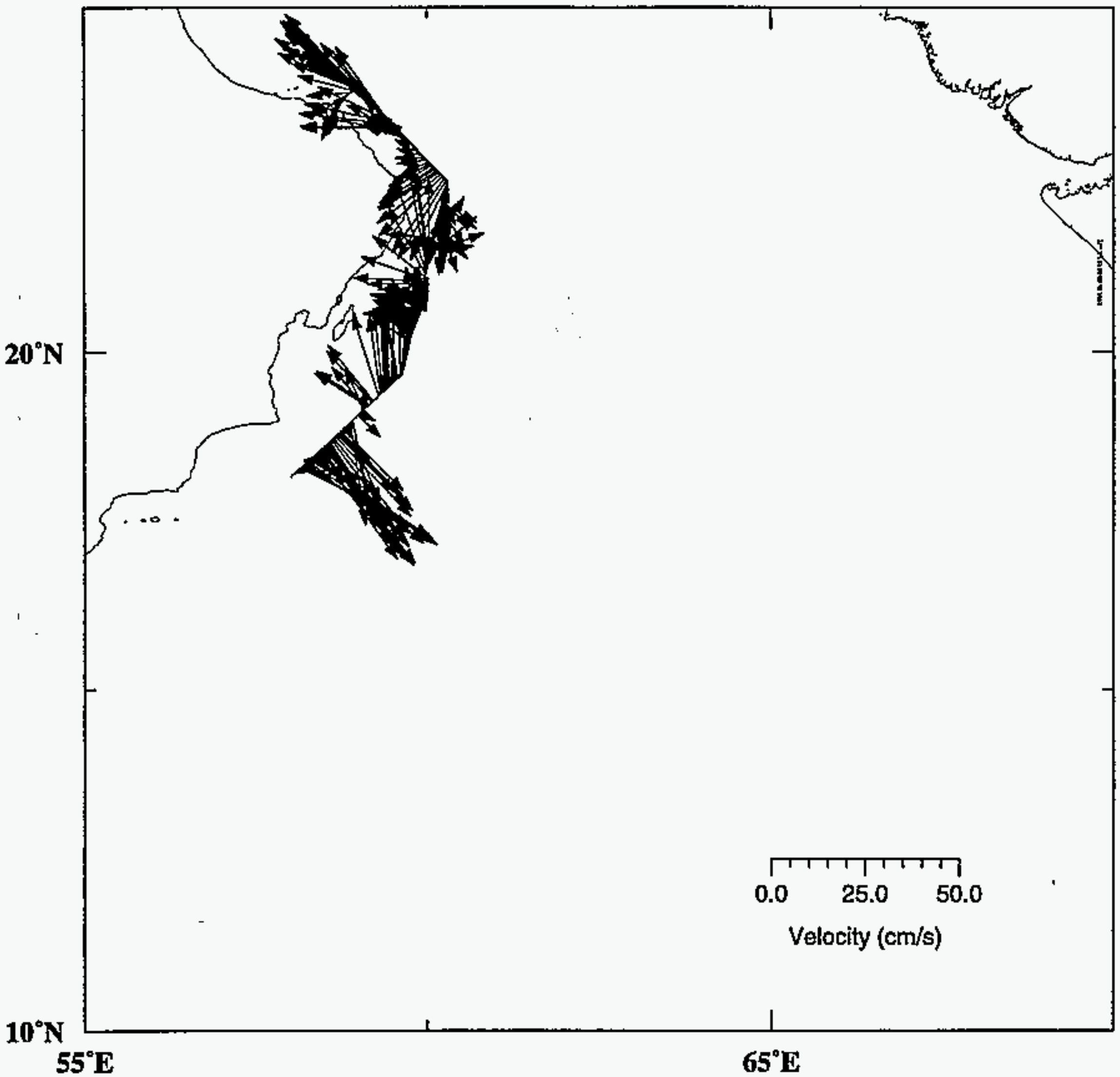



JGOFS Arabian Sea
TN044 Whole Cruise (02/08/95 to 02/25/95)
Layer: 200m to 300m
BNL
25°N
20°N
15°N
10°N
5°N
55°E
60°E
65°E
70°E
75°E
0.0
25.0
50.0
Velocity (cm/s)
Tue Jul 25 20:15:02 1995

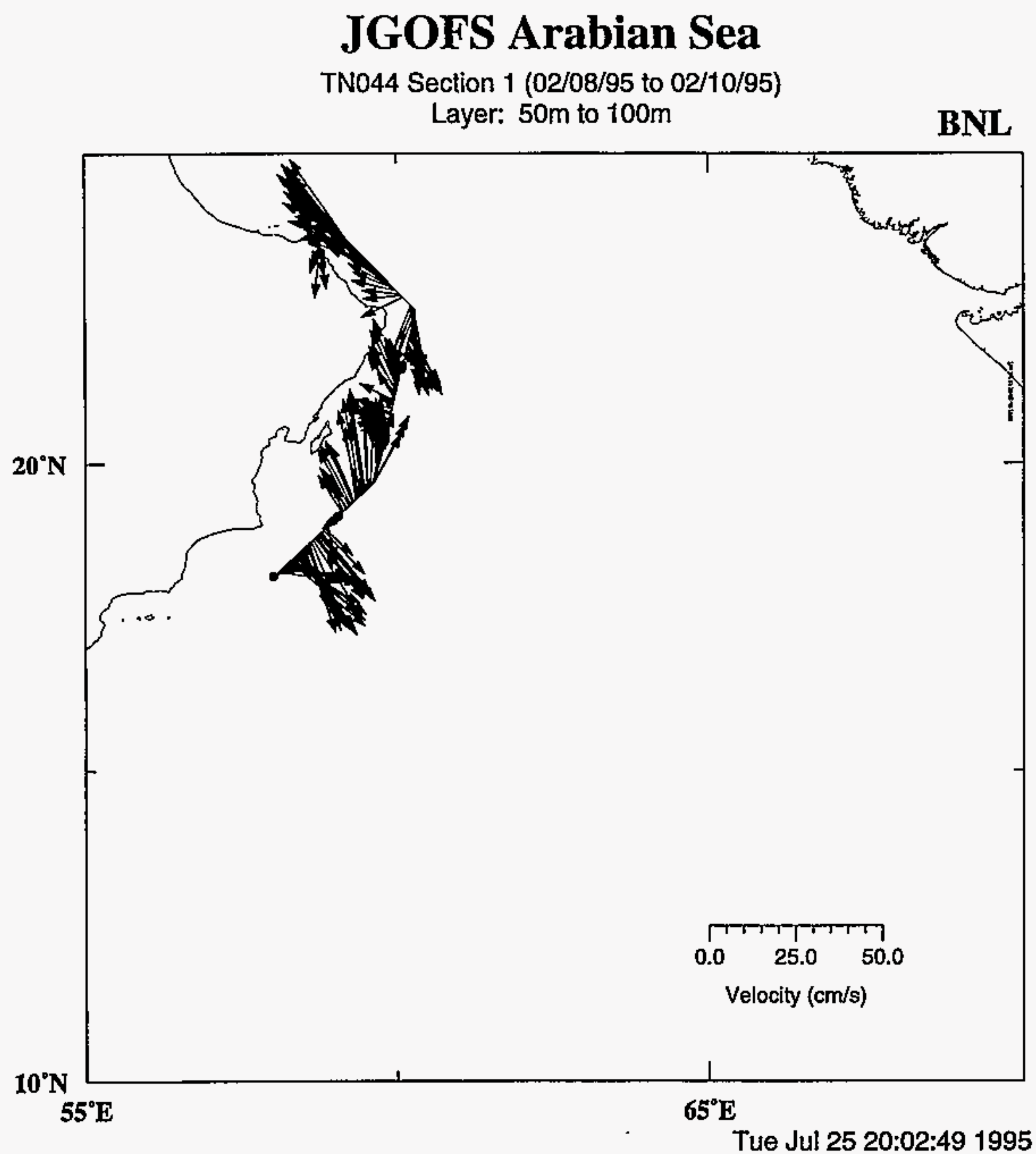
# JGOFS Arabian Sea

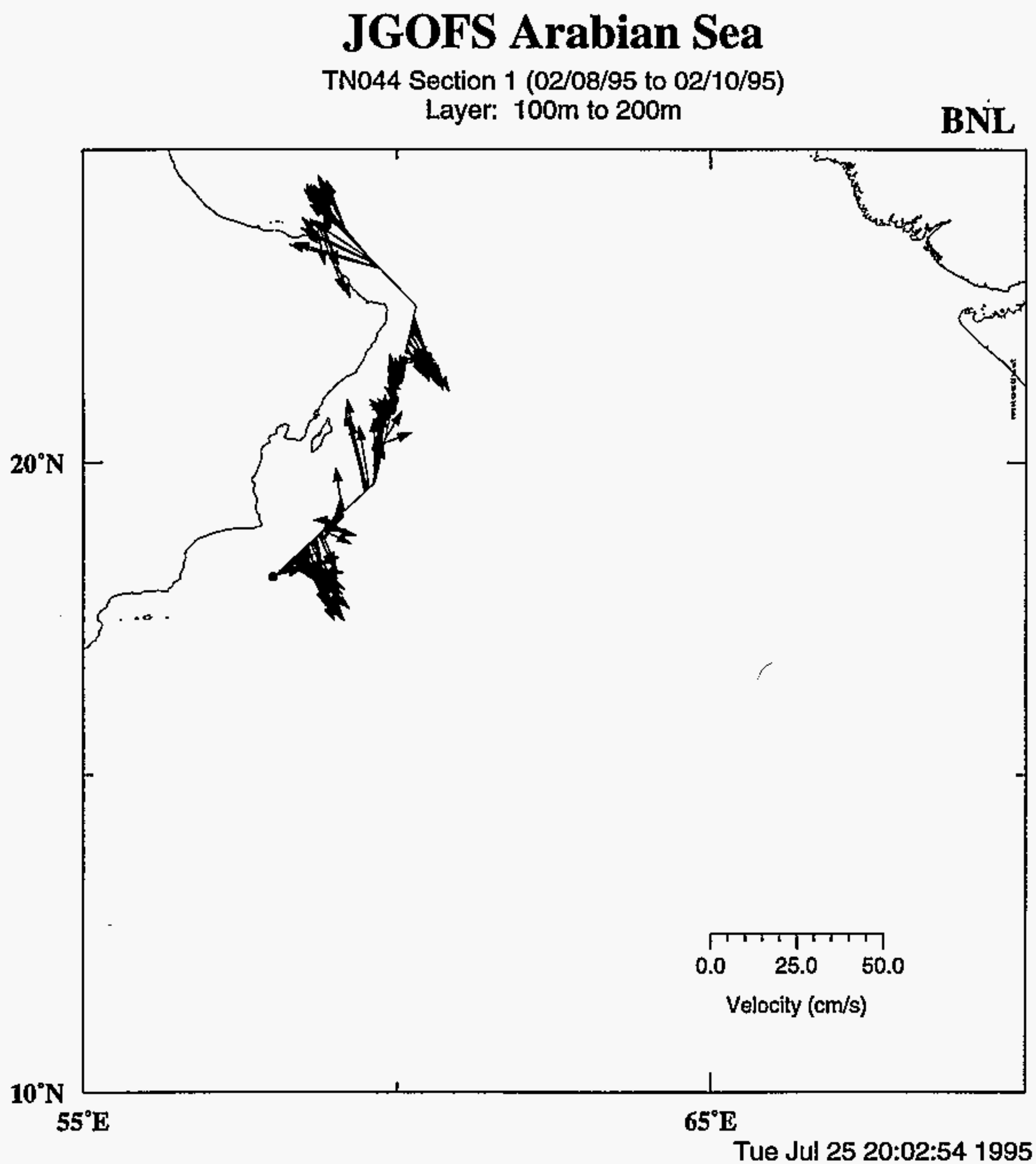
TN044 Section 1 (02/08/95 to 02/10/95)
Current Velocity 20m to 50m

BNL



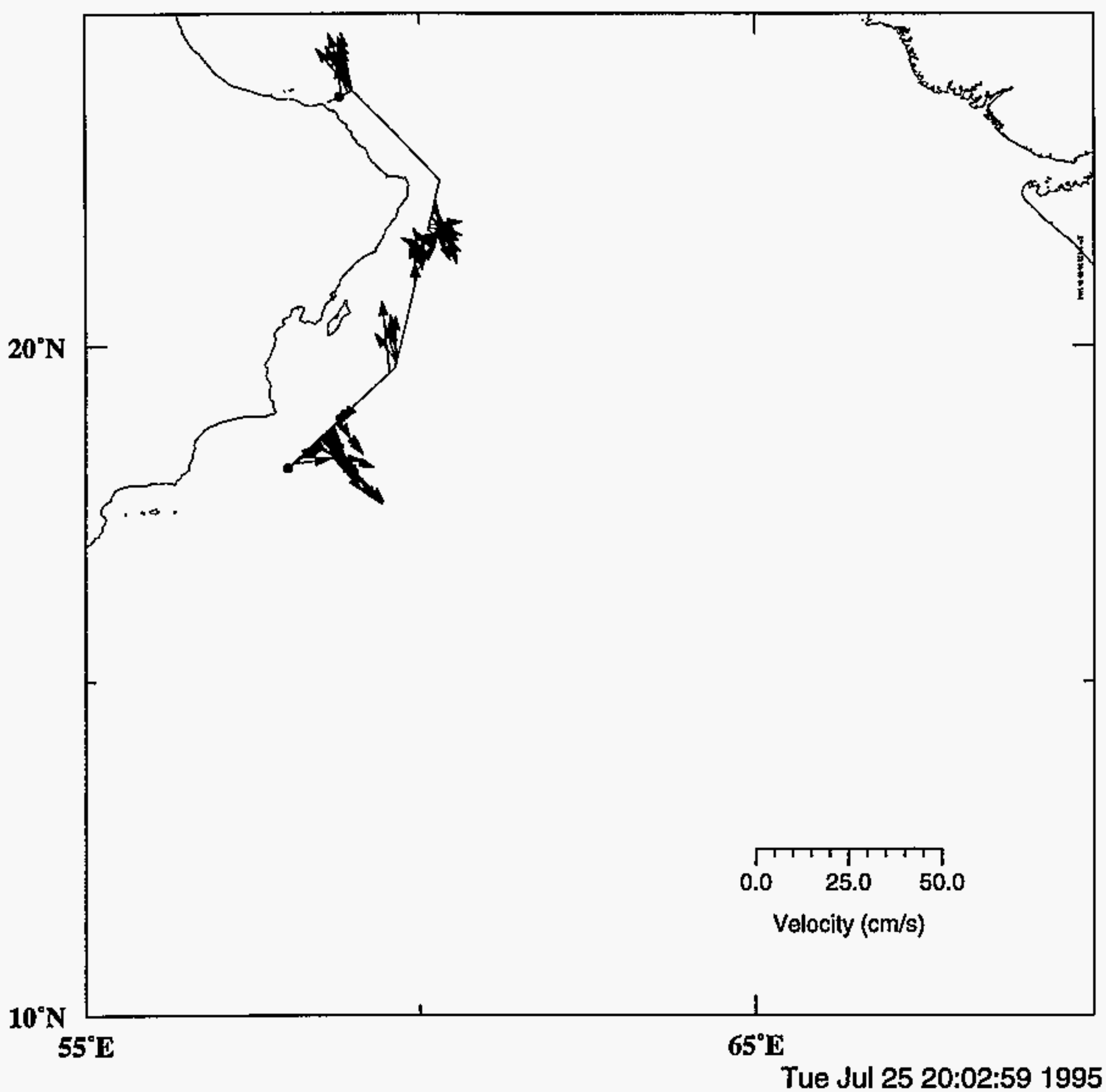

Tue Jul 25 20:02:43 1995


JGOFS Arabian Sea
TN044 Section 1 (02/08/95 to 02/10/95)
Layer: 50m to 100m
BNL
20°N
10°N
55°E
65°E
0.0
25.0
50.0
Velocity (cm/s)
Tue Jul 25 20:02:49 1995


JGOFS Arabian Sea
TN044 Section 1 (02/08/95 to 02/10/95)
Layer: 100m to 200m
BNL
20°N
10°N
55°E
65°E
0.0
25.0
50.0
Velocity (cm/s)
Tue Jul 25 20:02:54 1995

# JGOFS Arabian Sea

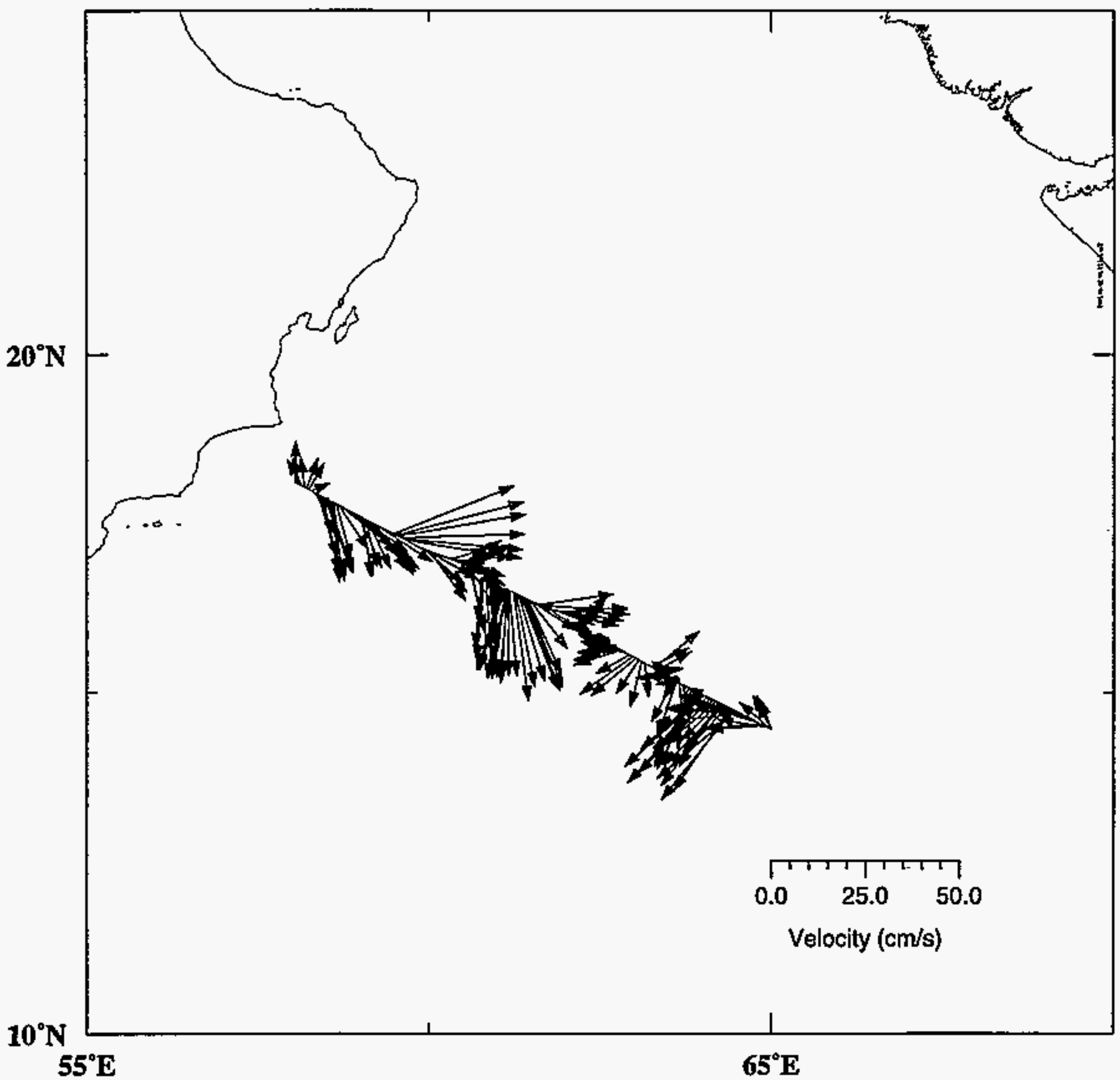
TN044 Section 1 (02/08/95 to 02/10/95)
Layer: 200m to 300m



# JGOFS Arabian Sea

TN044 Outbound Transect (02/10/95 to 02/16/95)
Current Velocity 20m to 50m

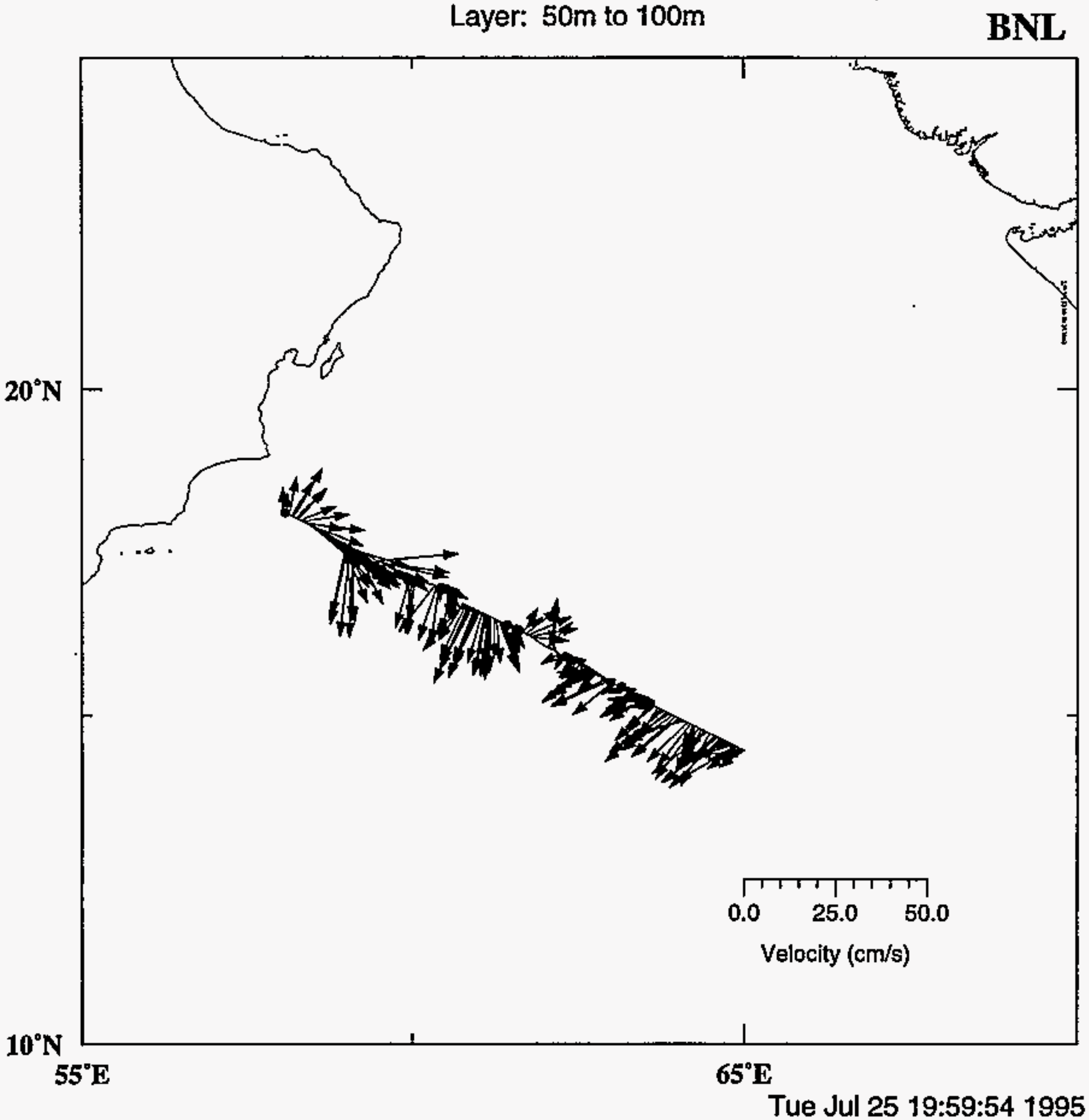
BNL




Tue Jul 25 19:59:49 1995

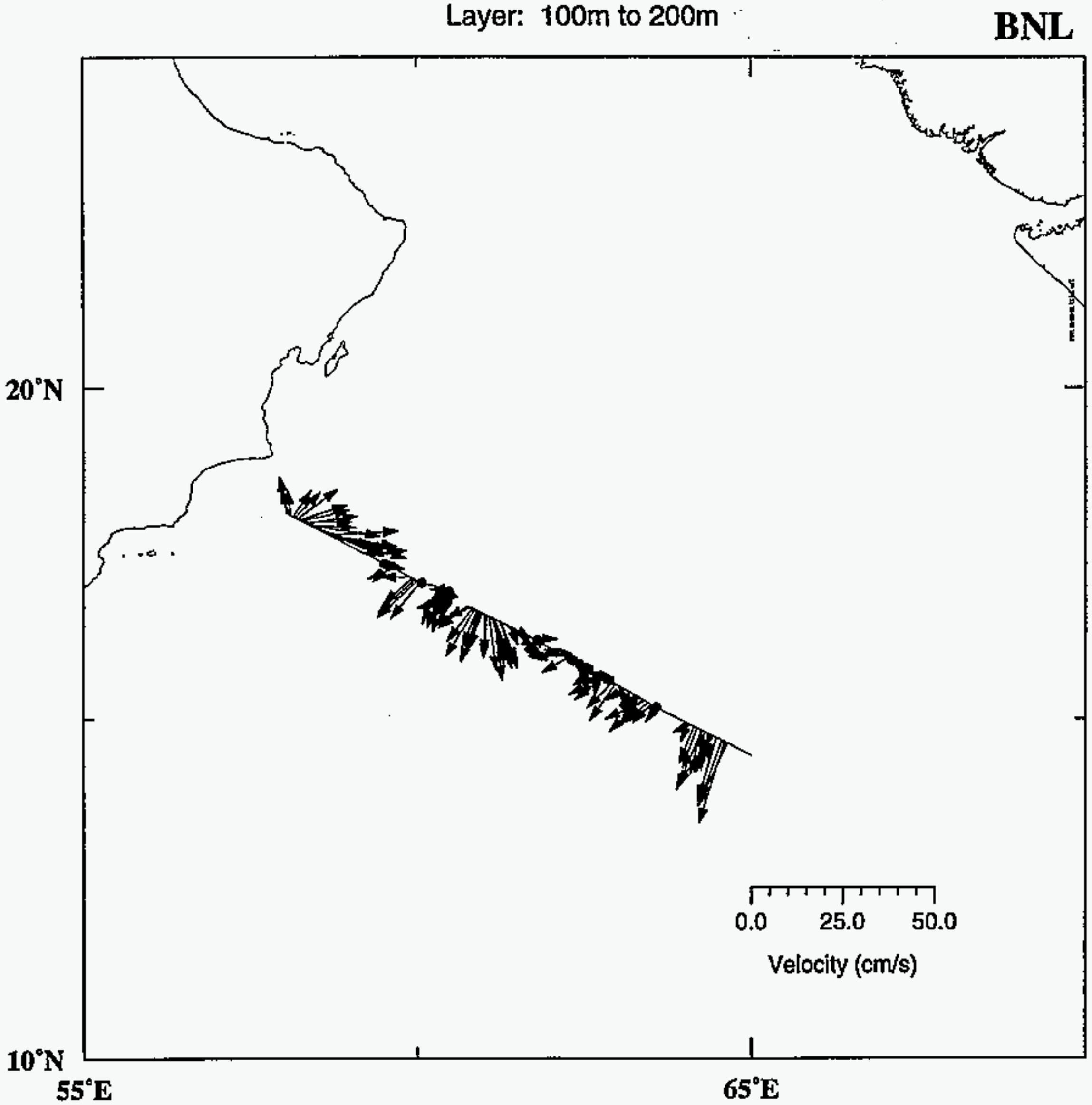
# JGOFS Arabian Sea

TN044 Outbound Transect (02/10/95 to 02/16/95)
Layer: 50m to 100m



# JGOFS Arabian Sea

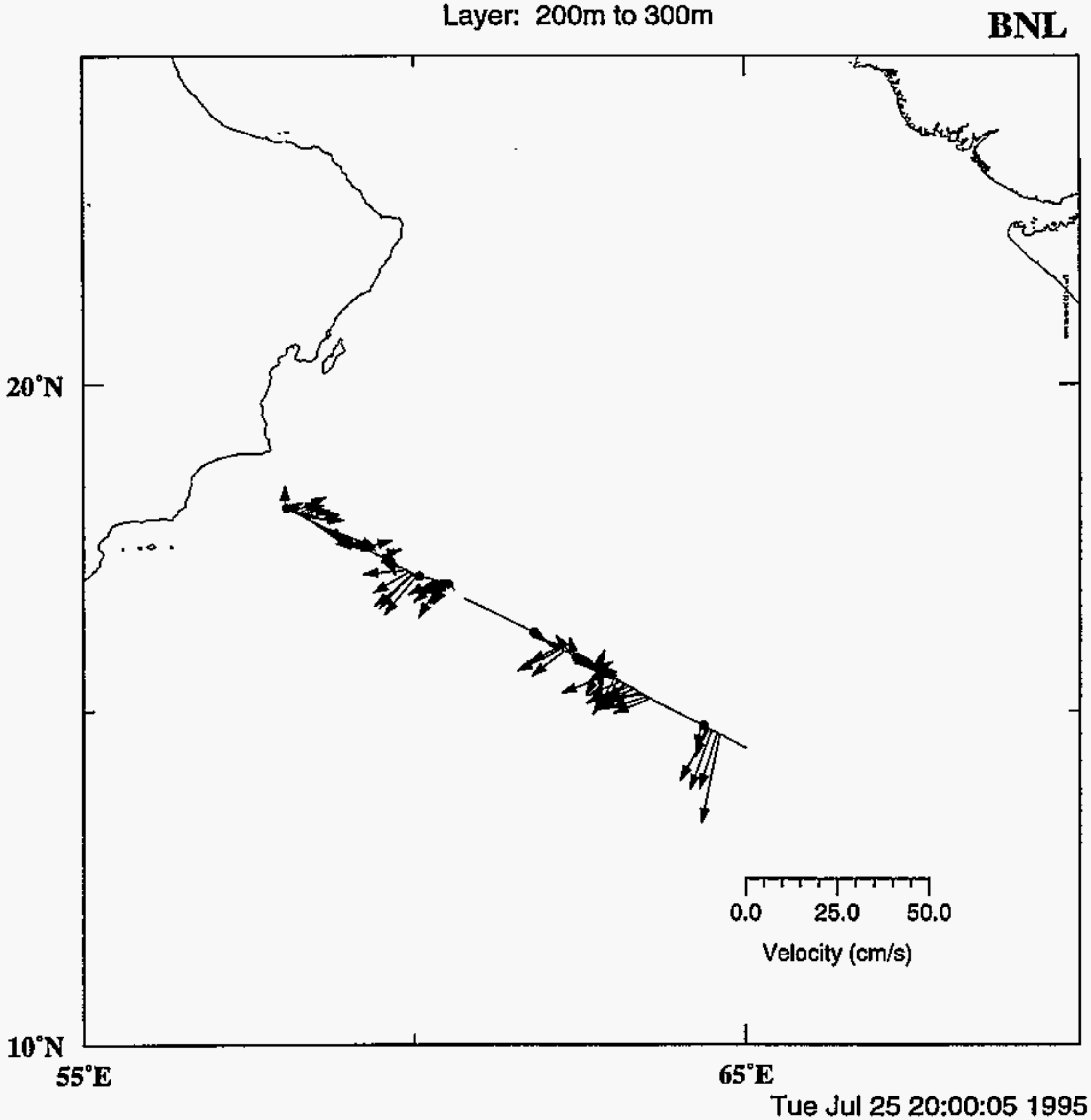
TN044 Outbound Transect (02/10/95 to 02/16/95)
Layer: 100m to 200m




Tue Jul 25 20:00:00 1995

# JGOFS Arabian Sea

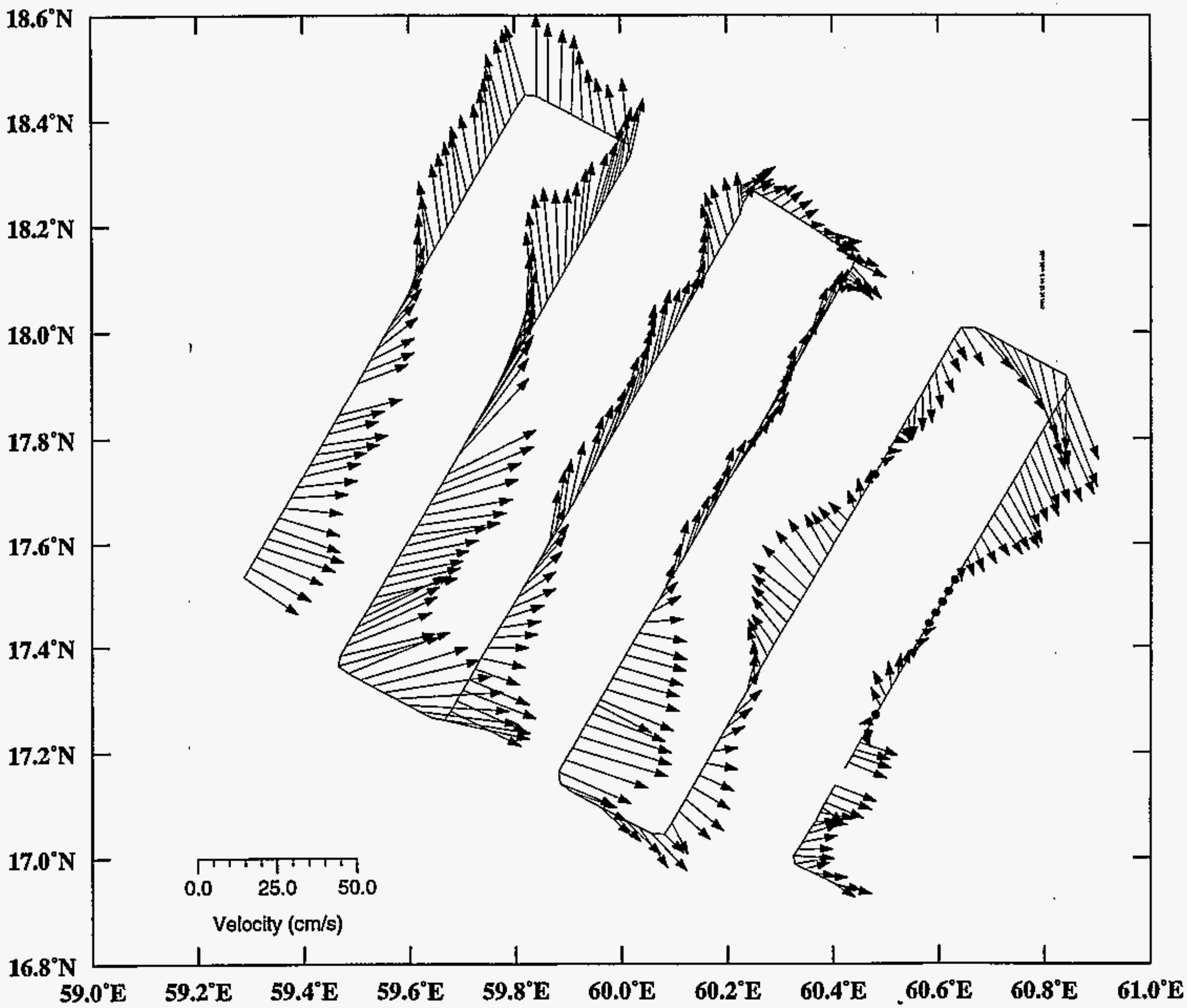
TN044 Outbound Transect (02/10/95 to 02/16/95)
Layer: 200m to 300m



# JGOFS Arabian Sea

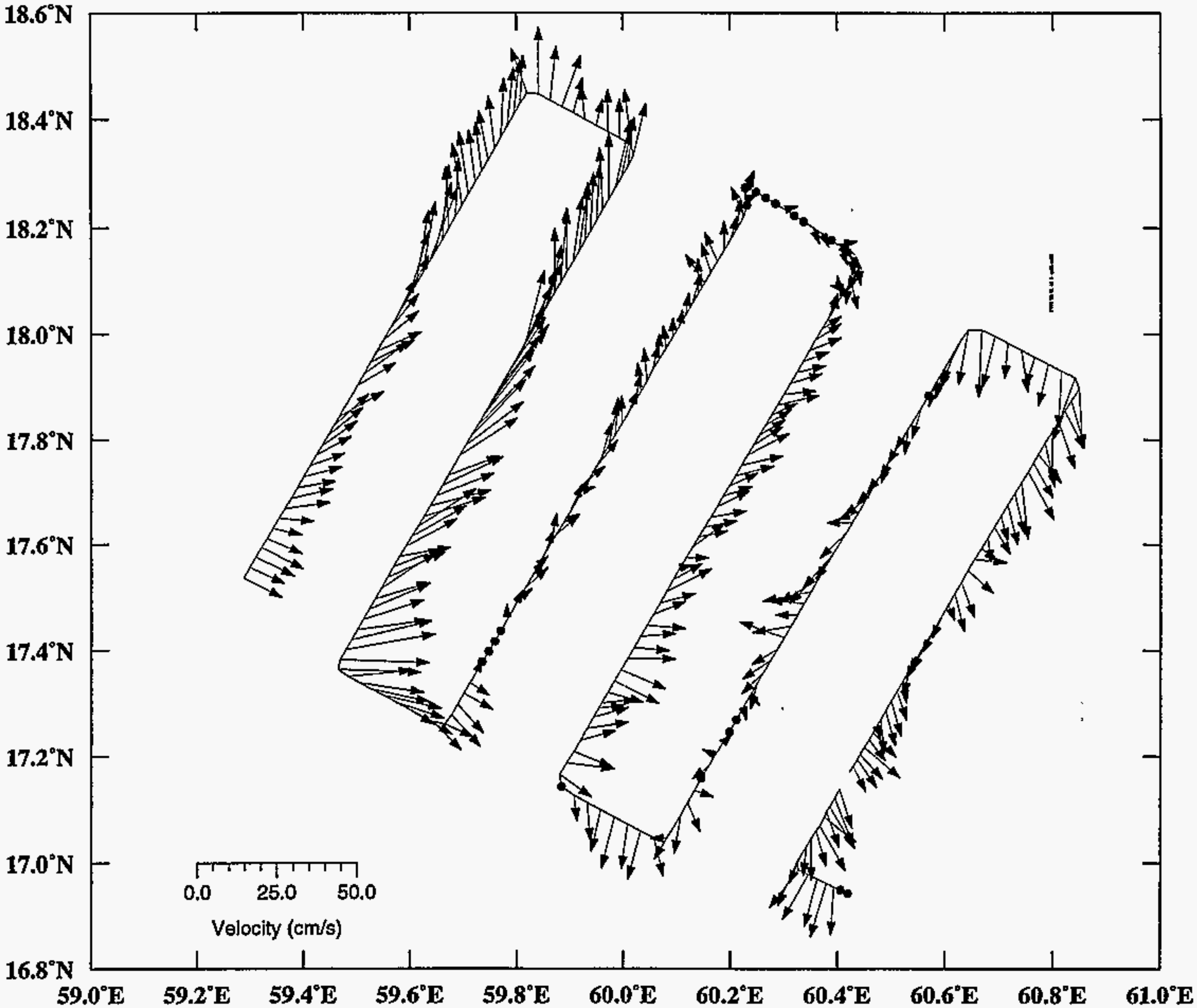
TN044 Section 2
Current Velocity 20m to 50m

BNL

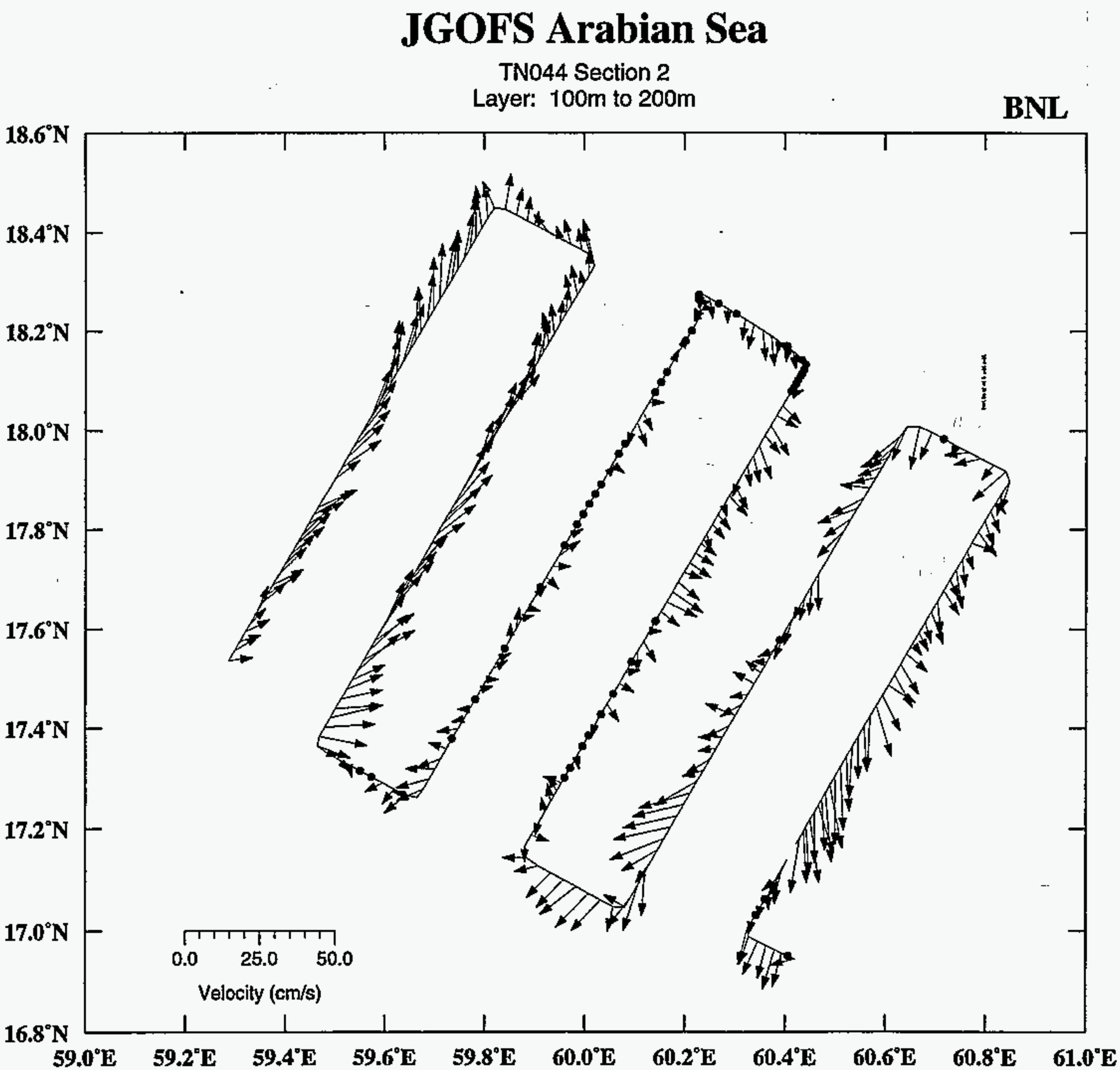


# JGOFS Arabian Sea

TN044 Section 2
Layer: 50m to 100m



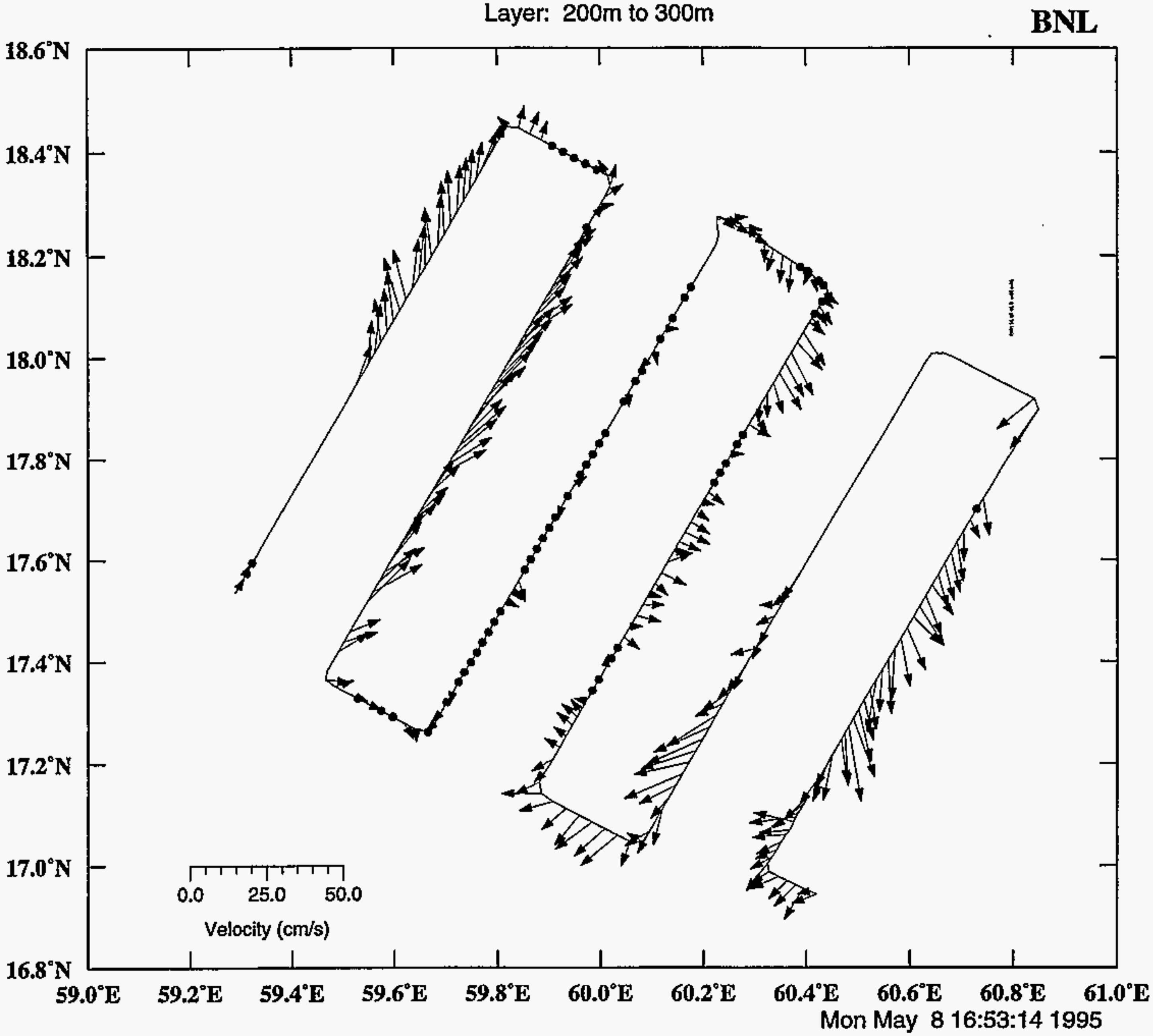

Mon May 8 16:53:02 1995



JGOFS Arabian Sea
TN044 Section 2
Layer: 100m to 200m
BNL
18.6°N
18.4°N
18.2°N
18.0°N
17.8°N
17.6°N
17.4°N
17.2°N
17.0°N
16.8°N
59.0°E
59.2°E
59.4°E
59.6°E
59.8°E
60.0°E
60.2°E
60.4°E
60.6°E
60.8°E
61.0°E
0.0
25.0
50.0
Velocity (cm/s)

# JGOFS Arabian Sea

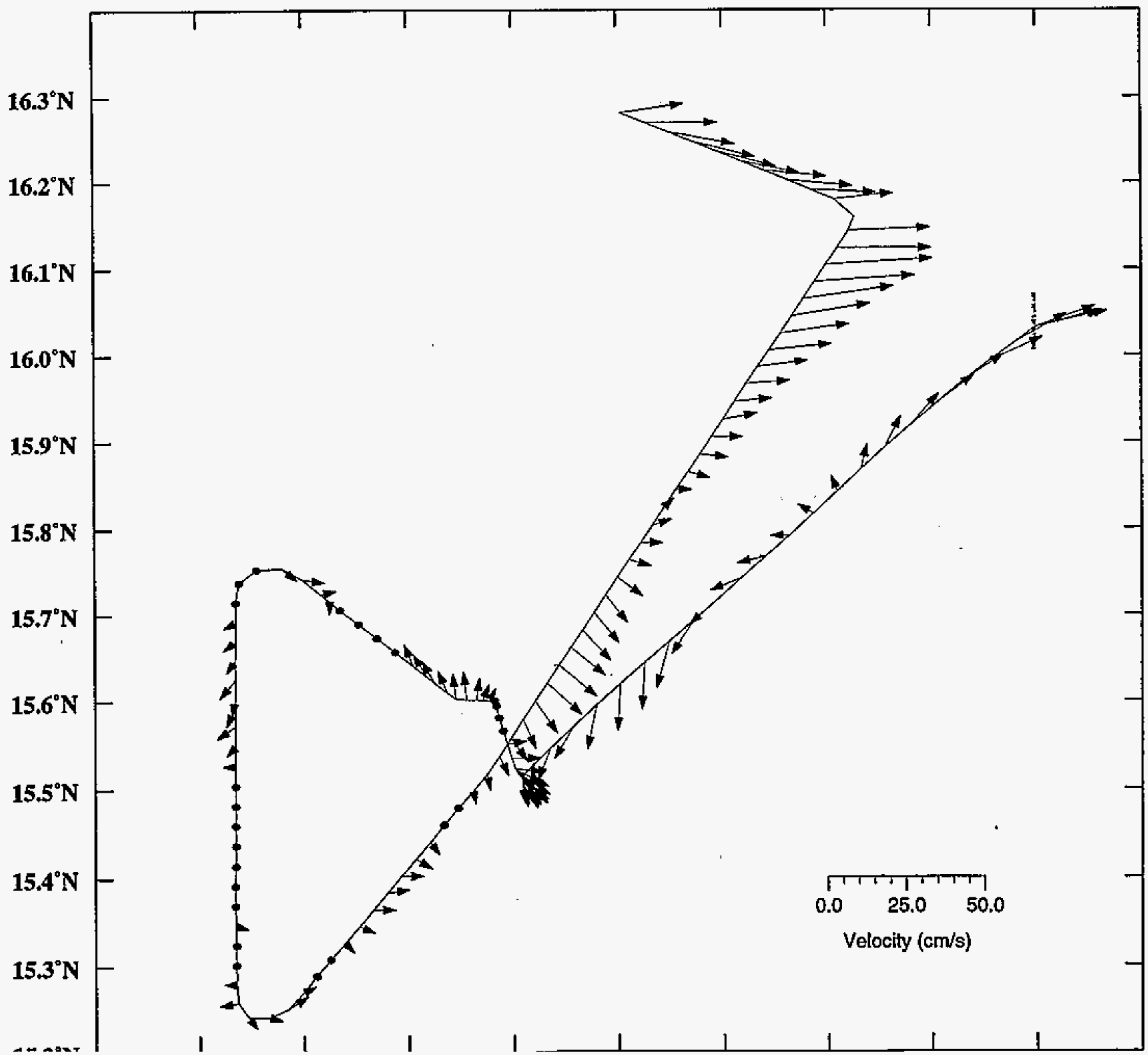
TN044 Section 2
Layer: 200m to 300m



# JGOFS Arabian Sea

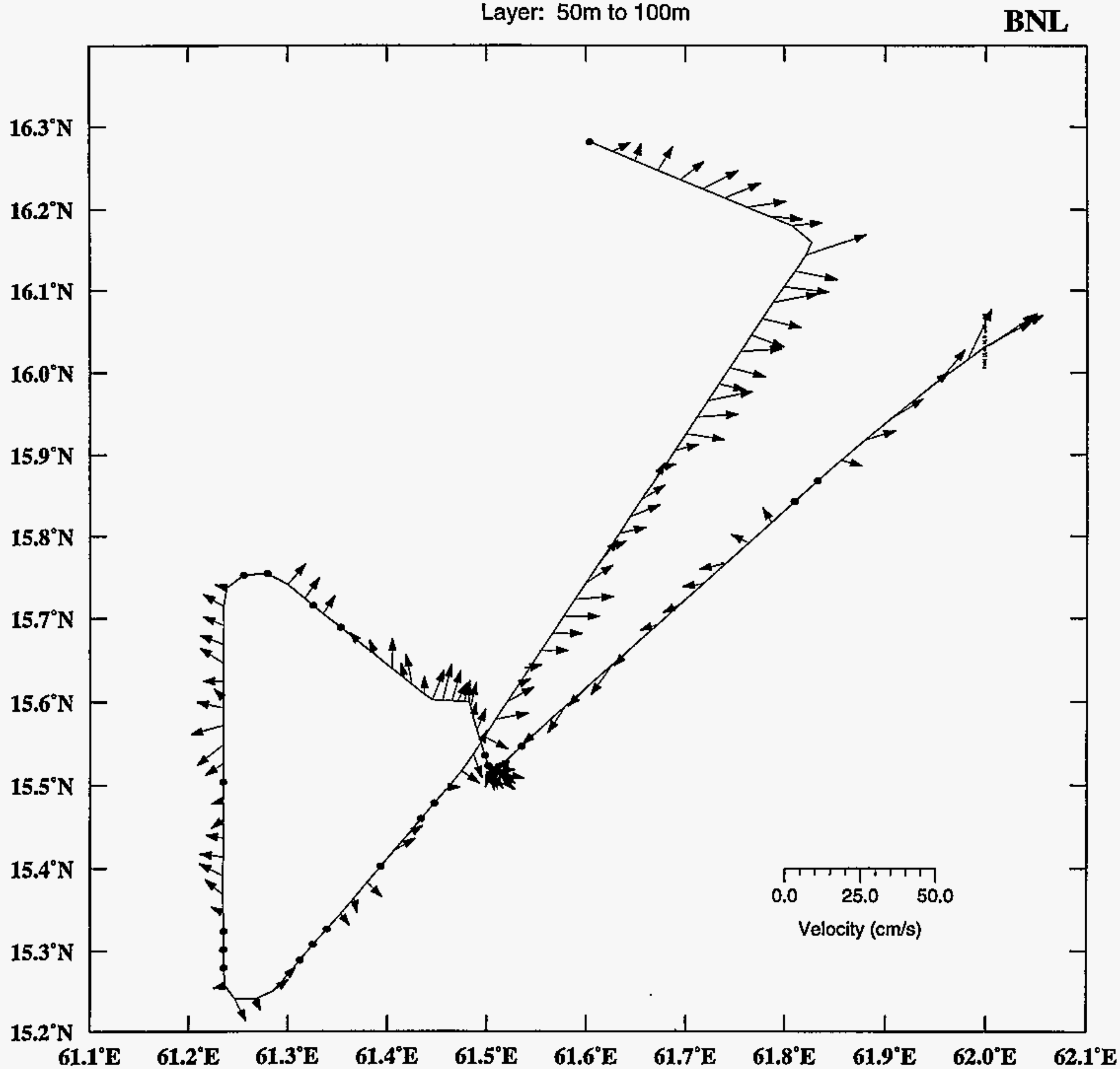
TN044 Section 3
Current Velocity 20m to 50m

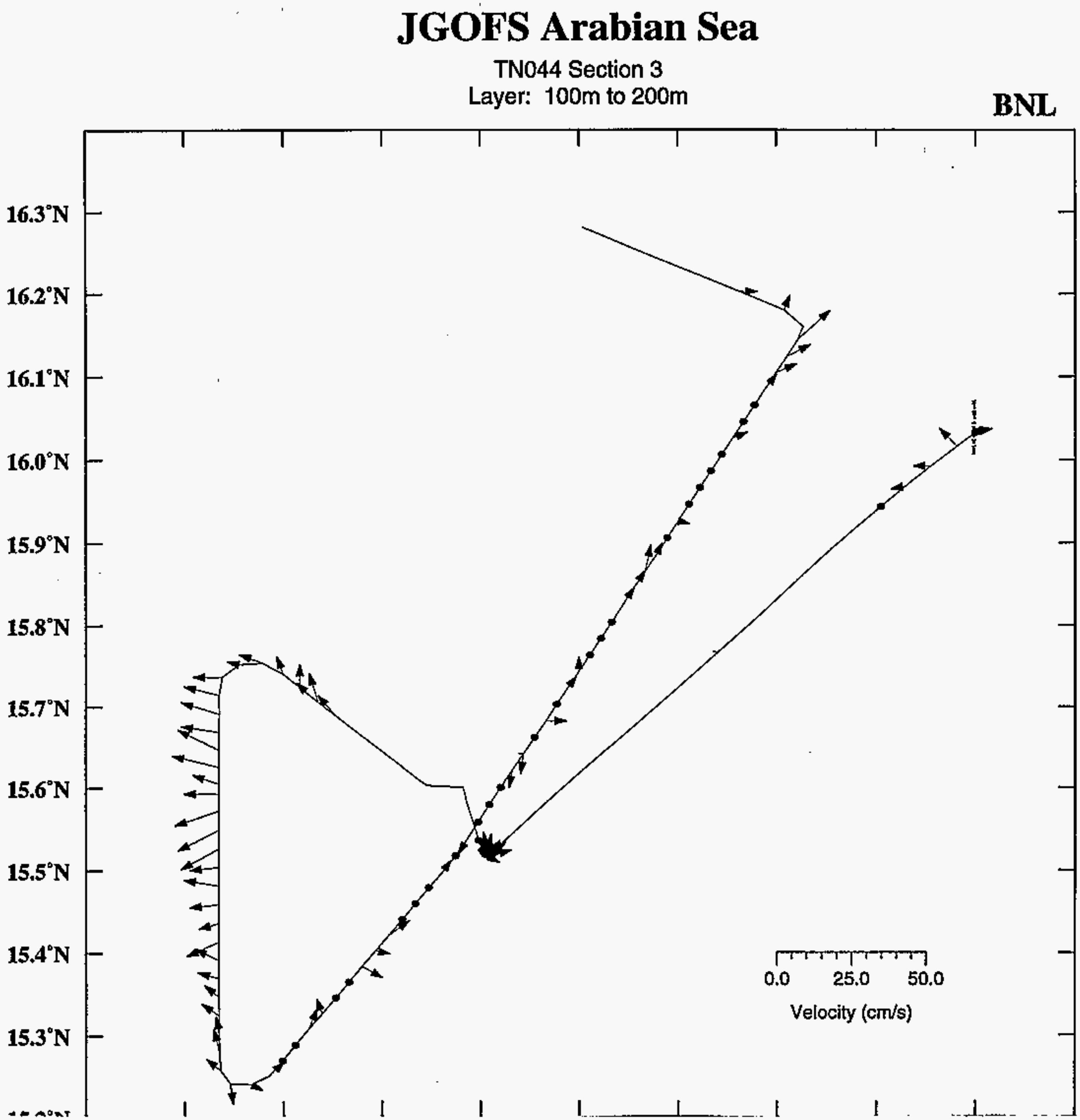
BNL



# JGOFS Arabian Sea

TN044 Section 3
Layer: 50m to 100m



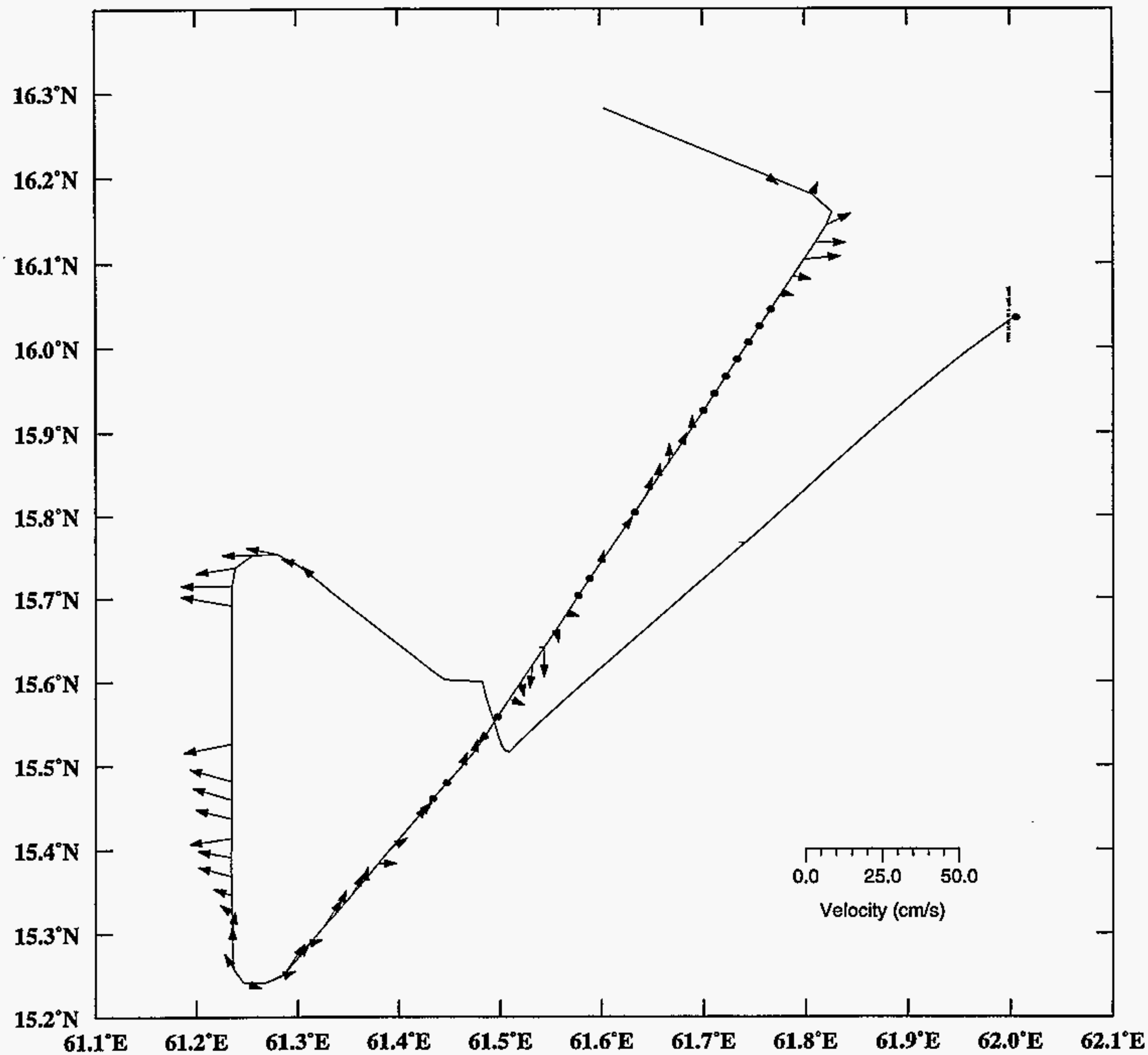


JGOFS Arabian Sea
TN044 Section 3
Layer: 100m to 200m
BNL
16.3°N
16.2°N
16.1°N
16.0°N
15.9°N
15.8°N
15.7°N
15.6°N
15.5°N
15.4°N
15.3°N
0.0
25.0
50.0
Velocity (cm/s)

# JGOFS Arabian Sea

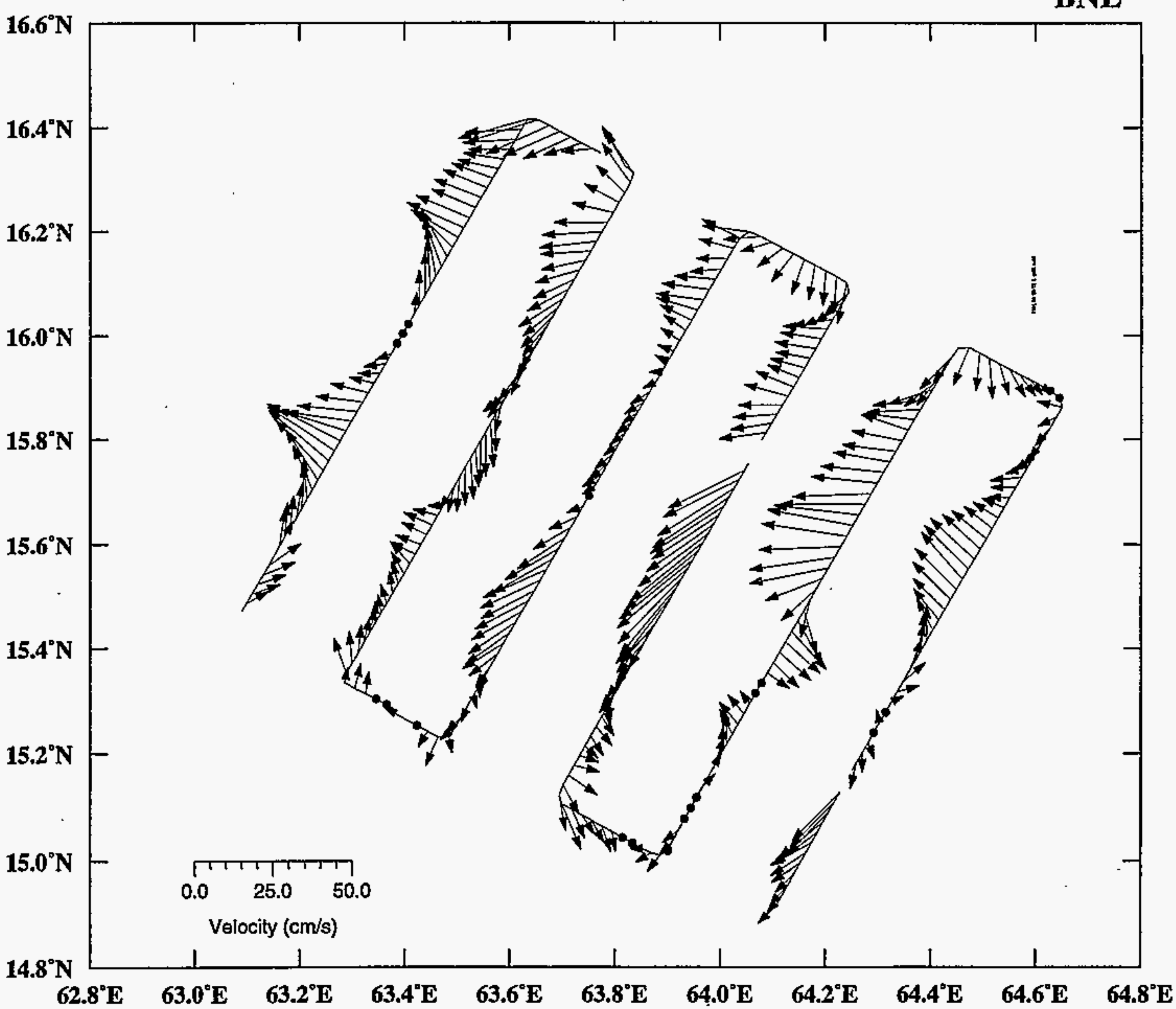
TN044 Section 3
Layer: 200m to 300m

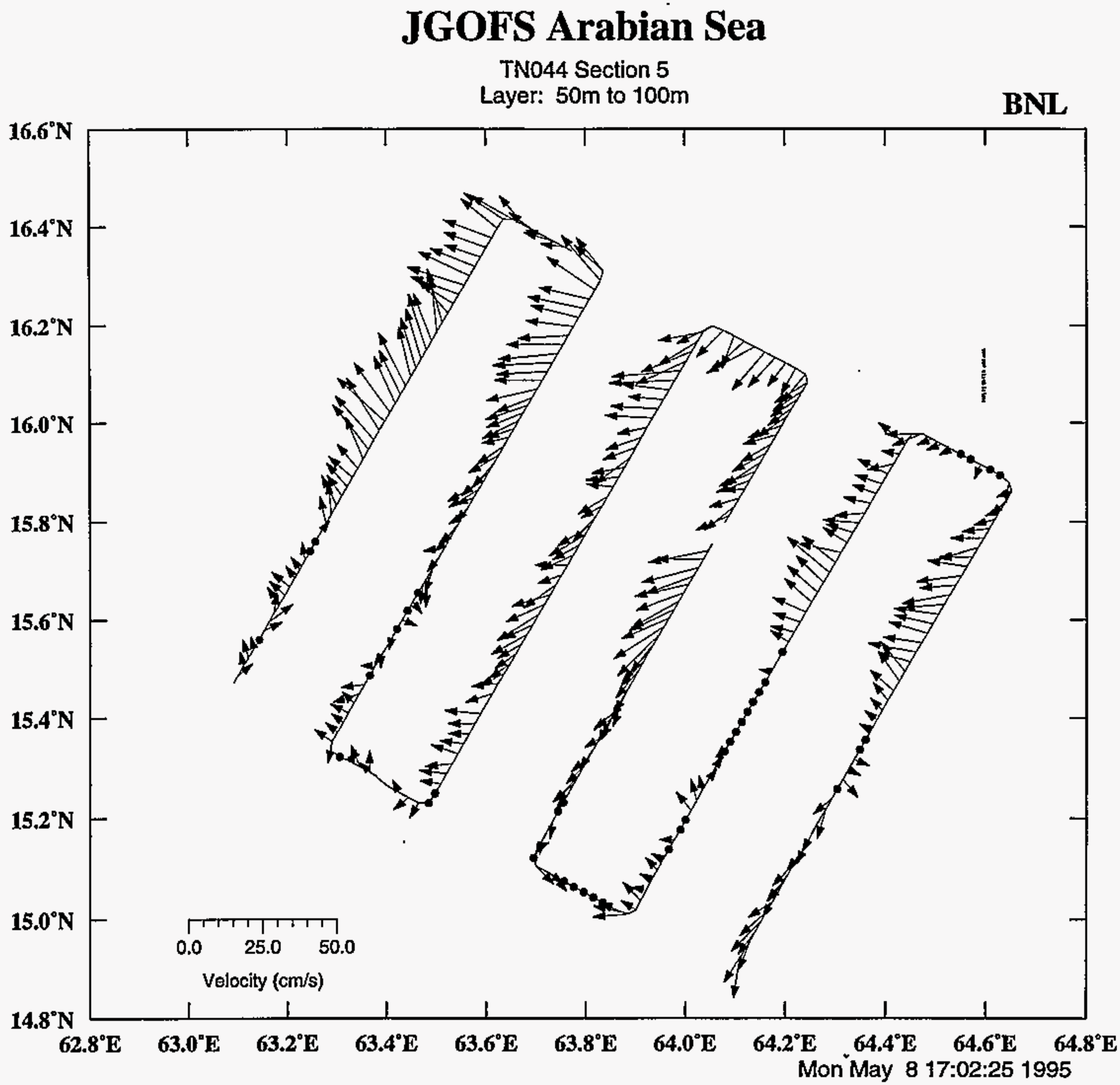
BNL

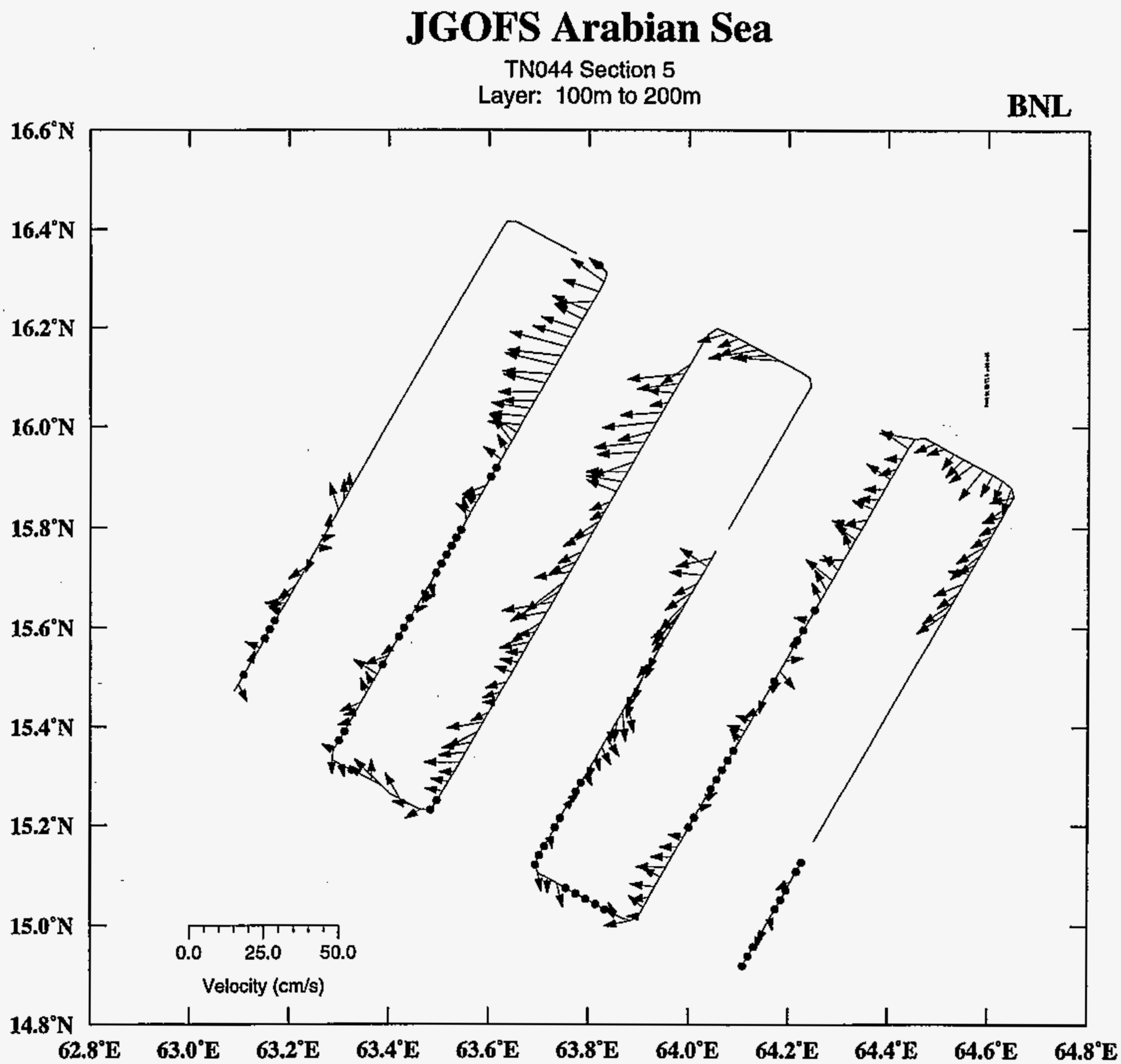


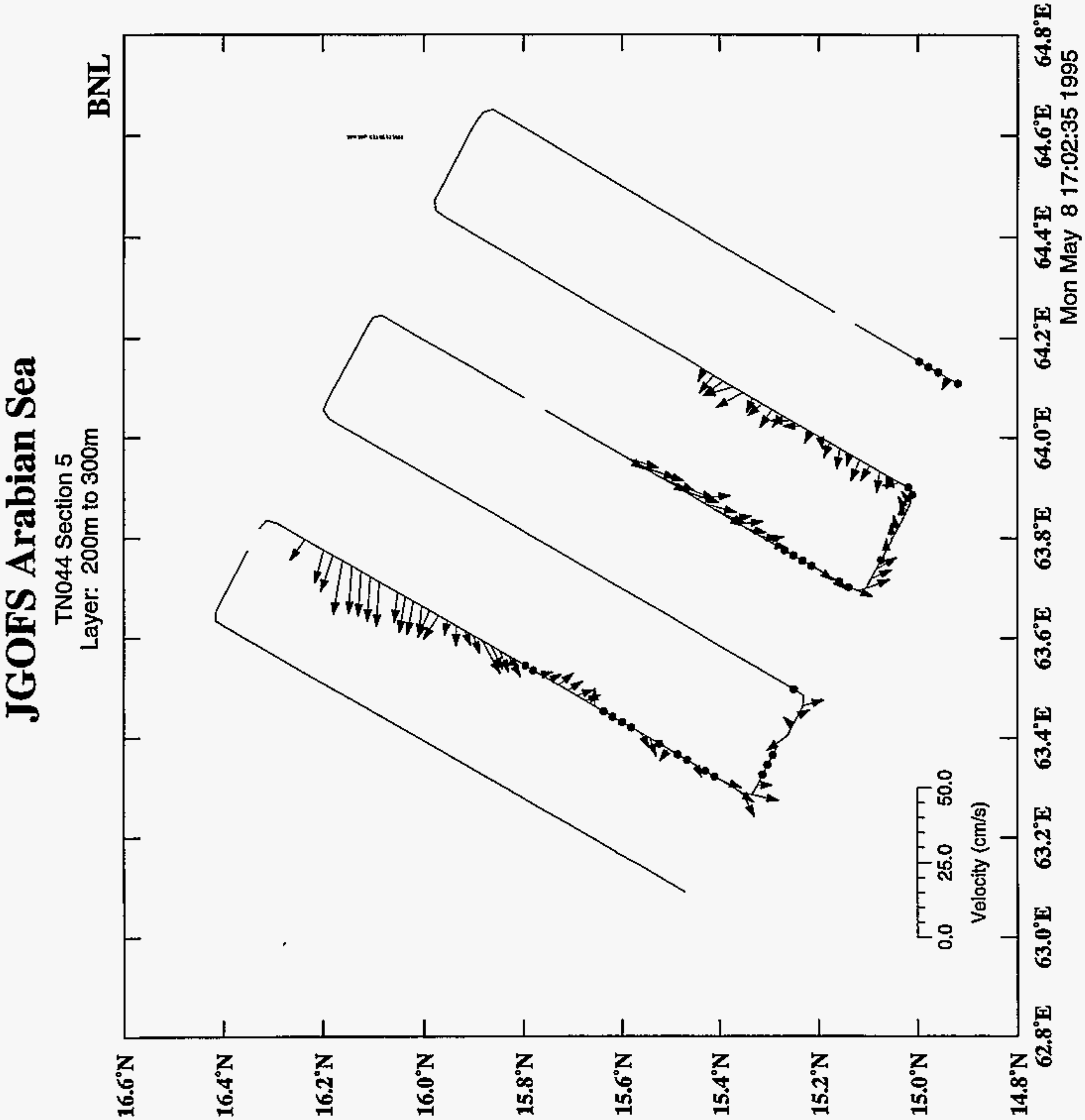
# JGOFS Arabian Sea

TN044 Section 5
Current Velocity 20m to 50m




JGOFS Arabian Sea
TN044 Section 5
Layer: 50m to 100m
BNL
16.6°N
16.4°N
16.2°N
16.0°N
15.8°N
15.6°N
15.4°N
15.2°N
15.0°N
14.8°N
62.8°E
63.0°E
63.2°E
63.4°E
63.6°E
63.8°E
64.0°E
64.2°E
64.4°E
64.6°E
64.8°E
0.0
25.0
50.0
Velocity (cm/s)
Mon May 8 17:02:25 1995

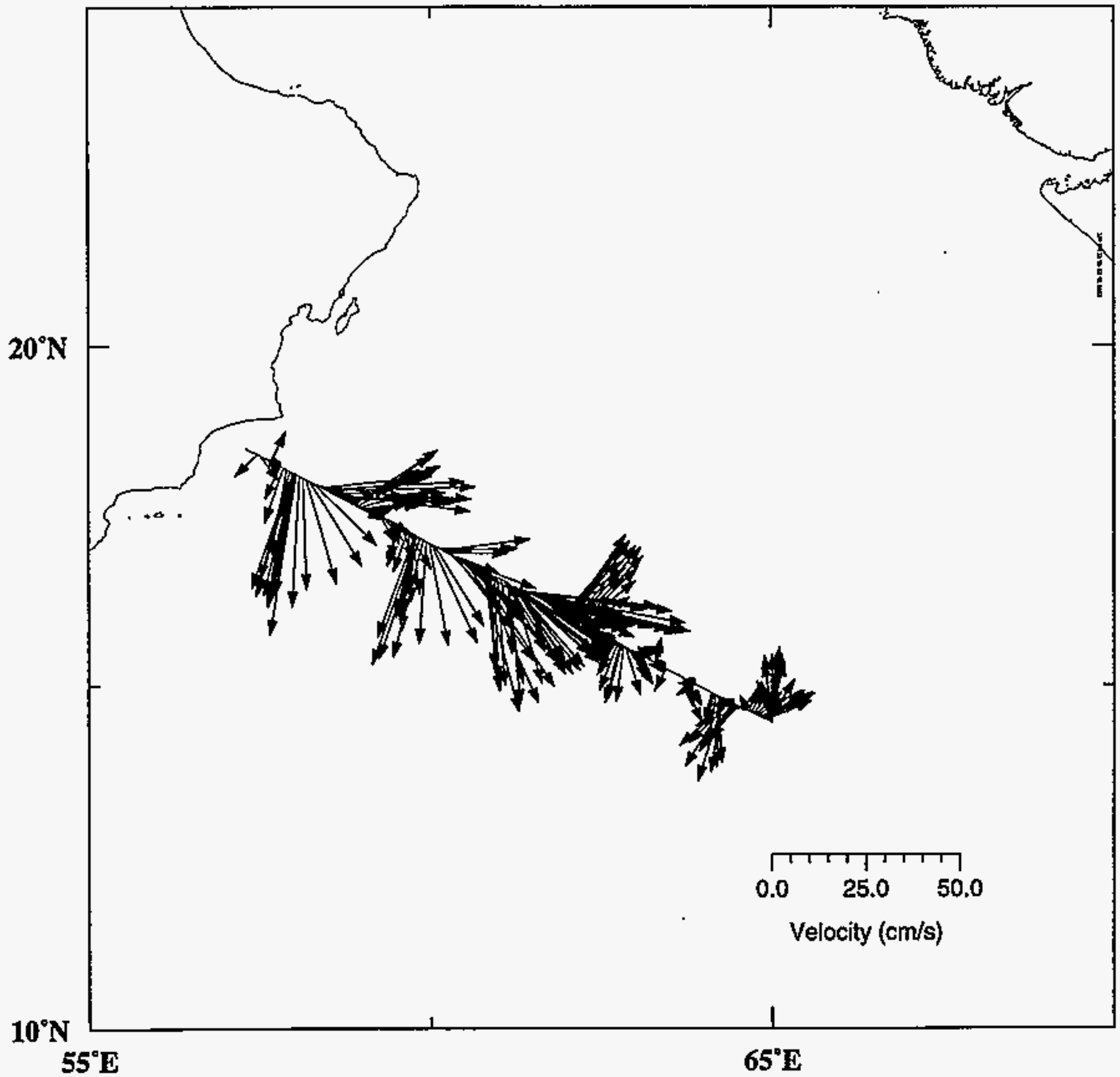

JGOFS Arabian Sea
TN044 Section 5
Layer: 100m to 200m
BNL
16.6°N
16.4°N
16.2°N
16.0°N
15.8°N
15.6°N
15.4°N
15.2°N
15.0°N
14.8°N
62.8°E
63.0°E
63.2°E
63.4°E
63.6°E
63.8°E
64.0°E
64.2°E
64.4°E
64.6°E
64.8°E
0.0
25.0
50.0
Velocity (cm/s)


JGOFS Arabian Sea
TN044 Section 5
Layer: 200m to 300m
BNL
16.6°N
16.4°N
16.2°N
16.0°N
15.8°N
15.6°N
15.4°N
15.2°N
15.0°N
14.8°N
62.8°E
63.0°E
63.2°E
63.4°E
63.6°E
63.8°E
64.0°E
64.2°E
64.4°E
64.6°E
64.8°E
0.0
25.0
50.0
Velocity (cm/s)
Mon May 8 17:02:35 1995

# JGOFS Arabian Sea

TN044 Inbound Transect (02/16/95 to 02/21/95)
Current Velocity 20m to 50m

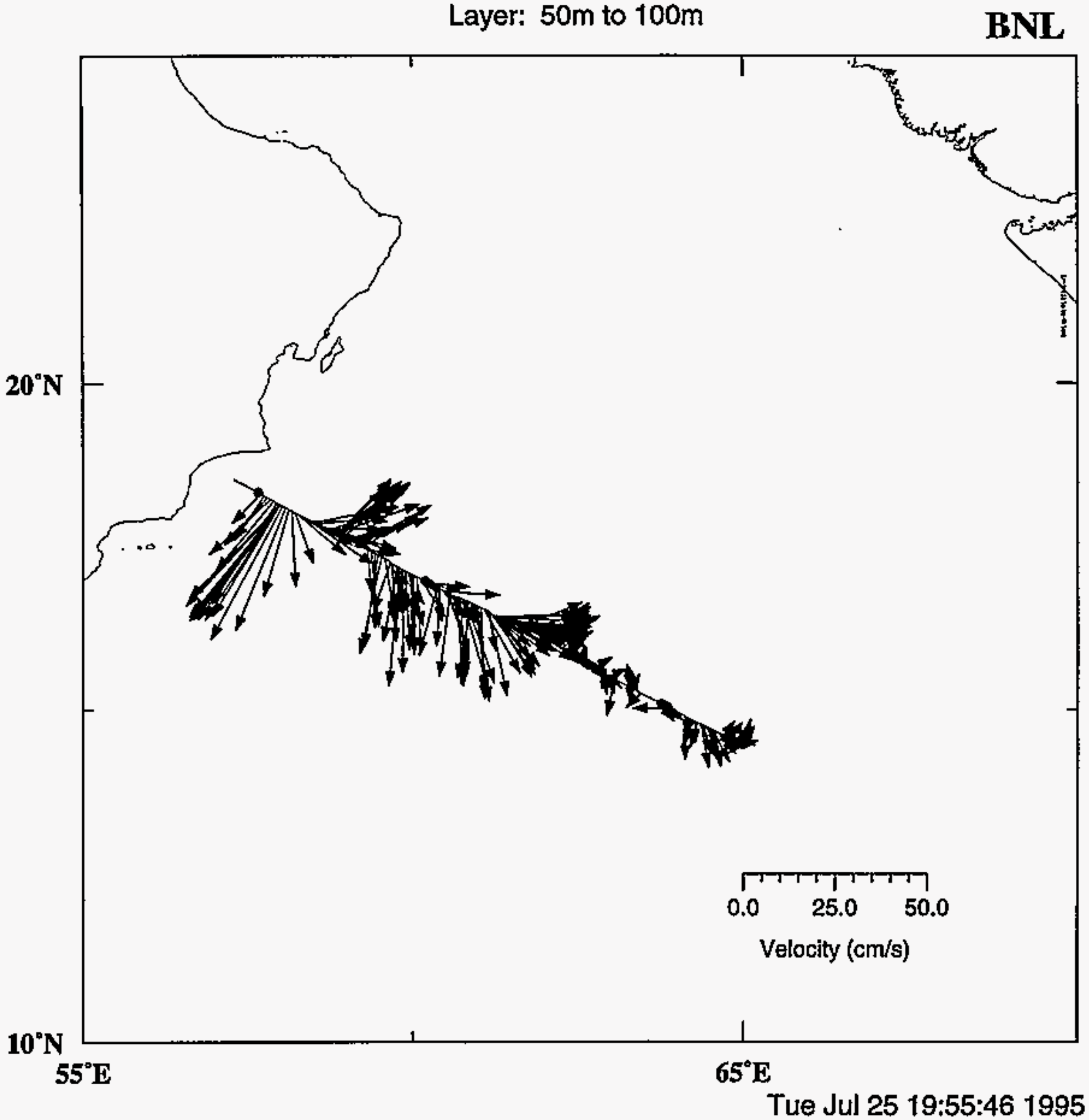
BNL




Tue Jul 25 19:55:41 1995

# JGOFS Arabian Sea

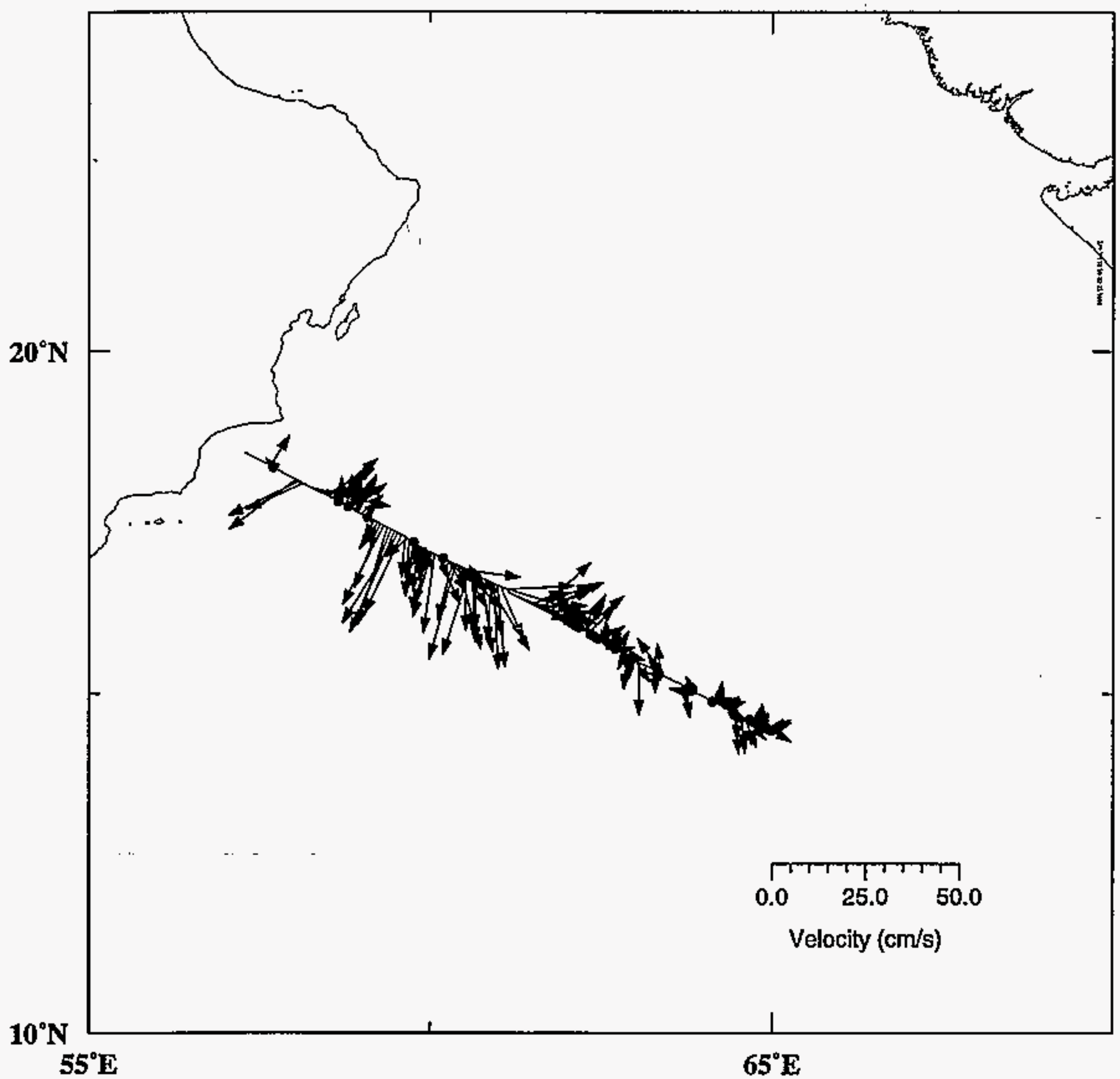
TN044 Inbound Transect (02/16/95 to 02/21/95)
Layer:  50m to 100m



# JGOFS Arabian Sea

TN044 Inbound Transect (02/16/95 to 02/21/95)
Layer: 100m to 200m

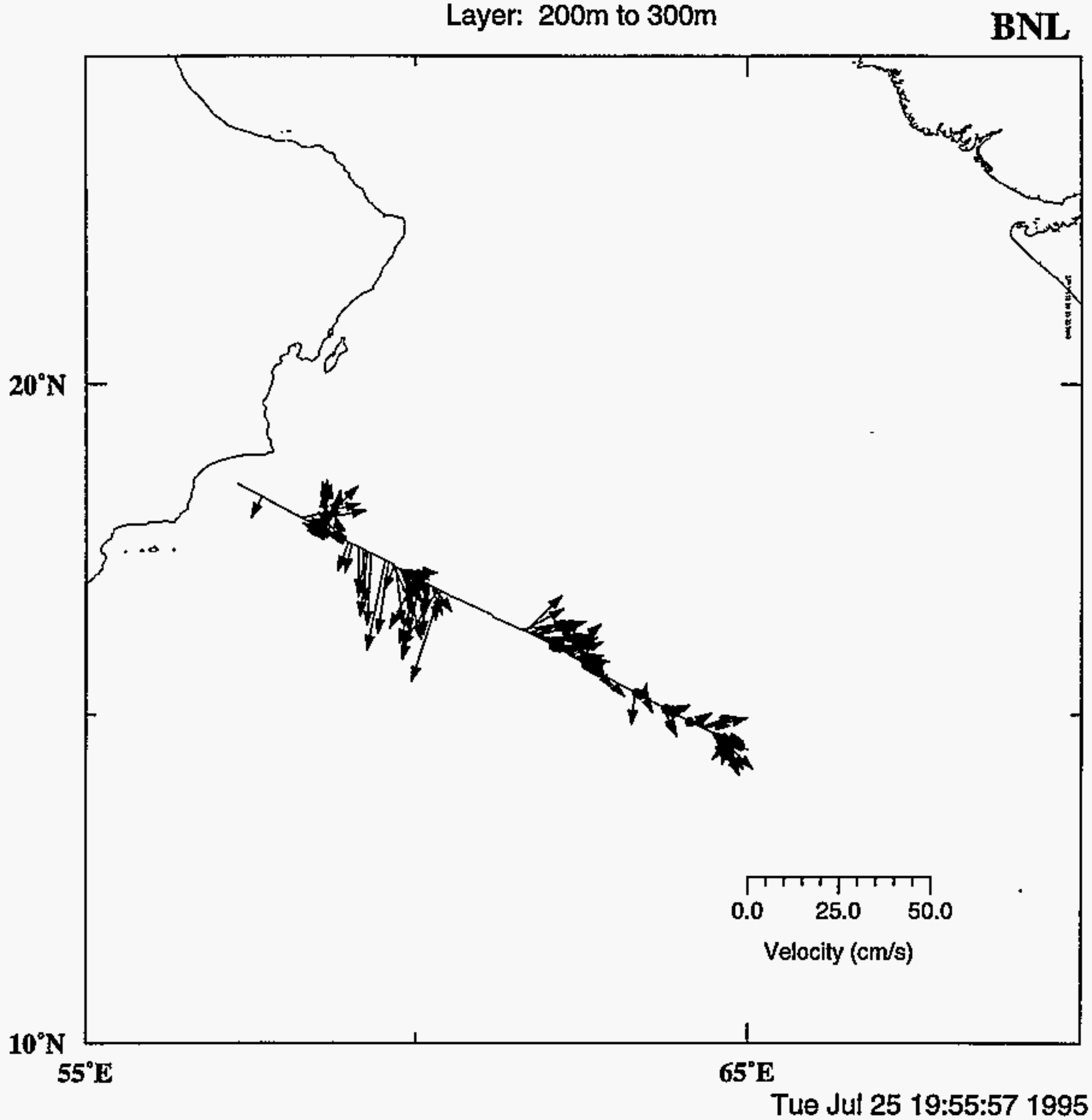
BNL

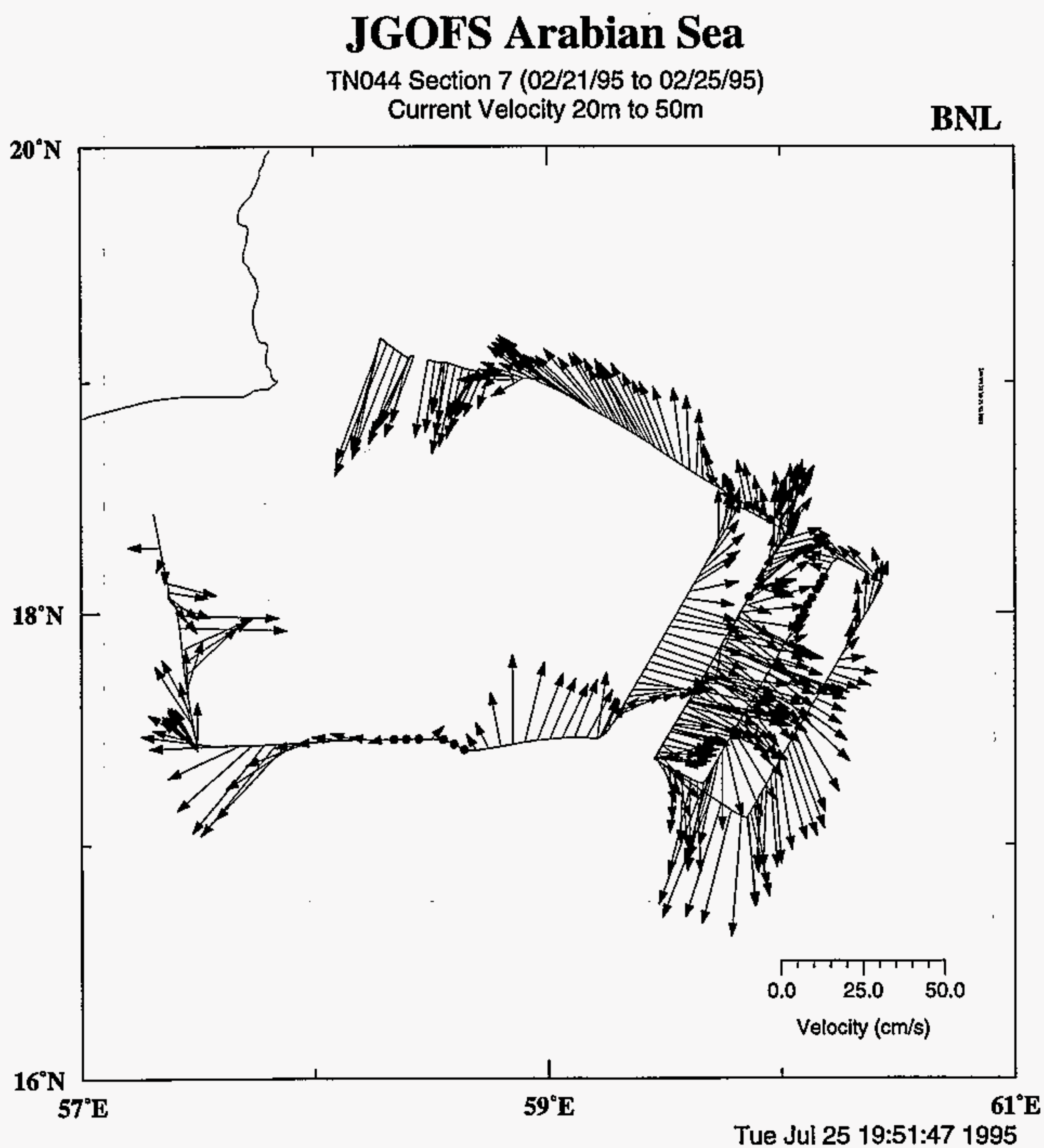


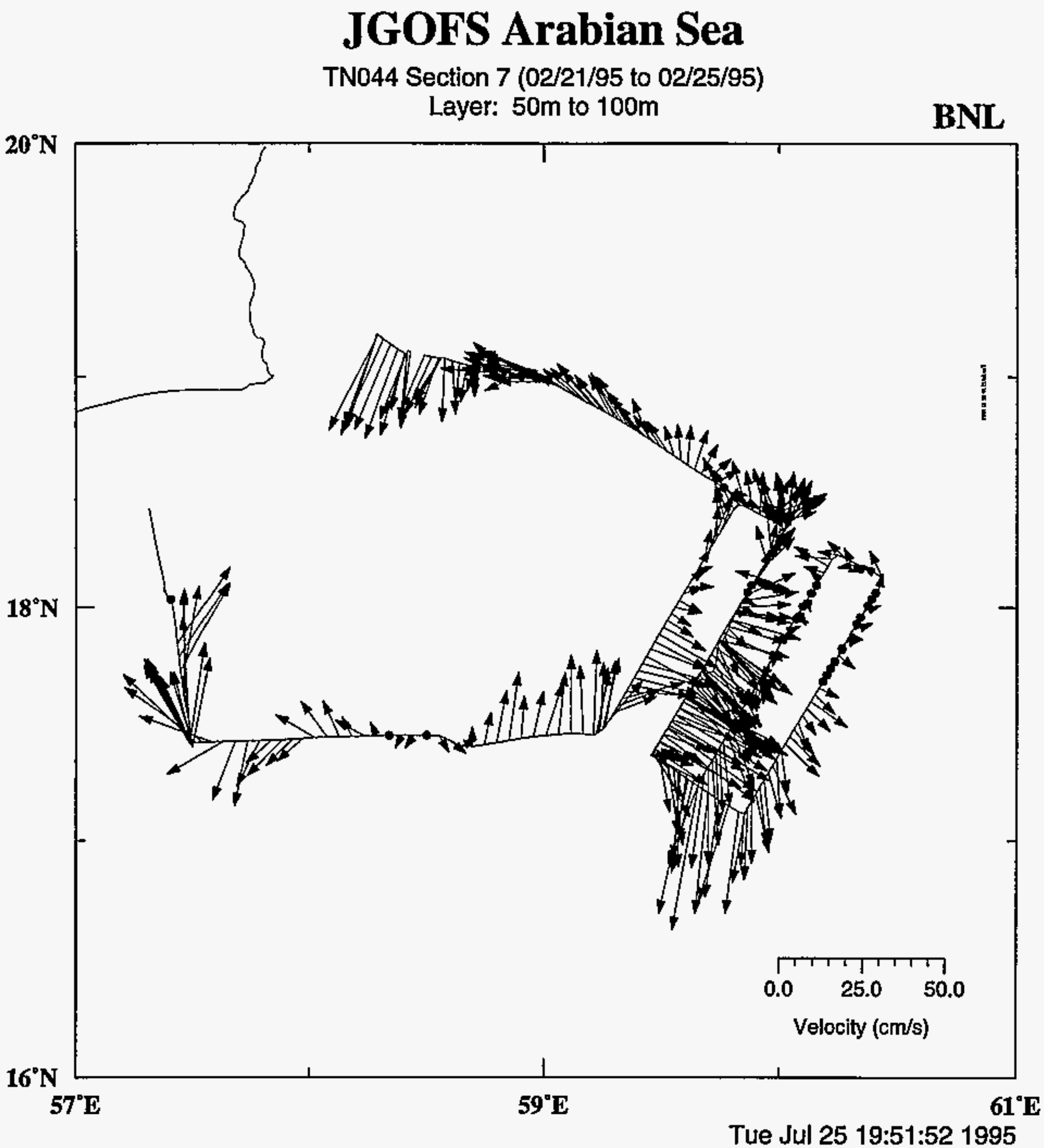

Tue Jul 25 19:55:51 1995

# JGOFS Arabian Sea

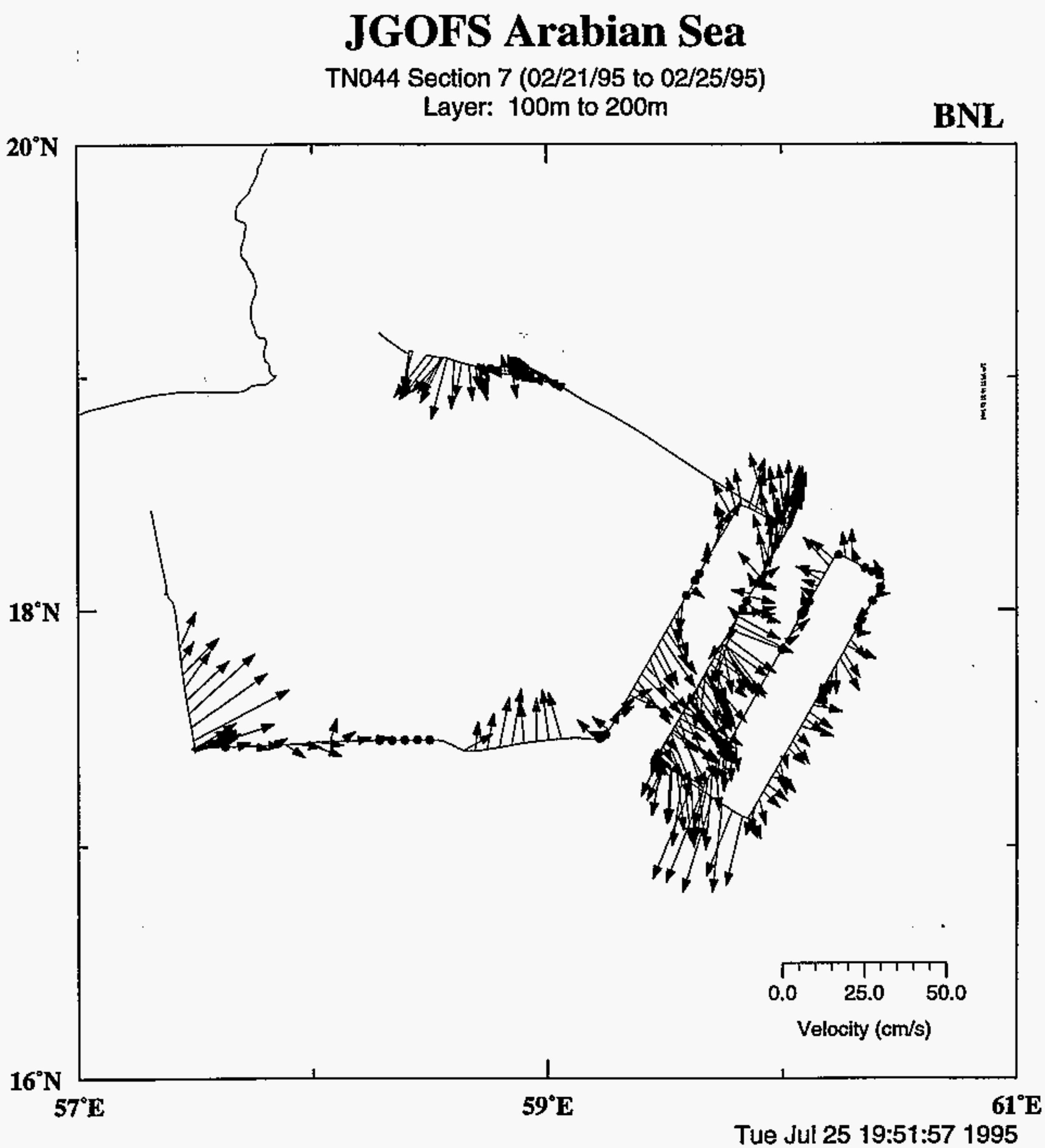
TN044 Inbound Transect (02/16/95 to 02/21/95)
Layer: 200m to 300m

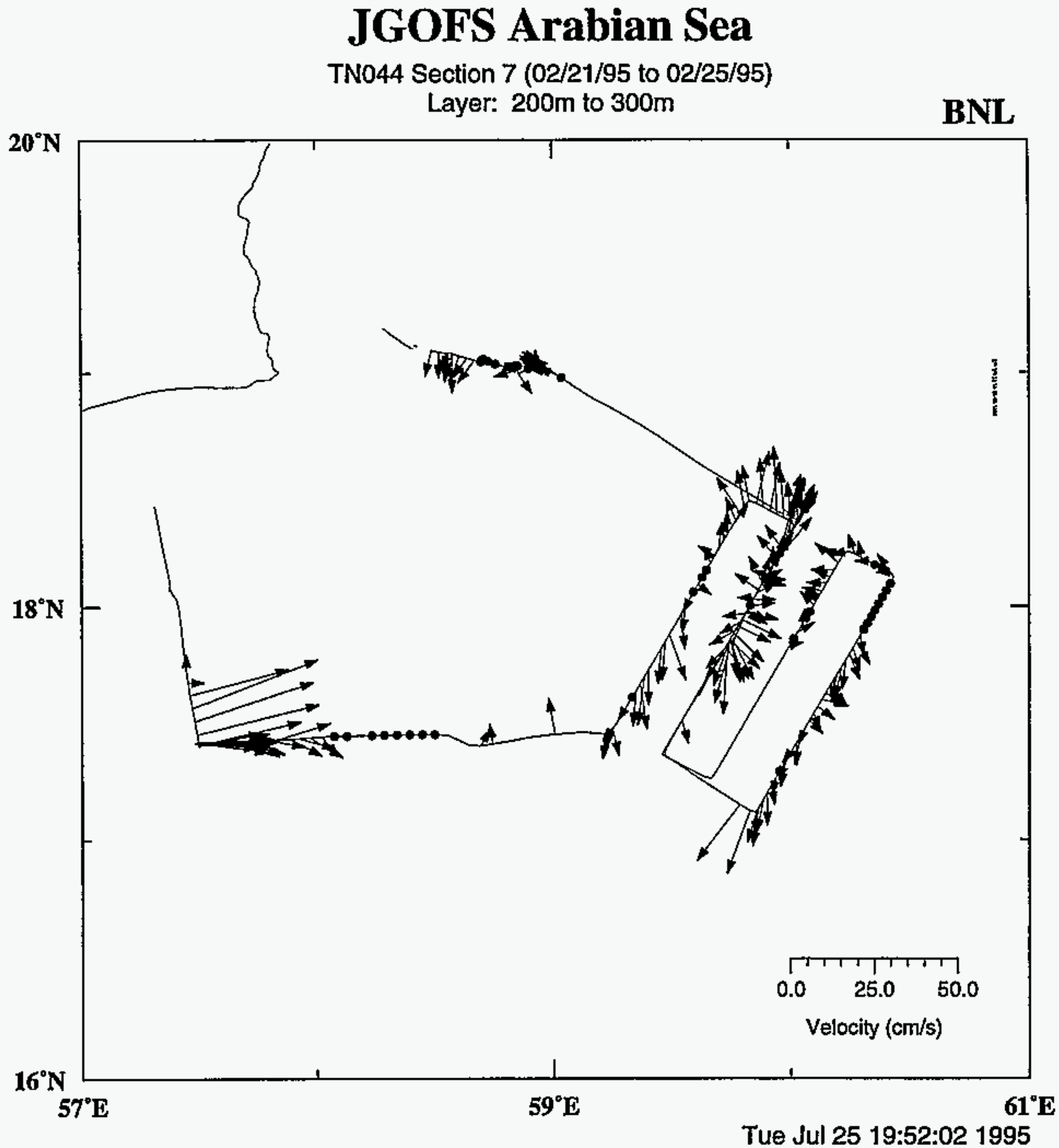


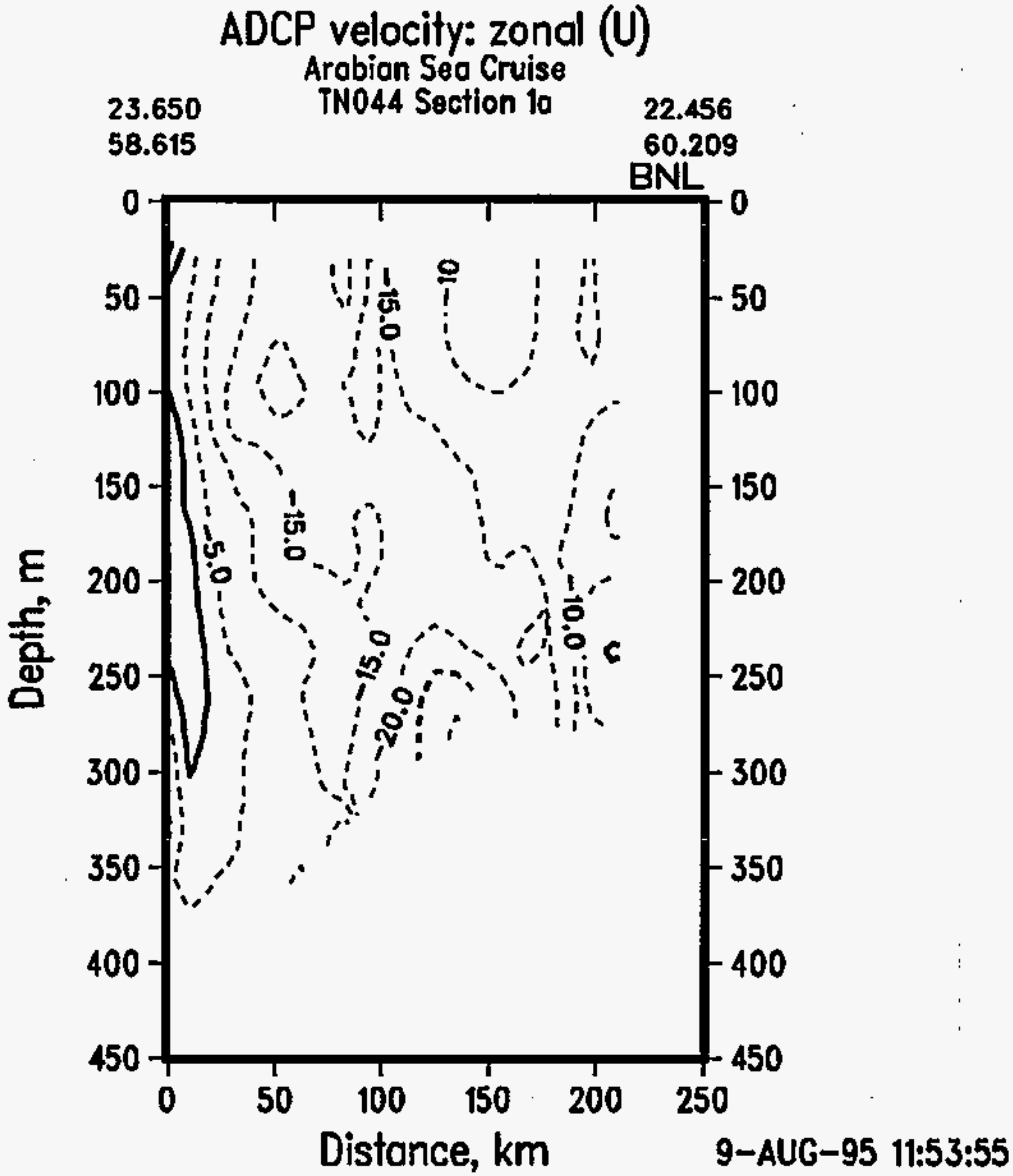

JGOFS Arabian Sea
TN044 Section 7 (02/21/95 to 02/25/95)
Current Velocity 20m to 50m
BNL
20°N
18°N
16°N
57°E
59°E
61°E
0.0
25.0
50.0
Velocity (cm/s)
Tue Jul 25 19:51:47 1995

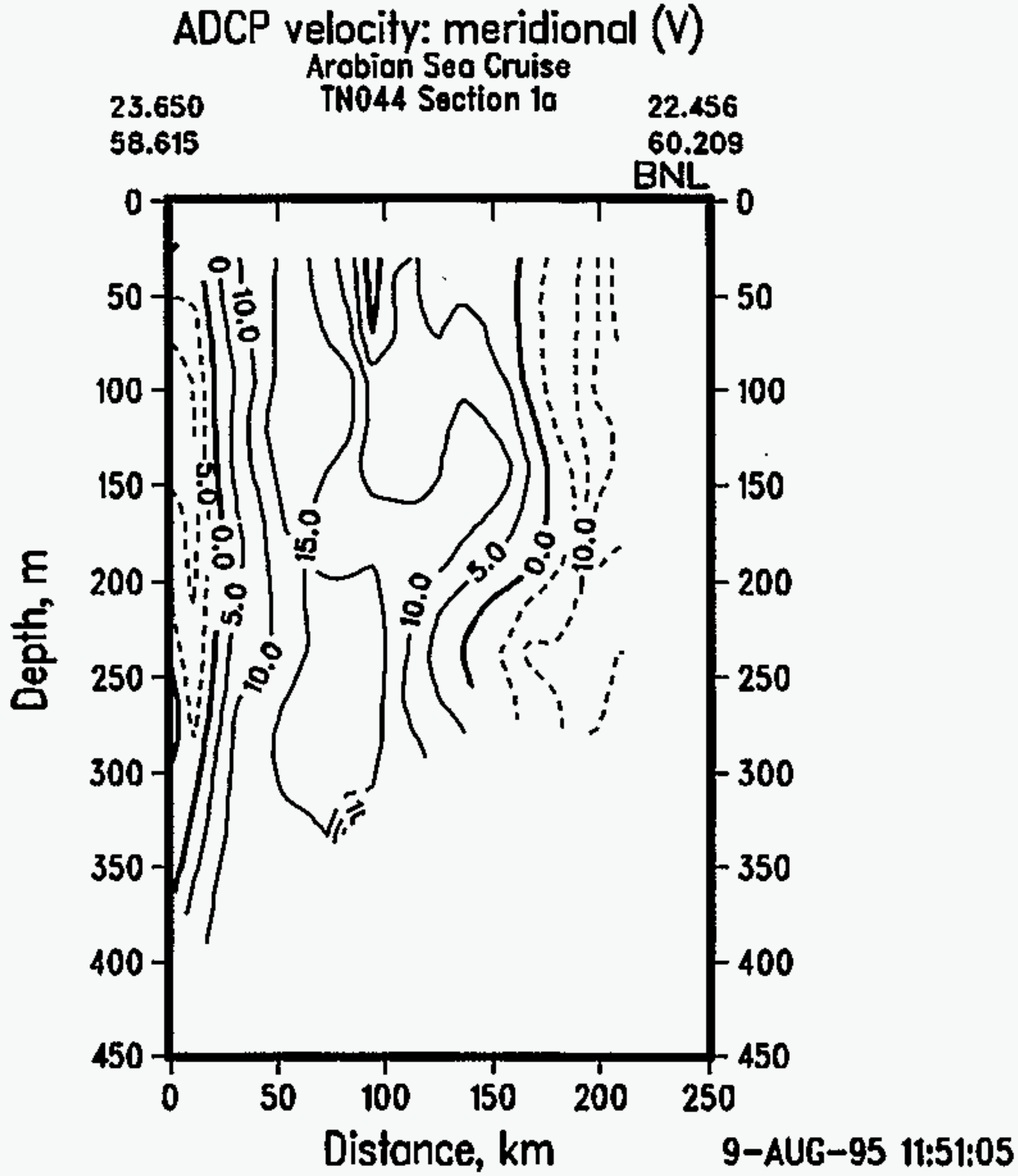


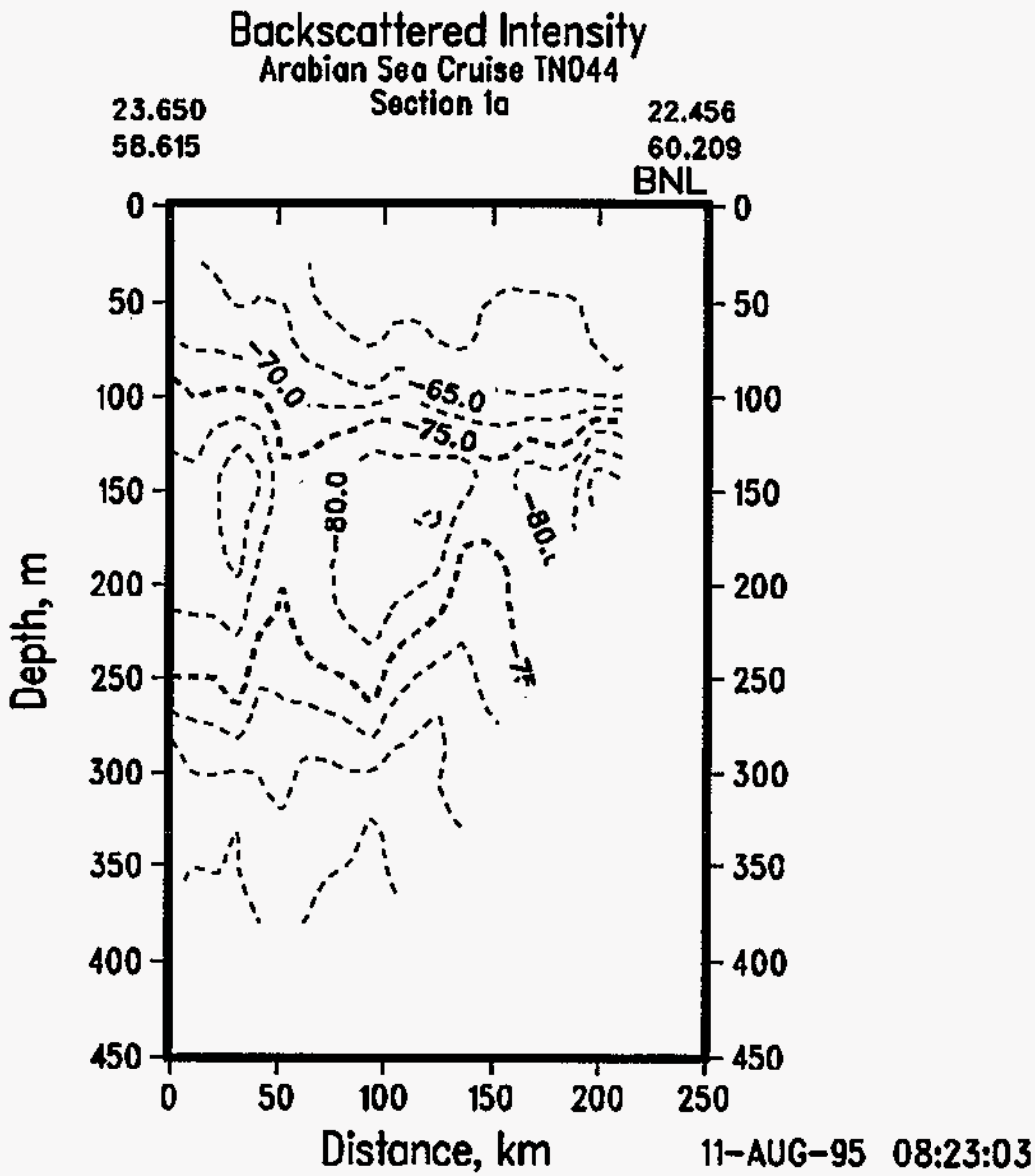
JGOFS Arabian Sea
TN044 Section 7 (02/21/95 to 02/25/95)
Layer: 50m to 100m
BNL
20°N
18°N
16°N
57°E
59°E
61°E
0.0
25.0
50.0
Velocity (cm/s)
Tue Jul 25 19:51:52 1995

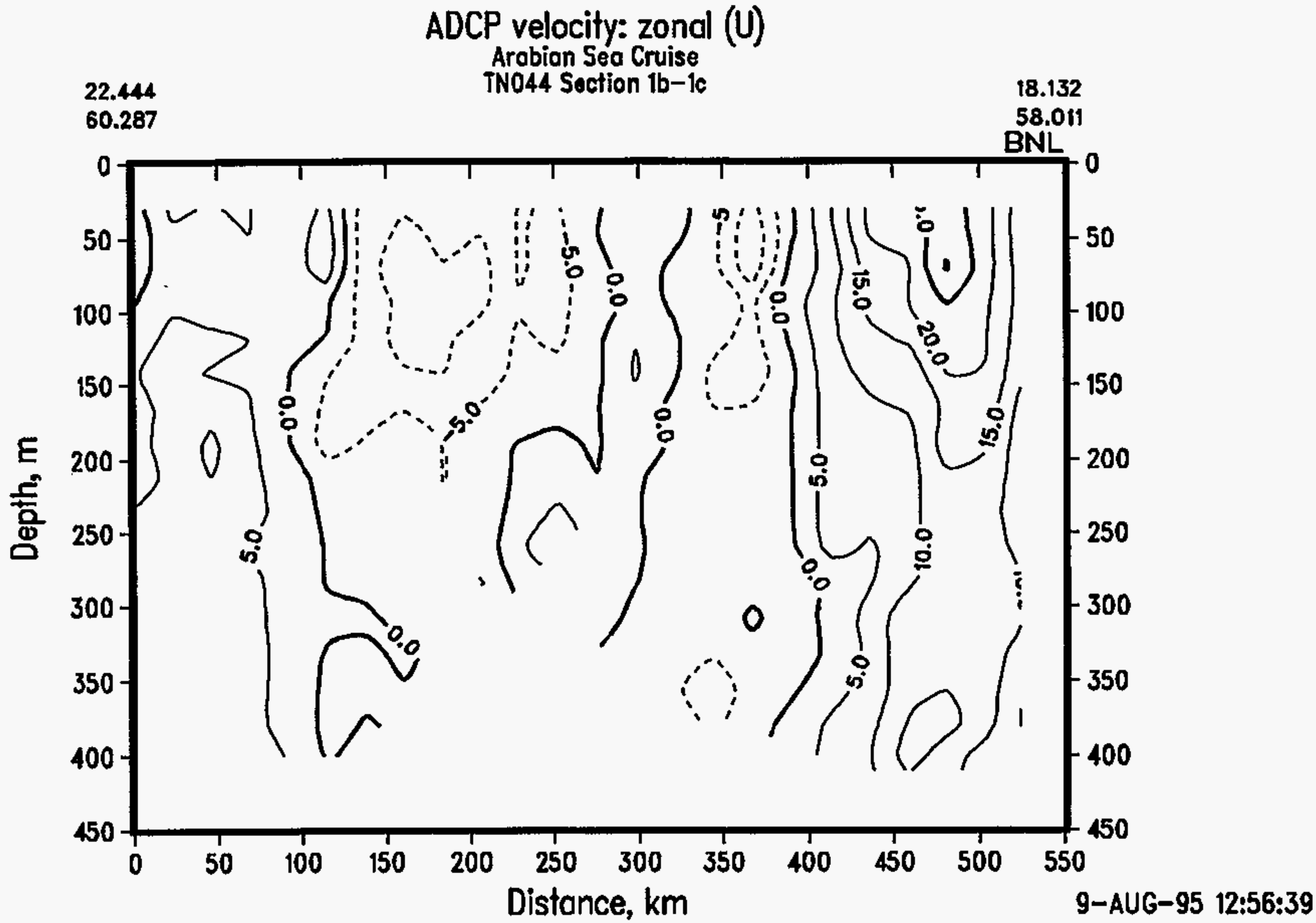

JGOFS Arabian Sea
TN044 Section 7 (02/21/95 to 02/25/95)
Layer: 100m to 200m
BNL
20°N
18°N
16°N
57°E
59°E
61°E
0.0
25.0
50.0
Velocity (cm/s)
Tue Jul 25 19:51:57 1995


JGOFS Arabian Sea
TN044 Section 7 (02/21/95 to 02/25/95)
Layer: 200m to 300m
BNL
20°N
18°N
16°N
57°E
59°E
61°E
0.0
25.0
50.0
Velocity (cm/s)
Tue Jul 25 19:52:02 1995

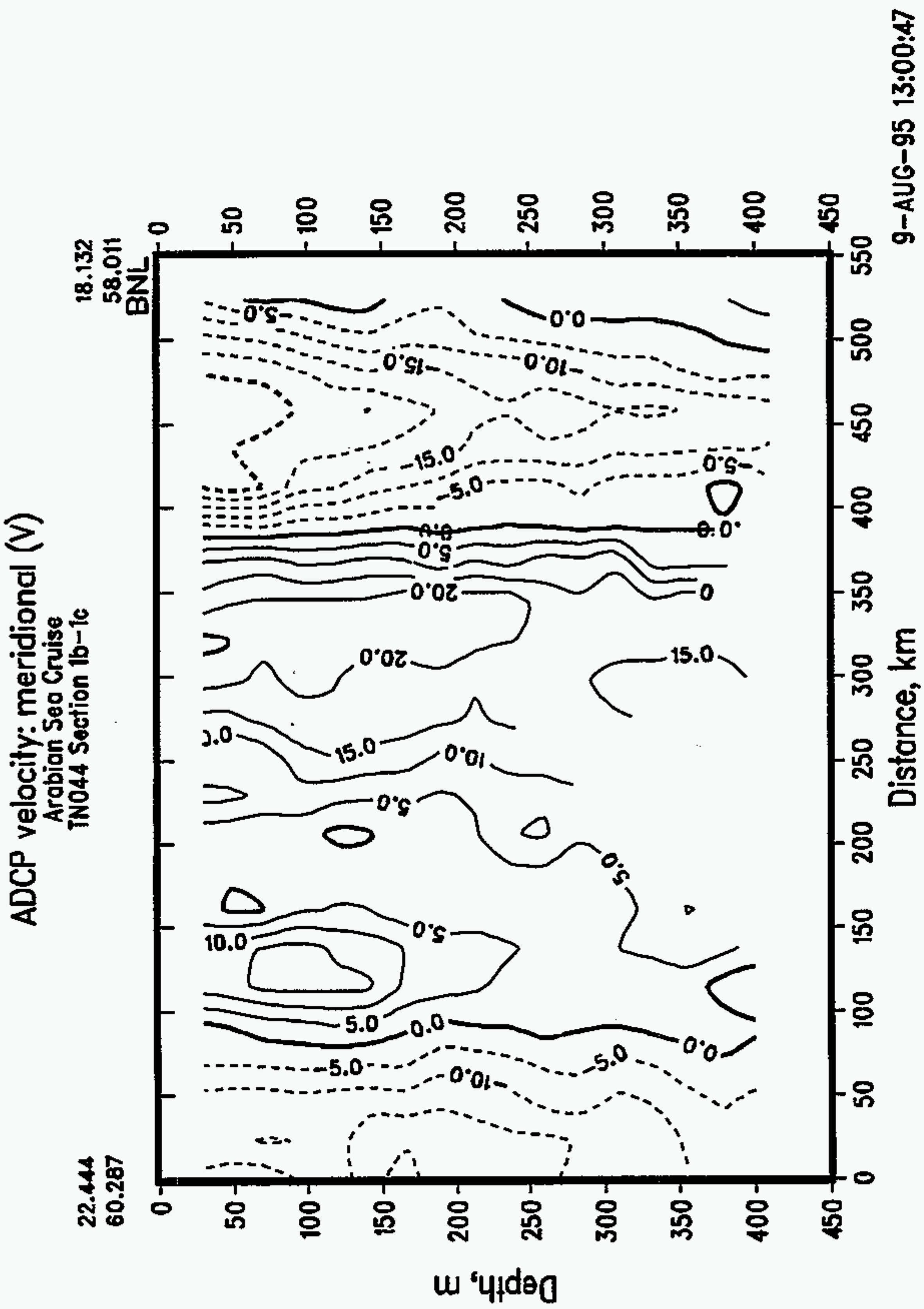

ADCP velocity: zonal (U)
Arabian Sea Cruise
TN044 Section 1a
23.650
58.615
22.456
60.209
BNL
-5.0
-15.0
-10.0
-20.0
Depth, m
Distance, km
9-AUG-95 11:53:55


ADCP velocity: meridional (V)
Arabian Sea Cruise
TN044 Section 1a
23.650
58.615
22.456
60.209
BNL
Depth, m
Distance, km
9-AUG-95 11:51:05
0
50
100
150
200
250
300
350
400
450
0
50
100
150
200
250
10.0
5.0
0.0
-5.0
15.0
10.0
5.0
0.0
-10.0

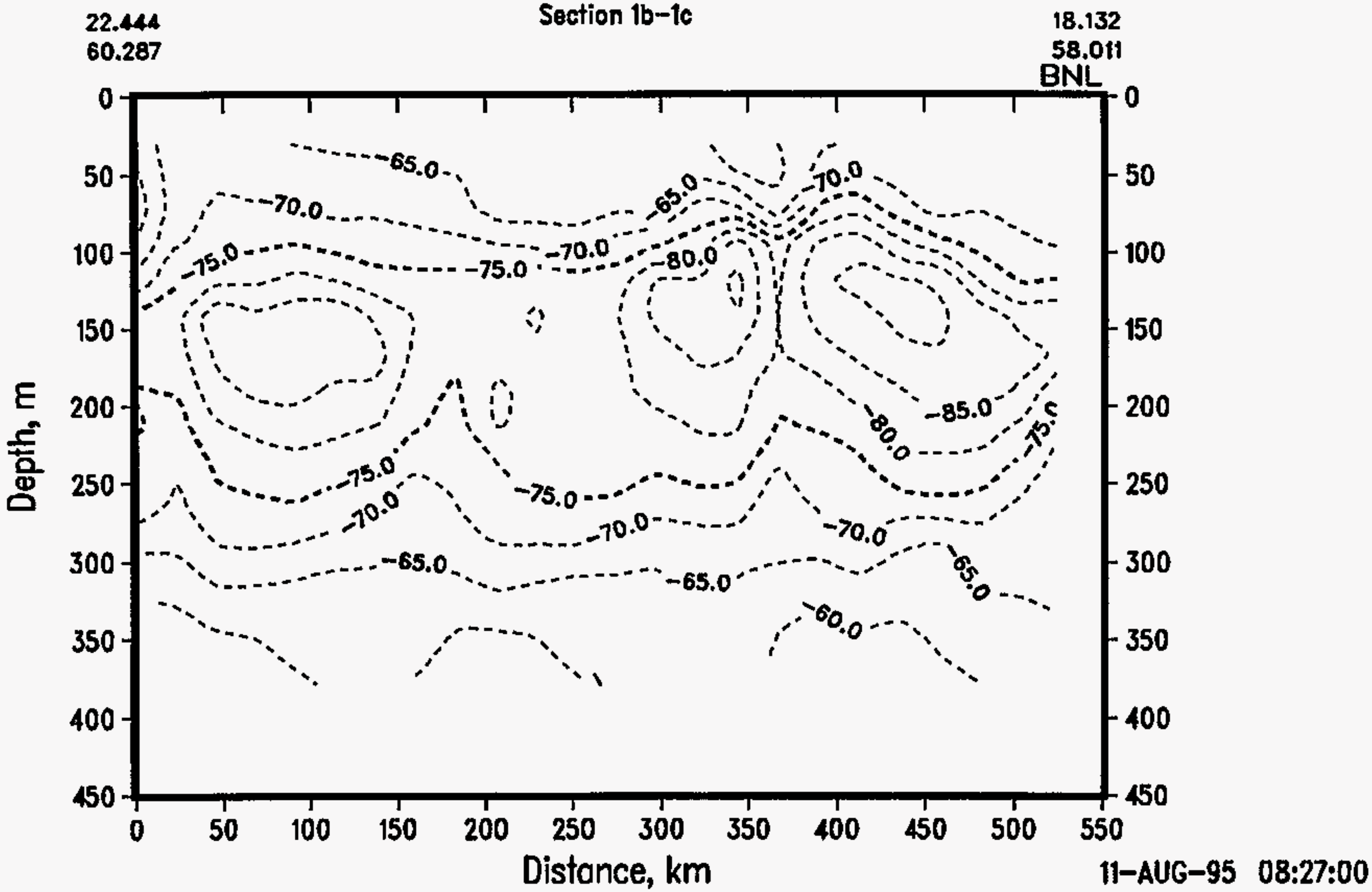

Backscattered Intensity
Arabian Sea Cruise TN044
Section 1a
23.650
58.615
22.456
60.209
BNL
Depth, m
Distance, km
-70.0
-65.0
-75.0
-80.0
-80.
-75
11-AUG-95 08:23:03

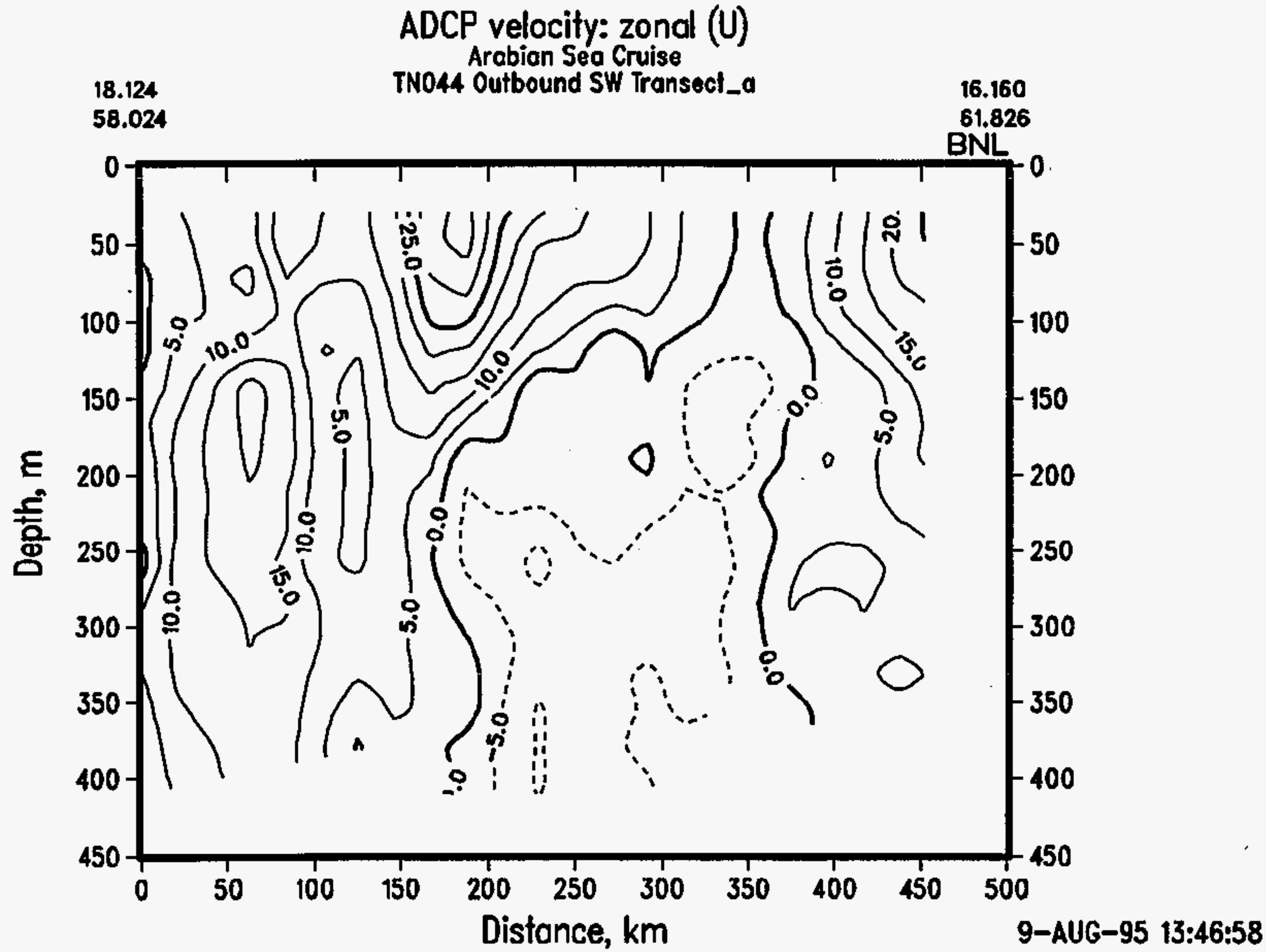


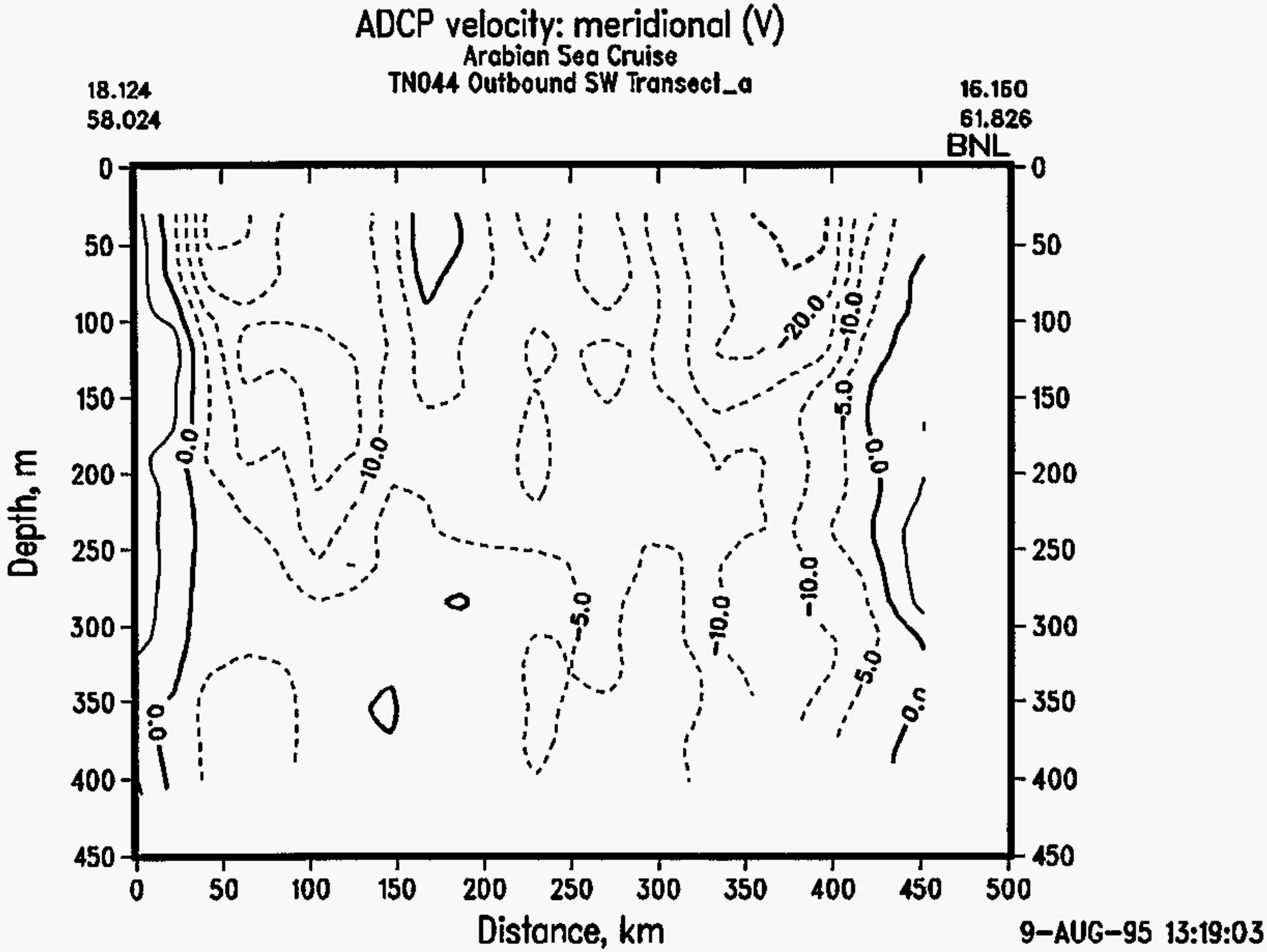
ADCP velocity: zonal (U)
Arabian Sea Cruise
TN044 Section 1b–1c
22.444
60.287
18.132
58.011
BNL
Depth, m
Distance, km
9–AUG–95 12:56:39

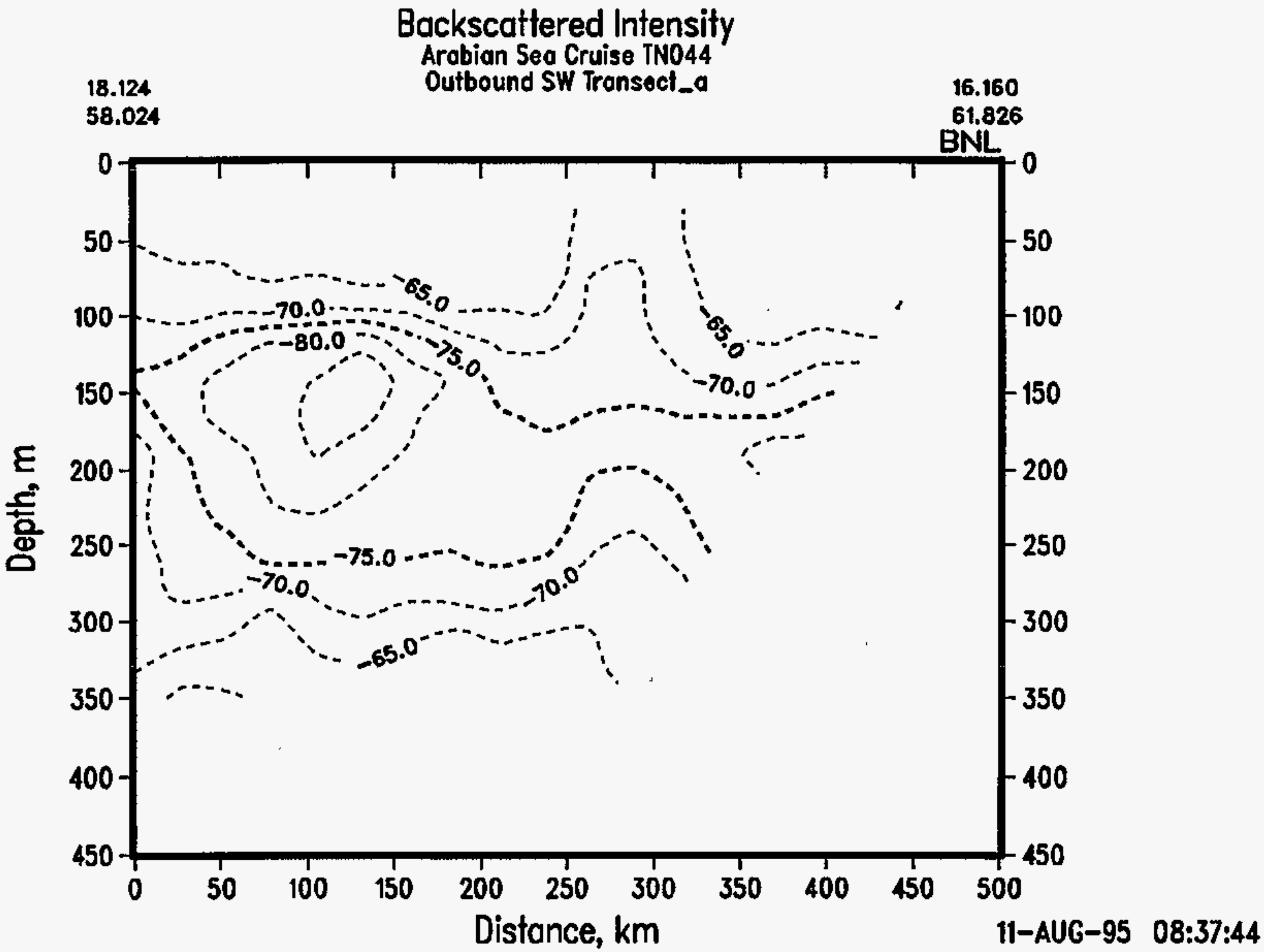

ADCP velocity: meridional (V)
Arabian Sea Cruise
TN044 Section 1b-1c
22.444
60.287
18.132
58.011
BNL
Depth, m
Distance, km
9-AUG-95 13:00:47
0
50
100
150
200
250
300
350
400
450
500
550
-5.0
-10.0
-15.0
0.0
5.0
10.0
15.0
20.0

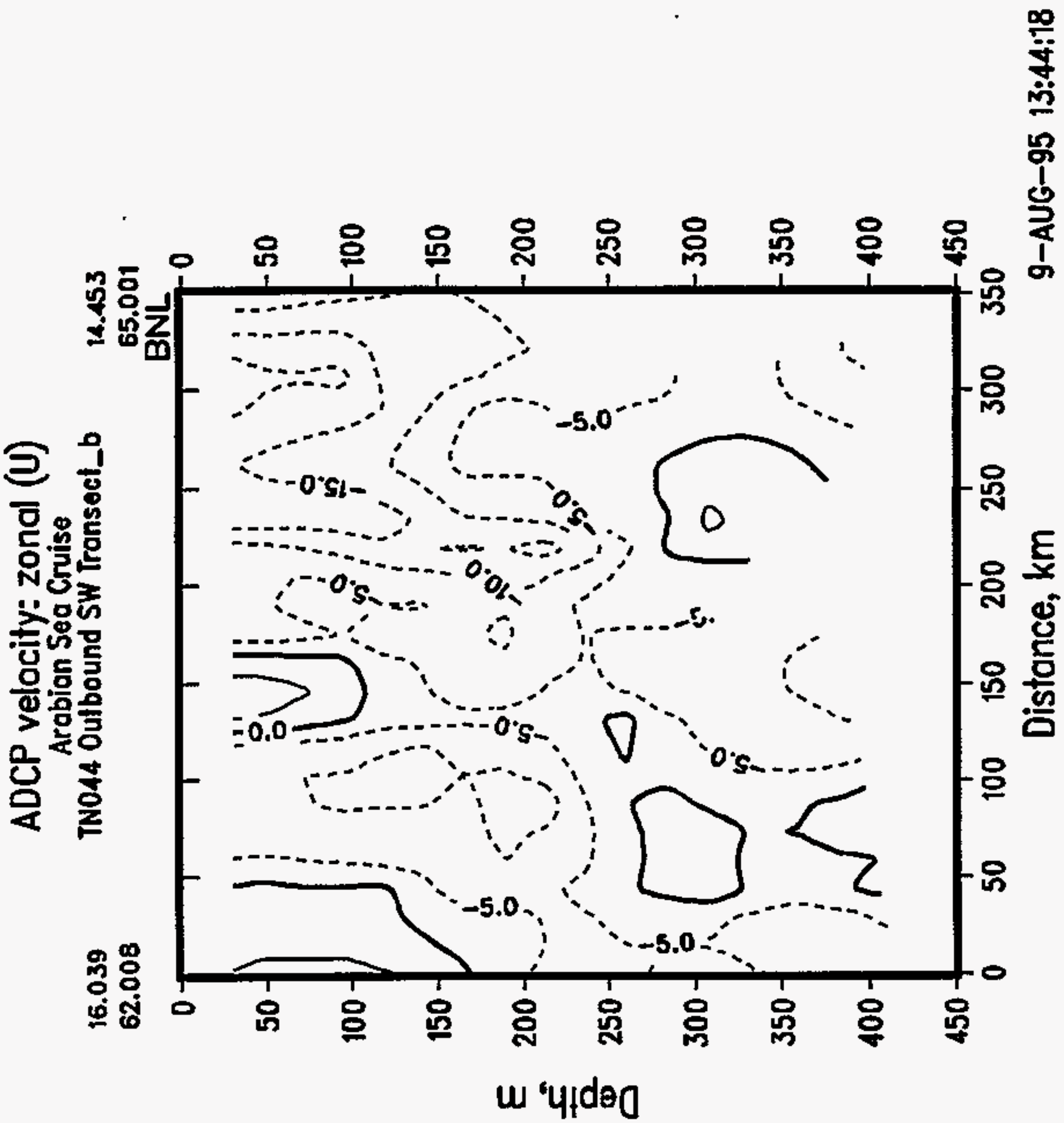
Backscattered Intensity
Arabian Sea Cruise TN044
Section 1b-1c




ADCP velocity: zonal (U)
Arabian Sea Cruise
TN044 Outbound SW Transect_a
18.124
58.024
16.160
61.826
BNL
Depth, m
Distance, km
9-AUG-95 13:46:58
25.0
20.
15.0
10.0
5.0
0.0
-5.0


ADCP velocity: meridional (V)
Arabian Sea Cruise
TN044 Outbound SW Transect_a
18.124
58.024
16.160
61.826
BNL
Depth, m
Distance, km
0
50
100
150
200
250
300
350
400
450
500
0.0
-10.0
-5.0
-20.0
9-AUG-95 13:19:03

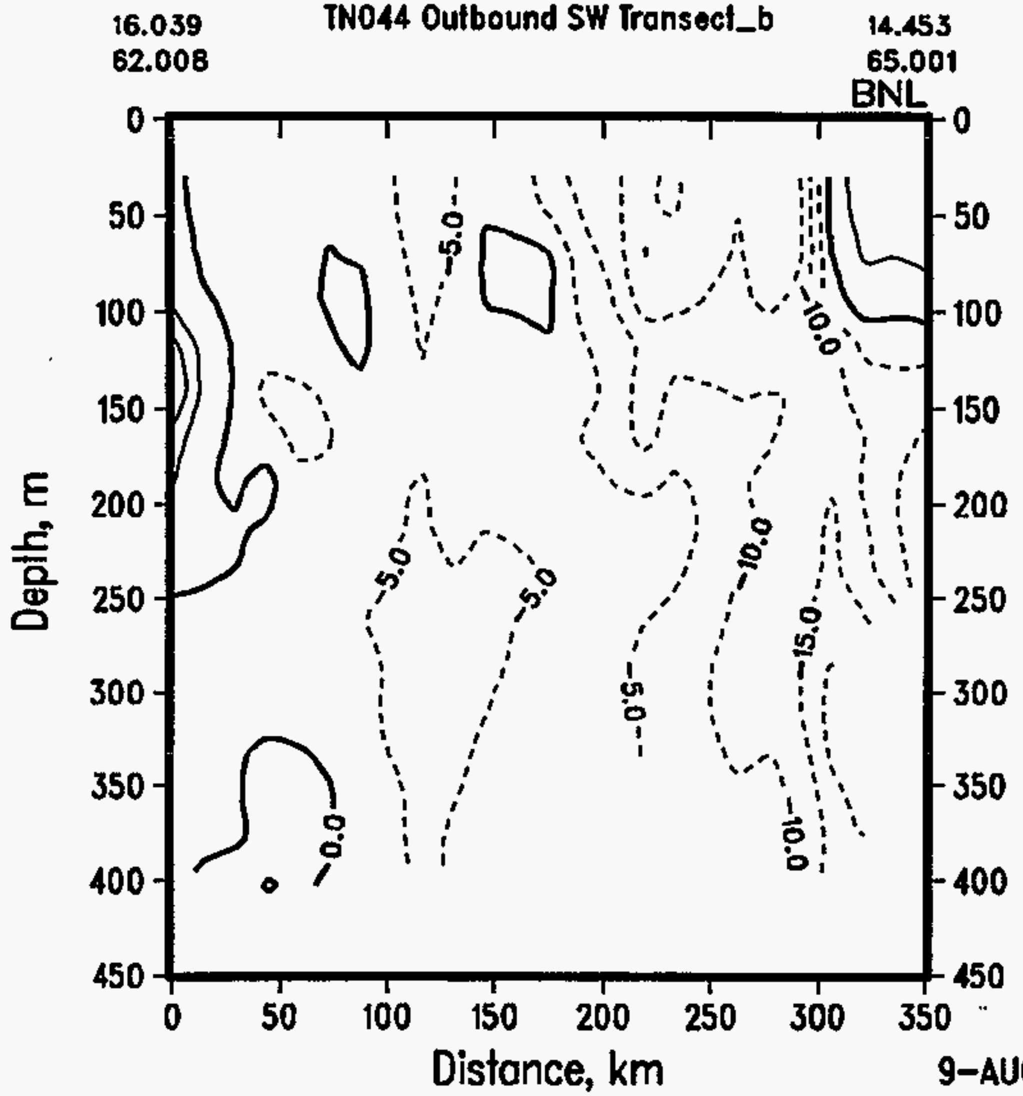

Backscattered Intensity
Arabian Sea Cruise TN044
Outbound SW Transect_a
18.124
58.024
16.160
61.826
BNL
Depth, m
Distance, km
-65.0
-70.0
-75.0
-80.0
11-AUG-95 08:37:44


ADCP velocity: zonal (U)
Arabian Sea Cruise
TN044 Outbound SW Transect_b
16.039
62.008
14.453
65.001
BNL
Depth, m
Distance, km
0
50
100
150
200
250
300
350
400
450
-5.0
-10.0
-15.0
0.0
9-AUG-95 13:44:18

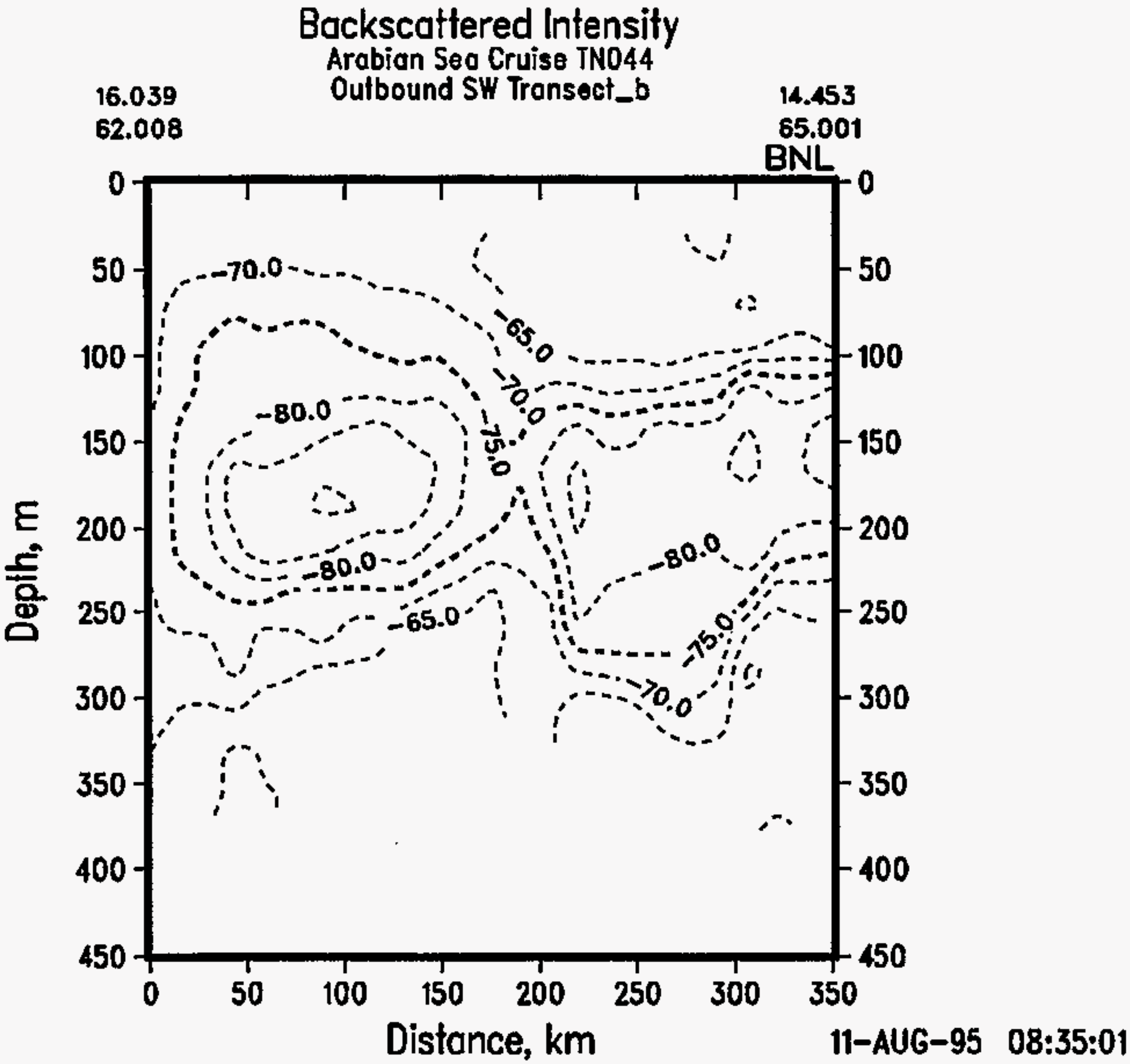
ADCP velocity: meridional (V)

Arabian Sea Cruise

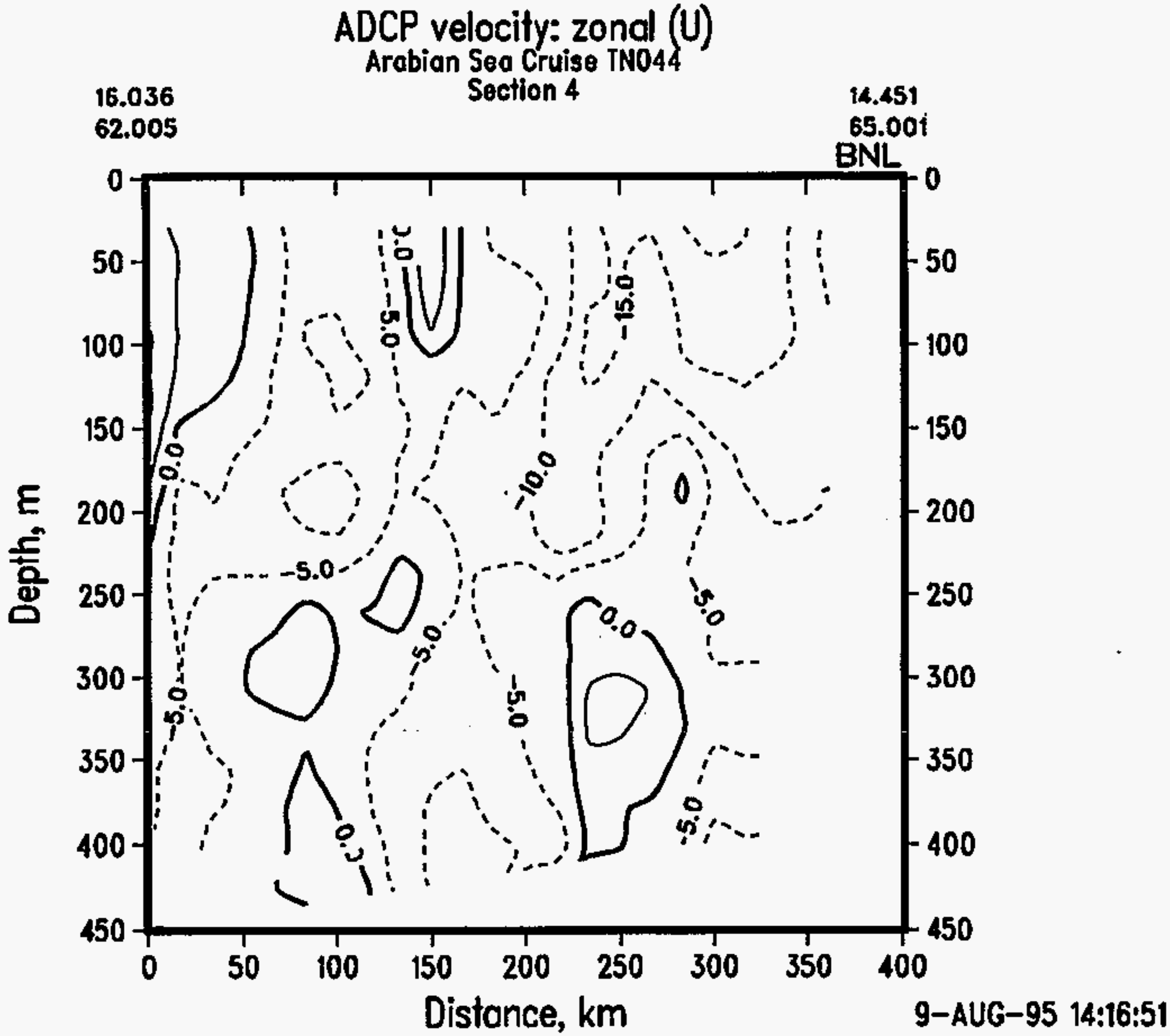
TN044 Outbound SW Transect_b

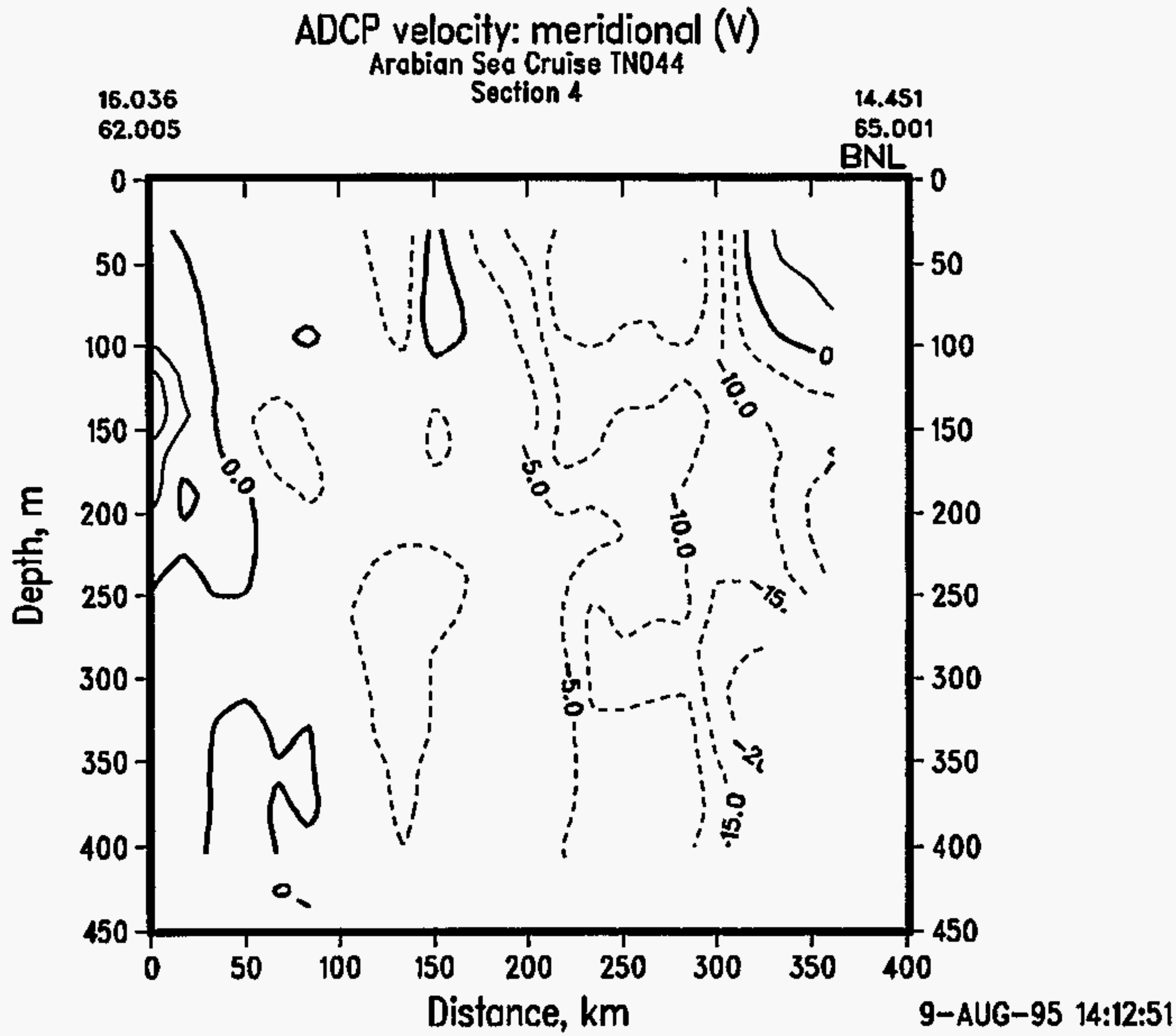



9-AUG-95 13:30:44

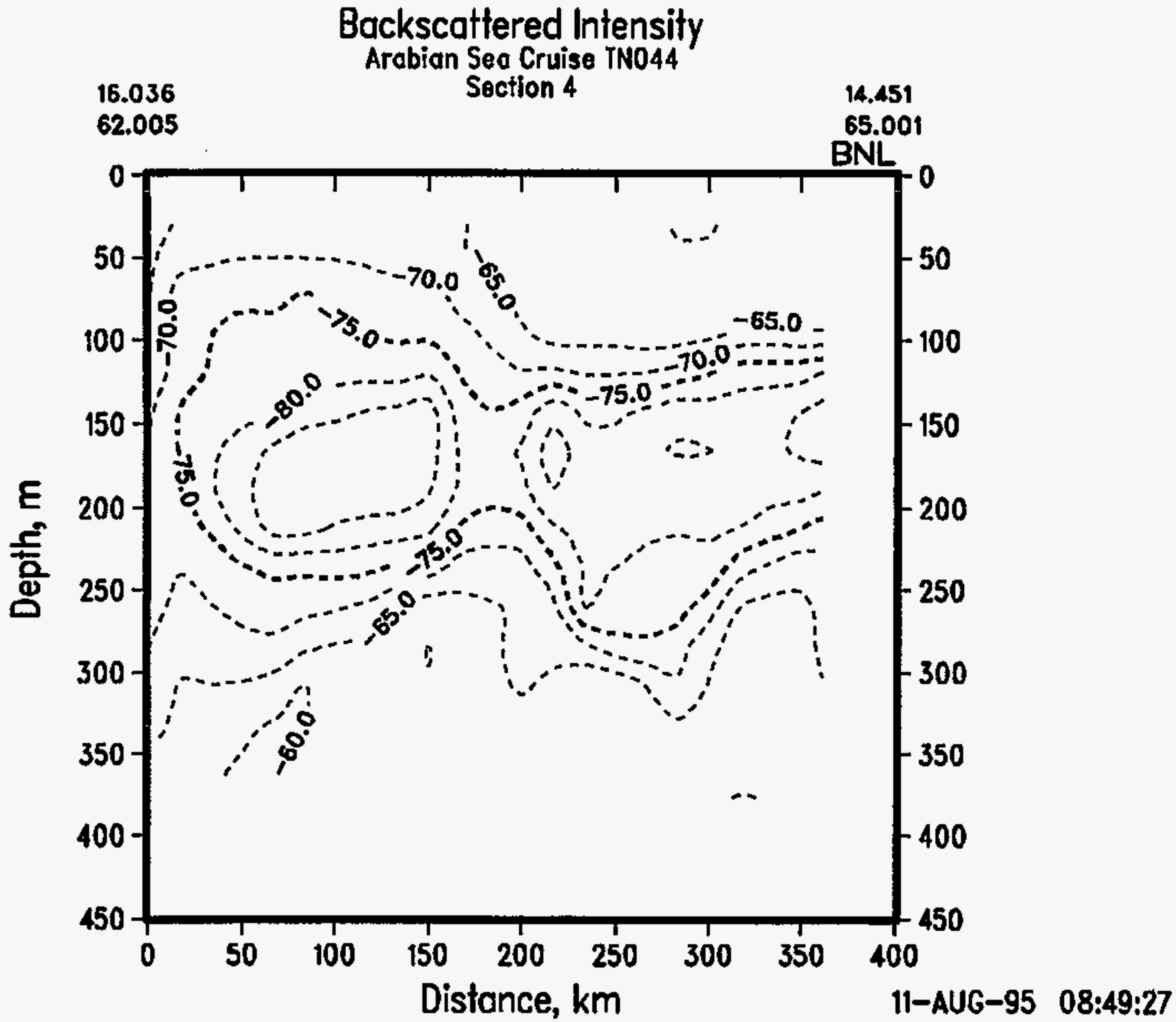


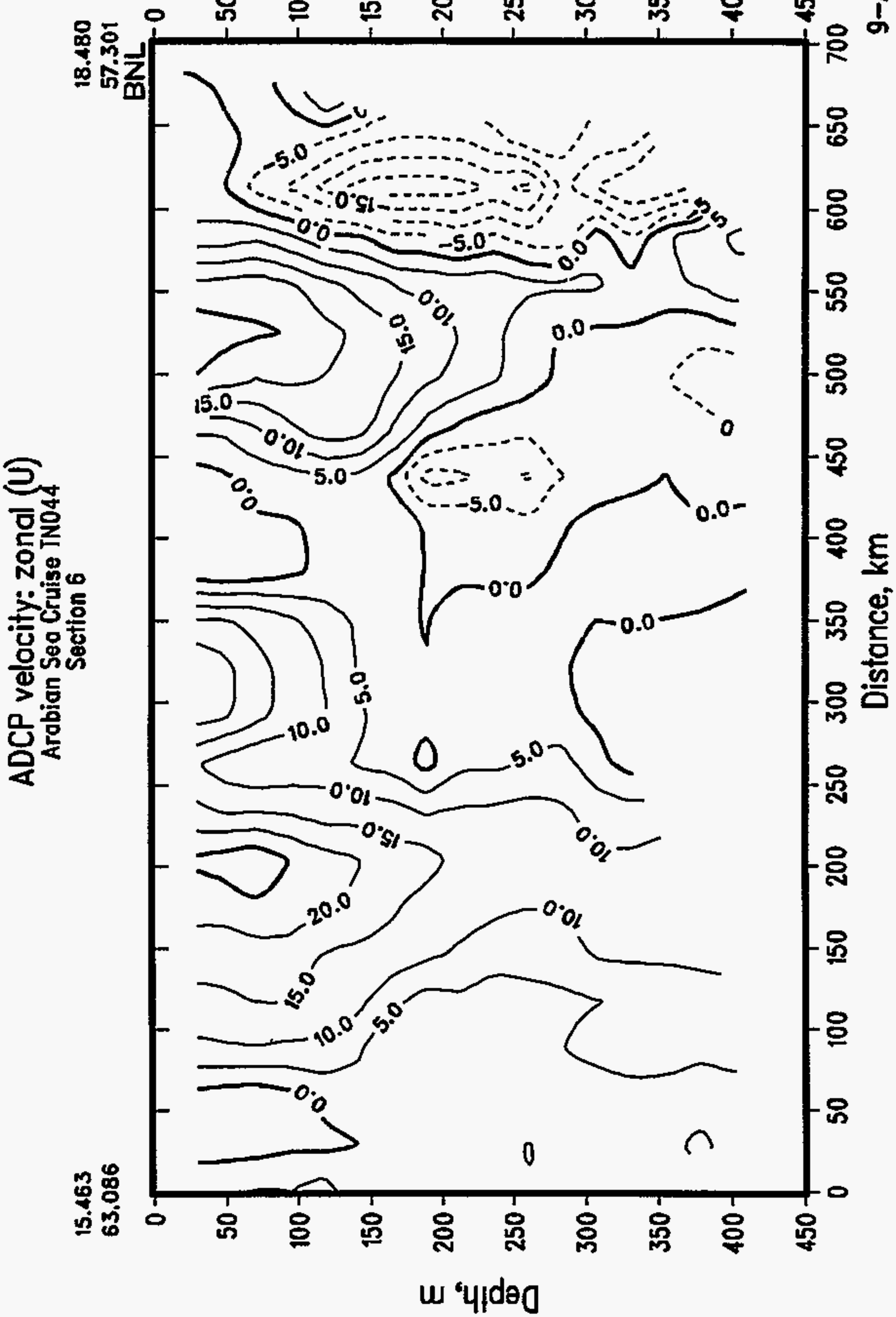
Backscattered Intensity
Arabian Sea Cruise TN044
Outbound SW Transect_b
16.039
62.008
14.453
65.001
BNL
-70.0
-65.0
-75.0
-80.0
Depth, m
Distance, km
11-AUG-95 08:35:01


ADCP velocity: zonal (U)
Arabian Sea Cruise TN044
Section 4
16.036
62.005
14.451
65.001
BNL
Depth, m
Distance, km
0
50
100
150
200
250
300
350
400
450
0.0
-5.0
-10.0
-15.0
9-AUG-95 14:16:51



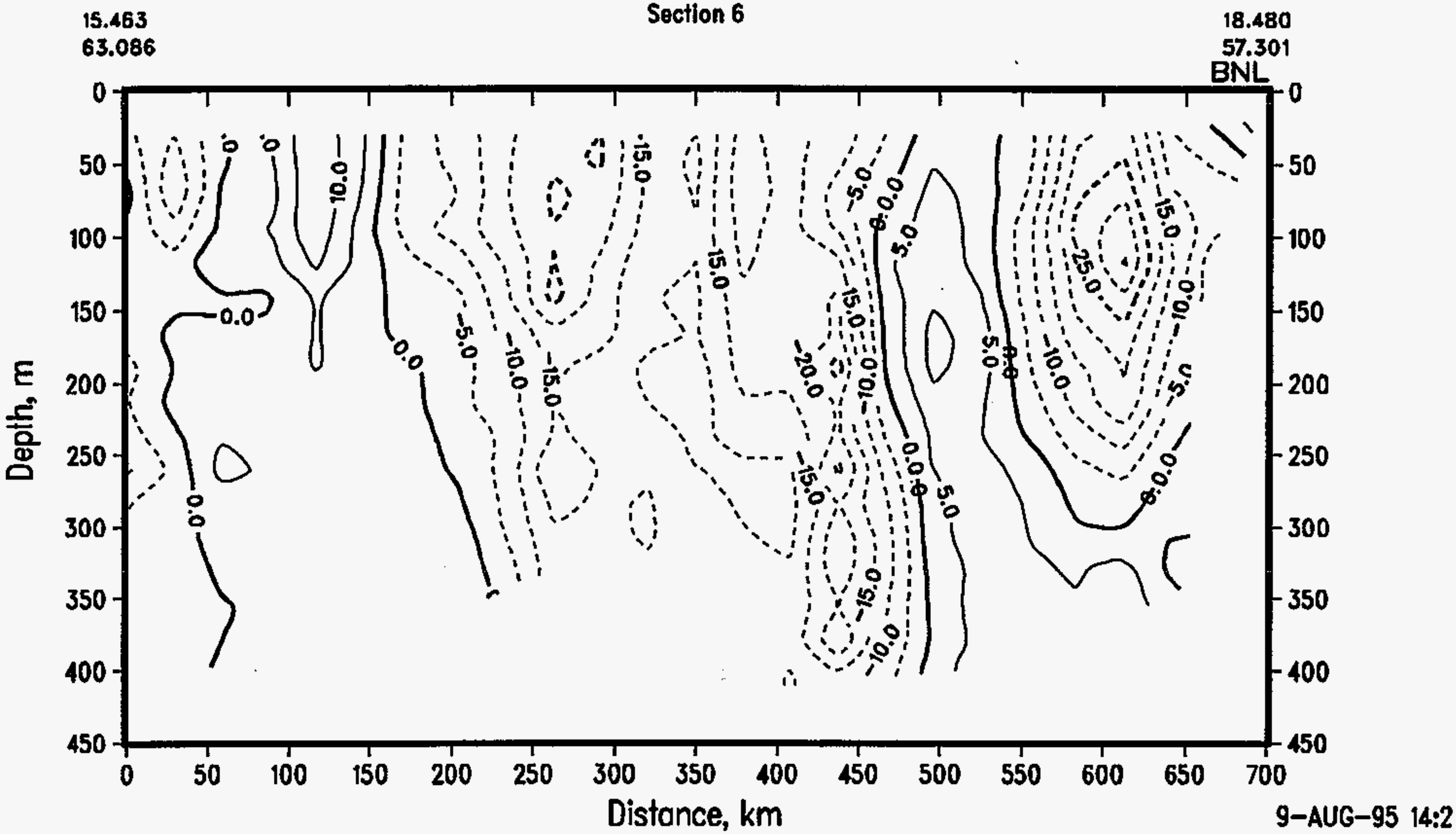
ADCP velocity: meridional (V)
Arabian Sea Cruise TN044
Section 4
16.036
62.005
14.451
65.001
BNL
Depth, m
Distance, km
0.0
-5.0
-10.0
-15.0
9-AUG-95 14:12:51


Backscattered Intensity
Arabian Sea Cruise TN044
Section 4
16.036
62.005
14.451
65.001
BNL
-70.0
-65.0
-75.0
-80.0
-60.0
Depth, m
Distance, km
11-AUG-95 08:49:27

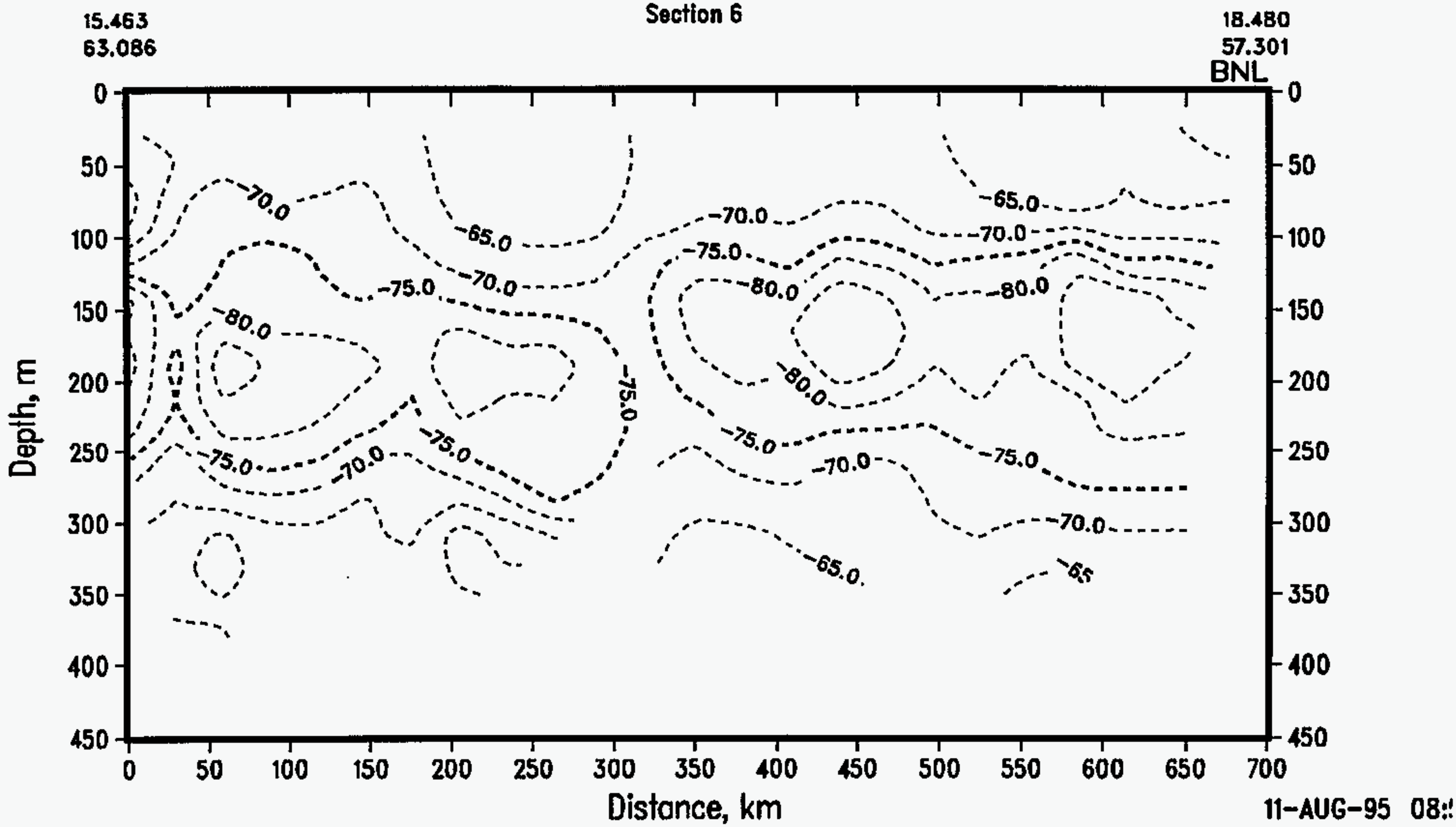

ADCP velocity: zonal (U)
Arabian Sea Cruise TN044
Section 6
Depth, m
Distance, km
15.463
63.086
18.480
57.301
BNL
9-AUG-95 14:1

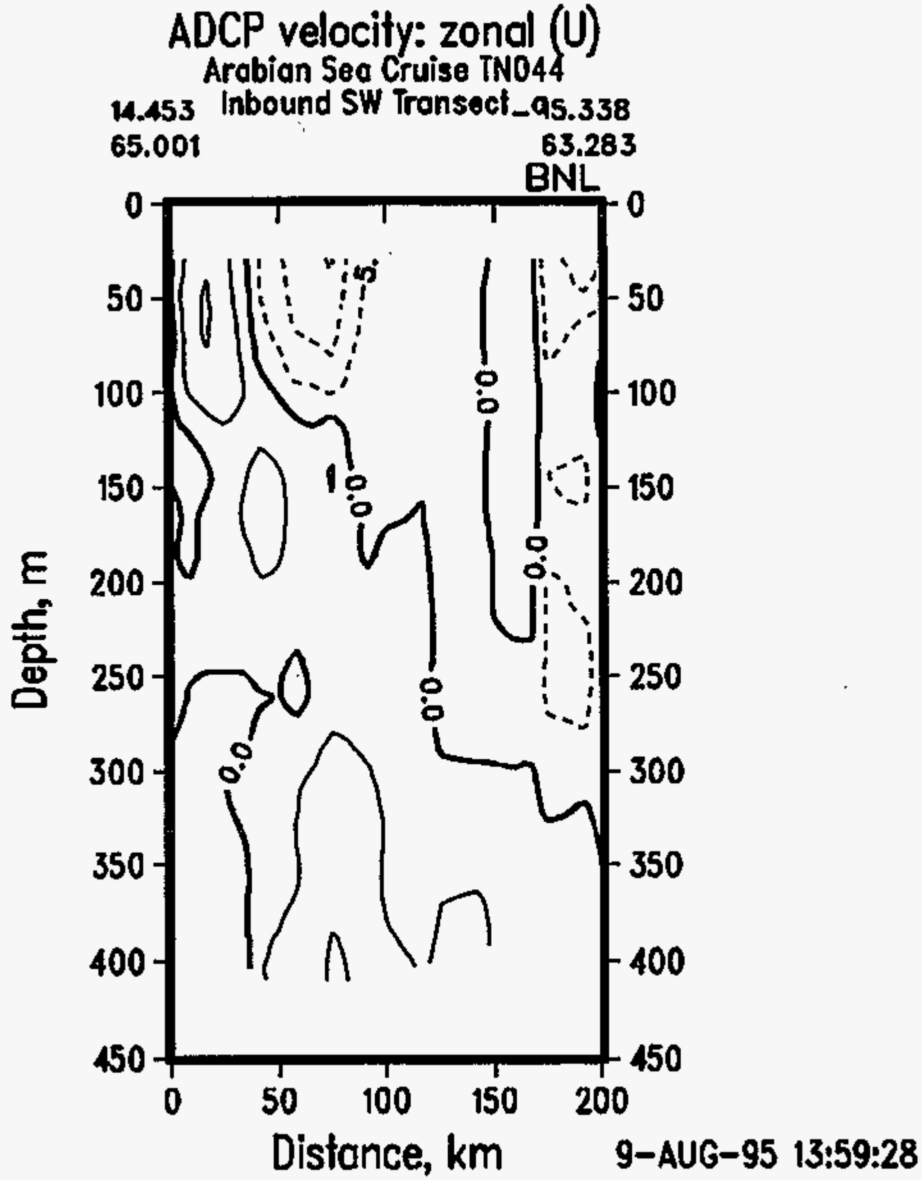
## ADCP velocity: meridional (V)

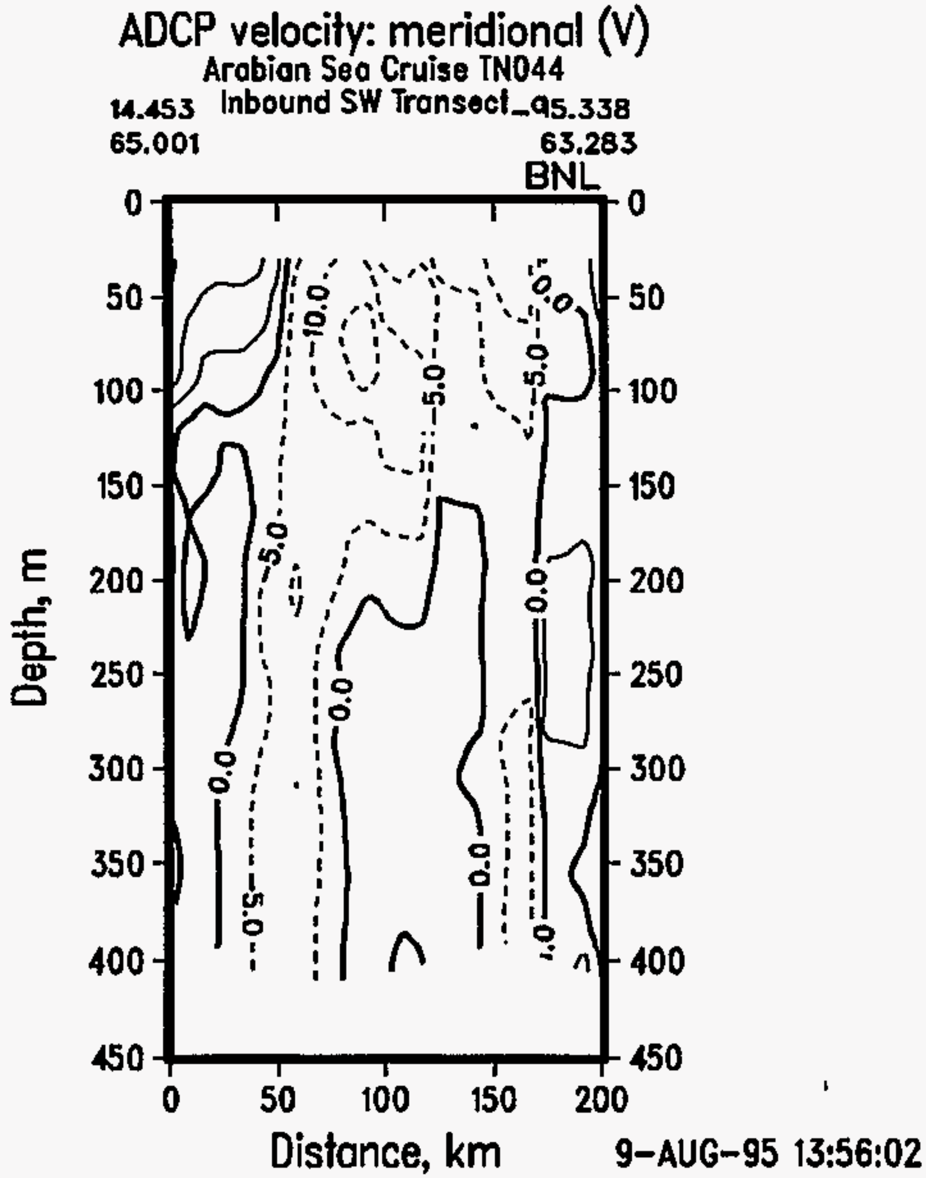
Arabian Sea Cruise TN044
Section 6

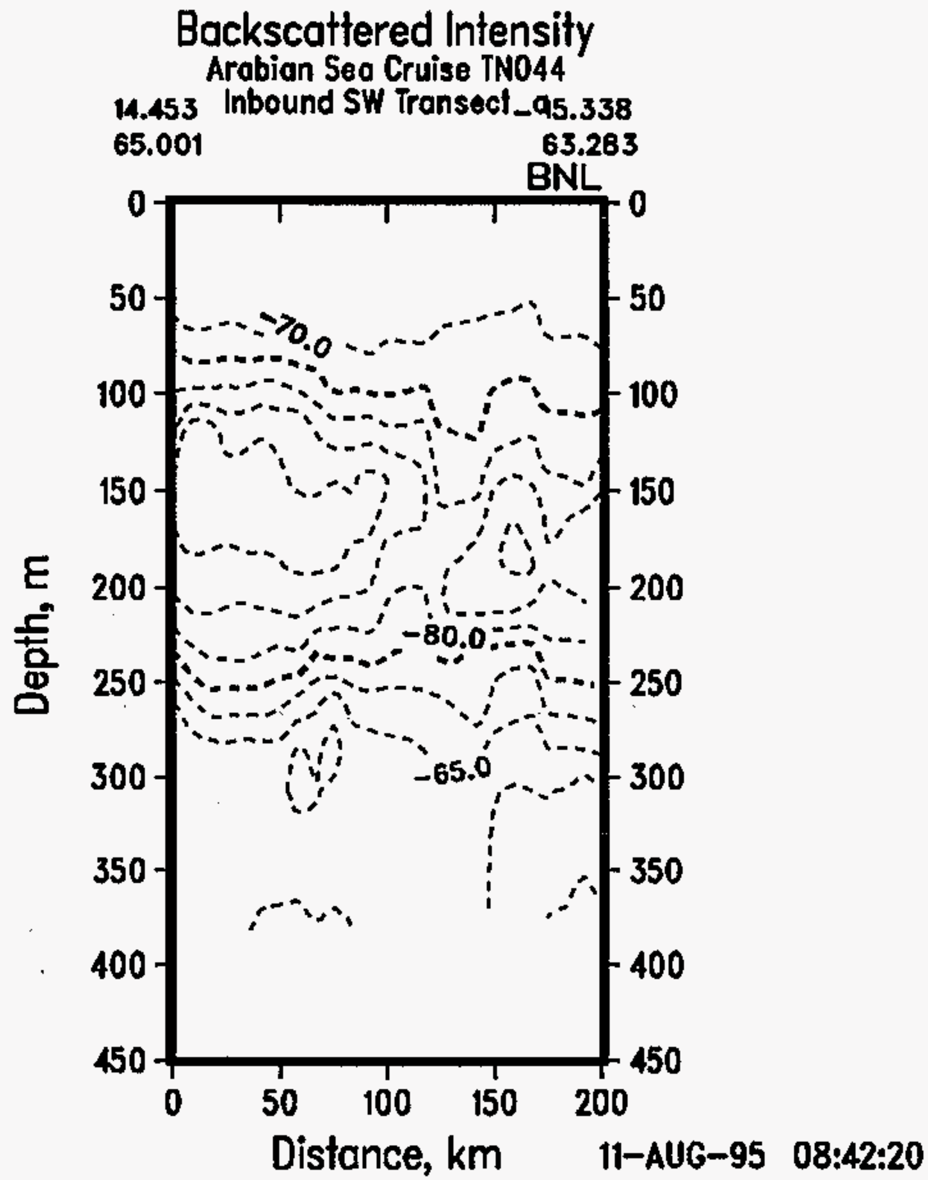


Backscattered Intensity
Arabian Sea Cruise TN044
Section 6

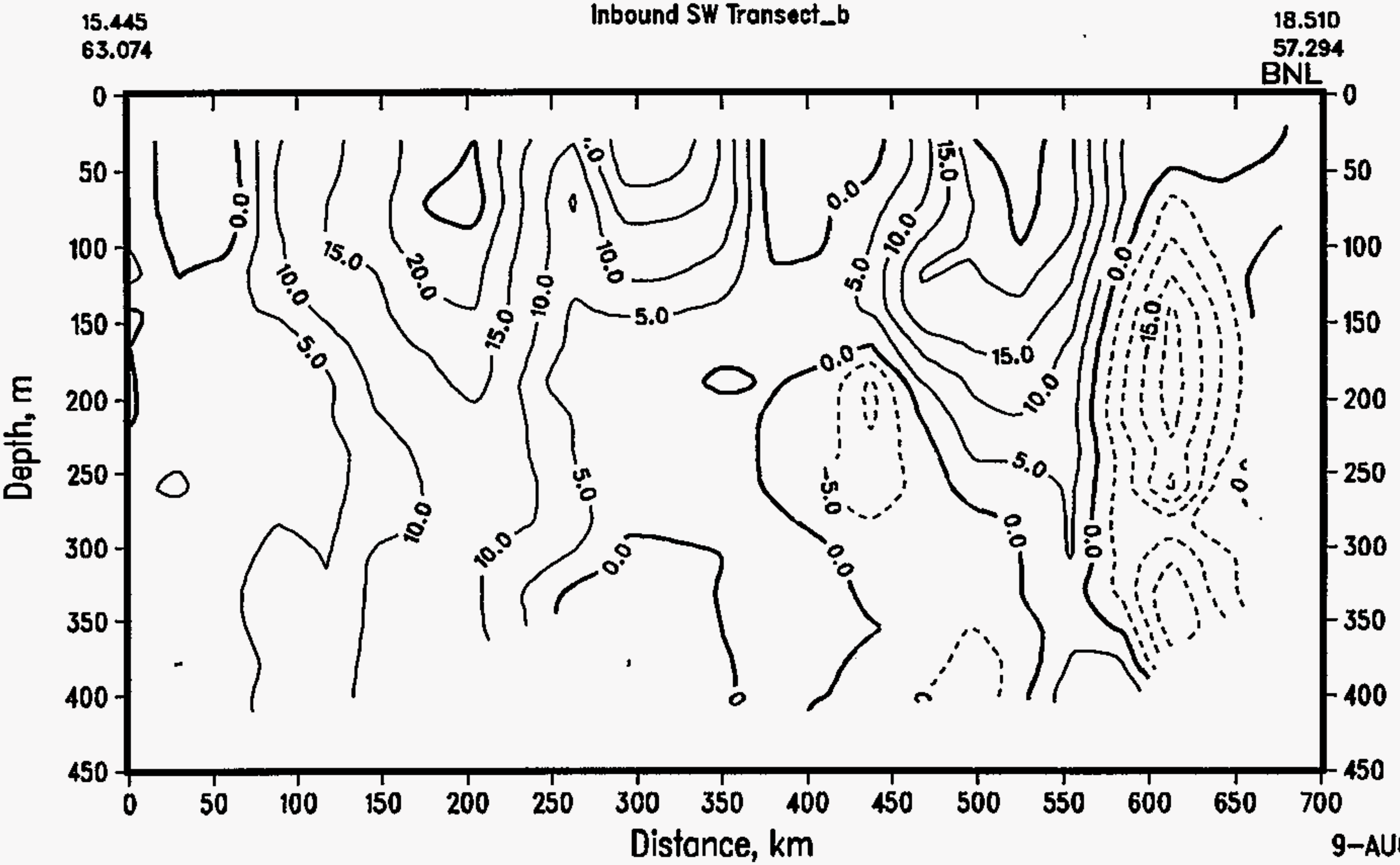



ADCP velocity: zonal (U)
Arabian Sea Cruise TN044
Inbound SW Transect_a
14.453
65.001
15.338
63.283
BNL
Depth, m
Distance, km
9-AUG-95 13:59:28

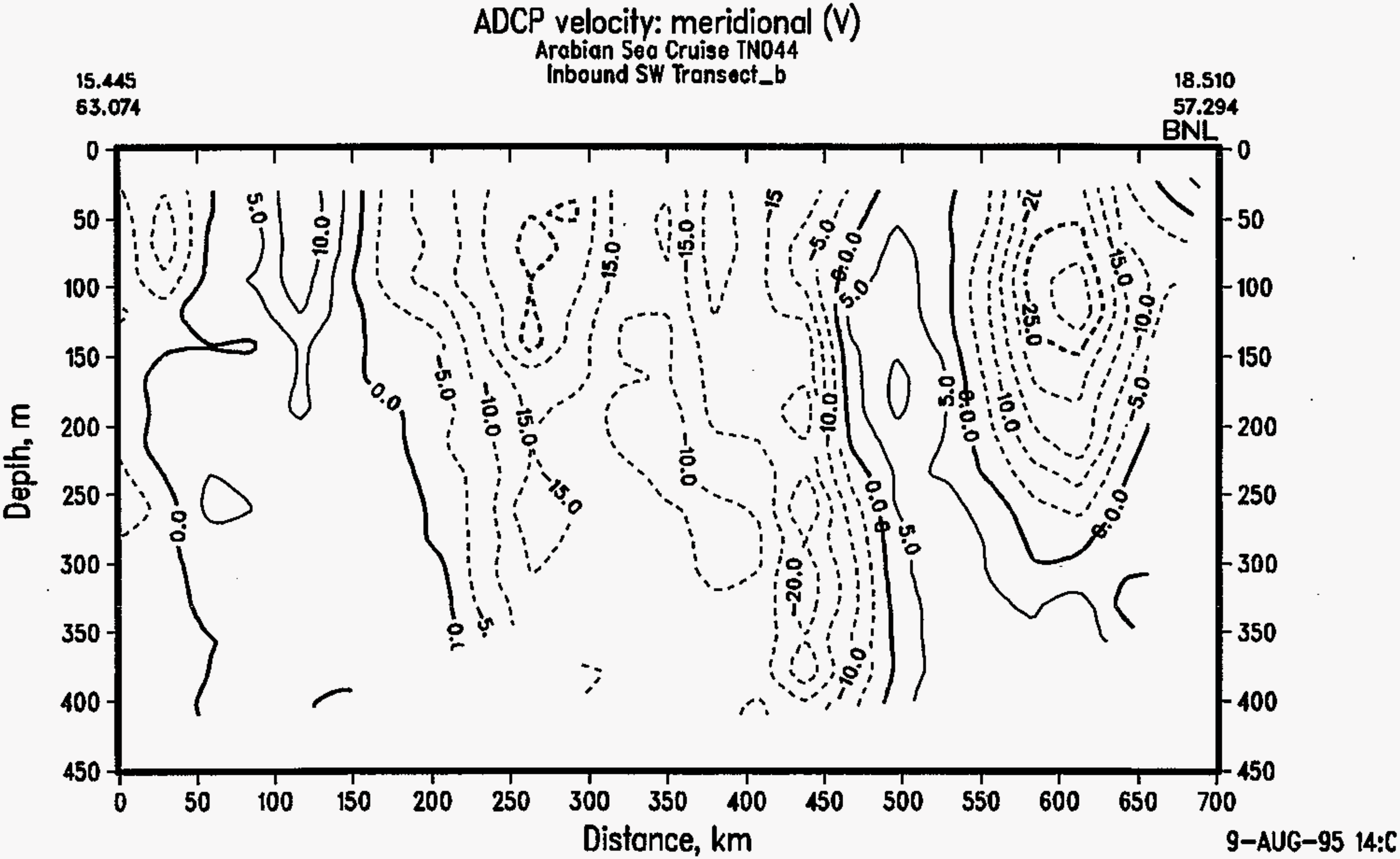

ADCP velocity: meridional (V)
Arabian Sea Cruise TN044
Inbound SW Transect_95.338
14.453
65.001
63.283
BNL
Depth, m
Distance, km
9-AUG-95 13:56:02
0
50
100
150
200
250
300
350
400
450
0
50
100
150
200
0.0
-5.0
-10.0
5.0


Backscattered Intensity
Arabian Sea Cruise TN044
14.453 Inbound SW Transect_q5.338
65.001
63.283
BNL
-70.0
-80.0
-65.0
Depth, m
Distance, km
11-AUG-95 08:42:20

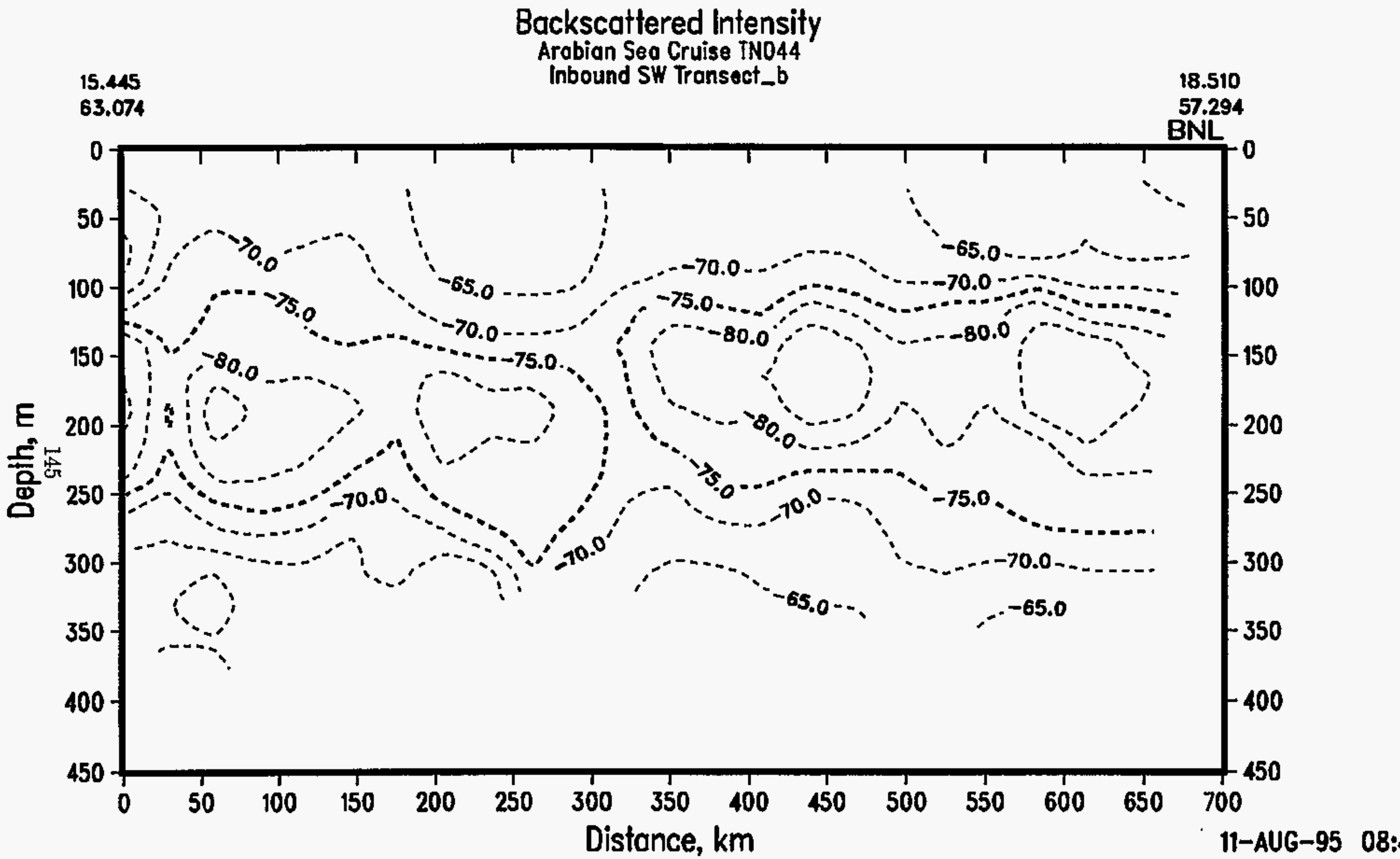
# ADCP velocity: zonal (U)
Arabian Sea Cruise TN044
Inbound SW Transect_b




9-AUG-95 14:C

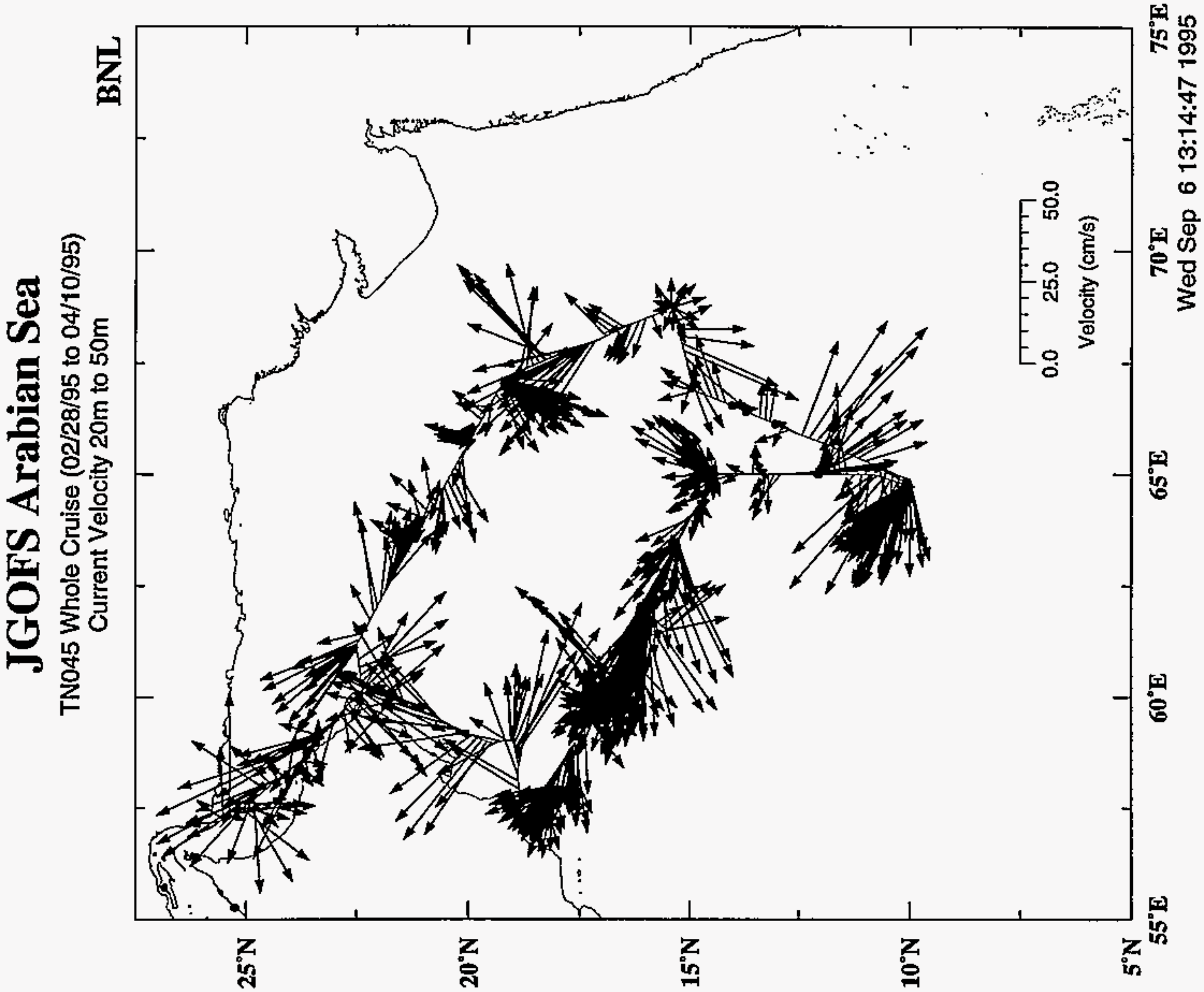


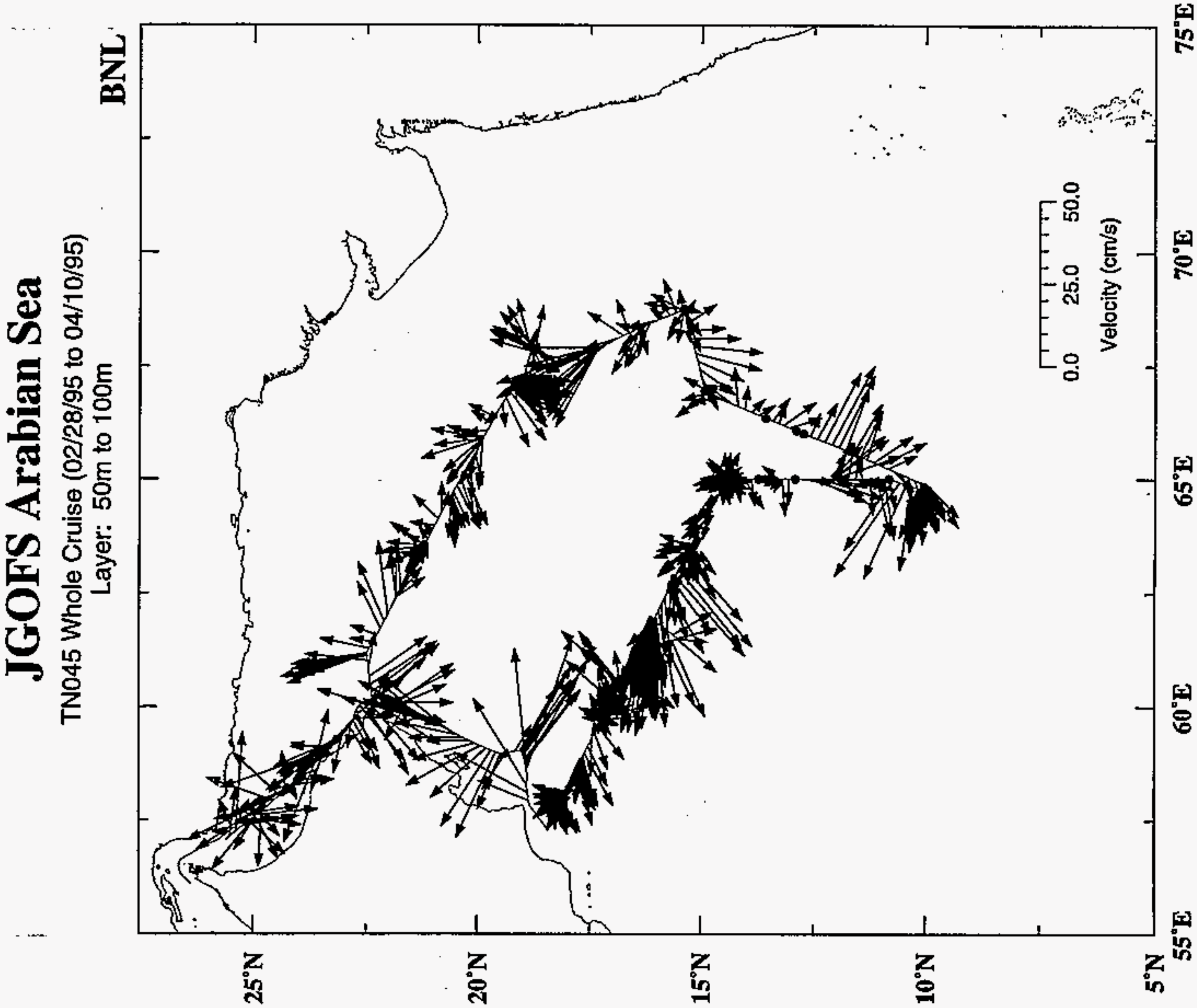
ADCP velocity: meridional (V)
Arabian Sea Cruise TN044
Inbound SW Transect_b
15.445
63.074
18.510
57.294
BNL
Depth, m
Distance, km
9-AUG-95 14:C



Backscattered Intensity
Arabian Sea Cruise TN044
Inbound SW Transect_b
15.445
63.074
18.510
57.294
BNL
Depth, m
Distance, km
-65.0
-70.0
-75.0
-80.0
0
50
100
150
200
250
300
350
400
450
500
550
600
650
700
11-AUG-95 08:

# TN045

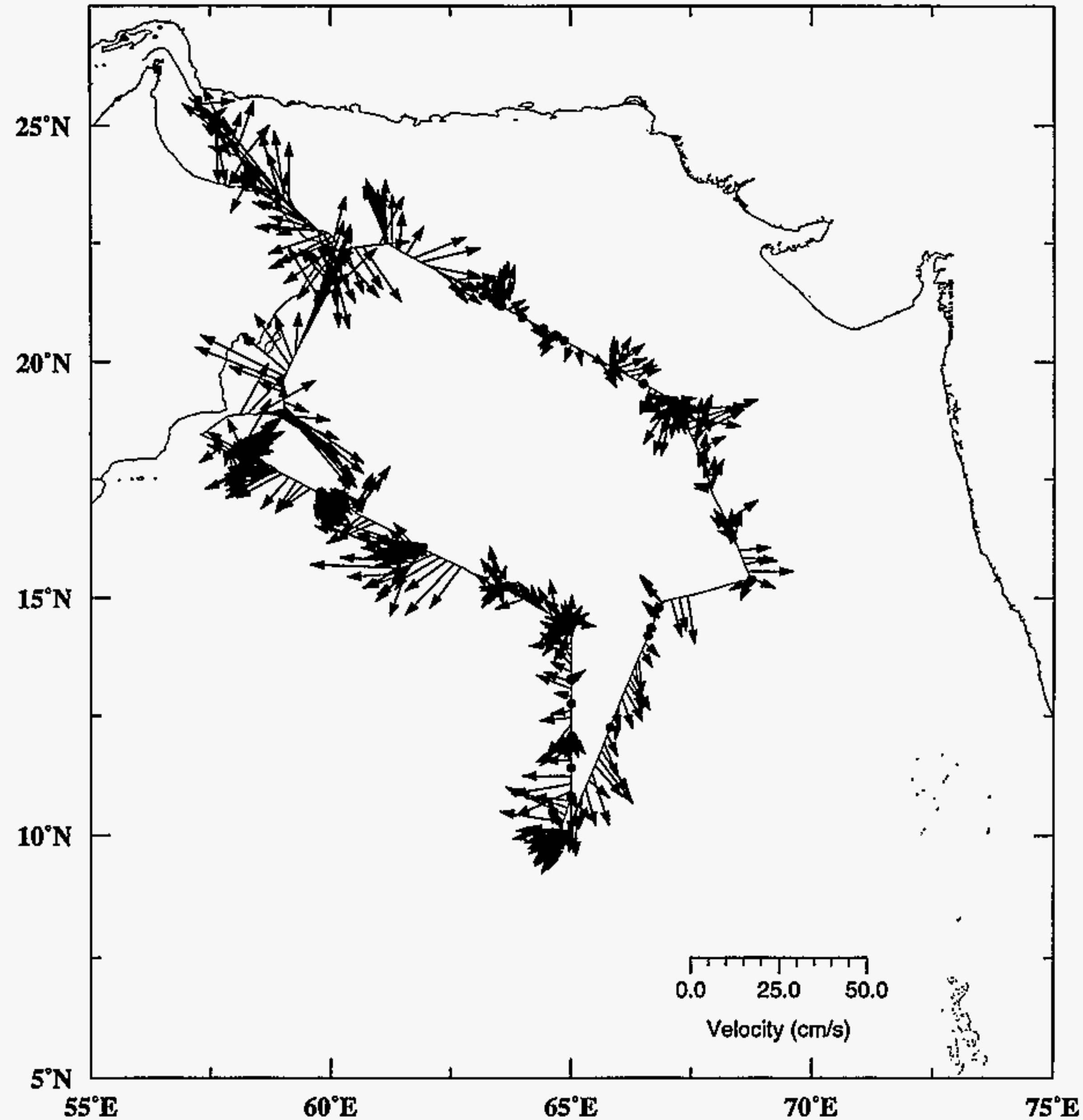

JGOFS Arabian Sea
TN045 Whole Cruise (02/28/95 to 04/10/95)
Current Velocity 20m to 50m
BNL
25°N
20°N
15°N
10°N
5°N
55°E
60°E
65°E
70°E
75°E
0.0
25.0
50.0
Velocity (cm/s)
Wed Sep 6 13:14:47 1995


JGOFS Arabian Sea
TN045 Whole Cruise (02/28/95 to 04/10/95)
Layer: 50m to 100m
BNL
0.0
25.0
50.0
Velocity (cm/s)
25°N
20°N
15°N
10°N
5°N
55°E
60°E
65°E
70°E
75°E

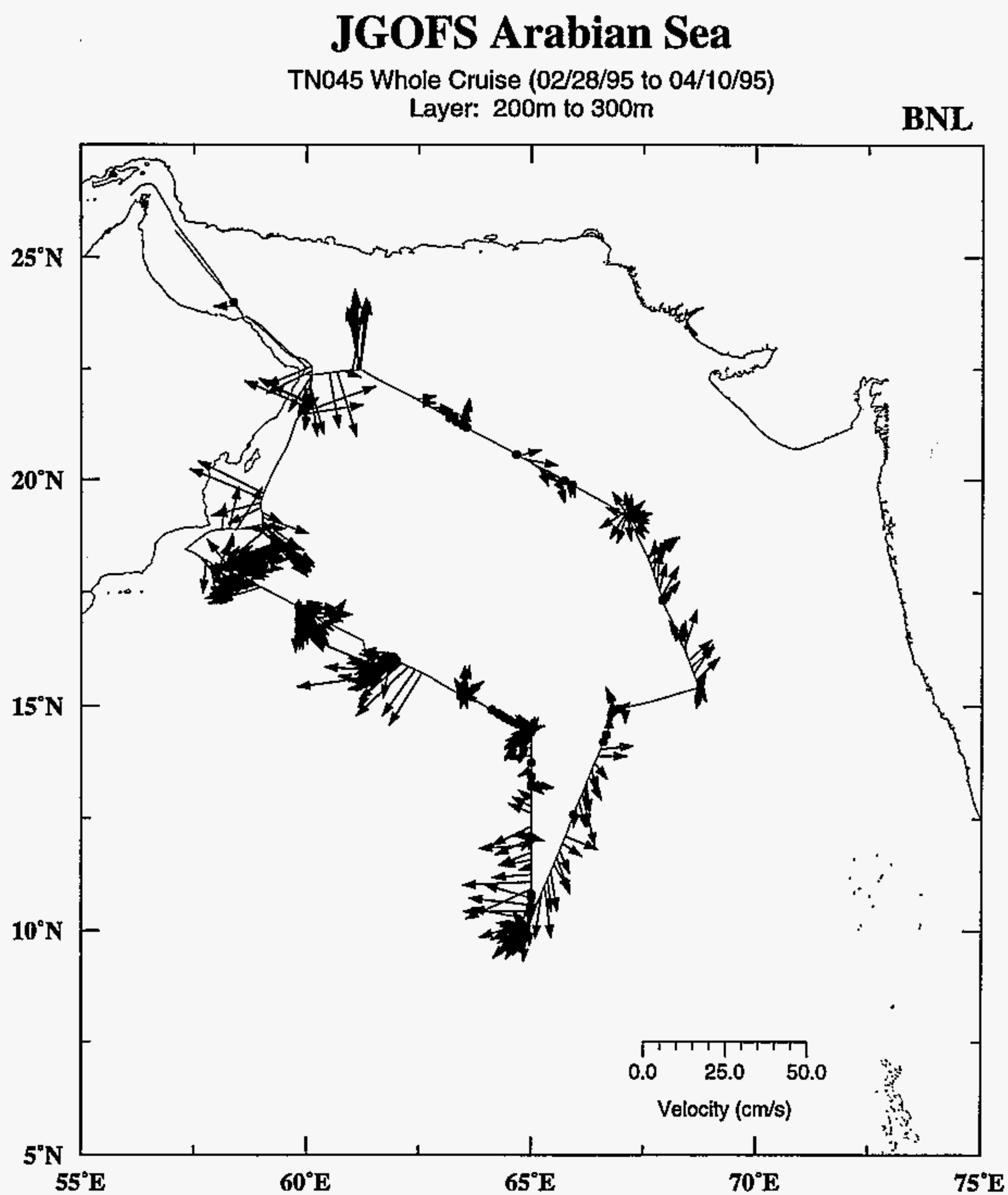
# JGOFS Arabian Sea

TN045 Whole Cruise (02/28/95 to 04/10/95)
Layer: 100m to 200m

BNL



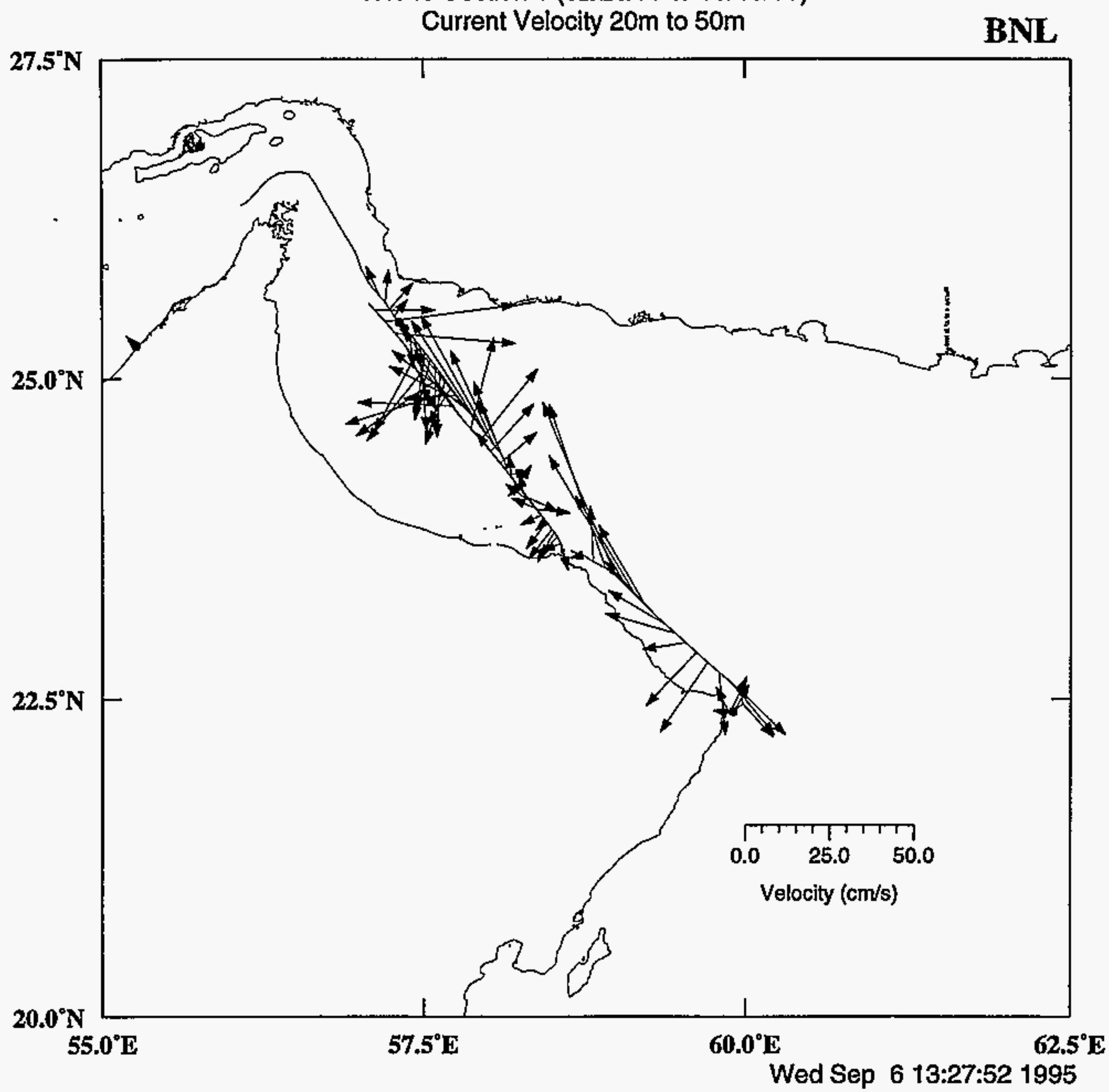

Wed Sep 6 13:15:01 1995

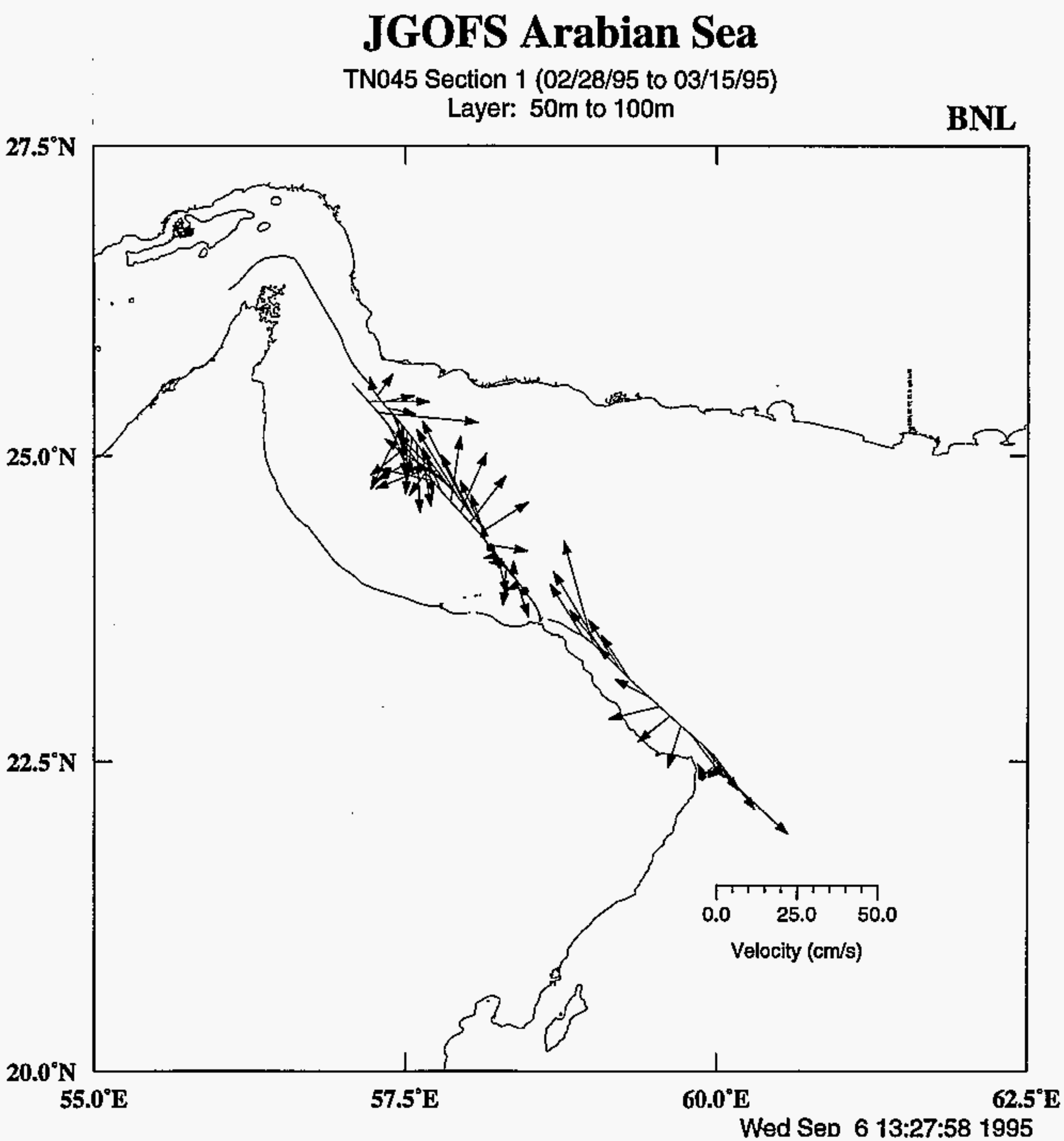


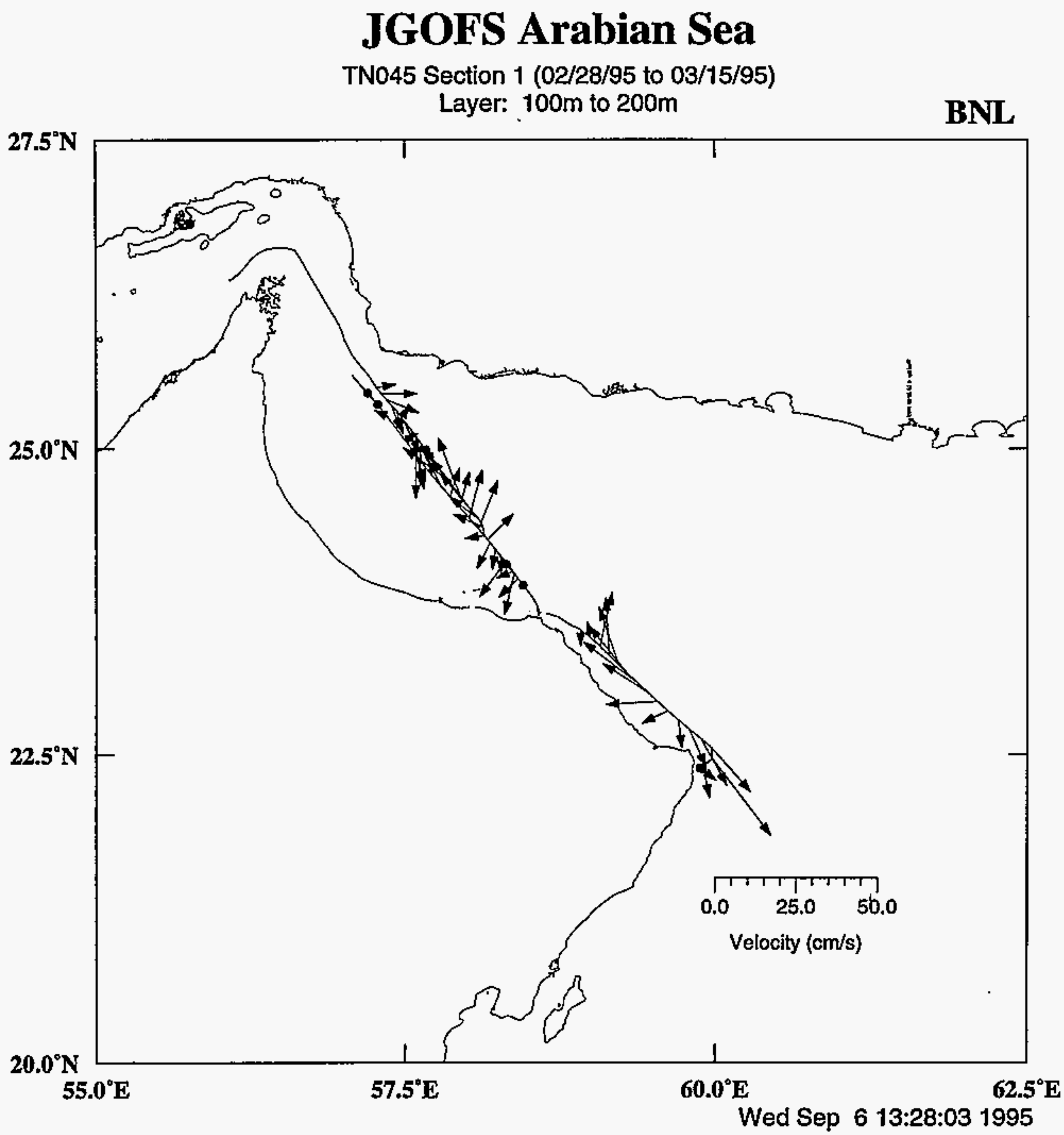
JGOFS Arabian Sea
TN045 Whole Cruise (02/28/95 to 04/10/95)
Layer: 200m to 300m
BNL
25°N
20°N
15°N
10°N
5°N
55°E
60°E
65°E
70°E
75°E
0.0
25.0
50.0
Velocity (cm/s)

# JGOFS Arabian Sea

TN045 Section 1 (02/28/95 to 03/15/95)
Current Velocity 20m to 50m

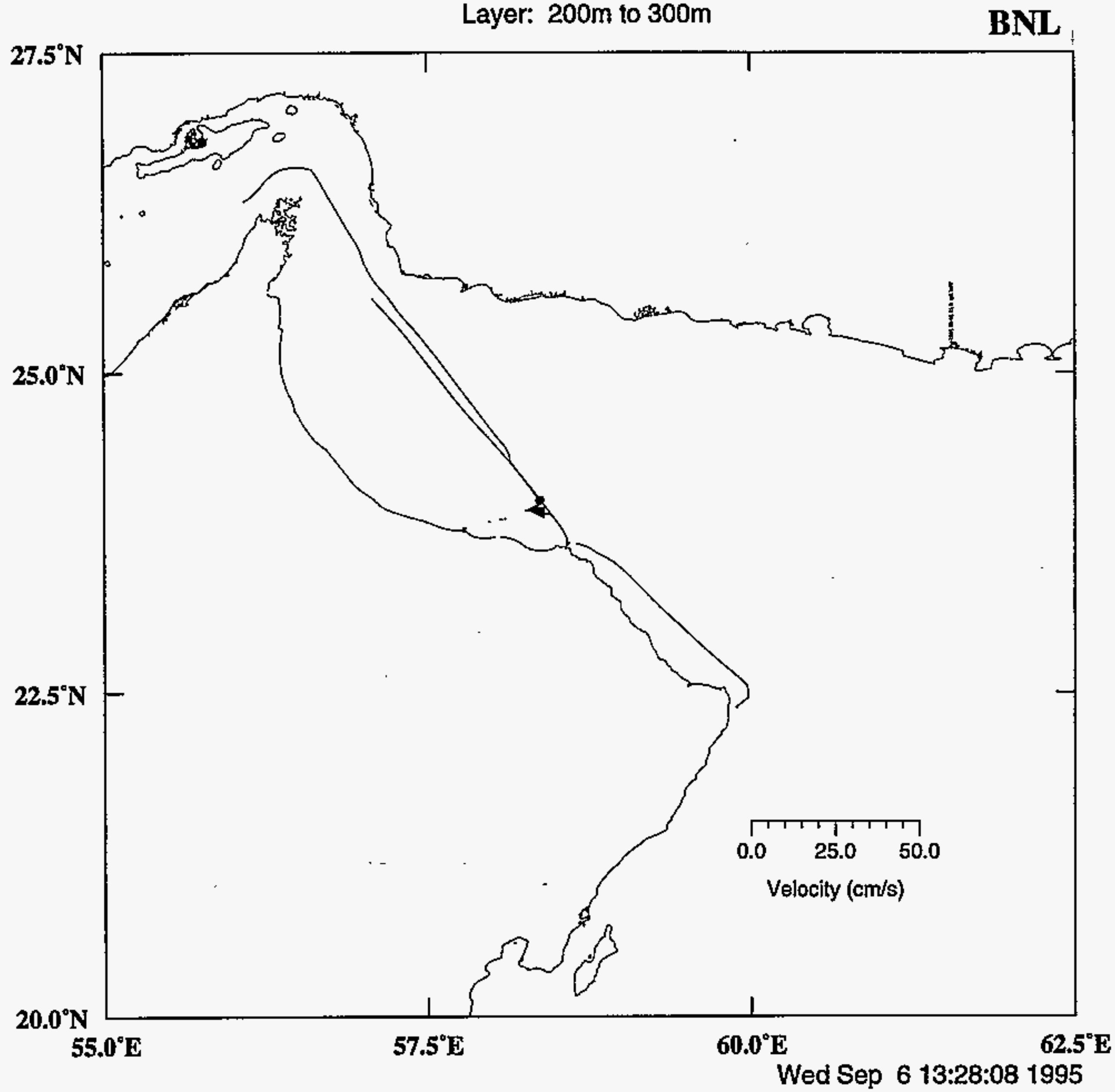


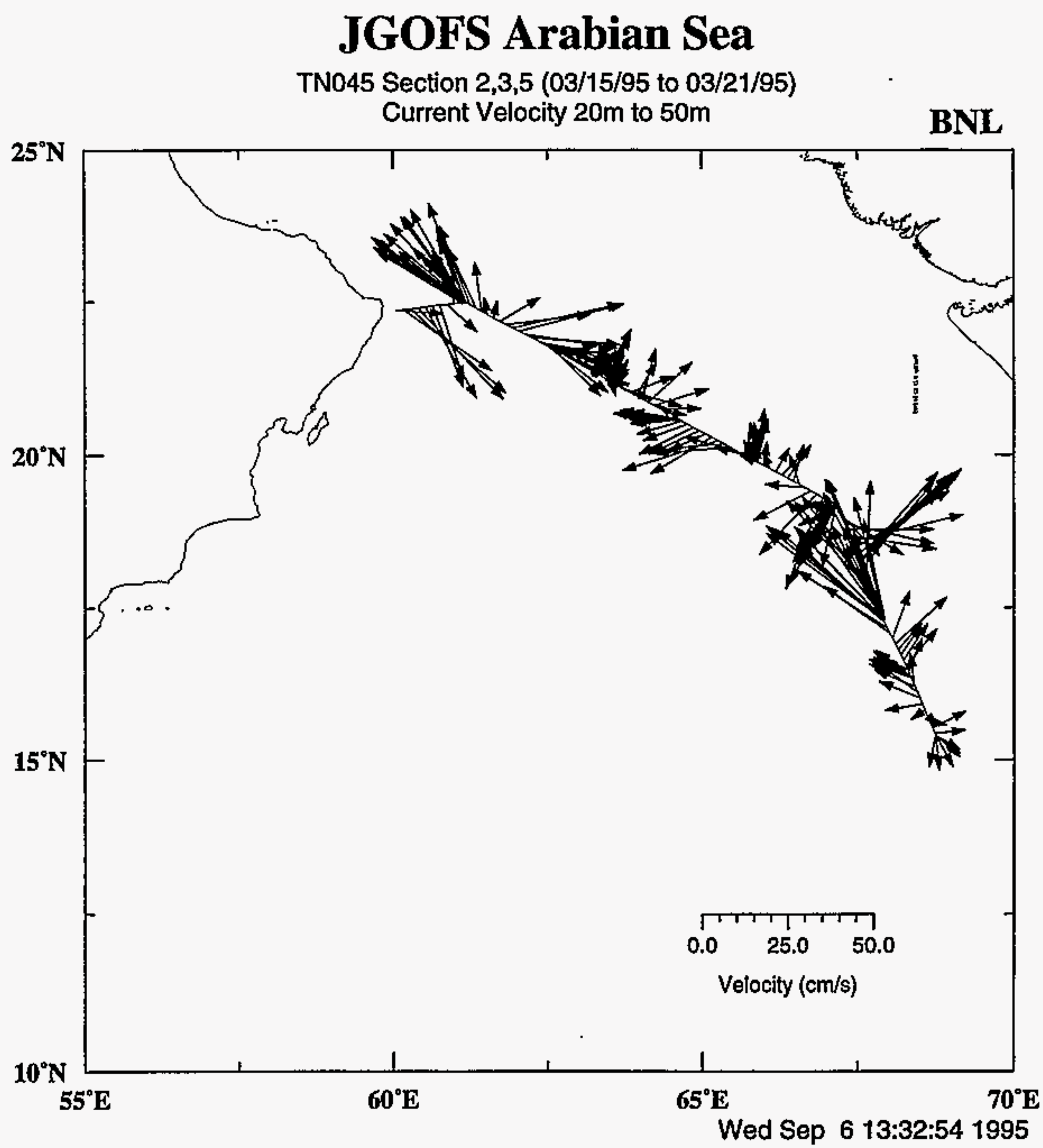

JGOFS Arabian Sea
TN045 Section 1 (02/28/95 to 03/15/95)
Layer: 50m to 100m
BNL
27.5°N
25.0°N
22.5°N
20.0°N
55.0°E
57.5°E
60.0°E
62.5°E
0.0
25.0
50.0
Velocity (cm/s)
Wed Sep 6 13:27:58 1995

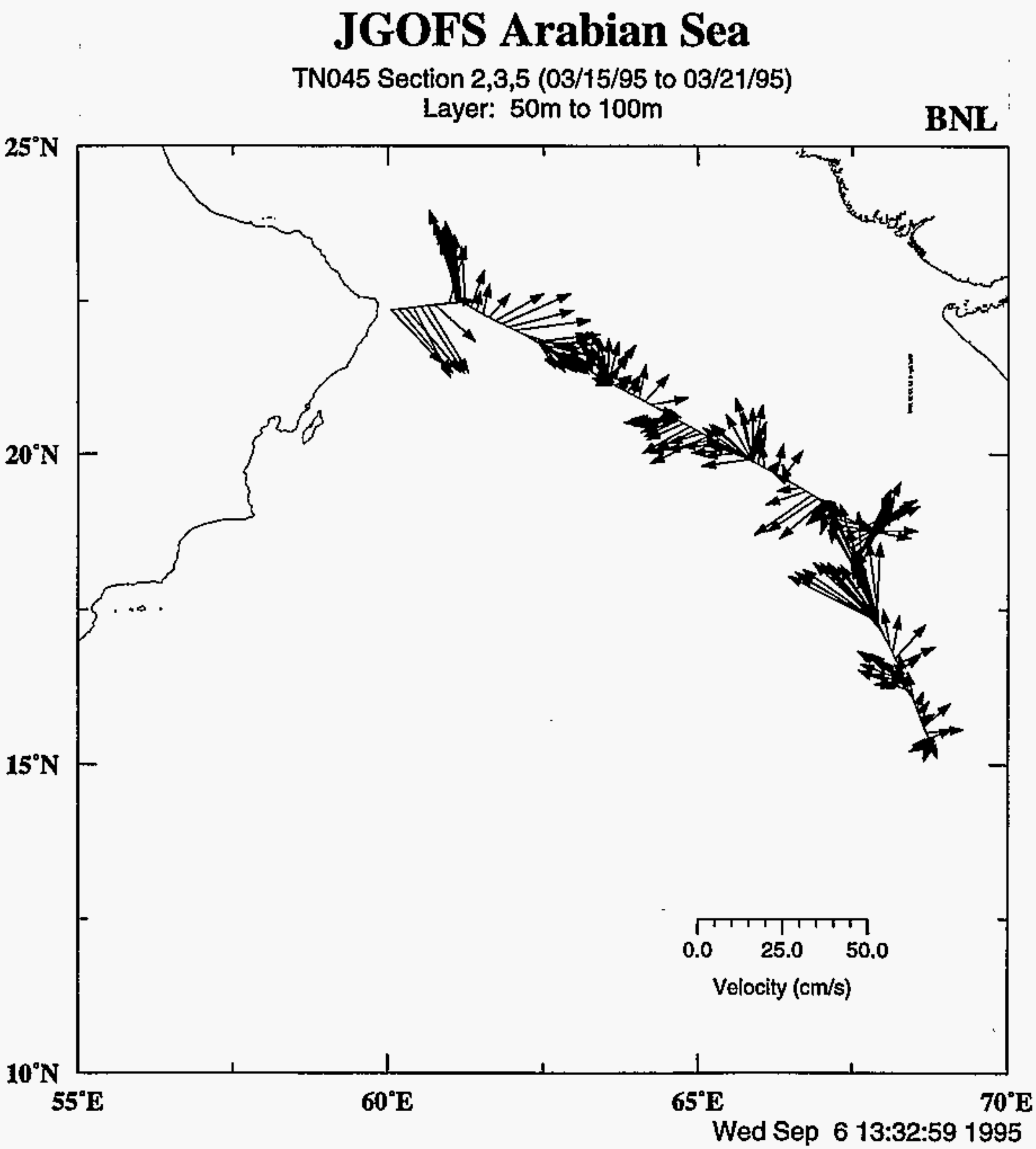

JGOFS Arabian Sea
TN045 Section 1 (02/28/95 to 03/15/95)
Layer: 100m to 200m
BNL
27.5°N
25.0°N
22.5°N
20.0°N
55.0°E
57.5°E
60.0°E
62.5°E
0.0
25.0
50.0
Velocity (cm/s)
Wed Sep 6 13:28:03 1995

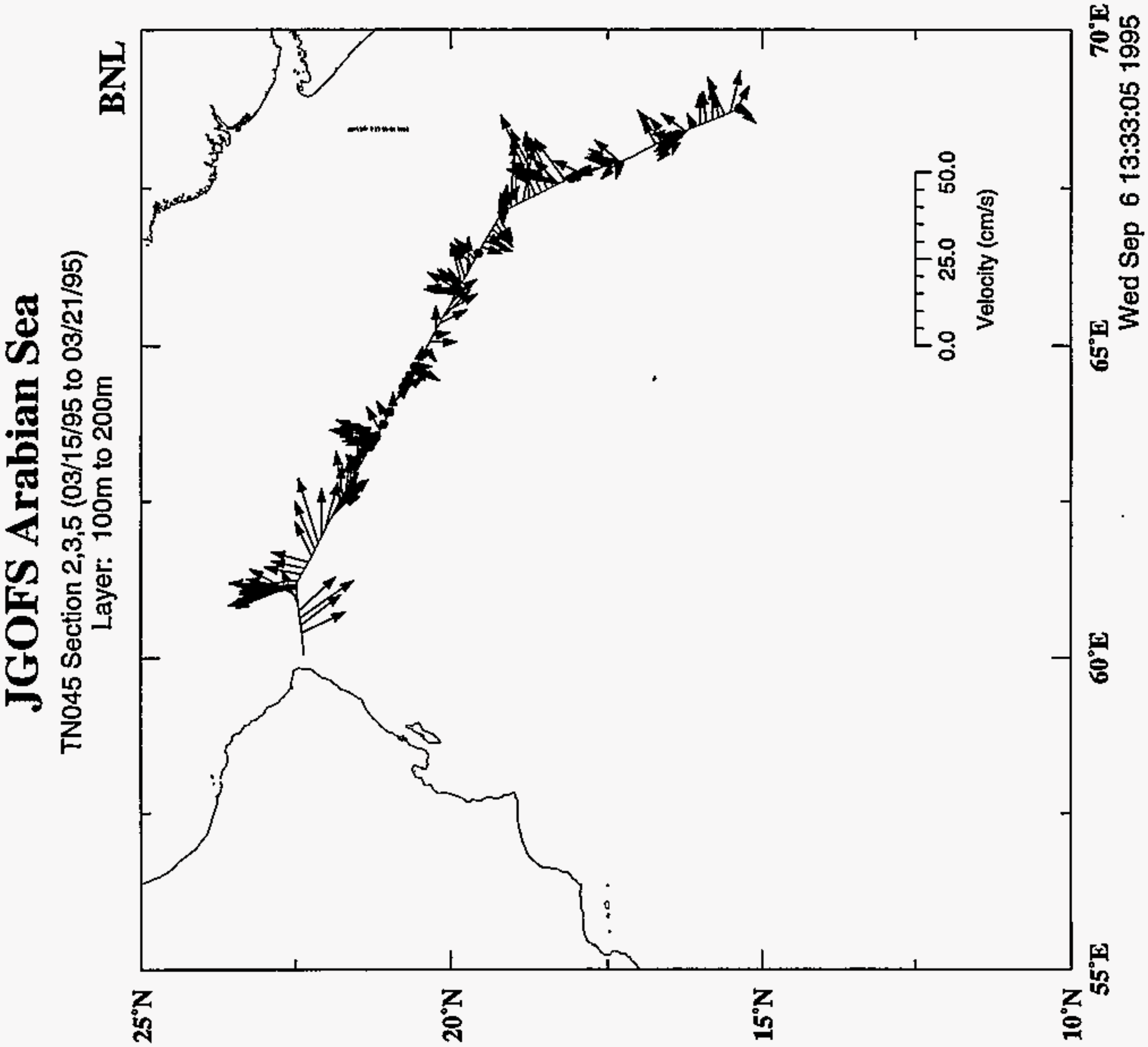
# JGOFS Arabian Sea

TN045 Section 1 (02/28/95 to 03/15/95)
Layer: 200m to 300m




JGOFS Arabian Sea
TN045 Section 2,3,5 (03/15/95 to 03/21/95)
Current Velocity 20m to 50m
BNL
25°N
20°N
15°N
10°N
55°E
60°E
65°E
70°E
0.0
25.0
50.0
Velocity (cm/s)
Wed Sep 6 13:32:54 1995

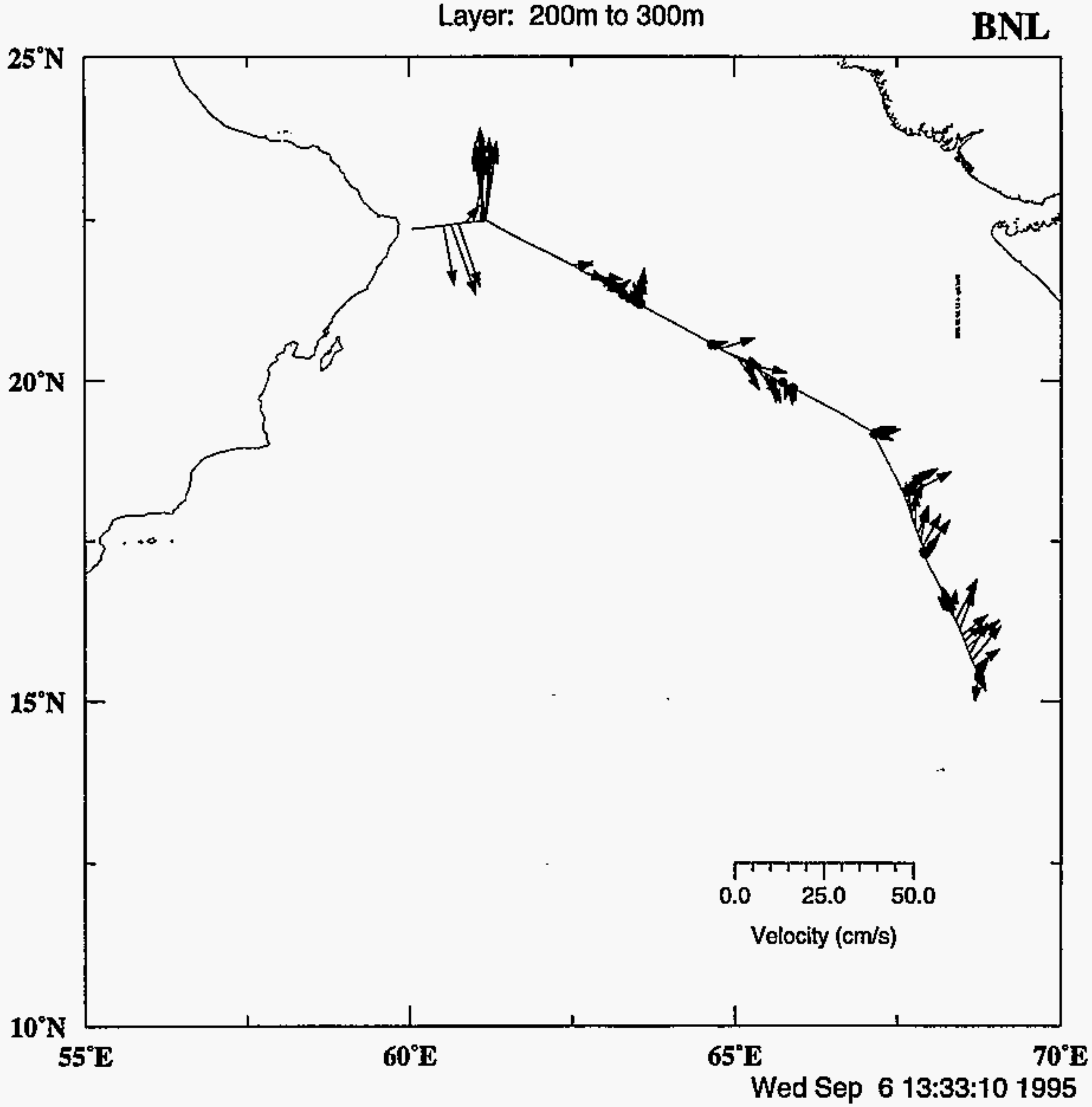

JGOFS Arabian Sea
TN045 Section 2,3,5 (03/15/95 to 03/21/95)
Layer: 50m to 100m
BNL
25°N
20°N
15°N
10°N
55°E
60°E
65°E
70°E
0.0
25.0
50.0
Velocity (cm/s)
Wed Sep 6 13:32:59 1995



JGOFS Arabian Sea
TN045 Section 2,3,5 (03/15/95 to 03/21/95)
Layer: 100m to 200m
BNL
25°N
20°N
15°N
10°N
55°E
60°E
65°E
70°E
0.0
25.0
50.0
Velocity (cm/s)
Wed Sep 6 13:33:05 1995

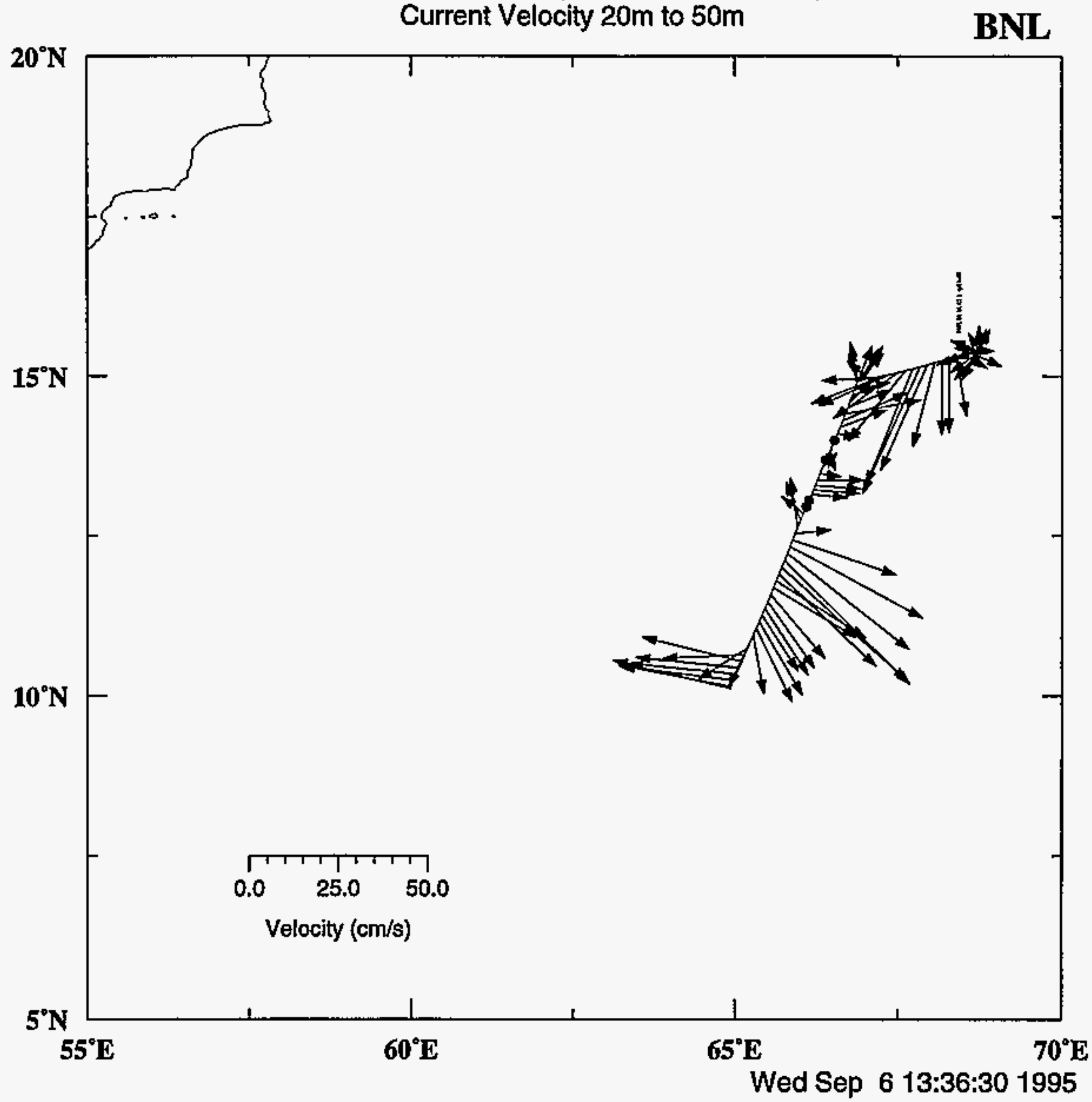
# JGOFS Arabian Sea

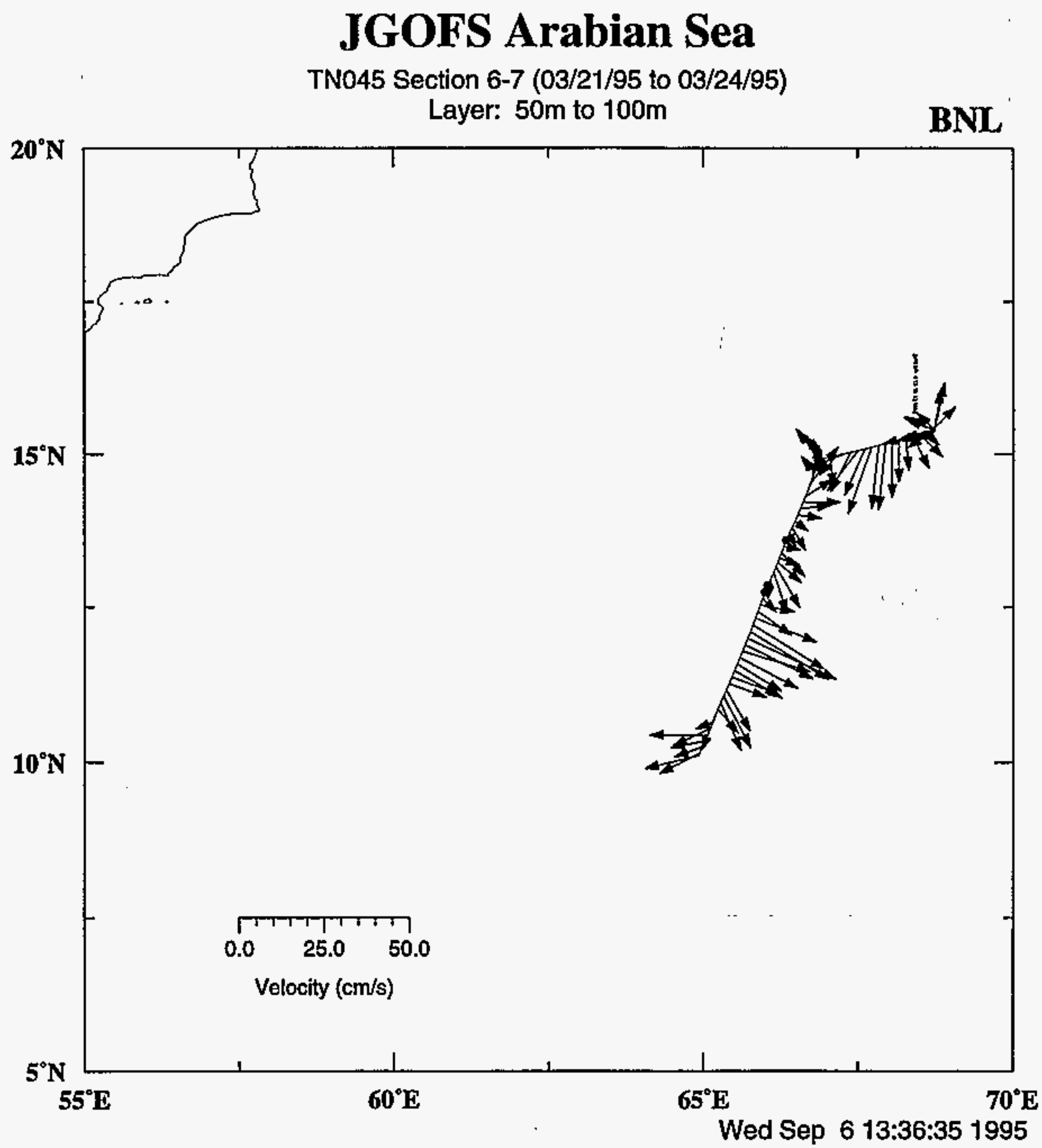
TN045 Section 2,3,5 (03/15/95 to 03/21/95)
Layer: 200m to 300m



# JGOFS Arabian Sea

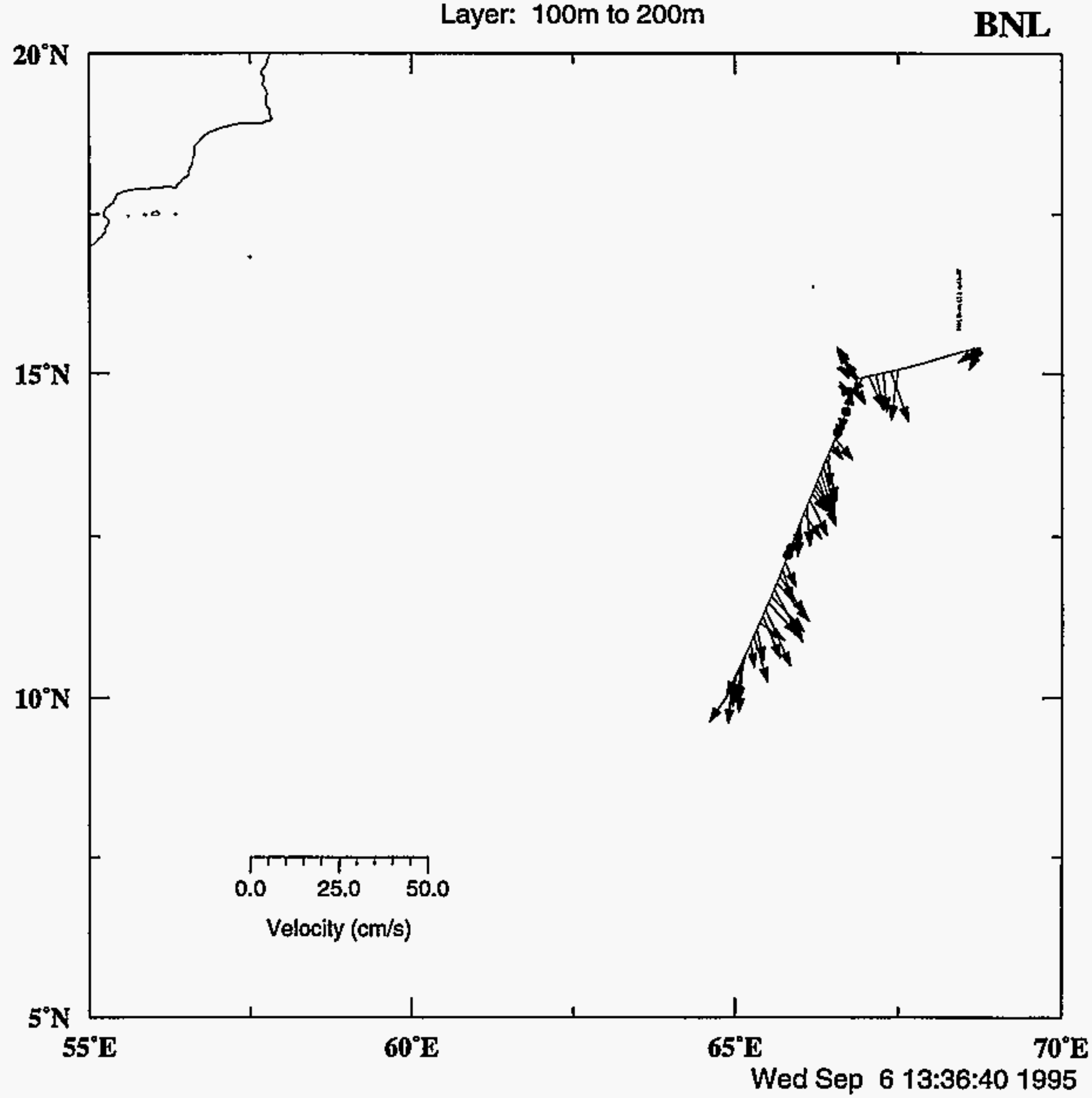
TN045 Section 6-7 (03/21/95 to 03/24/95)
Current Velocity 20m to 50m

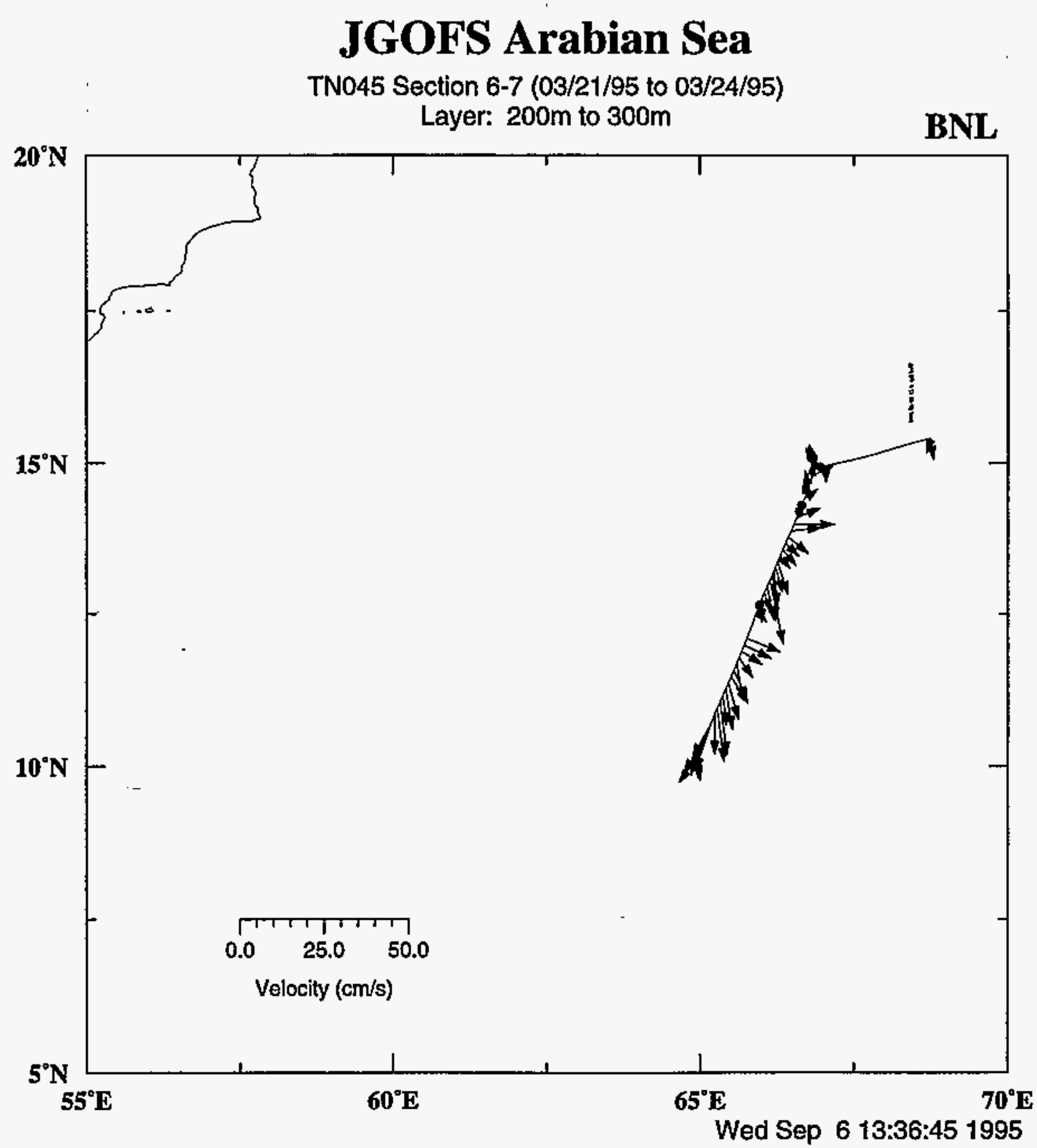



JGOFS Arabian Sea
TN045 Section 6-7 (03/21/95 to 03/24/95)
Layer: 50m to 100m
BNL
20°N
15°N
10°N
5°N
55°E
60°E
65°E
70°E
0.0
25.0
50.0
Velocity (cm/s)
Wed Sep 6 13:36:35 1995

# JGOFS Arabian Sea

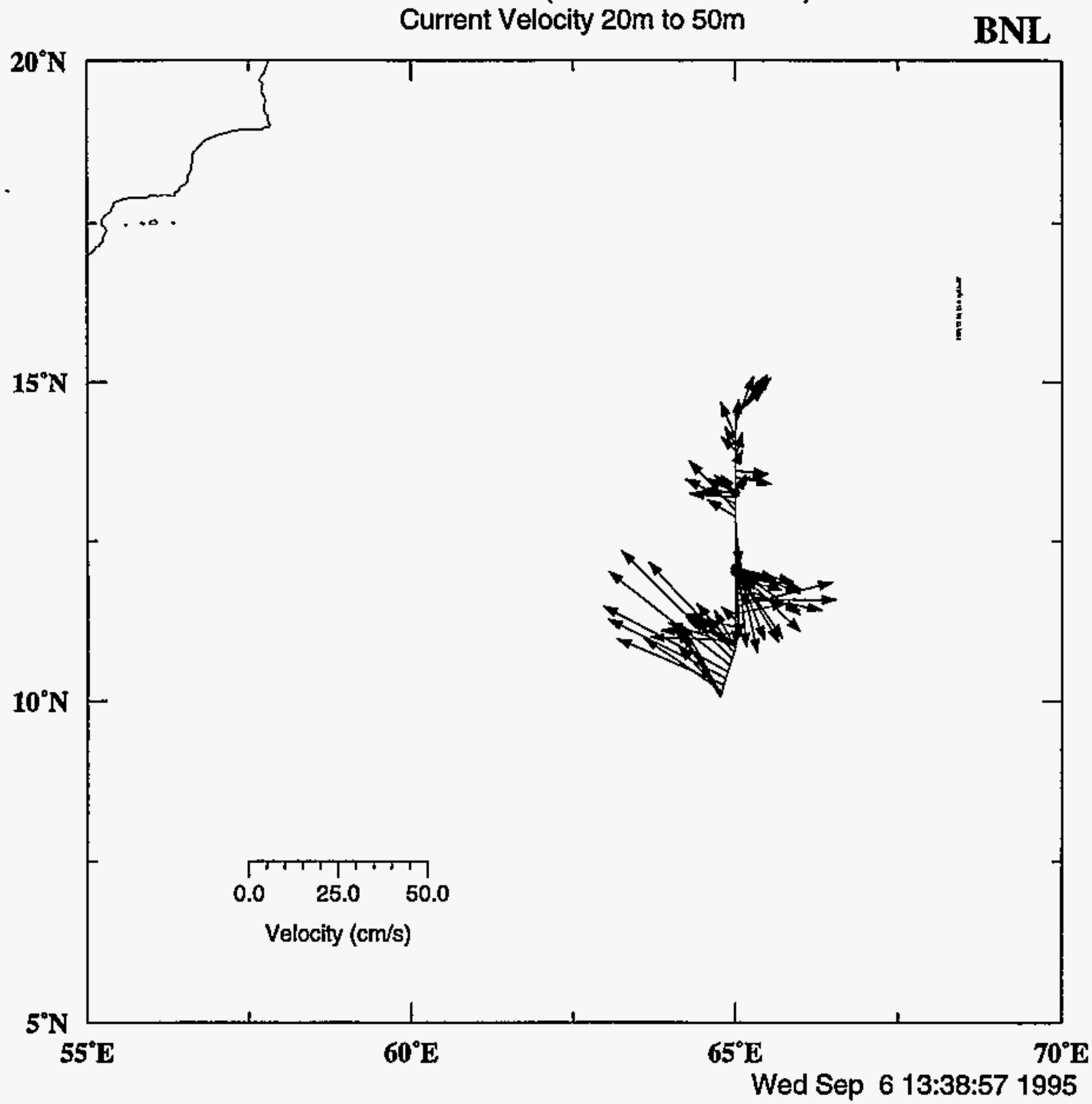
TN045 Section 6-7 (03/21/95 to 03/24/95)
Layer: 100m to 200m




JGOFS Arabian Sea
TN045 Section 6-7 (03/21/95 to 03/24/95)
Layer: 200m to 300m
BNL
20°N
15°N
10°N
5°N
55°E
60°E
65°E
70°E
0.0
25.0
50.0
Velocity (cm/s)
Wed Sep 6 13:36:45 1995

# JGOFS Arabian Sea

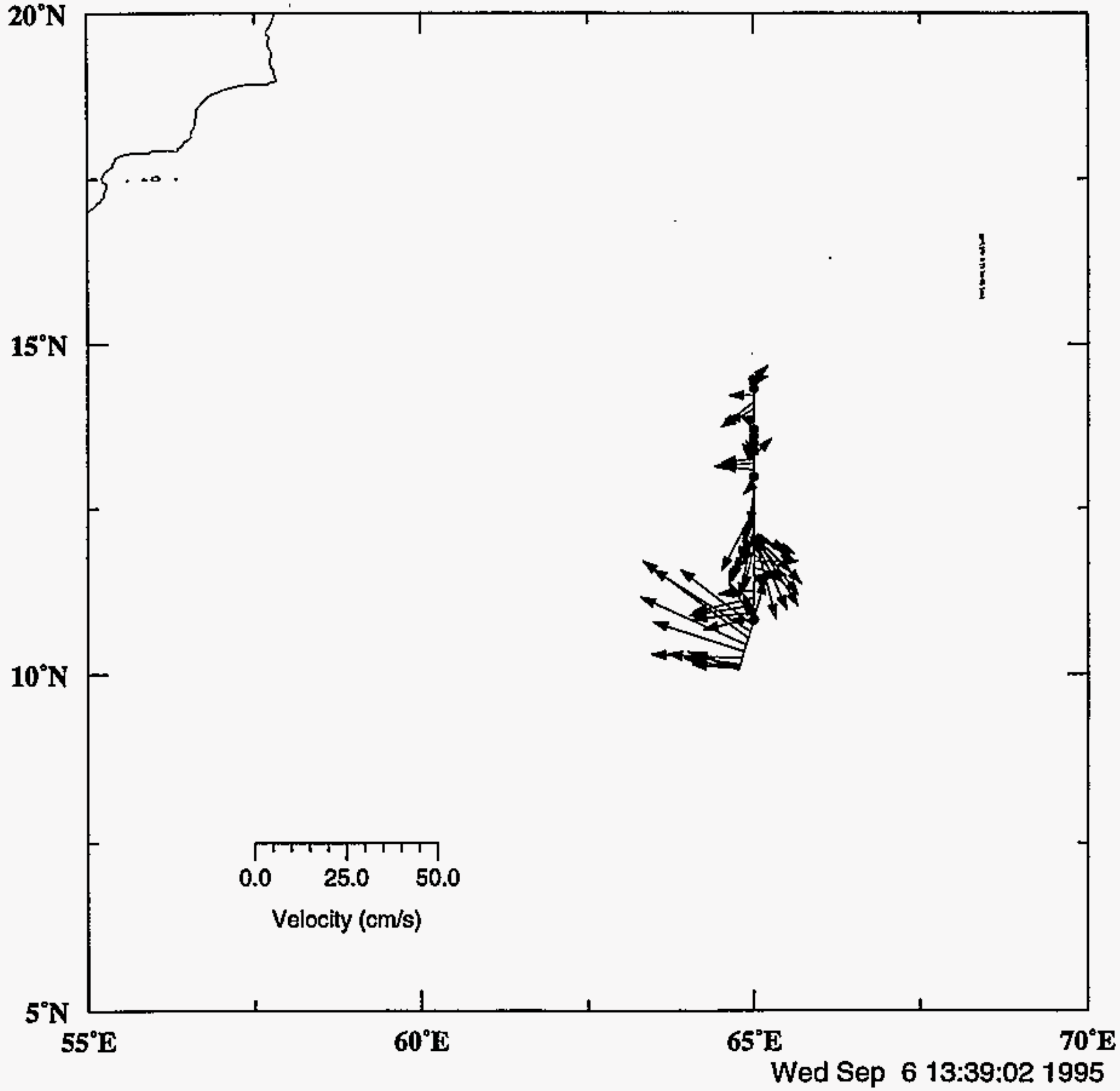
TN045 Section 8 (03/24/95 to 03/26/95)
Current Velocity 20m to 50m



# JGOFS Arabian Sea

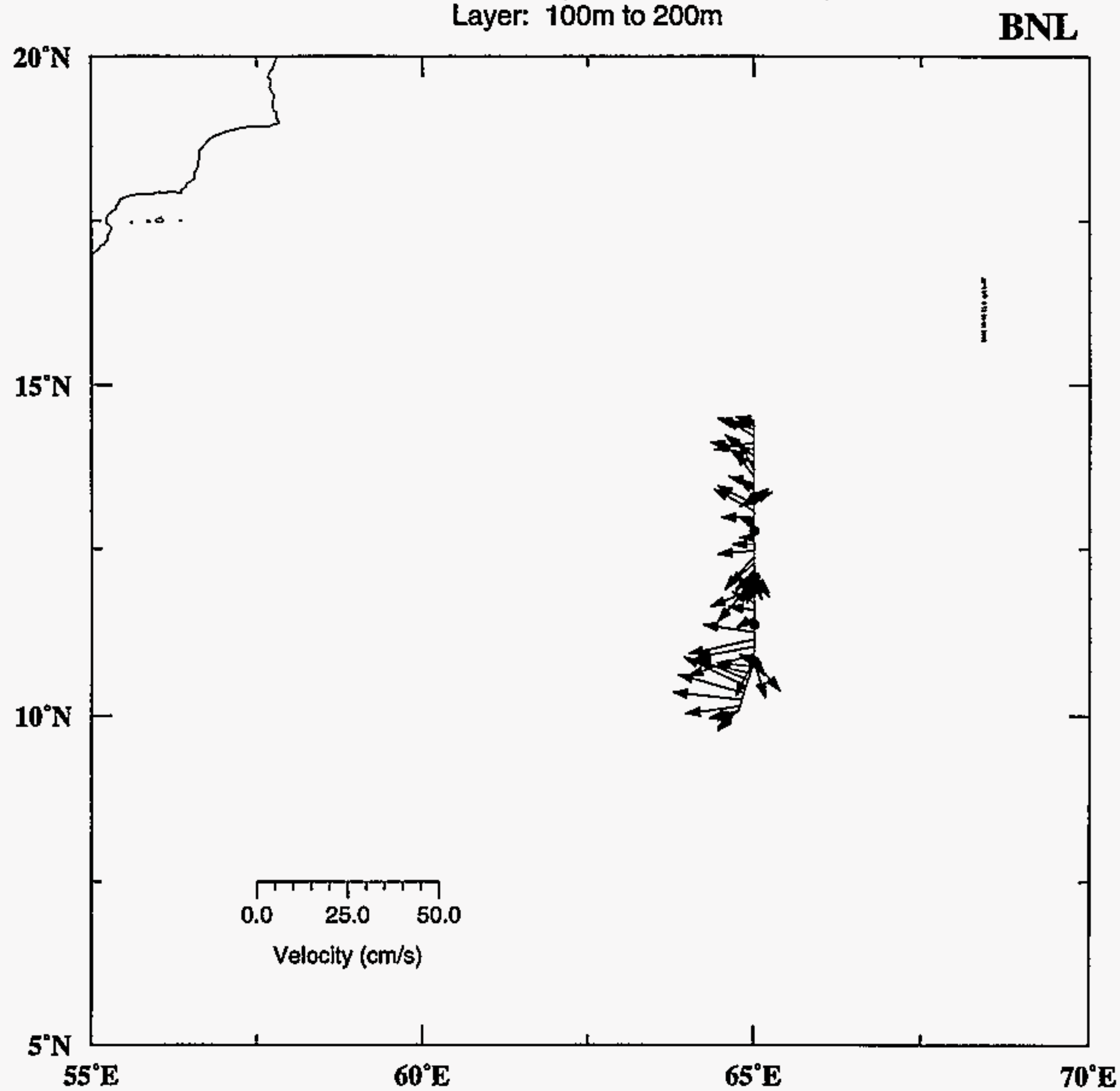
TN045 Section 8 (03/24/95 to 03/26/95)
Layer: 50m to 100m

BNL



# JGOFS Arabian Sea

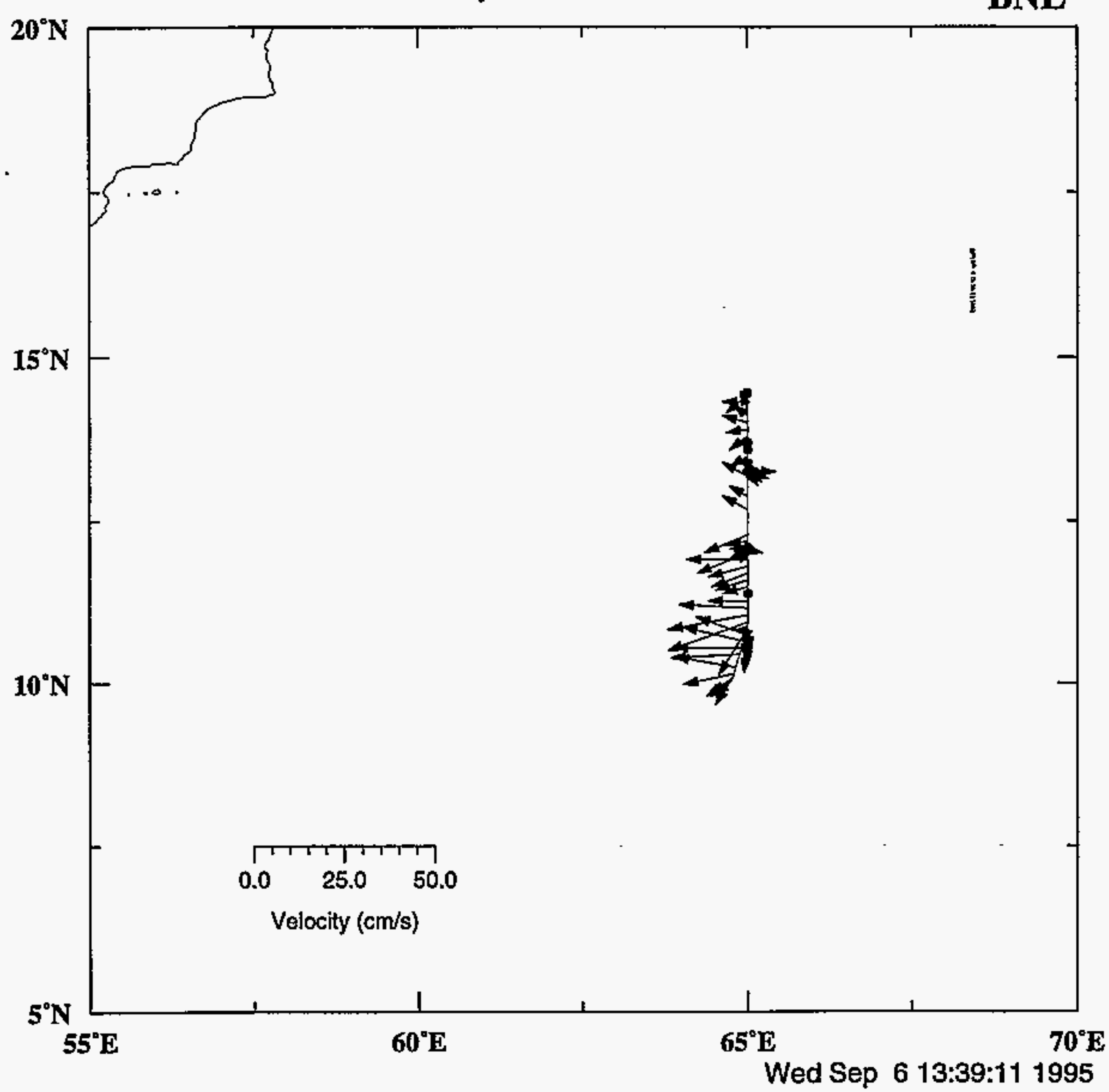
TN045 Section 8 (03/24/95 to 03/26/95)
Layer: 100m to 200m

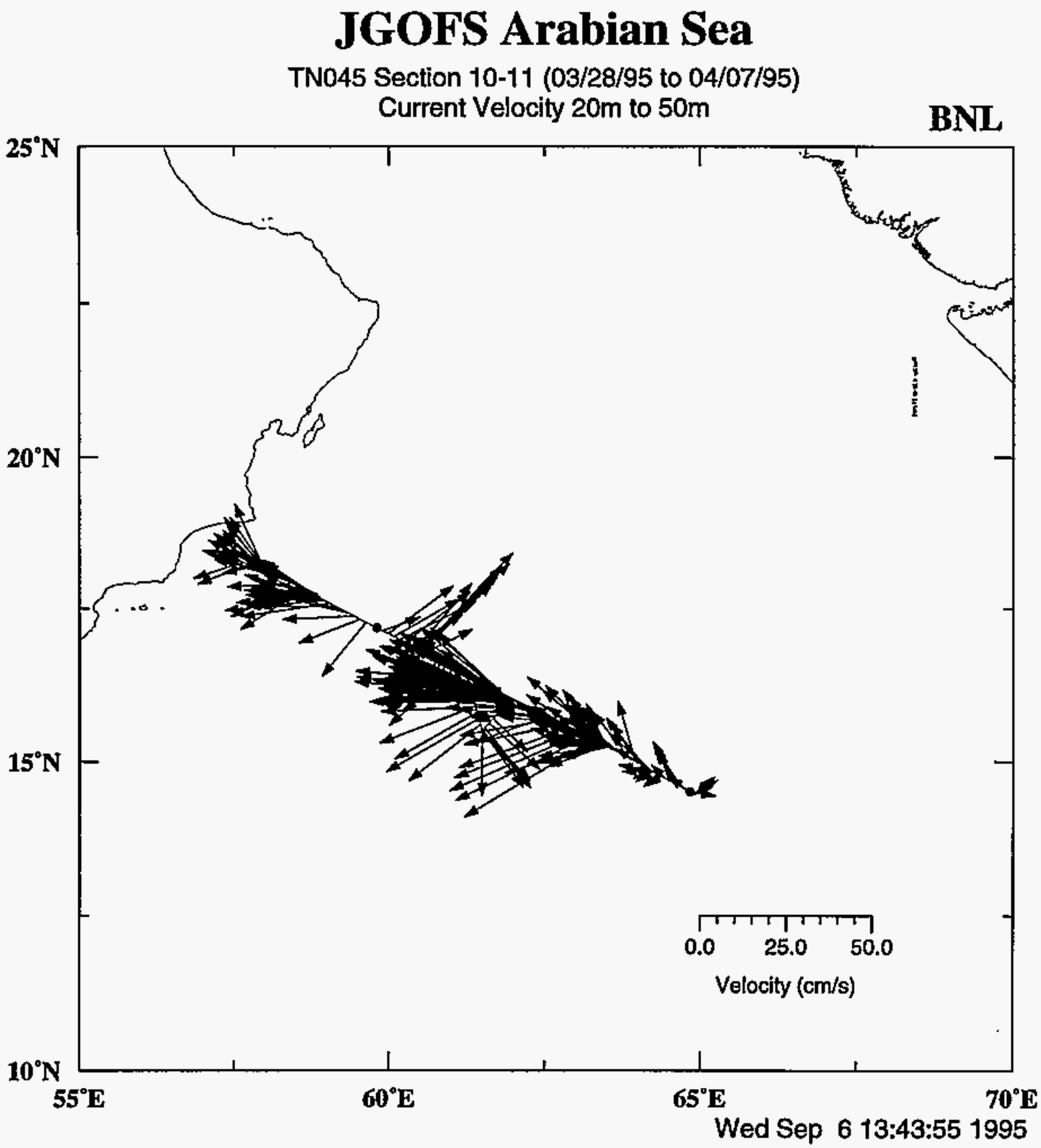


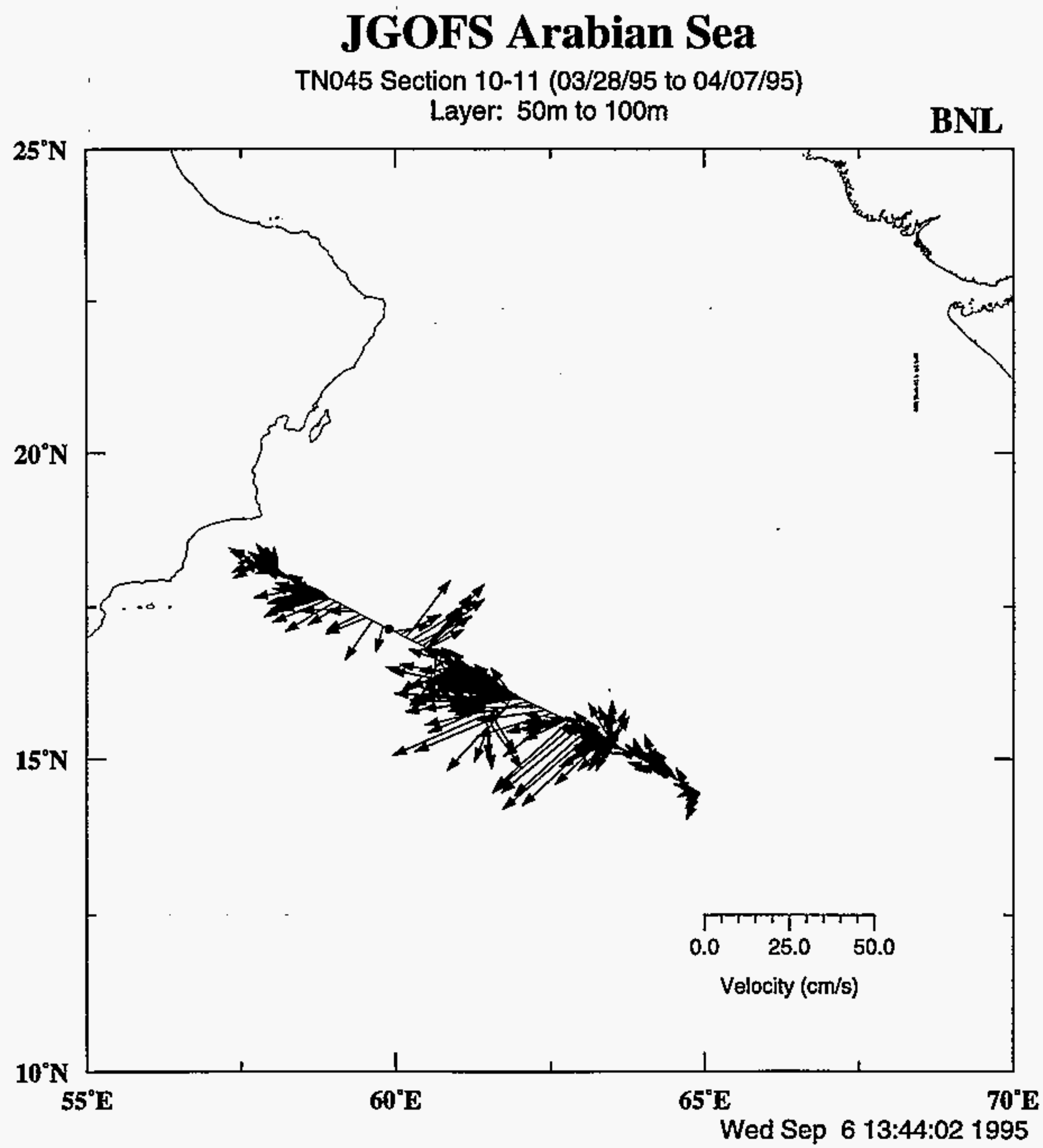

Wed Sep 6 13:39:06 1995

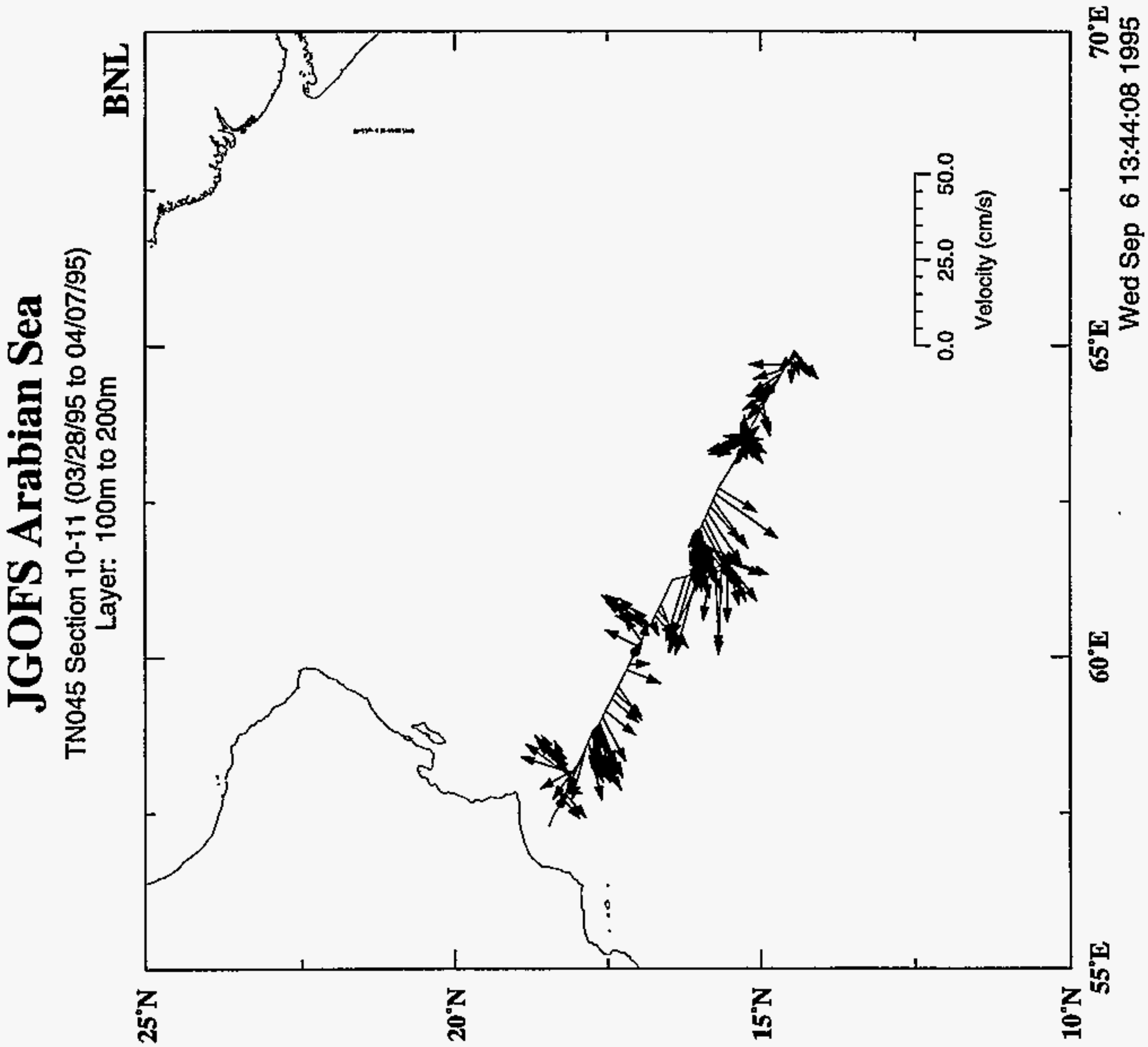
# JGOFS Arabian Sea

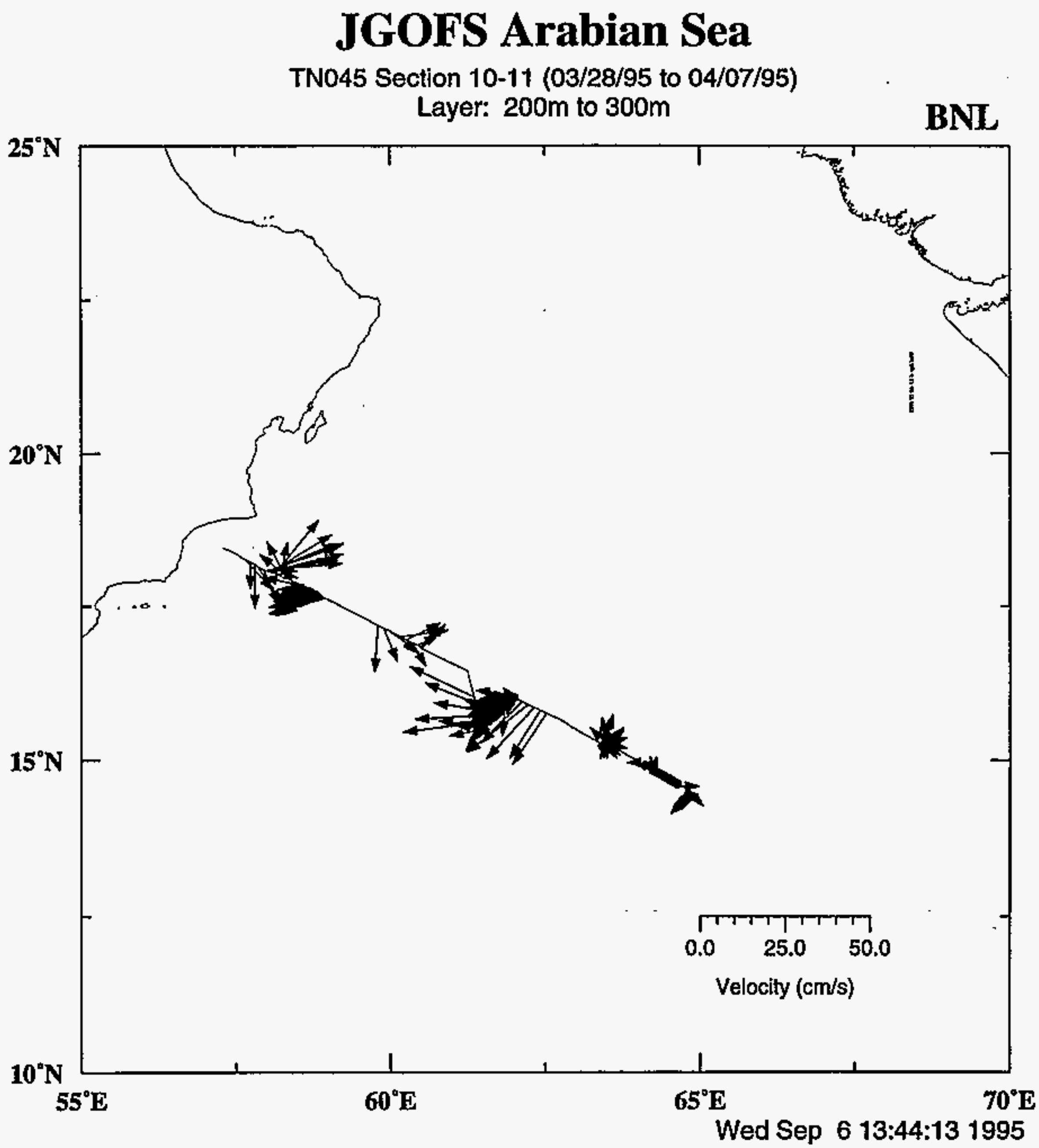
TN045 Section 8 (03/24/95 to 03/26/95)
Layer: 200m to 300m



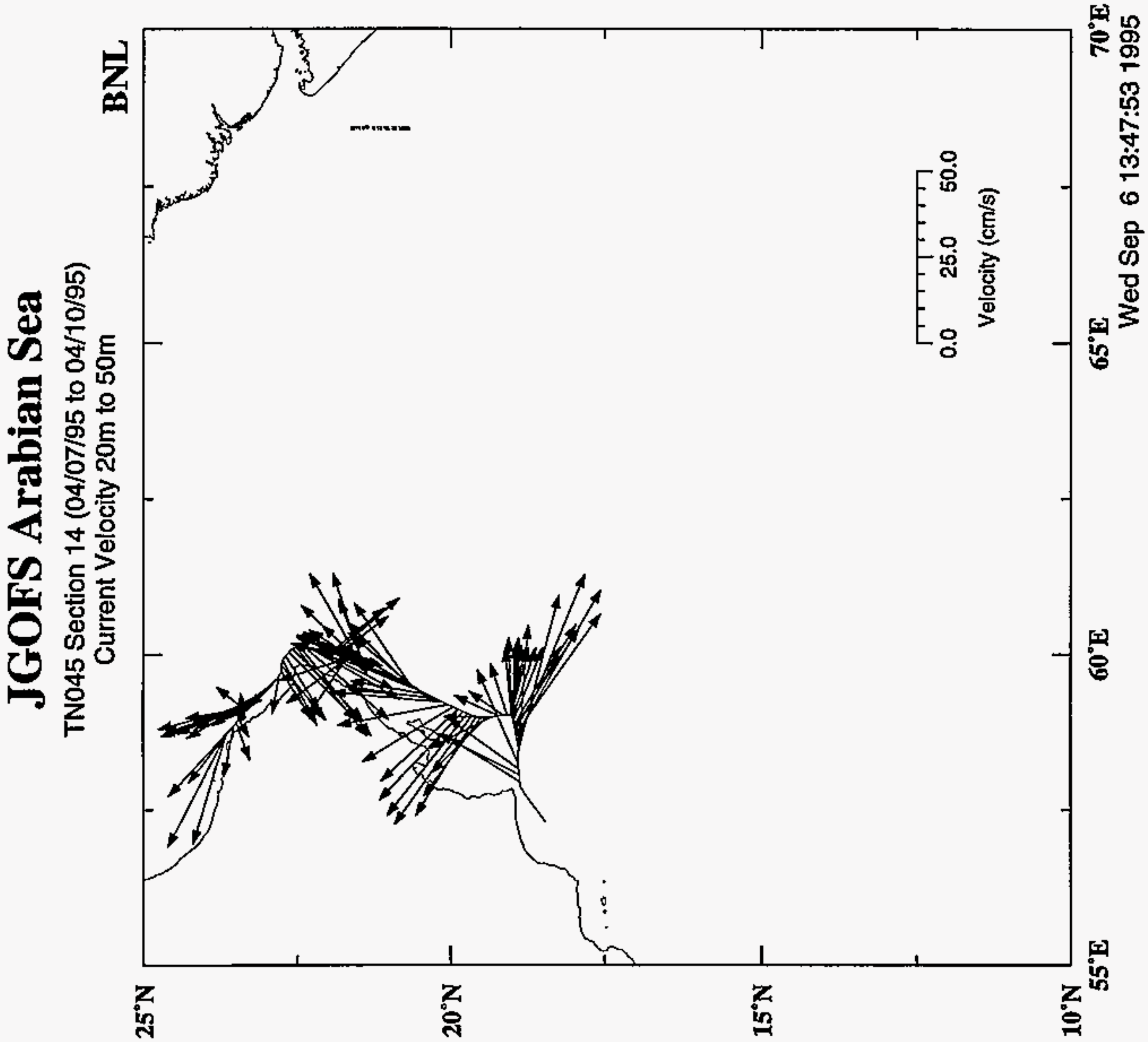

JGOFS Arabian Sea
TN045 Section 10-11 (03/28/95 to 04/07/95)
Current Velocity 20m to 50m
BNL
25°N
20°N
15°N
10°N
55°E
60°E
65°E
70°E
0.0
25.0
50.0
Velocity (cm/s)
Wed Sep 6 13:43:55 1995

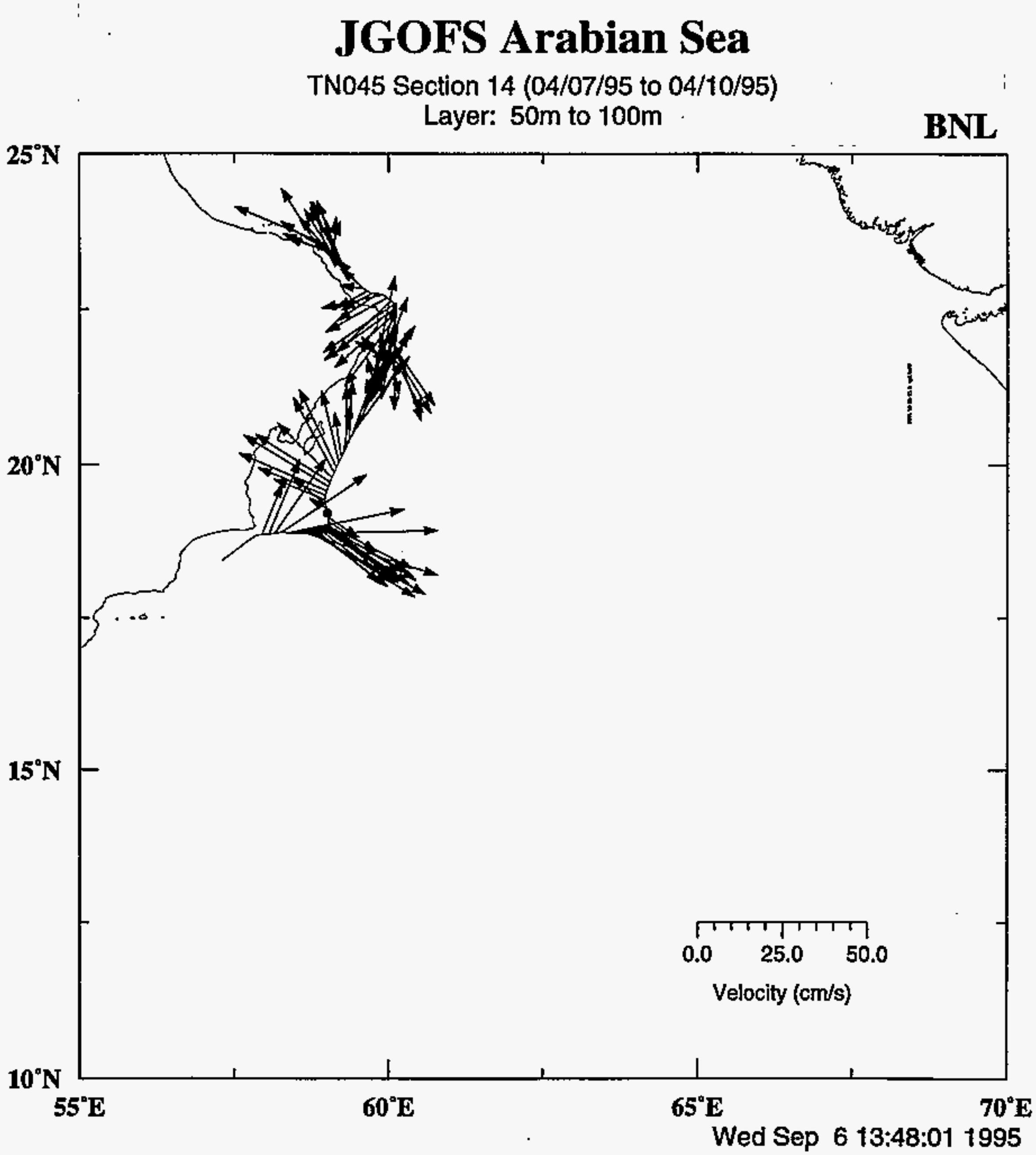

JGOFS Arabian Sea
TN045 Section 10-11 (03/28/95 to 04/07/95)
Layer: 50m to 100m
BNL
25°N
20°N
15°N
10°N
55°E
60°E
65°E
70°E
0.0
25.0
50.0
Velocity (cm/s)
Wed Sep 6 13:44:02 1995

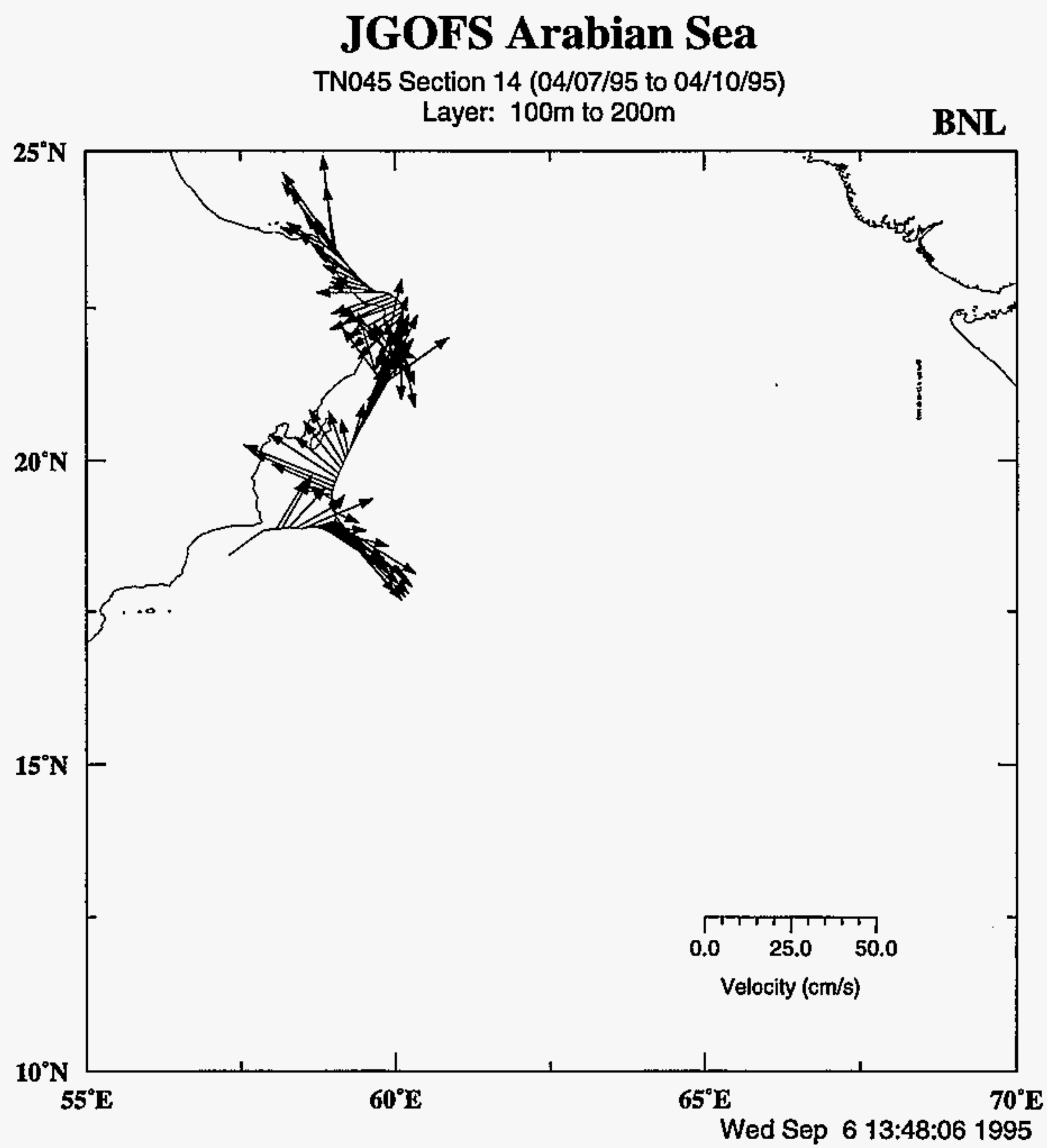

JGOFS Arabian Sea
TN045 Section 10-11 (03/28/95 to 04/07/95)
Layer: 100m to 200m
BNL
25°N
20°N
15°N
10°N
55°E
60°E
65°E
70°E
0.0
25.0
50.0
Velocity (cm/s)
Wed Sep 6 13:44:08 1995

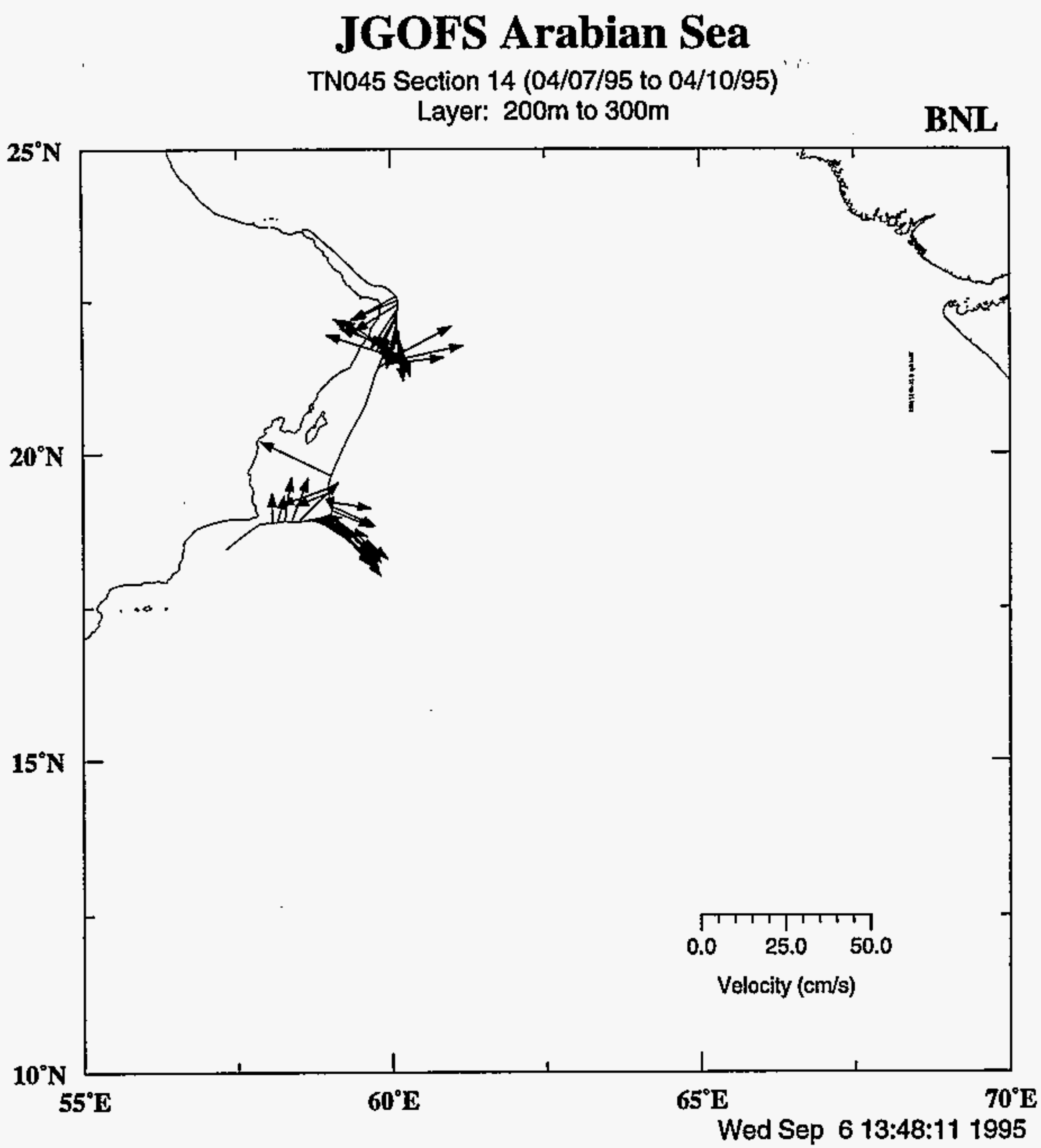


JGOFS Arabian Sea
TN045 Section 10-11 (03/28/95 to 04/07/95)
Layer: 200m to 300m
BNL
25°N
20°N
15°N
10°N
55°E
60°E
65°E
70°E
0.0
25.0
50.0
Velocity (cm/s)
Wed Sep 6 13:44:13 1995

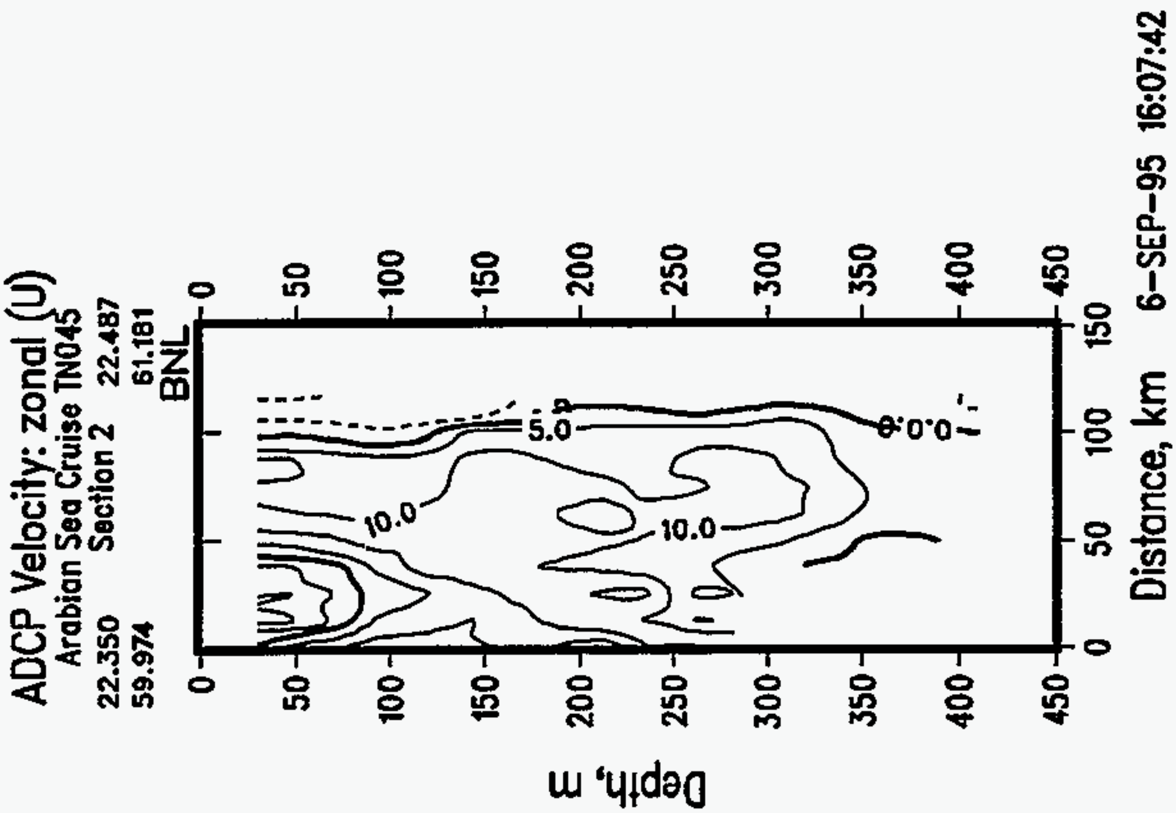

JGOFS Arabian Sea
TN045 Section 14 (04/07/95 to 04/10/95)
Current Velocity 20m to 50m
BNL
25°N
20°N
15°N
10°N
55°E
60°E
65°E
70°E
0.0
25.0
50.0
Velocity (cm/s)
Wed Sep 6 13:47:53 1995

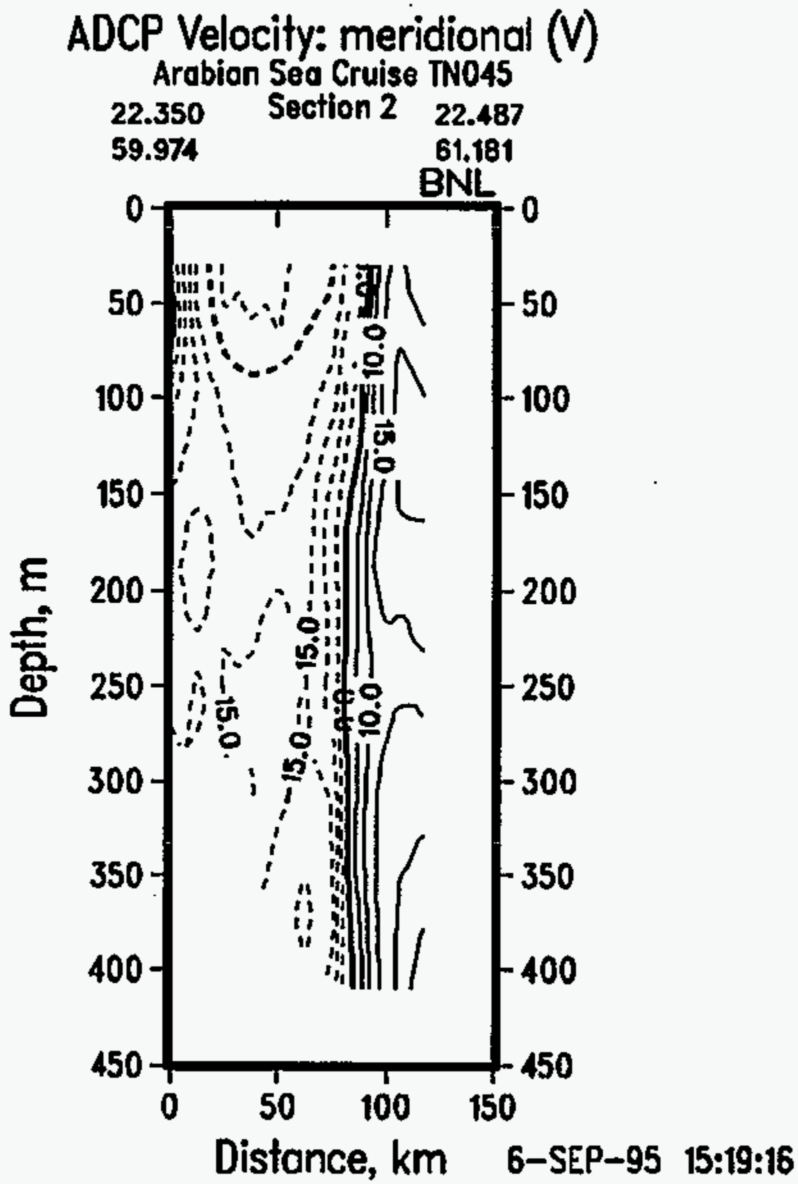

JGOFS Arabian Sea
TN045 Section 14 (04/07/95 to 04/10/95)
Layer: 50m to 100m
BNL
25°N
20°N
15°N
10°N
55°E
60°E
65°E
70°E
0.0
25.0
50.0
Velocity (cm/s)
Wed Sep 6 13:48:01 1995

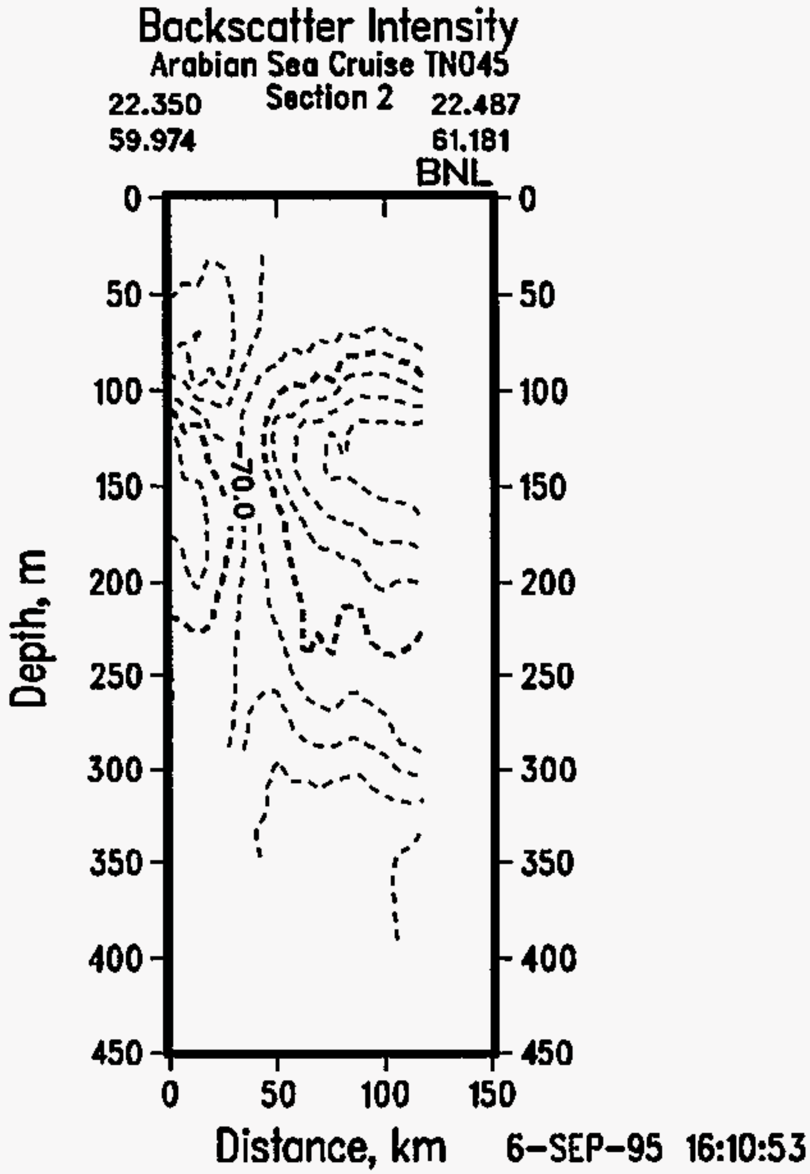

JGOFS Arabian Sea
TN045 Section 14 (04/07/95 to 04/10/95)
Layer: 100m to 200m
BNL
25°N
20°N
15°N
10°N
55°E
60°E
65°E
70°E
0.0
25.0
50.0
Velocity (cm/s)
Wed Sep 6 13:48:06 1995



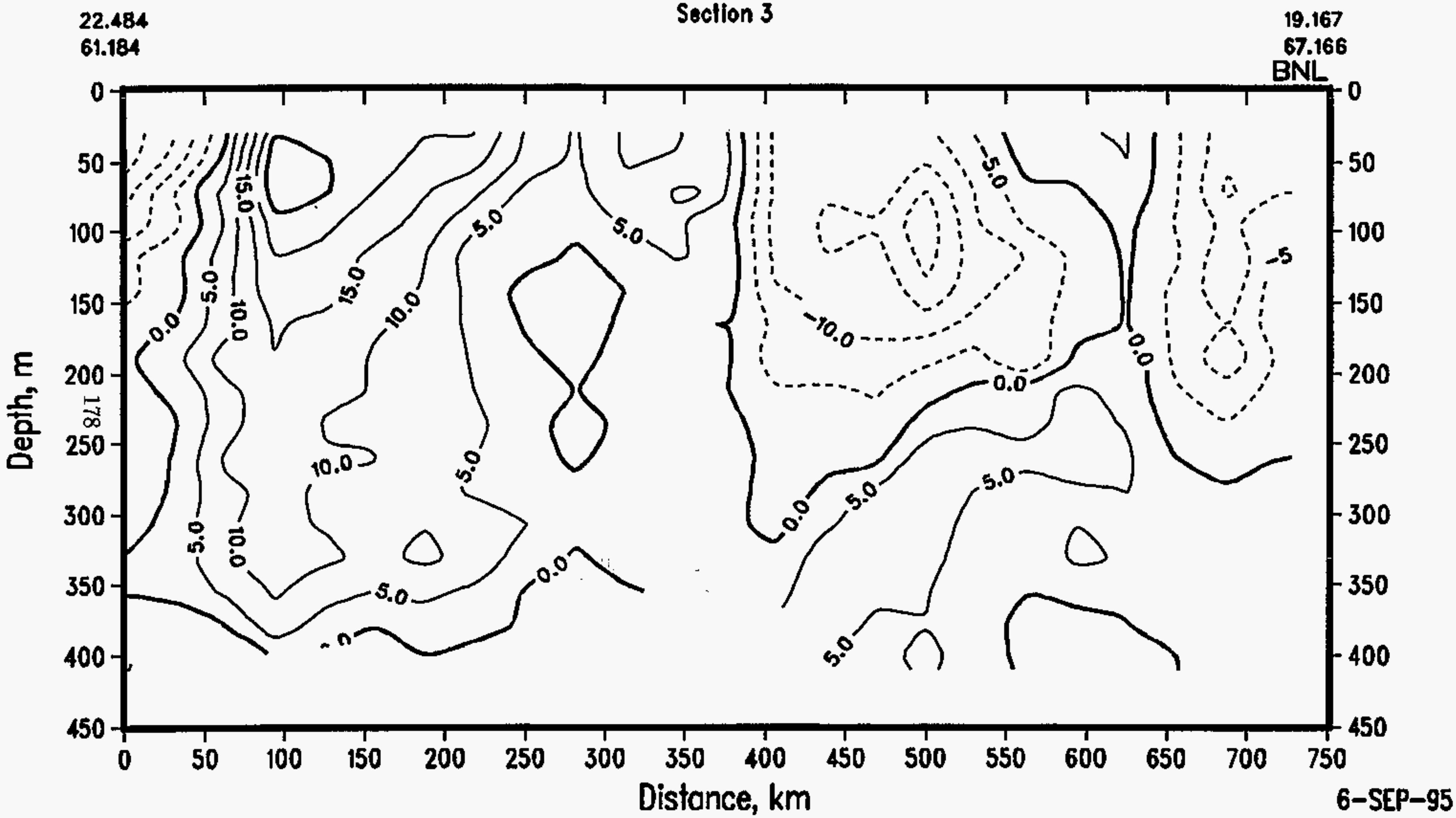
JGOFS Arabian Sea
TN045 Section 14 (04/07/95 to 04/10/95)
Layer: 200m to 300m
BNL
25°N
20°N
15°N
10°N
55°E
60°E
65°E
70°E
0.0
25.0
50.0
Velocity (cm/s)
Wed Sep 6 13:48:11 1995

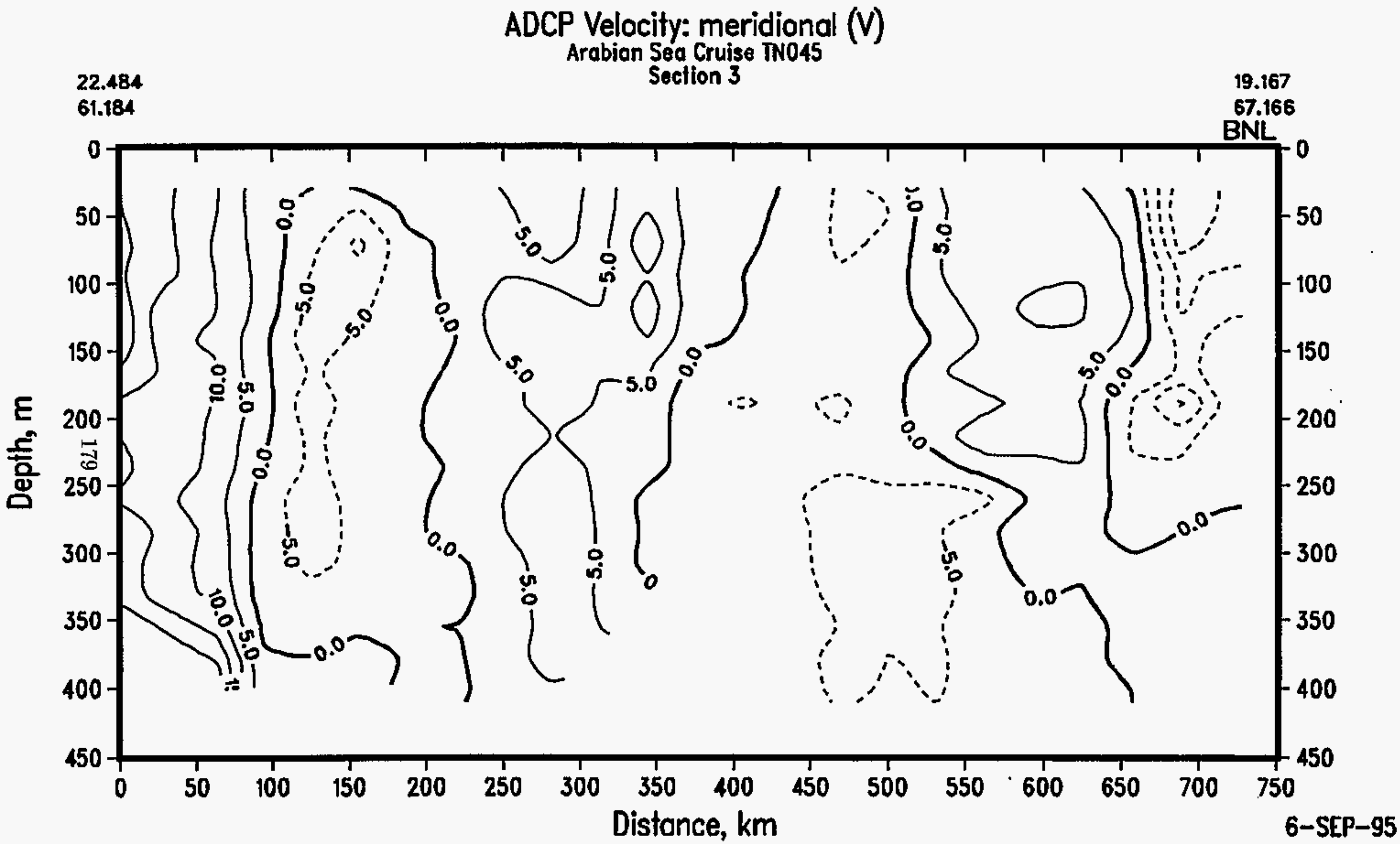

ADCP Velocity: zonal (U)
Arabian Sea Cruise TN045
Section 2
22.350
59.974
22.487
61.181
BNL
Depth, m
Distance, km
10.0
5.0
0.0
6-SEP-95 16:07:42


ADCP Velocity: meridional (V)
Arabian Sea Cruise TN045
Section 2
22.350
59.974
22.487
61.181
BNL
Depth, m
Distance, km
-15.0
10.0
15.0
6-SEP-95 15:19:16


Backscatter Intensity
Arabian Sea Cruise TN045
Section 2
22.350
59.974
22.487
61.181
BNL
70.0
Depth, m
Distance, km
6-SEP-95 16:10:53

ADCP Velocity: zonal (U)
Arabian Sea Cruise TN045
Section 3

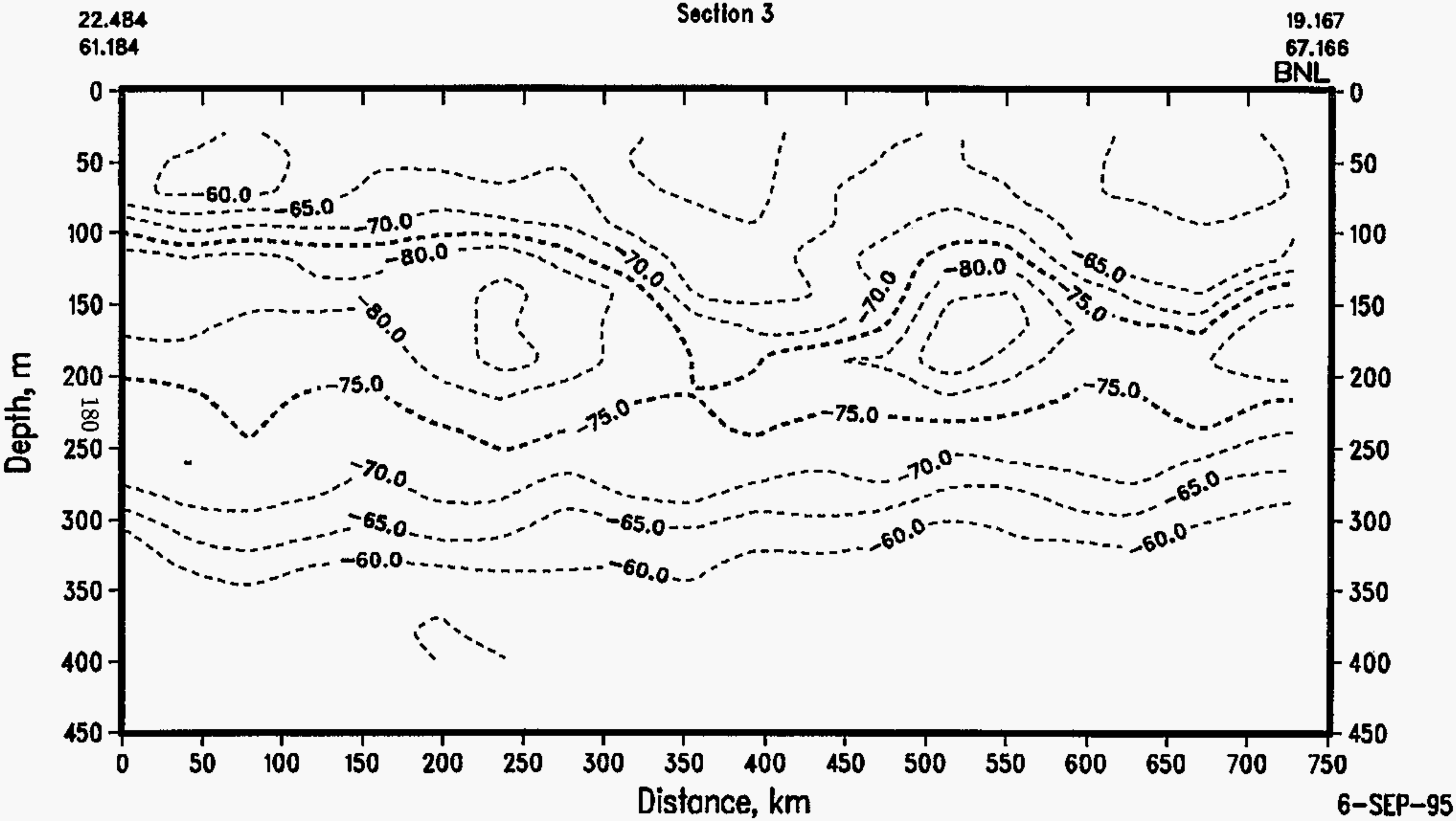


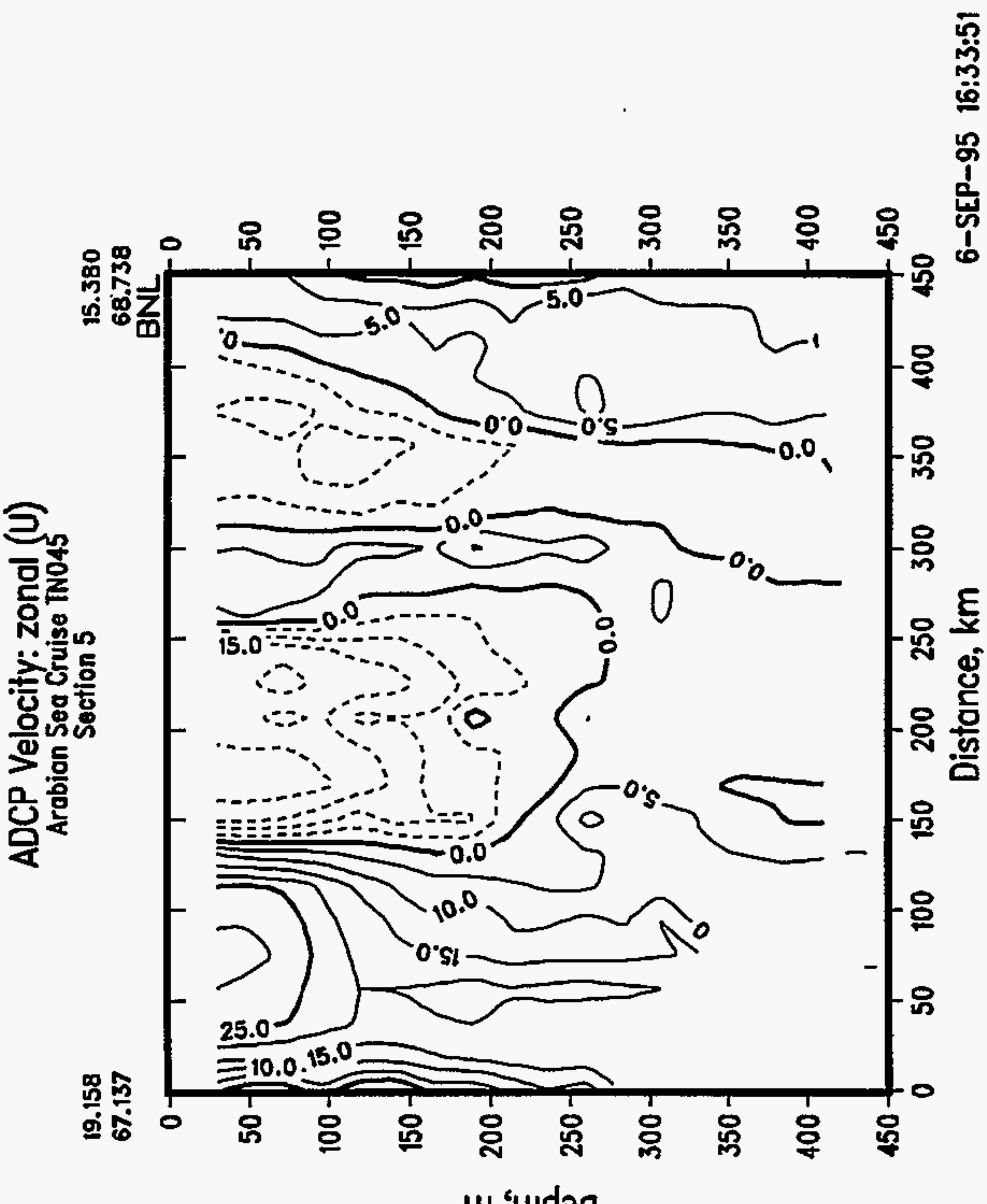


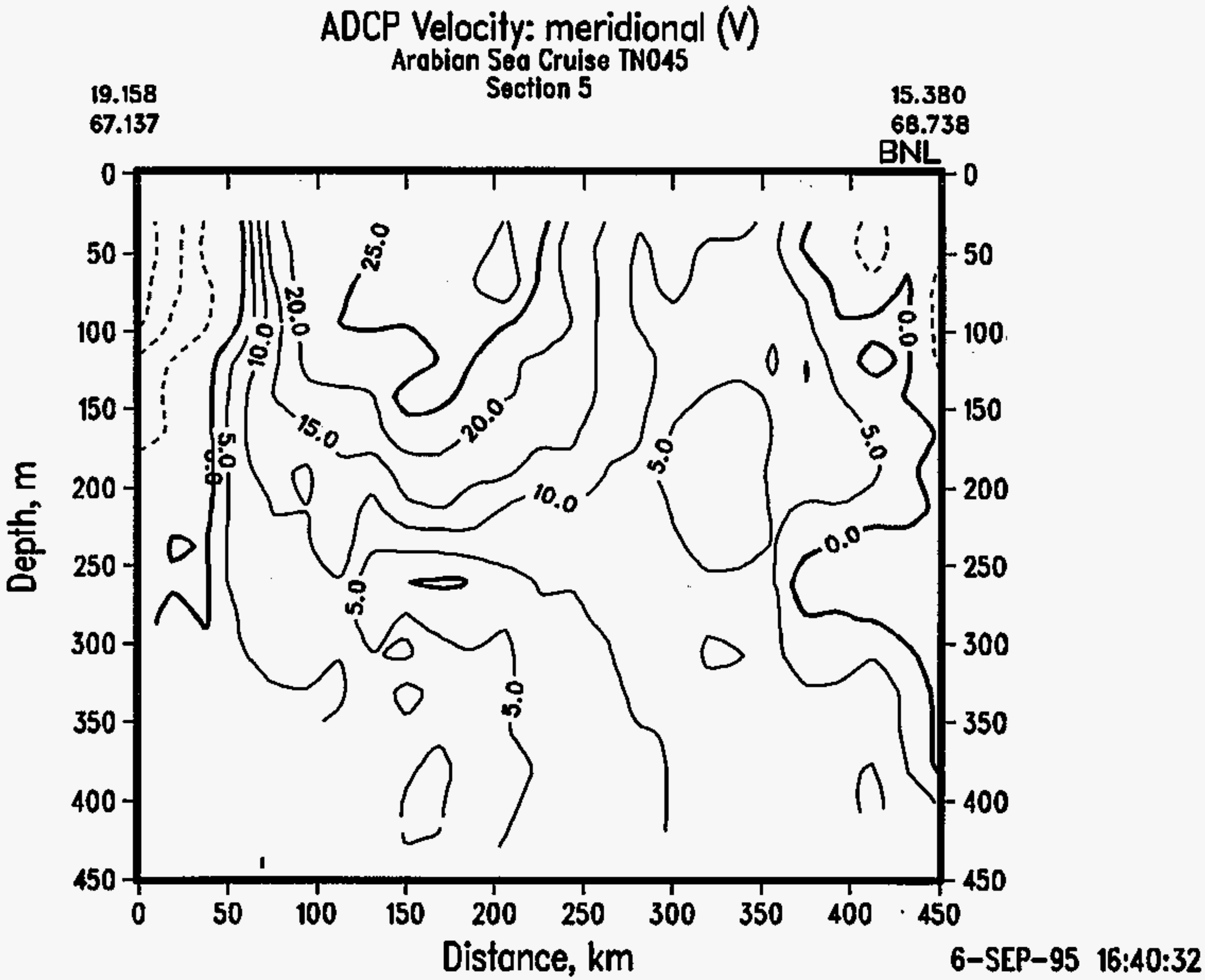
ADCP Velocity: meridional (V)
Arabian Sea Cruise TN045
Section 3
22.484
61.184
19.167
67.166
BNL
Depth, m
Distance, km
6-SEP-95


179

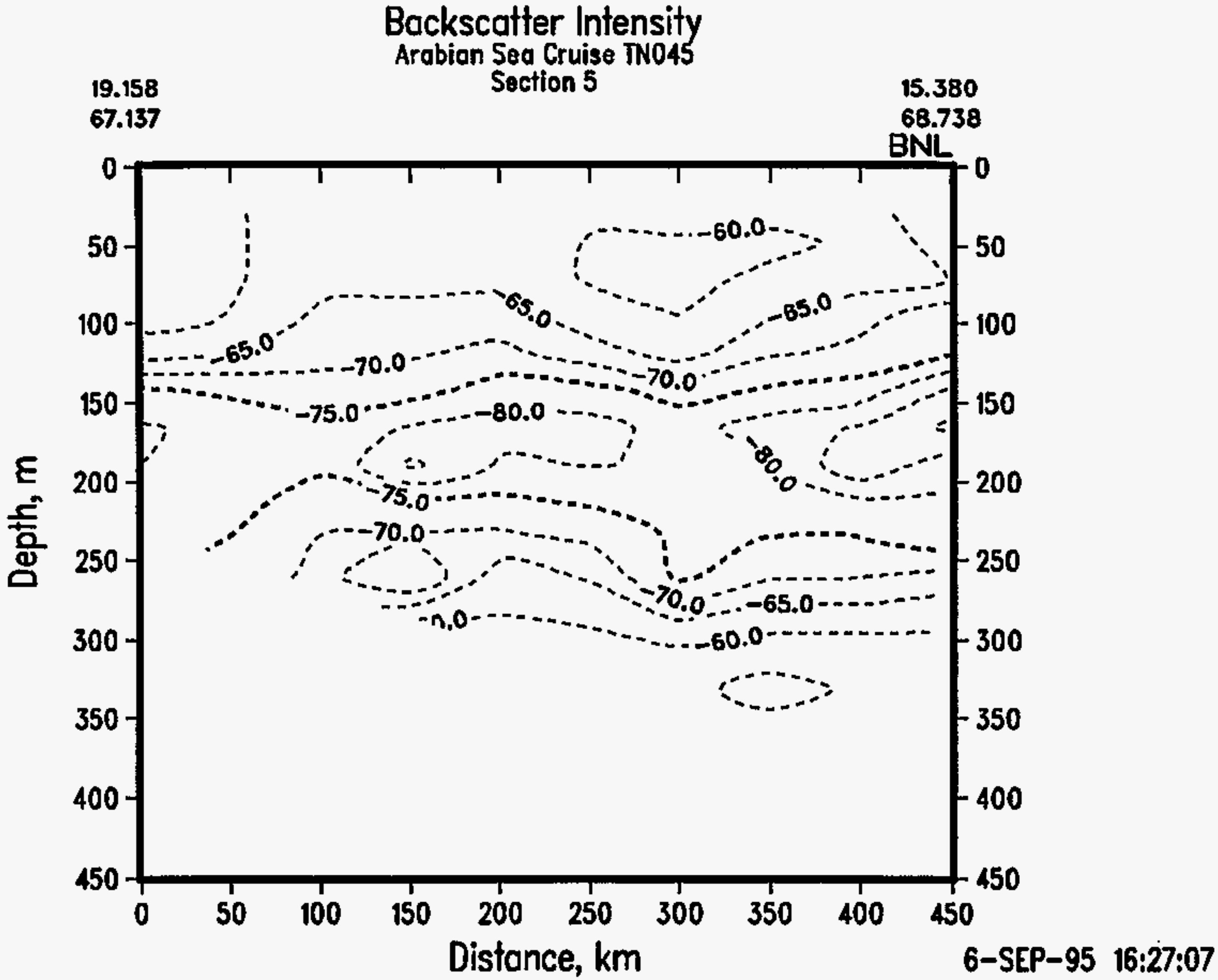
Backscatter Intensity
Arabian Sea Cruise TN045
Section 3

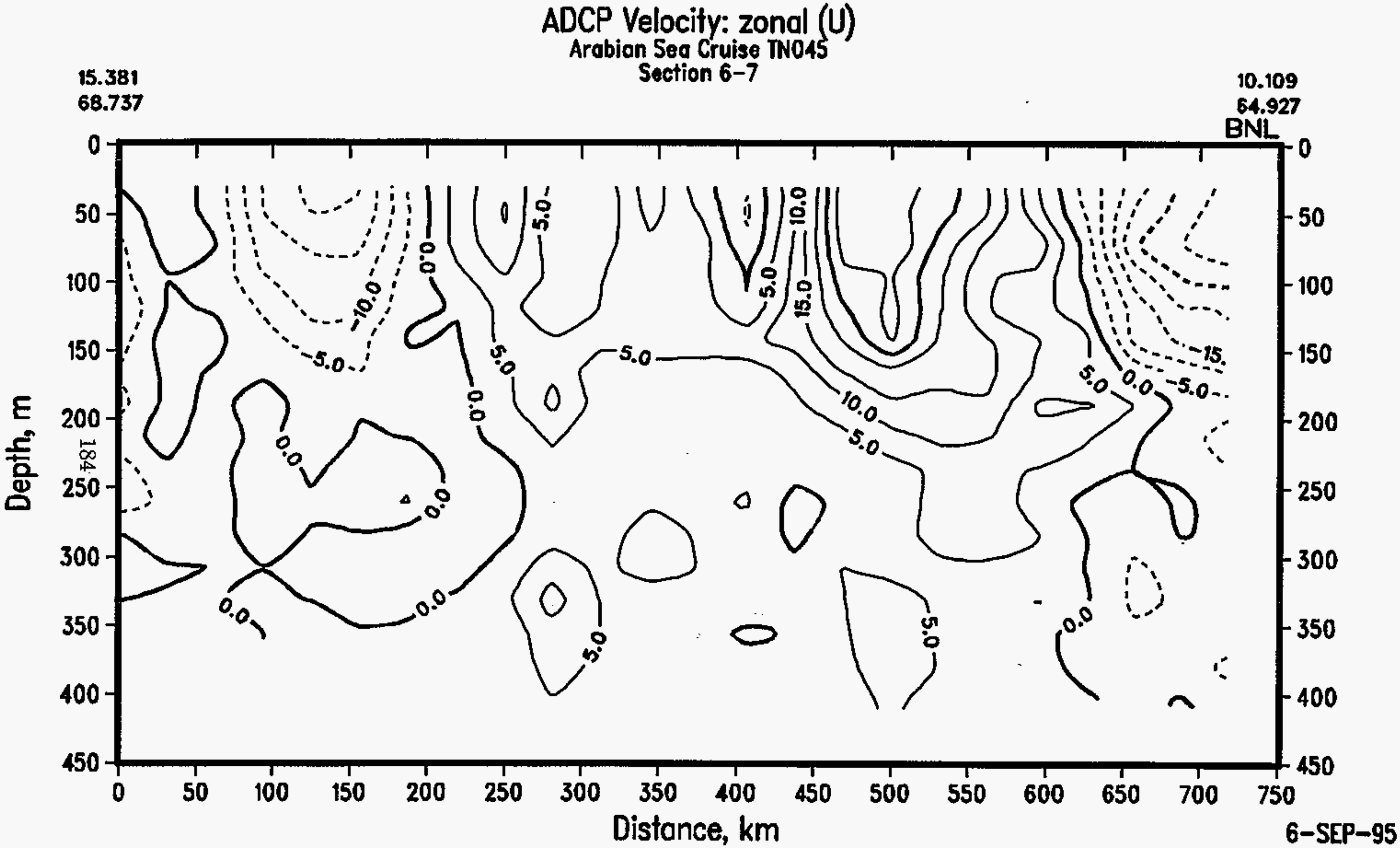



ADCP Velocity: zonal (U)
Arabian Sea Cruise TN045
Section 5
Depth, m
Distance, km
19.158
67.137
15.380
68.738
BNL
6-SEP-95 16:33:51



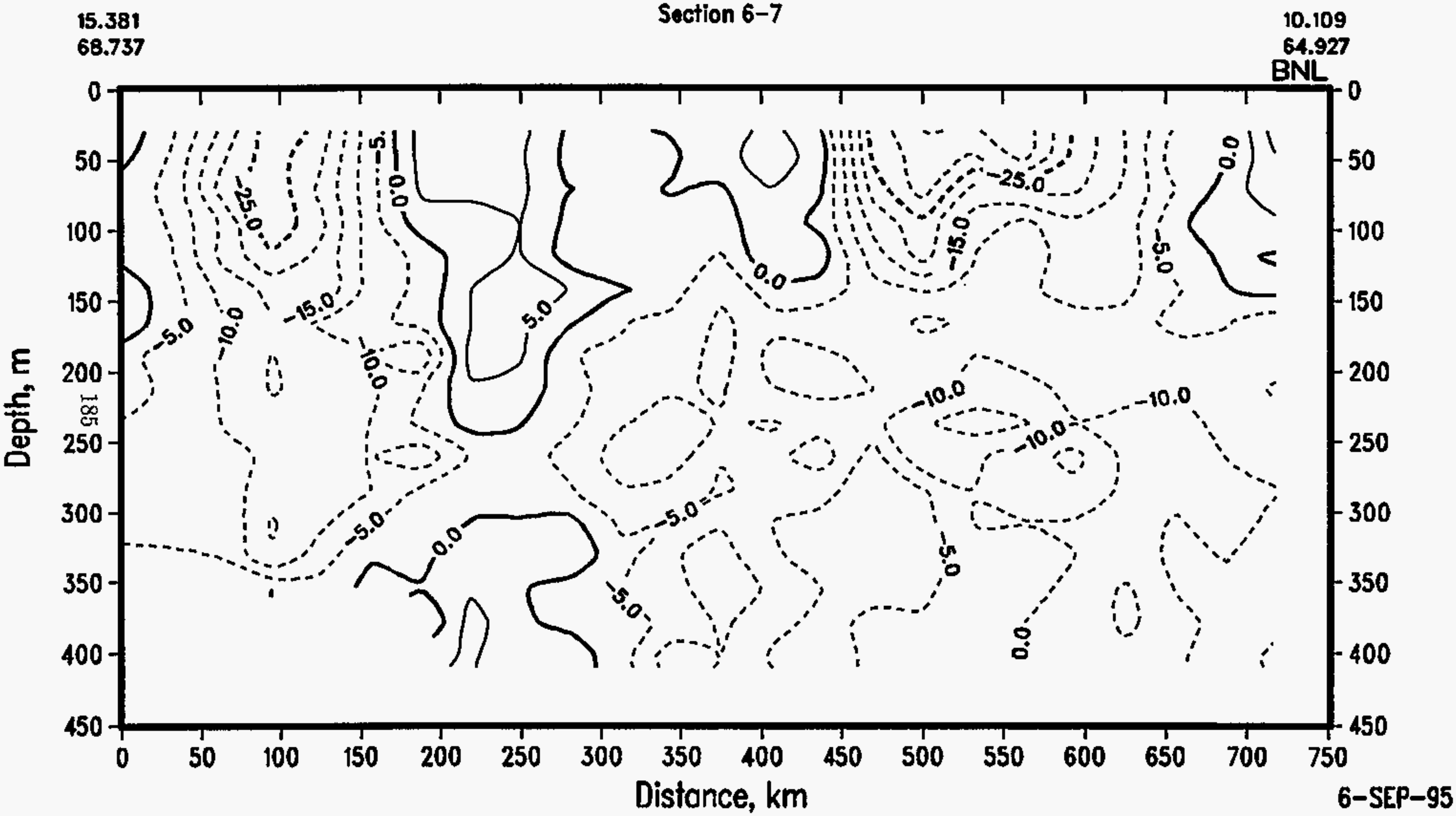
ADCP Velocity: meridional (V)
Arabian Sea Cruise TN045
Section 5
19.158
67.137
15.380
68.738
BNL
Depth, m
Distance, km
25.0
20.0
15.0
10.0
5.0
0.0
6-SEP-95 16:40:32

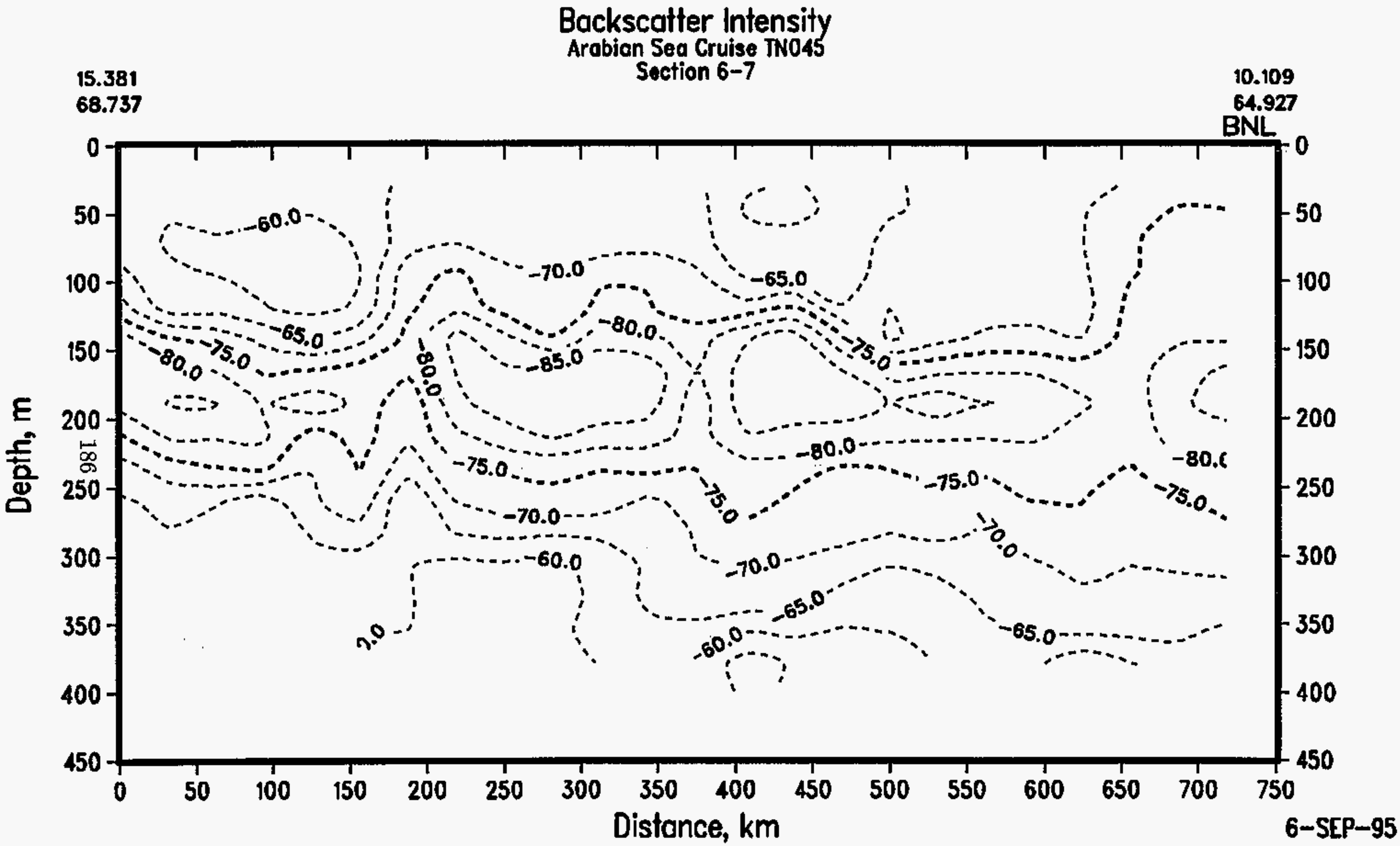

Backscatter Intensity
Arabian Sea Cruise TN045
Section 5
19.158
67.137
15.380
68.738
BNL
Depth, m
Distance, km
6-SEP-95 16:27:07
-60.0
-65.0
-70.0
-75.0
-80.0

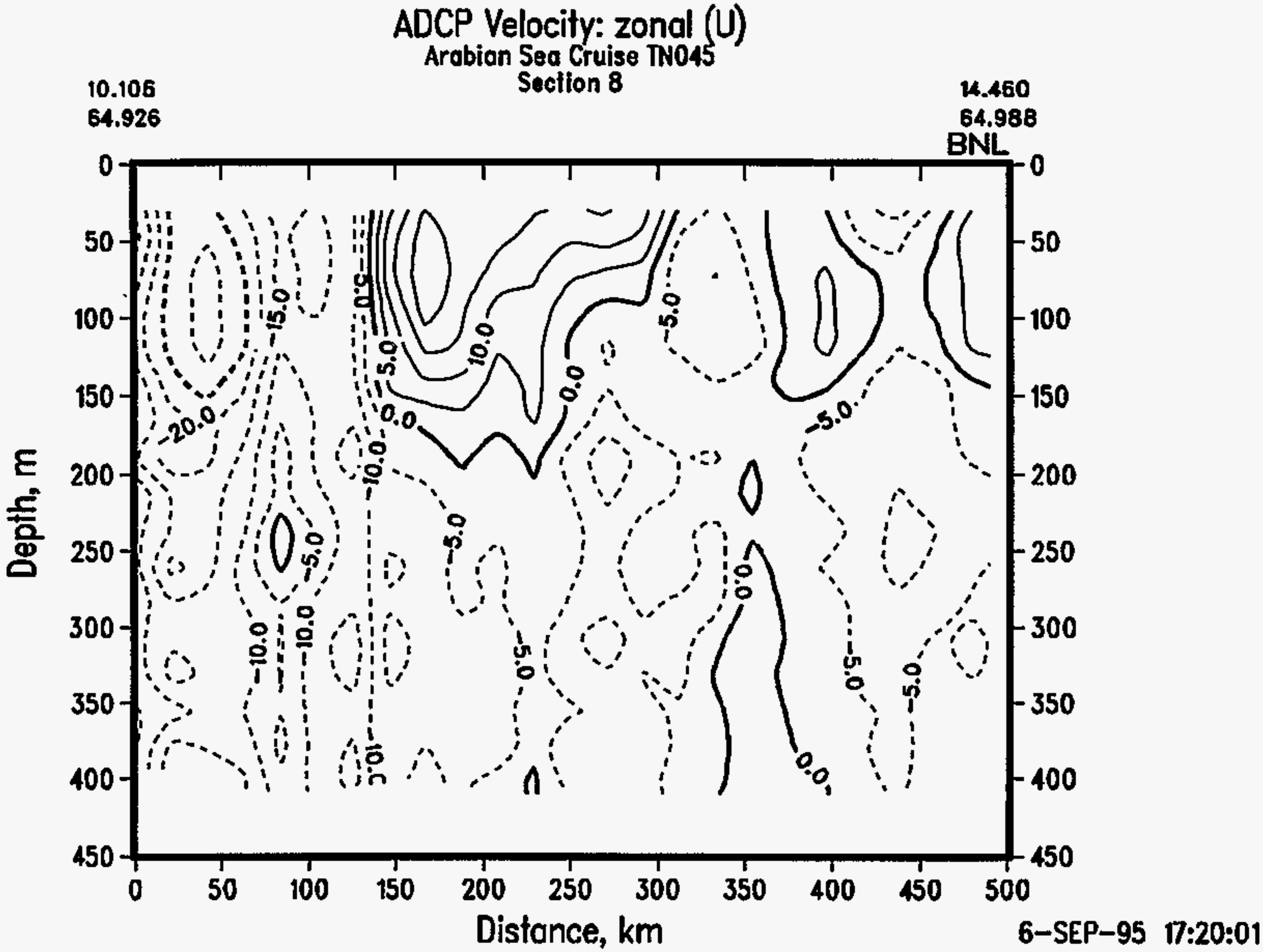


ADCP Velocity: zonal (U)
Arabian Sea Cruise TN045
Section 6-7
15.381
68.737
10.109
64.927
BNL
Depth, m
Distance, km
6-SEP-95
184

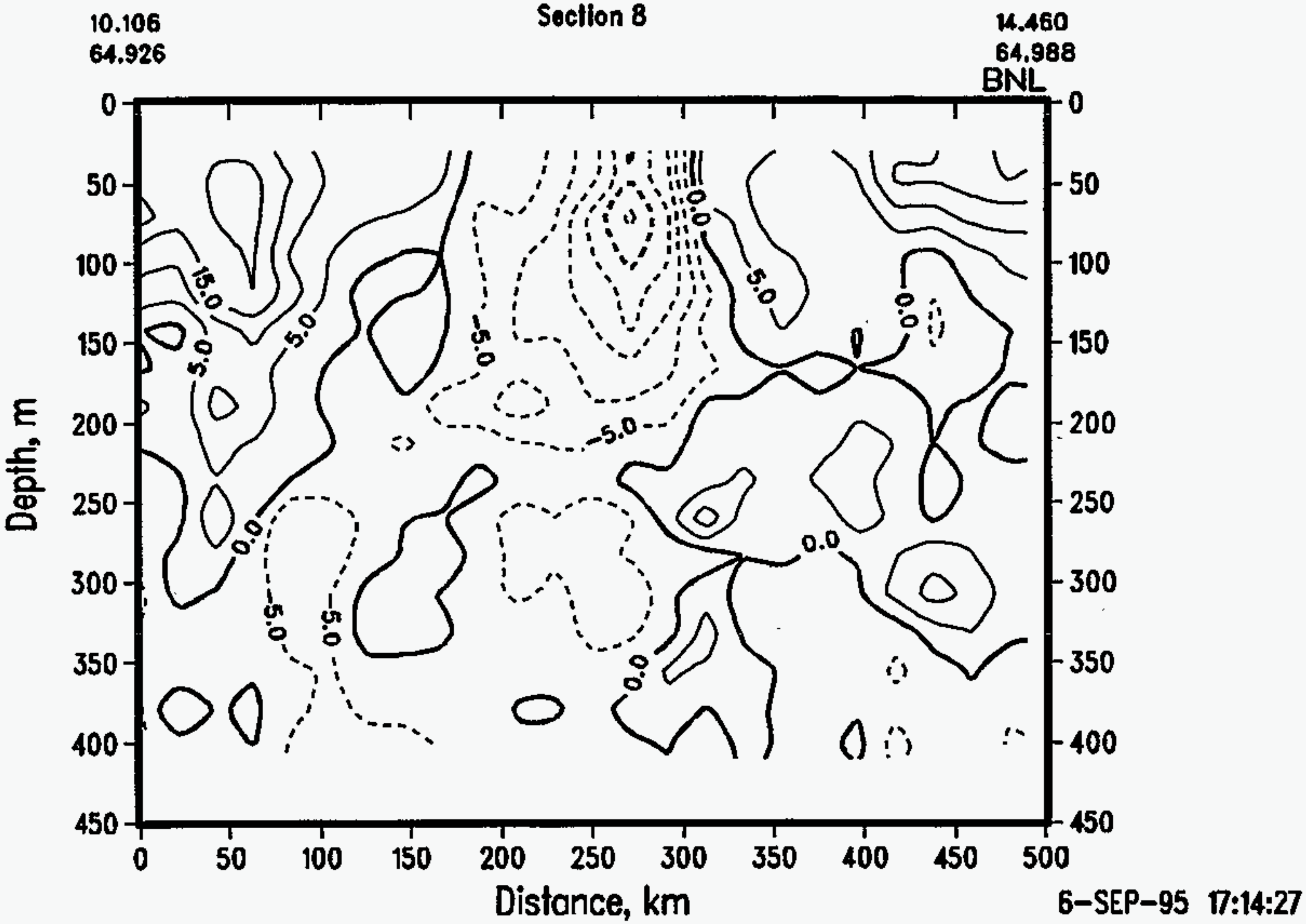
ADCP Velocity: meridional (V)
Arabian Sea Cruise TN045
Section 6-7

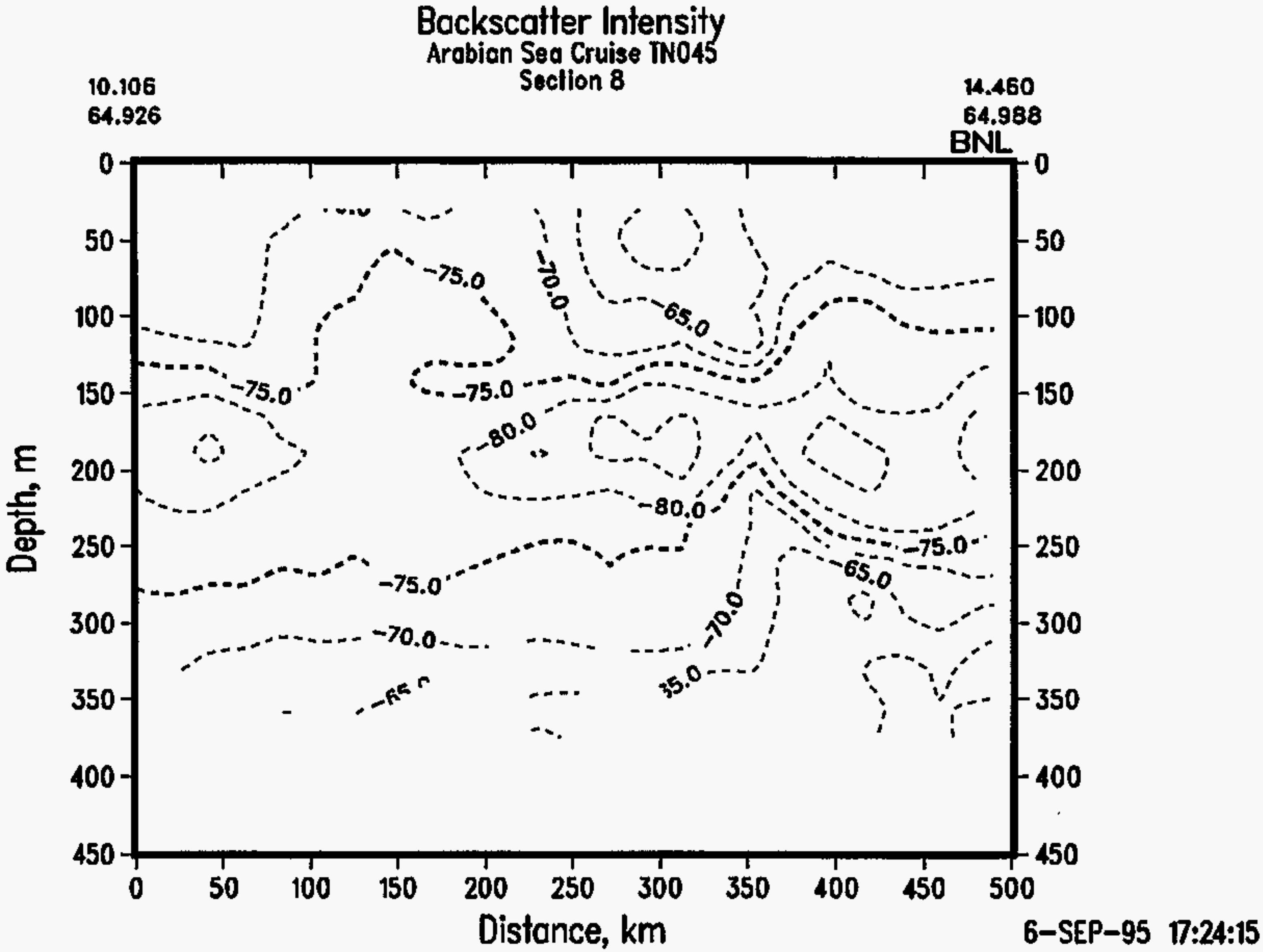


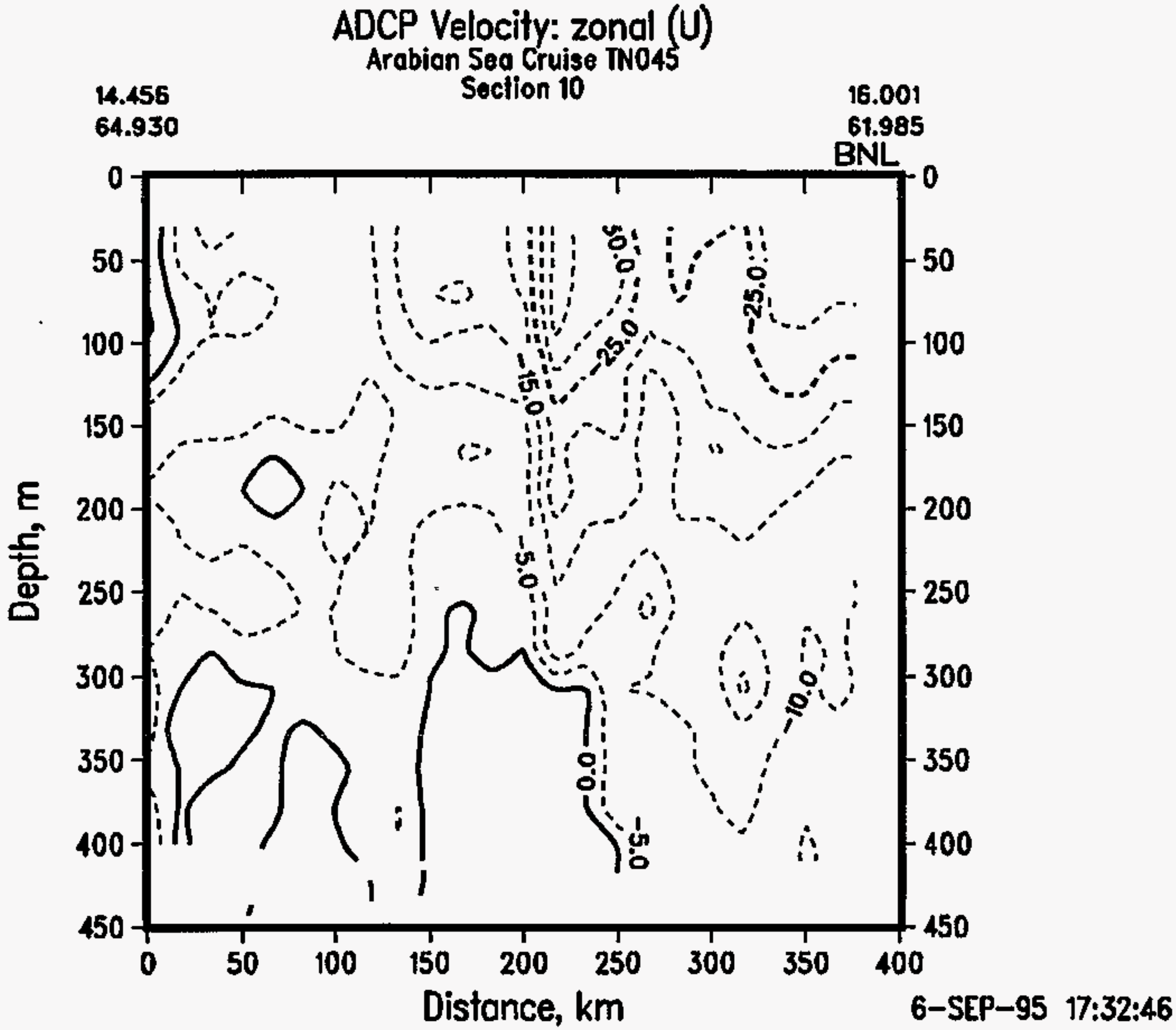

Backscatter Intensity
Arabian Sea Cruise TN045
Section 6-7
15.381
68.737
10.109
64.927
BNL
Depth, m
Distance, km
6-SEP-95
-60.0
-65.0
-70.0
-75.0
-80.0
-85.0

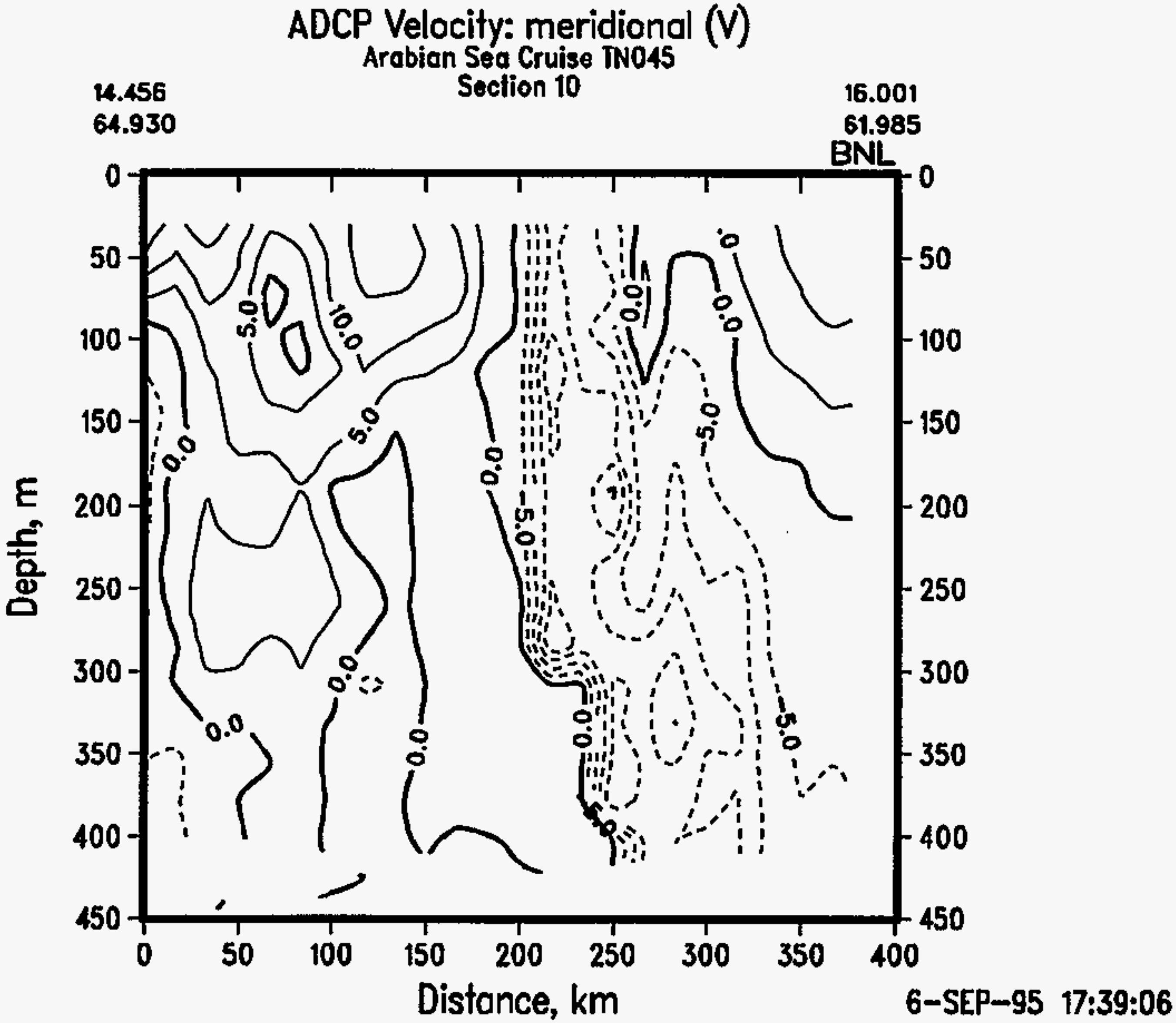

ADCP Velocity: zonal (U)
Arabian Sea Cruise TN045
Section 8
10.106
64.926
14.460
64.988
BNL
Depth, m
Distance, km
6-SEP-95 17:20:01

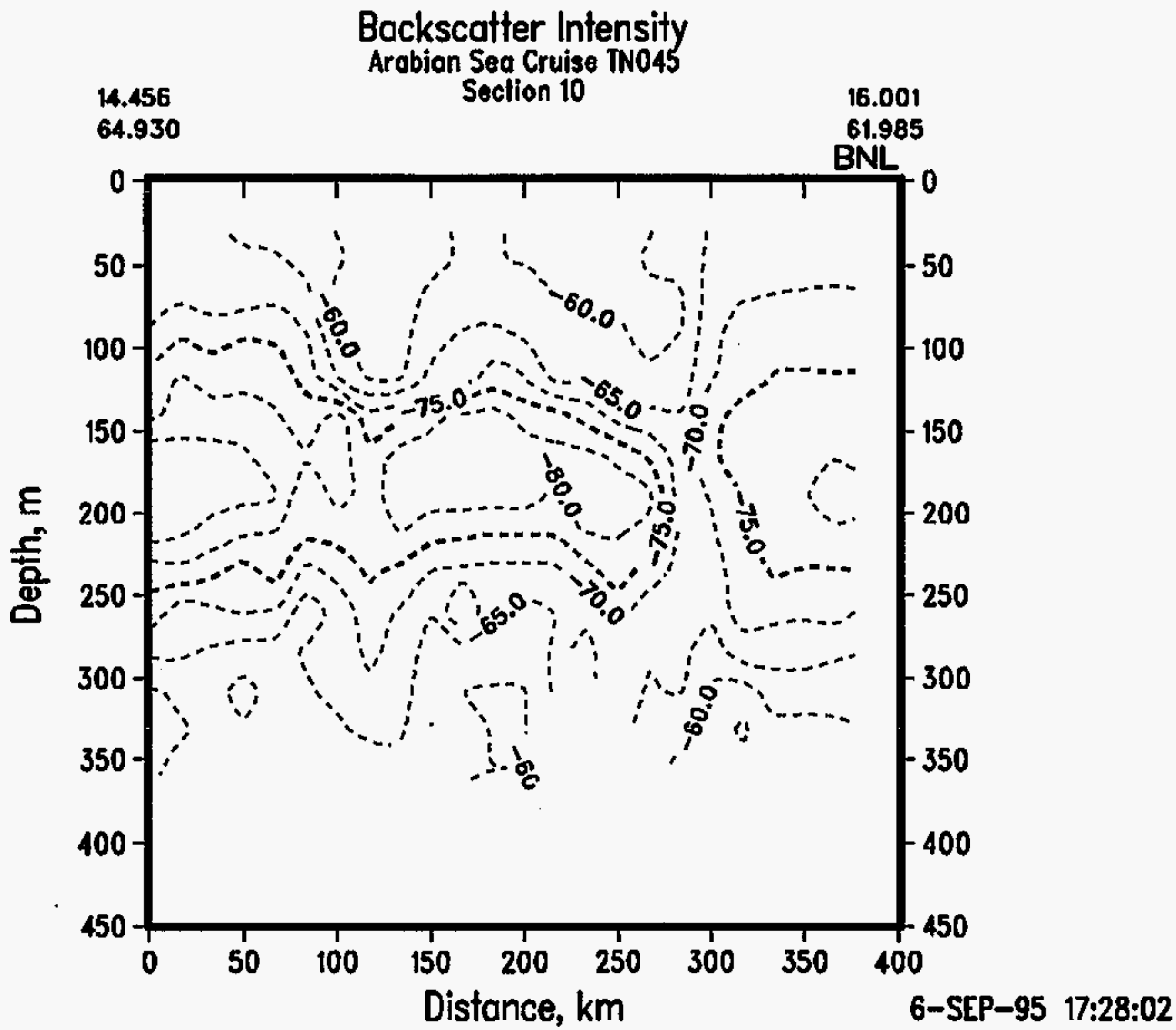
ADCP Velocity: meridional (V)
Arabian Sea Cruise TN045
Section 8

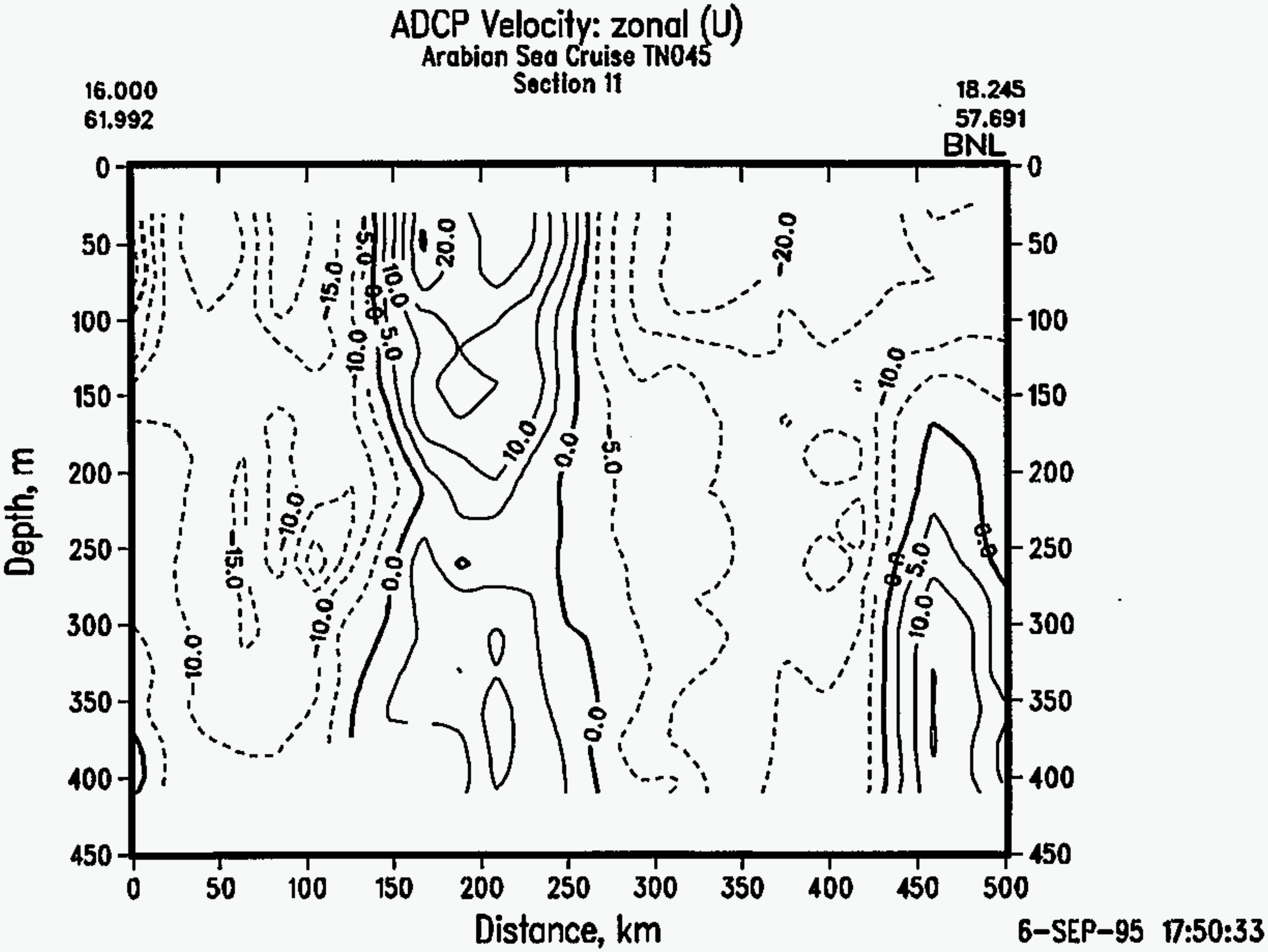



Backscatter Intensity
Arabian Sea Cruise TN045
Section 8
10.106
64.926
14.460
64.988
BNL
Depth, m
Distance, km
-75.0
-70.0
-65.0
-80.0
6-SEP-95 17:24:15

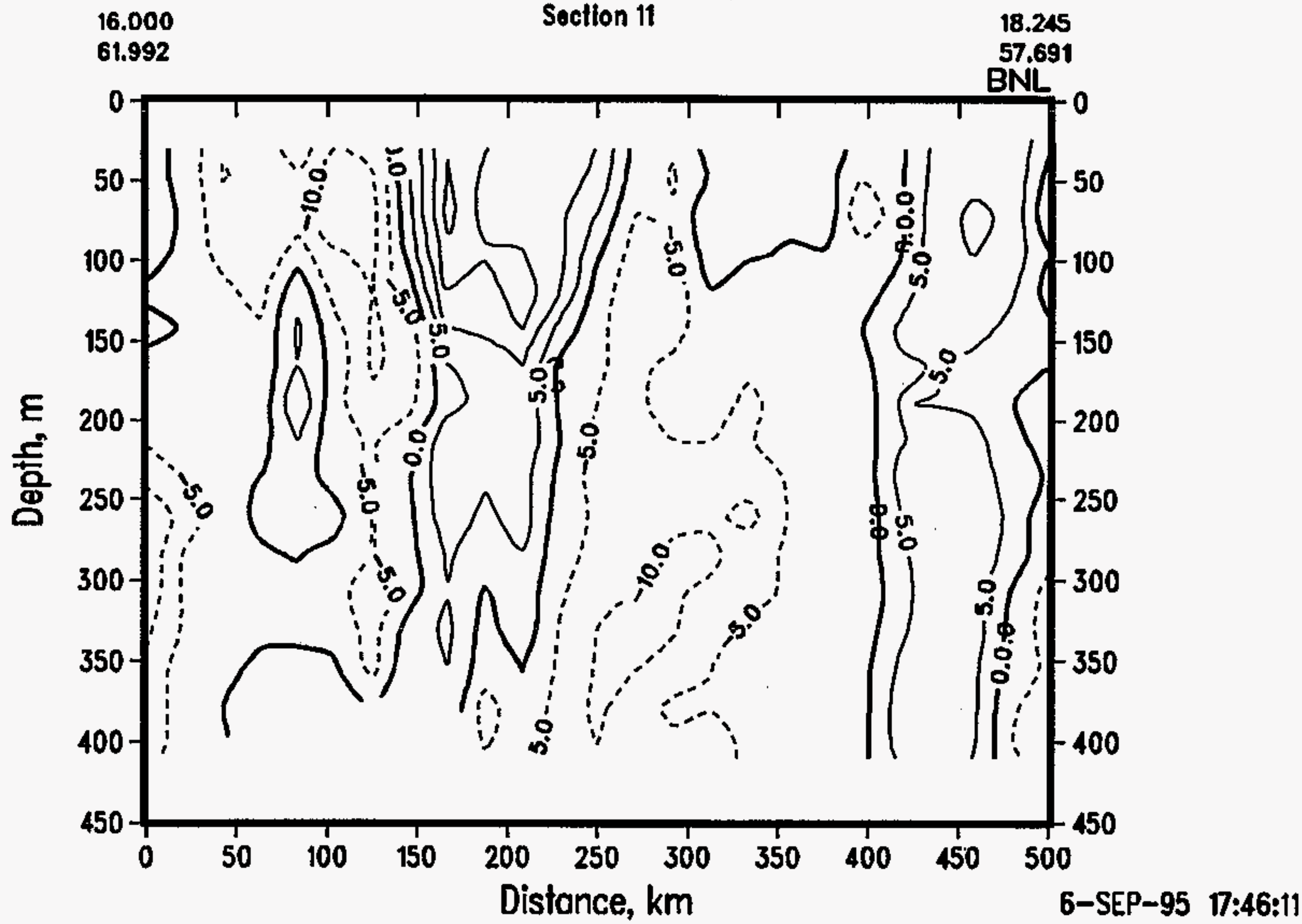

ADCP Velocity: zonal (U)
Arabian Sea Cruise TN045
Section 10
14.456
64.930
16.001
61.985
BNL
Depth, m
Distance, km
6-SEP-95 17:32:46

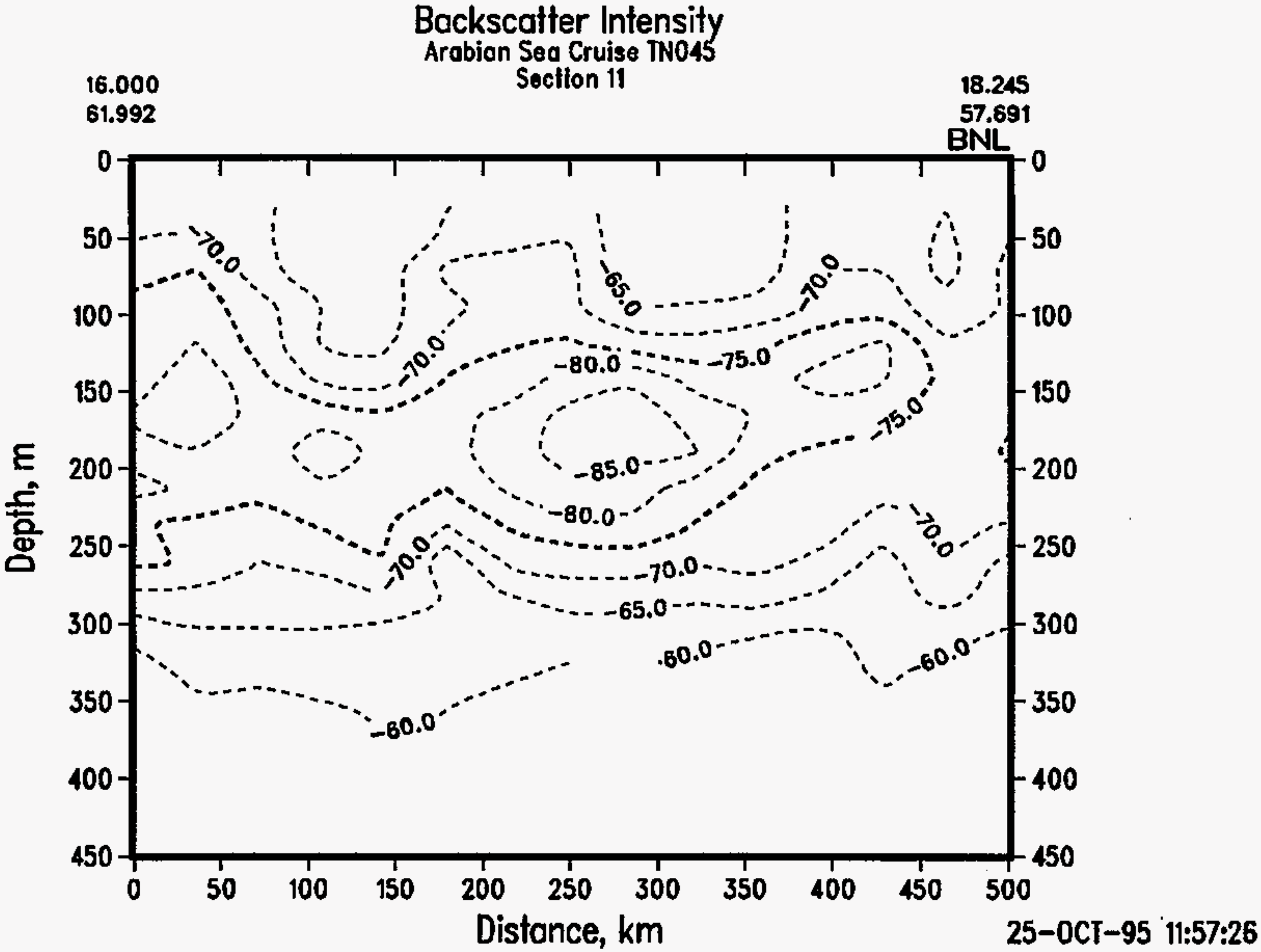

ADCP Velocity: meridional (V)
Arabian Sea Cruise TN045
Section 10
14.456
64.930
16.001
61.985
BNL
Depth, m
Distance, km
0 50 100 150 200 250 300 350 400 450
0 50 100 150 200 250 300 350 400
0.0
5.0
10.0
-5.0
6-SEP-95 17:39:06

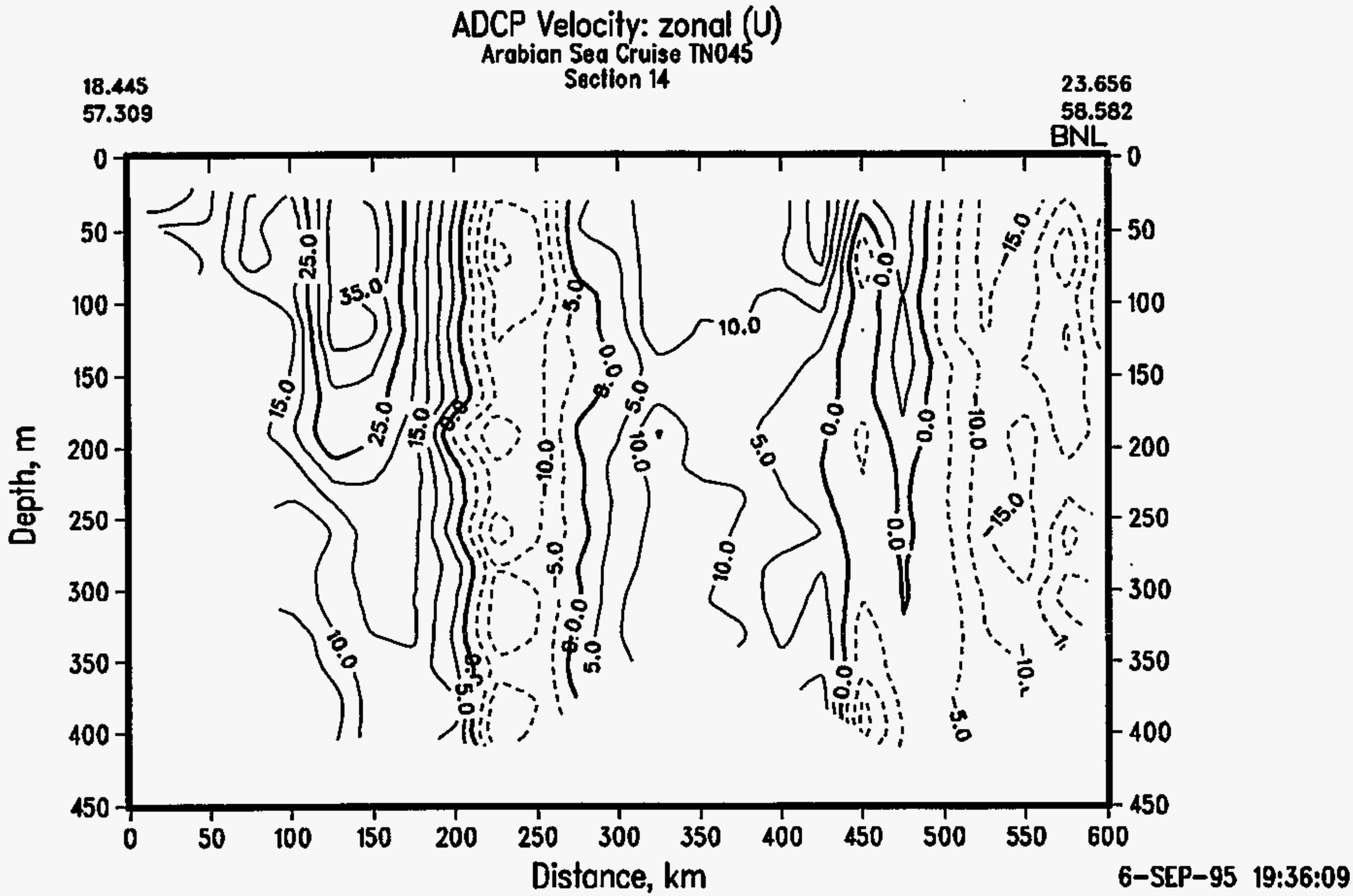

Backscatter Intensity
Arabian Sea Cruise TN045
Section 10
14.456
64.930
16.001
61.985
BNL
Depth, m
Distance, km
6-SEP-95 17:28:02


ADCP Velocity: zonal (U)
Arabian Sea Cruise TN045
Section 11
16.000
61.992
18.245
57.691
BNL
Depth, m
Distance, km
6-SEP-95 17:50:33

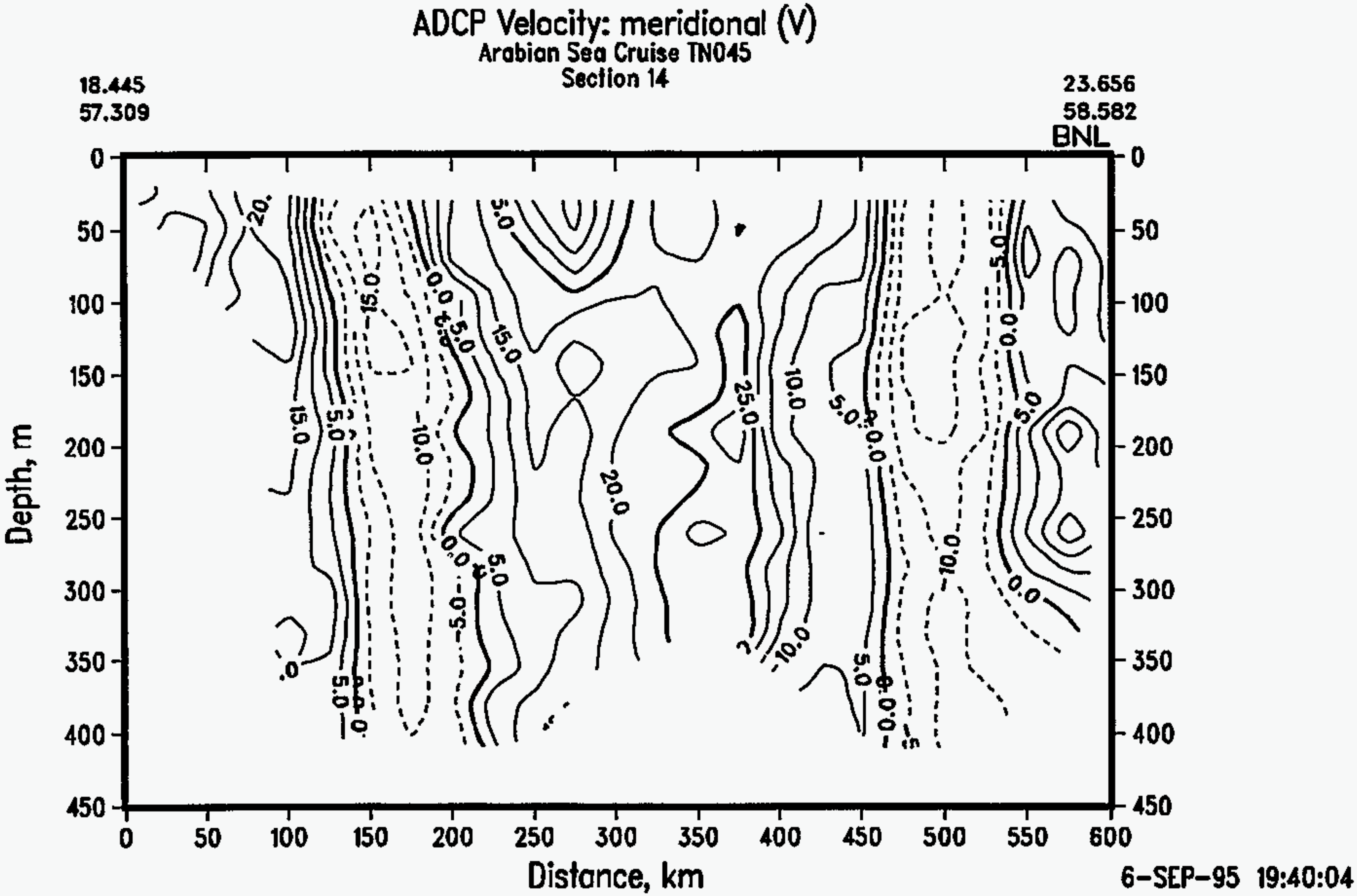
ADCP Velocity: meridional (V)
Arabian Sea Cruise TN045
Section 11

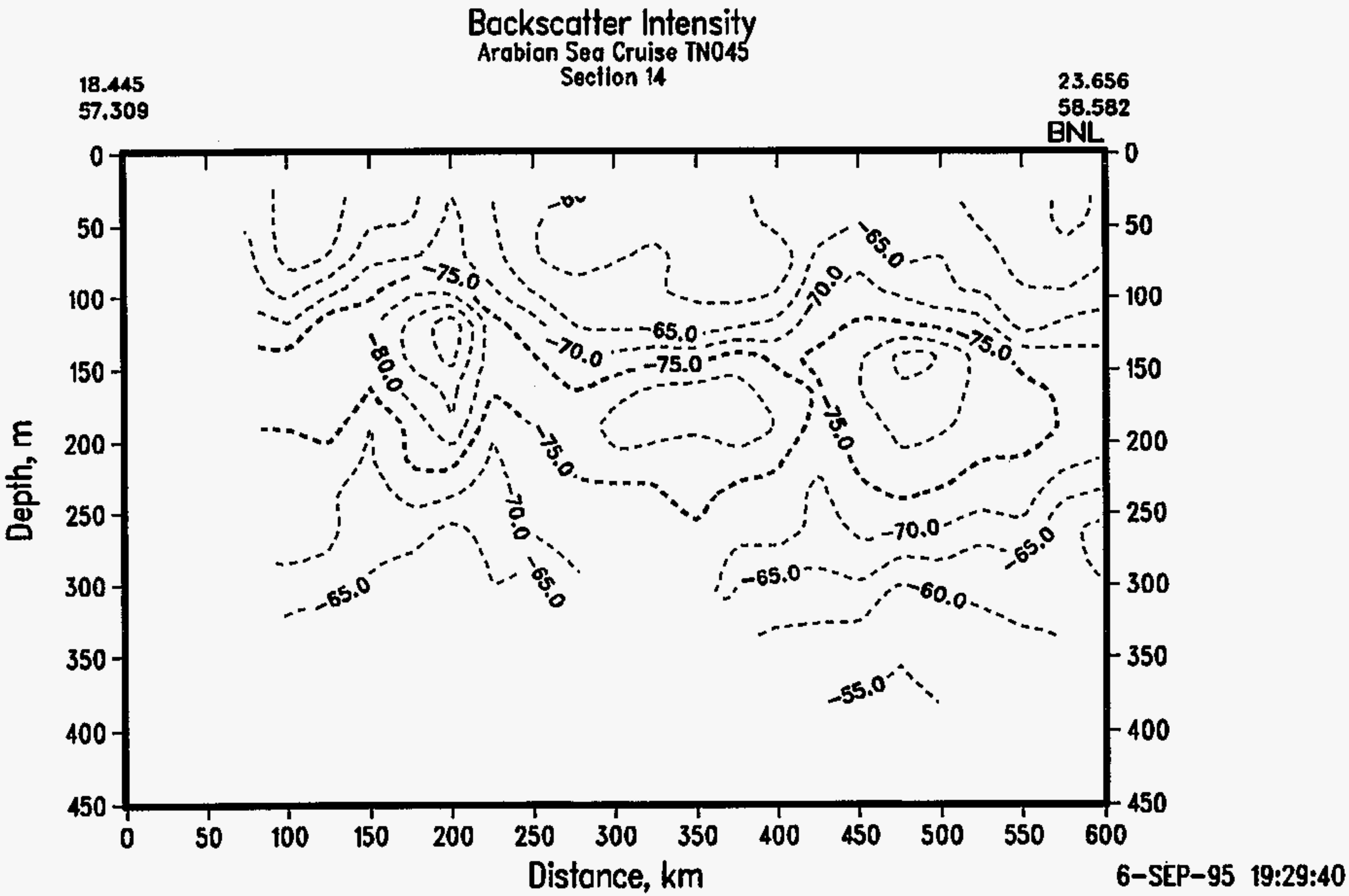



Backscatter Intensity
Arabian Sea Cruise TN045
Section 11
16.000
61.992
18.245
57.691
BNL
Depth, m
Distance, km
-60.0
-65.0
-70.0
-75.0
-80.0
-85.0
25-OCT-95 11:57:26

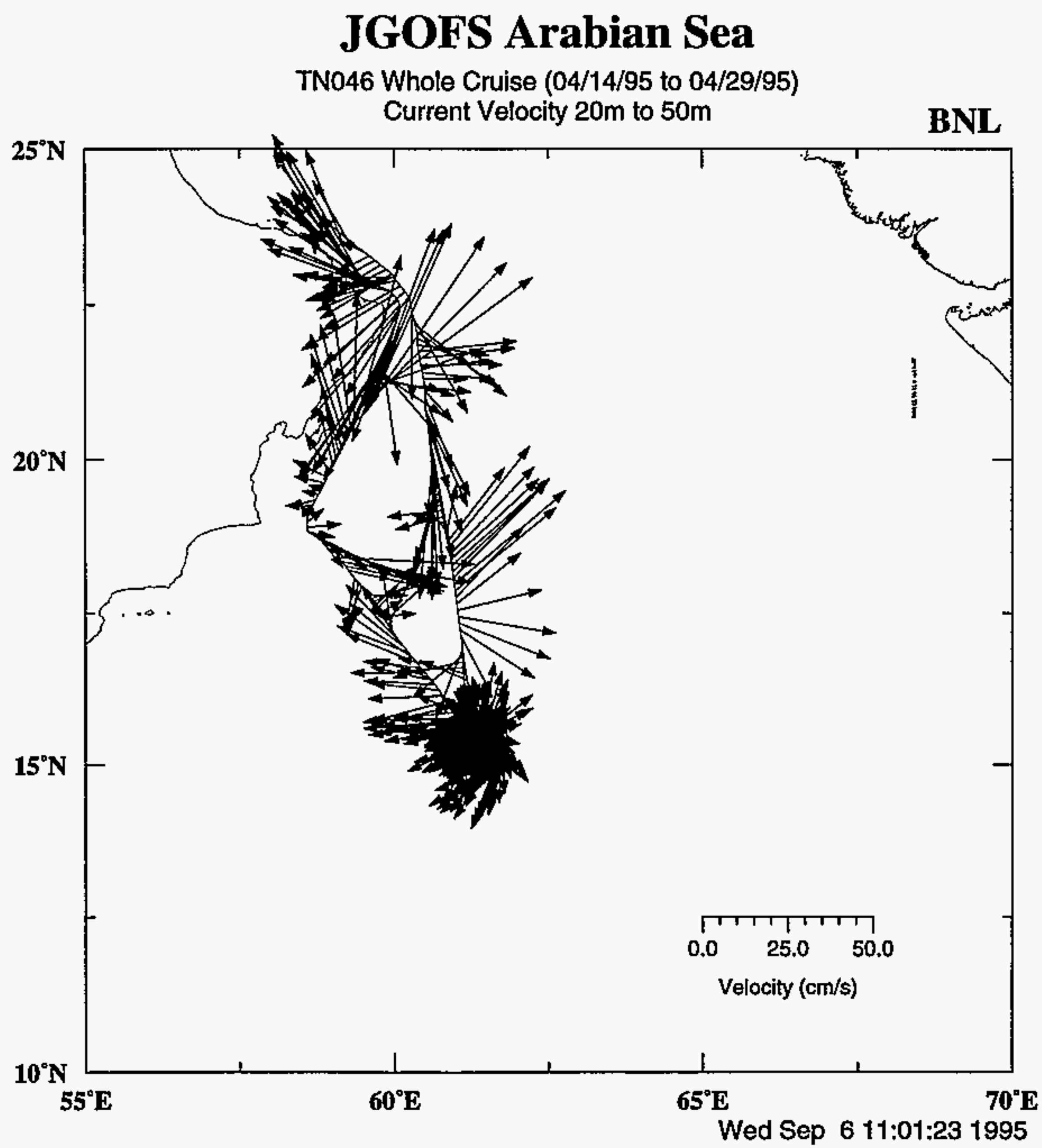


ADCP Velocity: zonal (U)
Arabian Sea Cruise TN045
Section 14
18.445
57.309
23.656
58.582
BNL
Depth, m
Distance, km
6-SEP-95 19:36:09


ADCP Velocity: meridional (V)
Arabian Sea Cruise TN045
Section 14
18.445
57.309
23.656
58.582
BNL
Depth, m
Distance, km
6-SEP-95 19:40:04

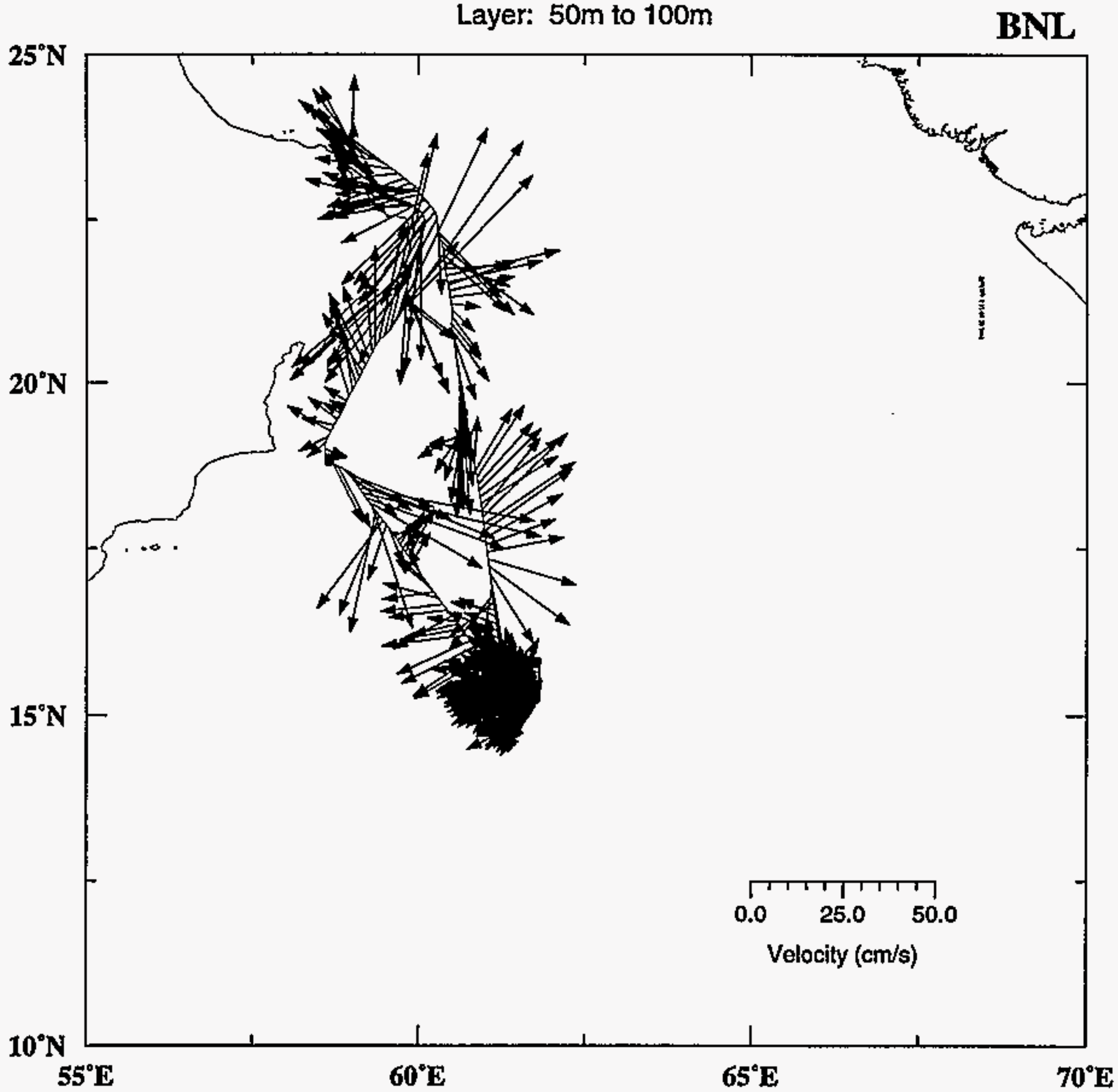

Backscatter Intensity
Arabian Sea Cruise TN045
Section 14
18.445
57.309
23.656
58.582
BNL
Depth, m
Distance, km
0
50
100
150
200
250
300
350
400
450
500
550
600
-65.0
-70.0
-75.0
-80.0
-60.0
-55.0
6-SEP-95 19:29:40

# TN046

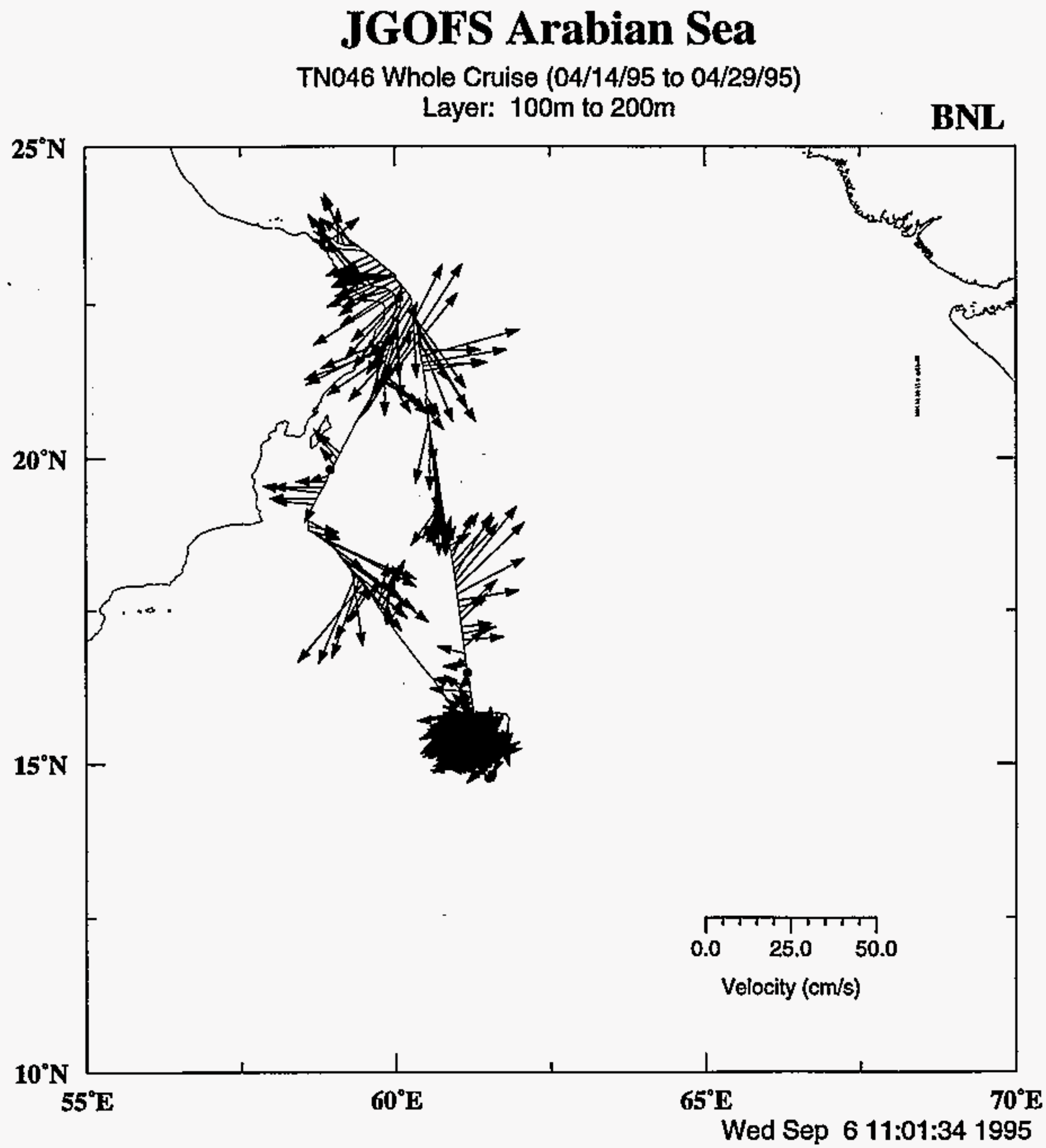

JGOFS Arabian Sea
TN046 Whole Cruise (04/14/95 to 04/29/95)
Current Velocity 20m to 50m
BNL
25°N
20°N
15°N
10°N
55°E
60°E
65°E
70°E
0.0
25.0
50.0
Velocity (cm/s)
Wed Sep 6 11:01:23 1995

# JGOFS Arabian Sea

TN046 Whole Cruise (04/14/95 to 04/29/95)
Layer:  50m to 100m

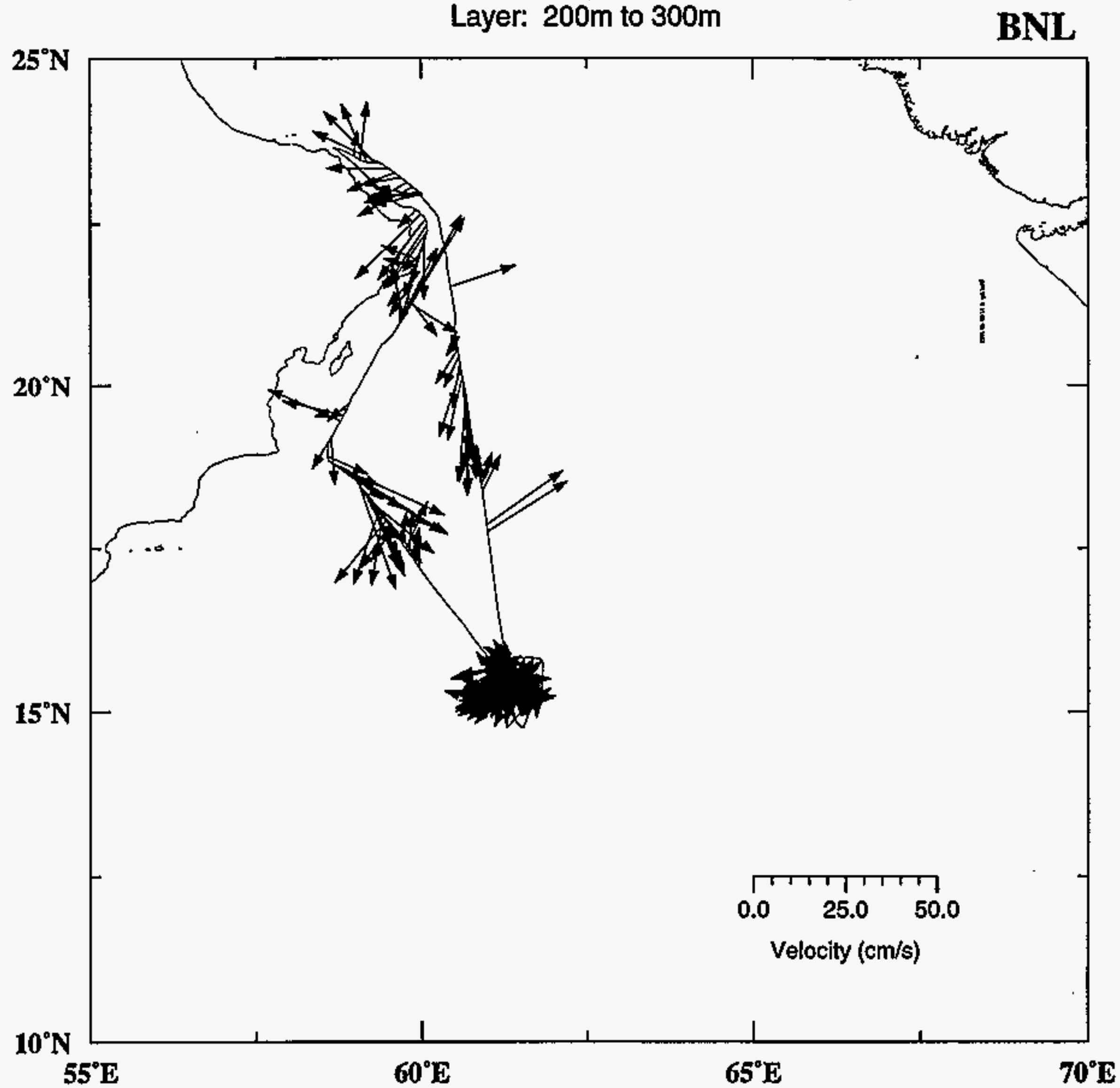



Wed Sep  6 11:01:28 1995


JGOFS Arabian Sea
TN046 Whole Cruise (04/14/95 to 04/29/95)
Layer: 100m to 200m
BNL
25°N
20°N
15°N
10°N
55°E
60°E
65°E
70°E
0.0
25.0
50.0
Velocity (cm/s)
Wed Sep 6 11:01:34 1995

# JGOFS Arabian Sea

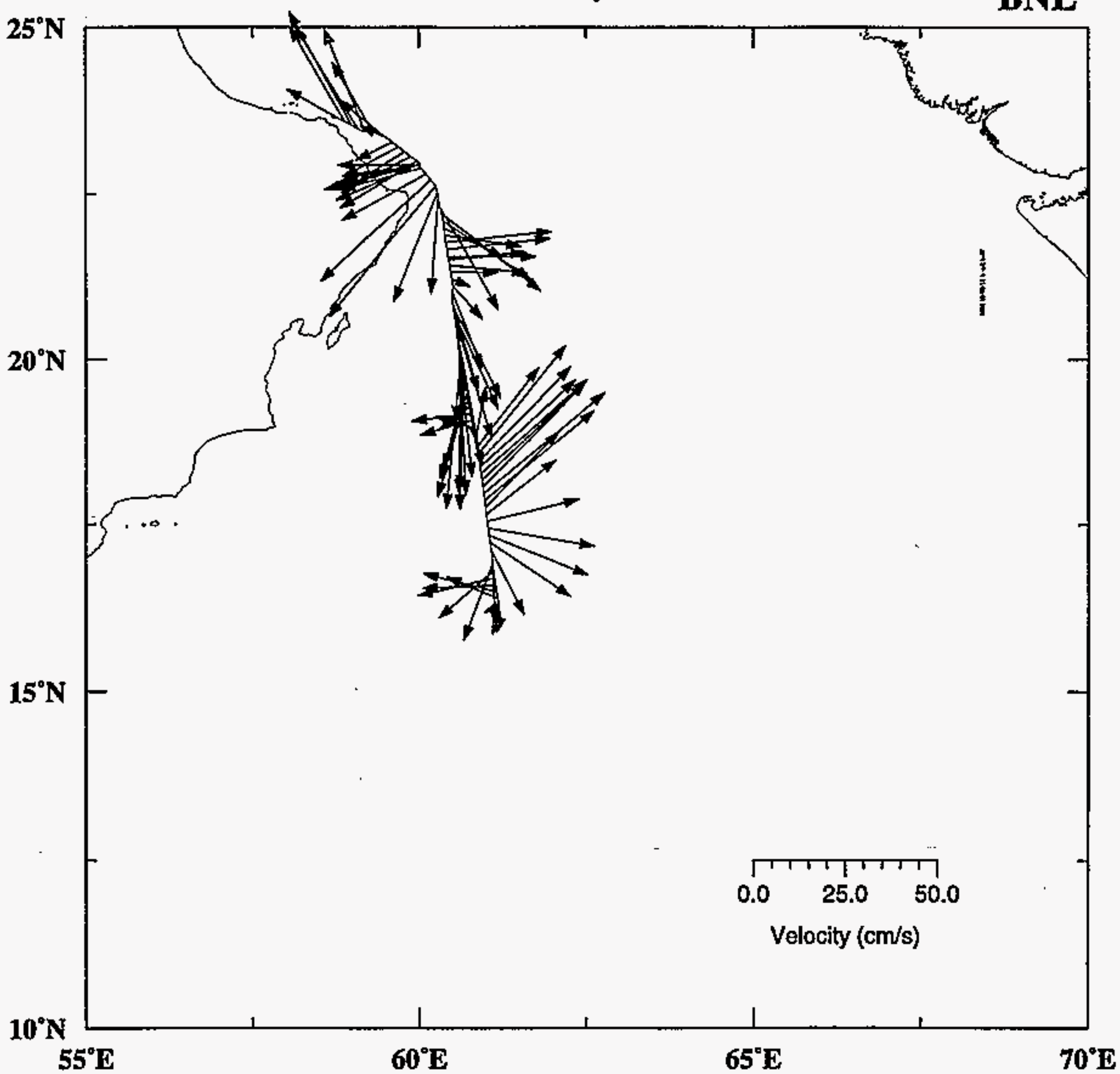
TN046 Whole Cruise (04/14/95 to 04/29/95)
Layer: 200m to 300m



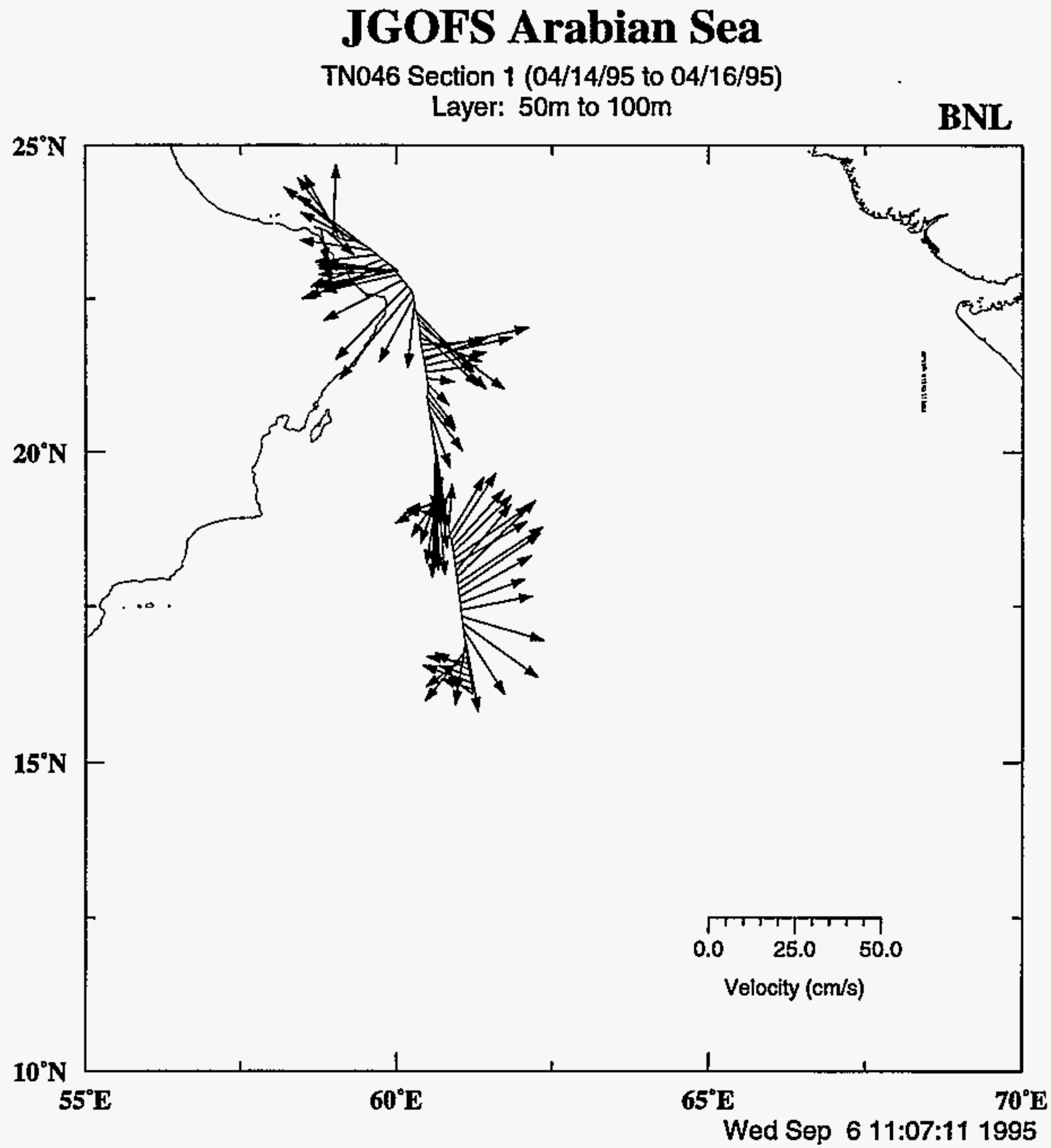

Wed Sep 6 11:01:40 1995

# JGOFS Arabian Sea

TN046 Section 1 (04/14/95 to 04/16/95)
Current Velocity 20m to 50m

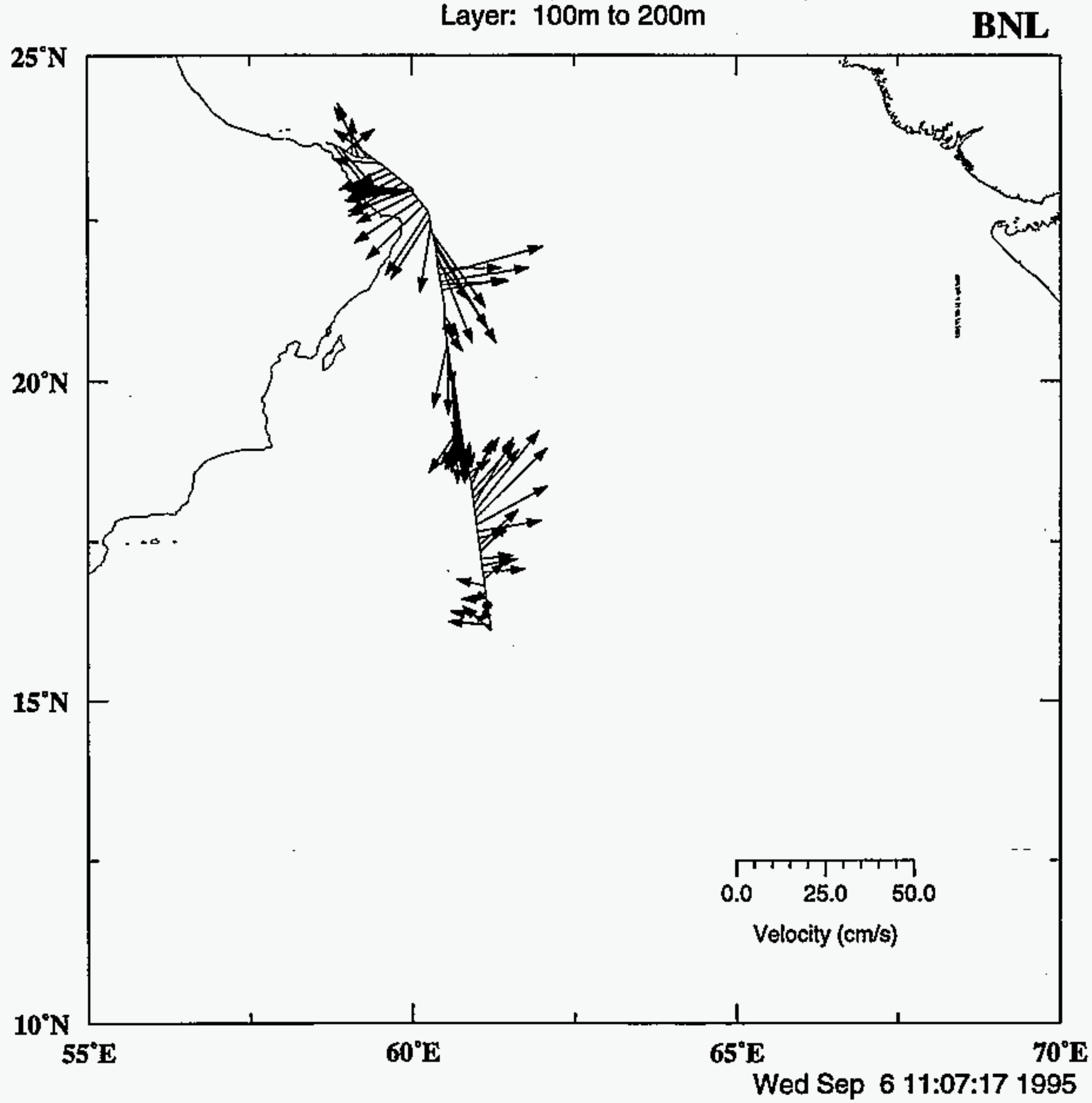


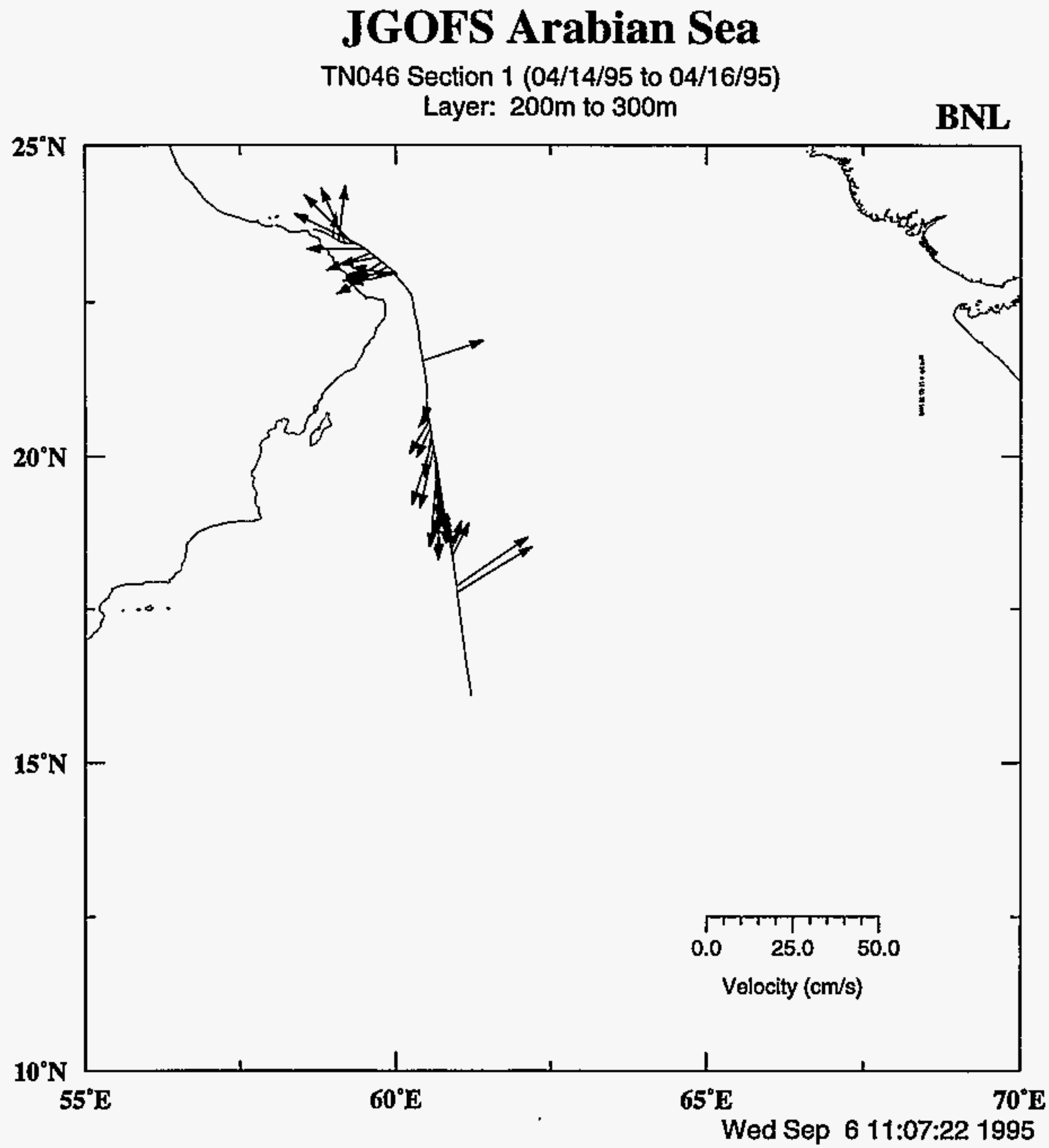

Wed Sep 6 11:07:06 1995


JGOFS Arabian Sea
TN046 Section 1 (04/14/95 to 04/16/95)
Layer: 50m to 100m
BNL
25°N
20°N
15°N
10°N
55°E
60°E
65°E
70°E
0.0
25.0
50.0
Velocity (cm/s)
Wed Sep 6 11:07:11 1995

# JGOFS Arabian Sea

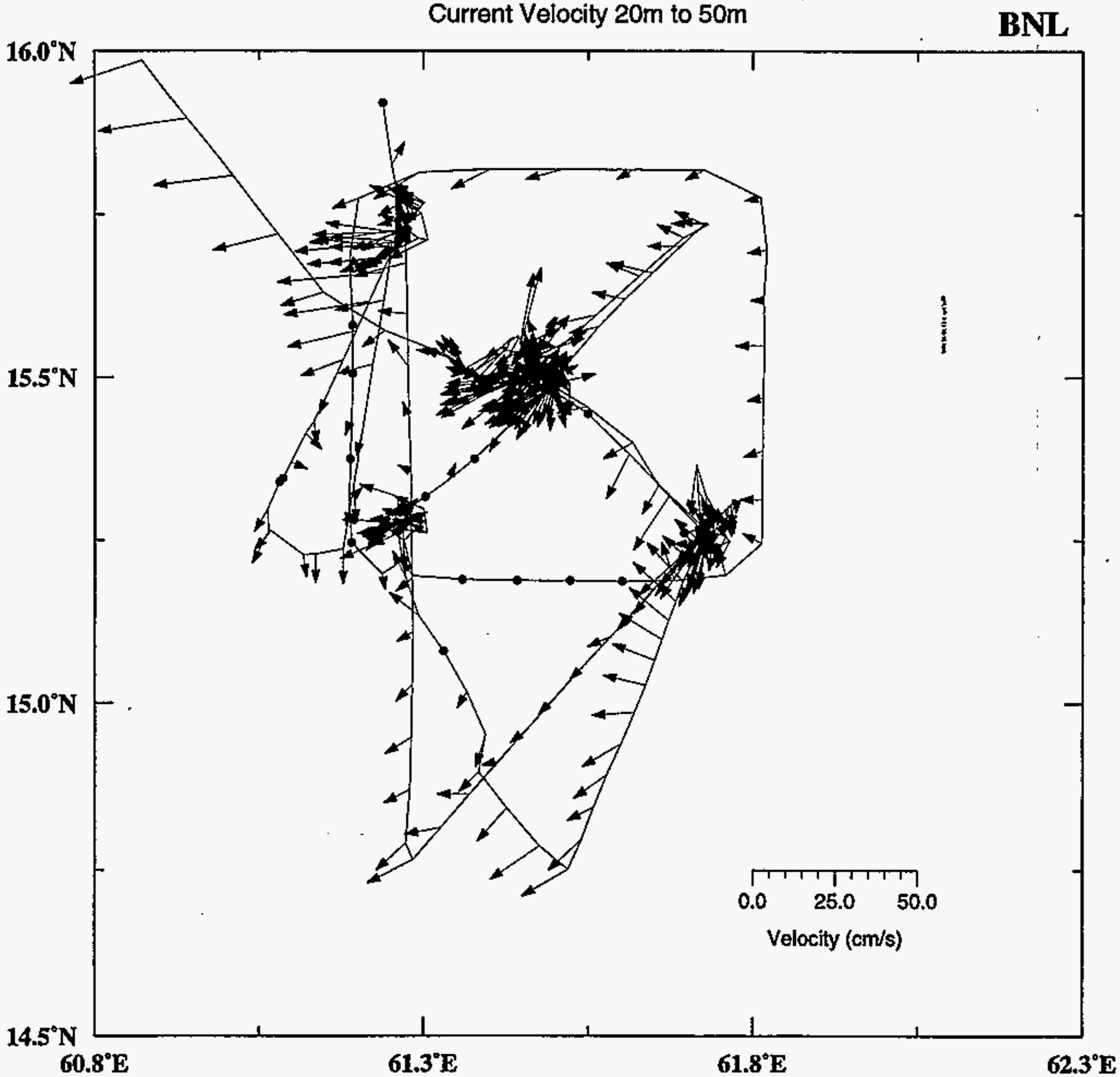
TN046 Section 1 (04/14/95 to 04/16/95)
Layer: 100m to 200m




JGOFS Arabian Sea
TN046 Section 1 (04/14/95 to 04/16/95)
Layer: 200m to 300m
BNL
25°N
20°N
15°N
10°N
55°E
60°E
65°E
70°E
0.0
25.0
50.0
Velocity (cm/s)
Wed Sep 6 11:07:22 1995

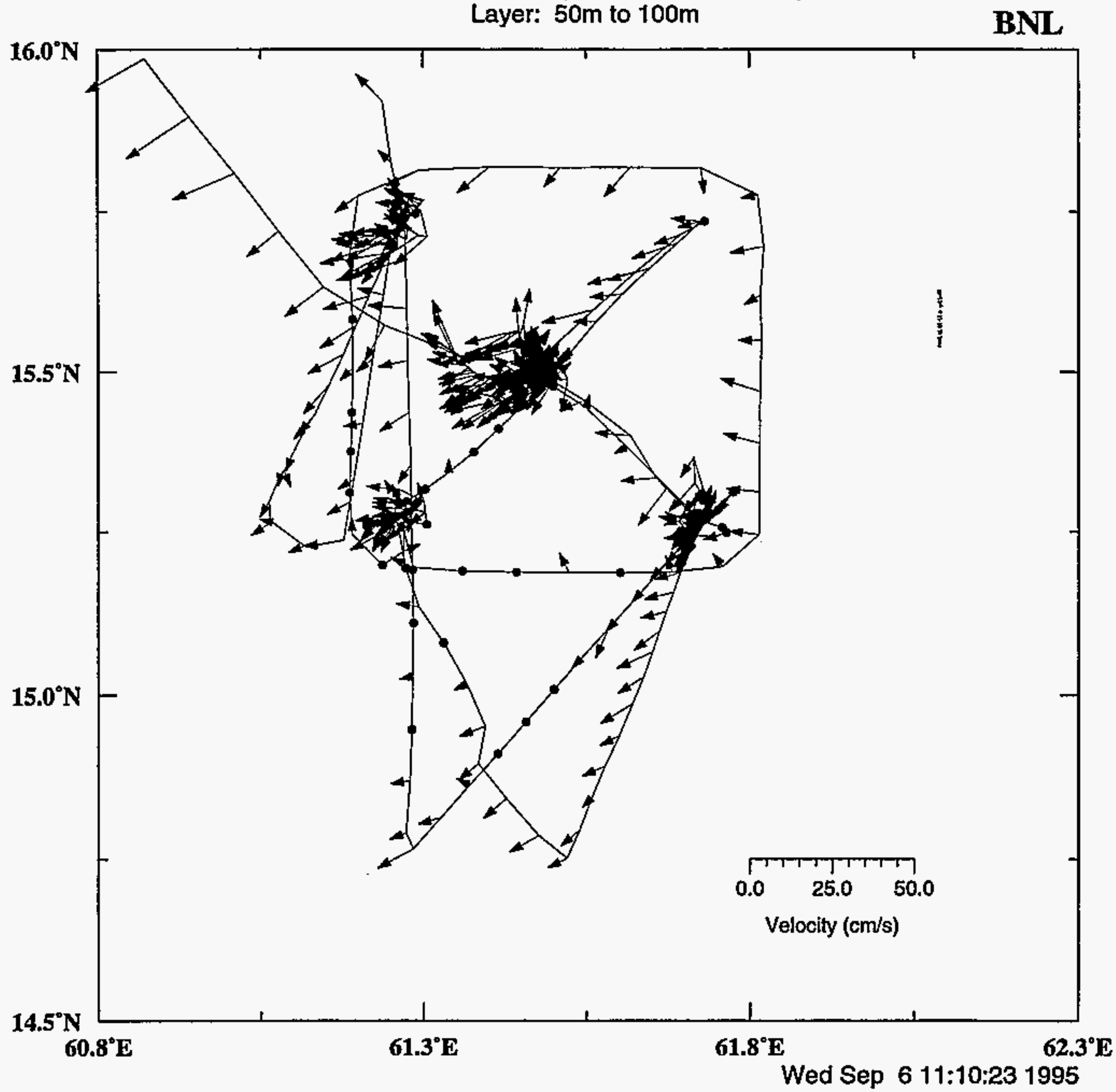
# JGOFS Arabian Sea

TN046 Section 2 (04/16/95 to 04/26/95)
Current Velocity 20m to 50m



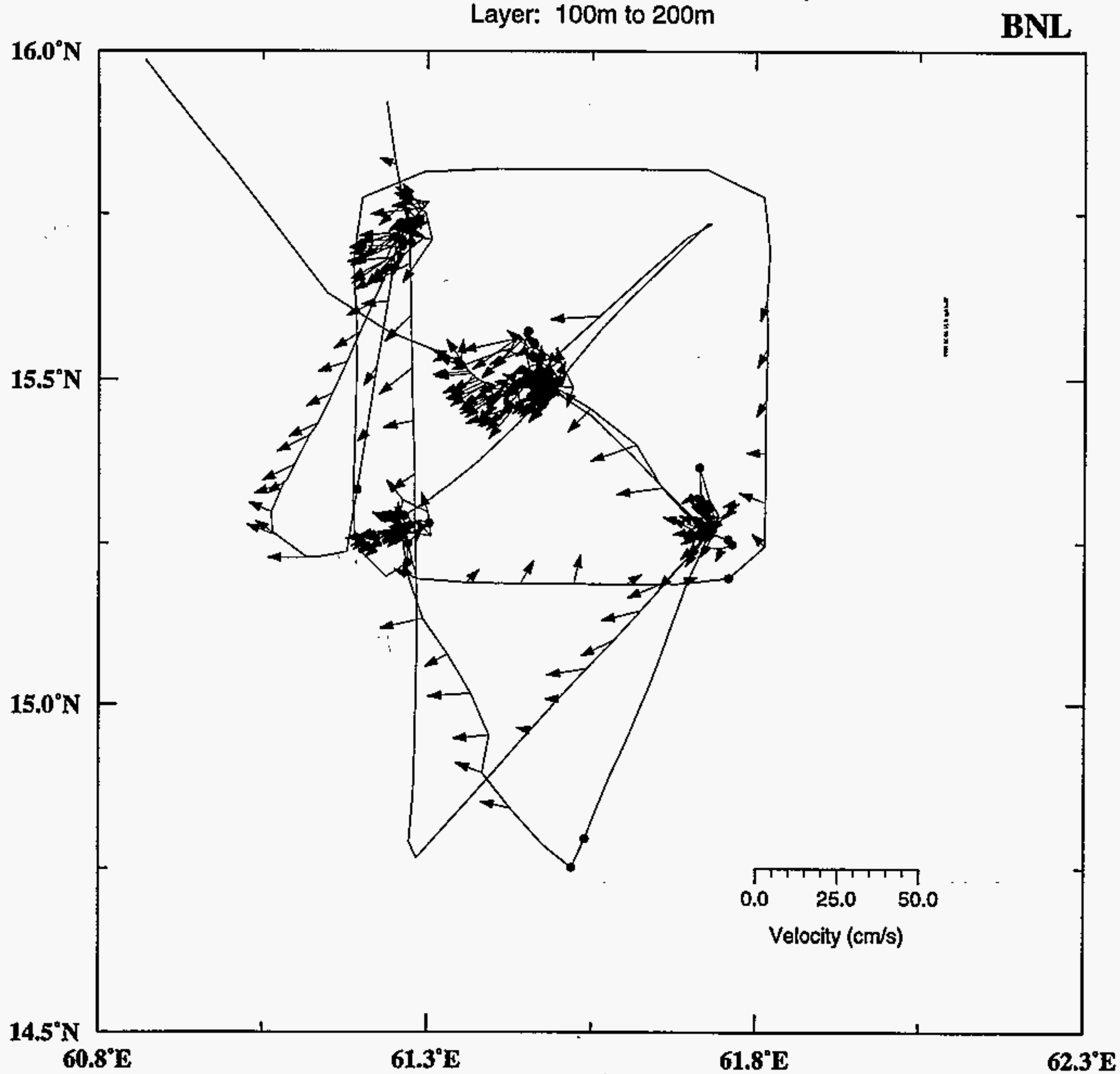
# JGOFS Arabian Sea

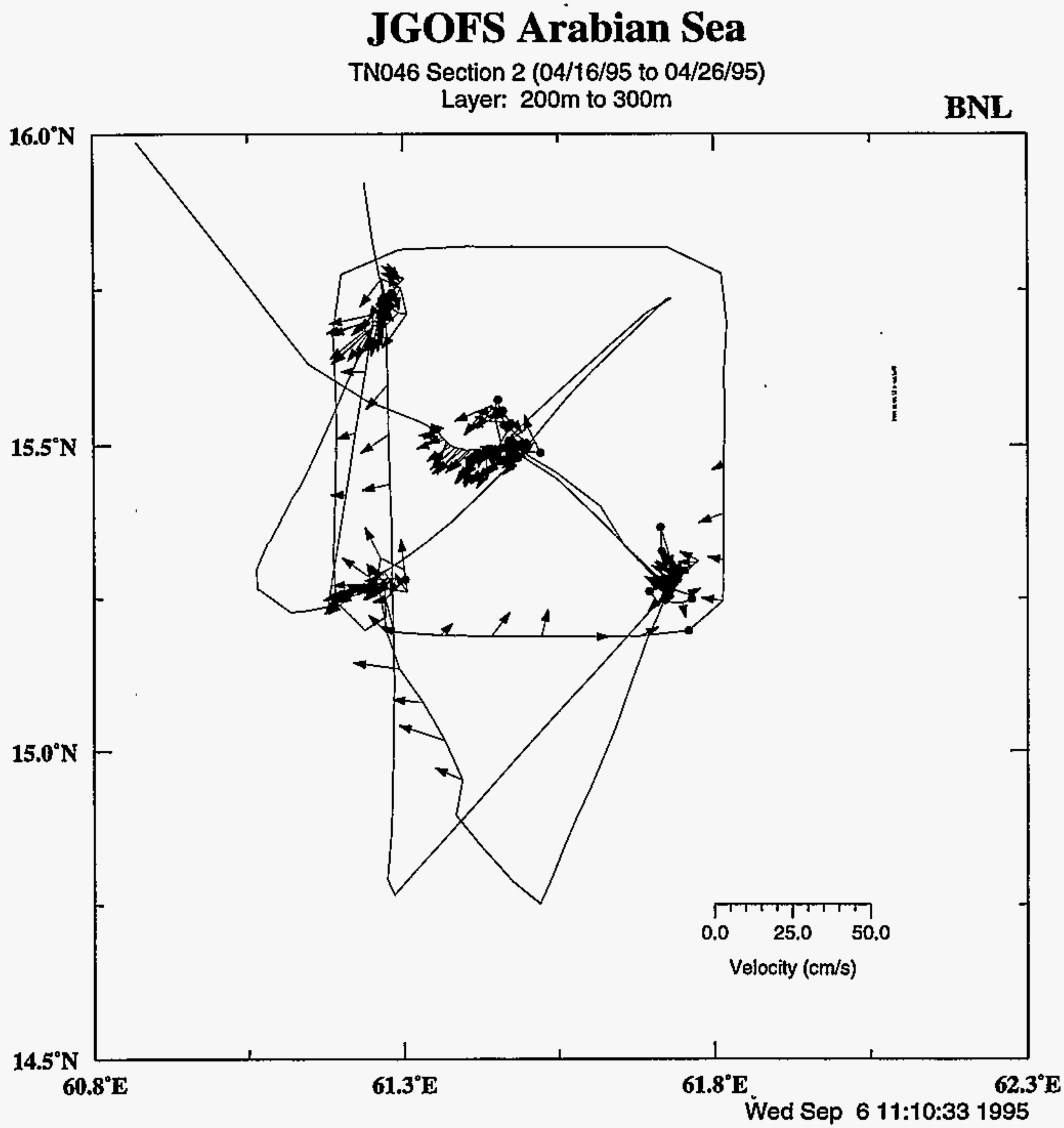
TN046 Section 2 (04/16/95 to 04/26/95)
Layer: 50m to 100m

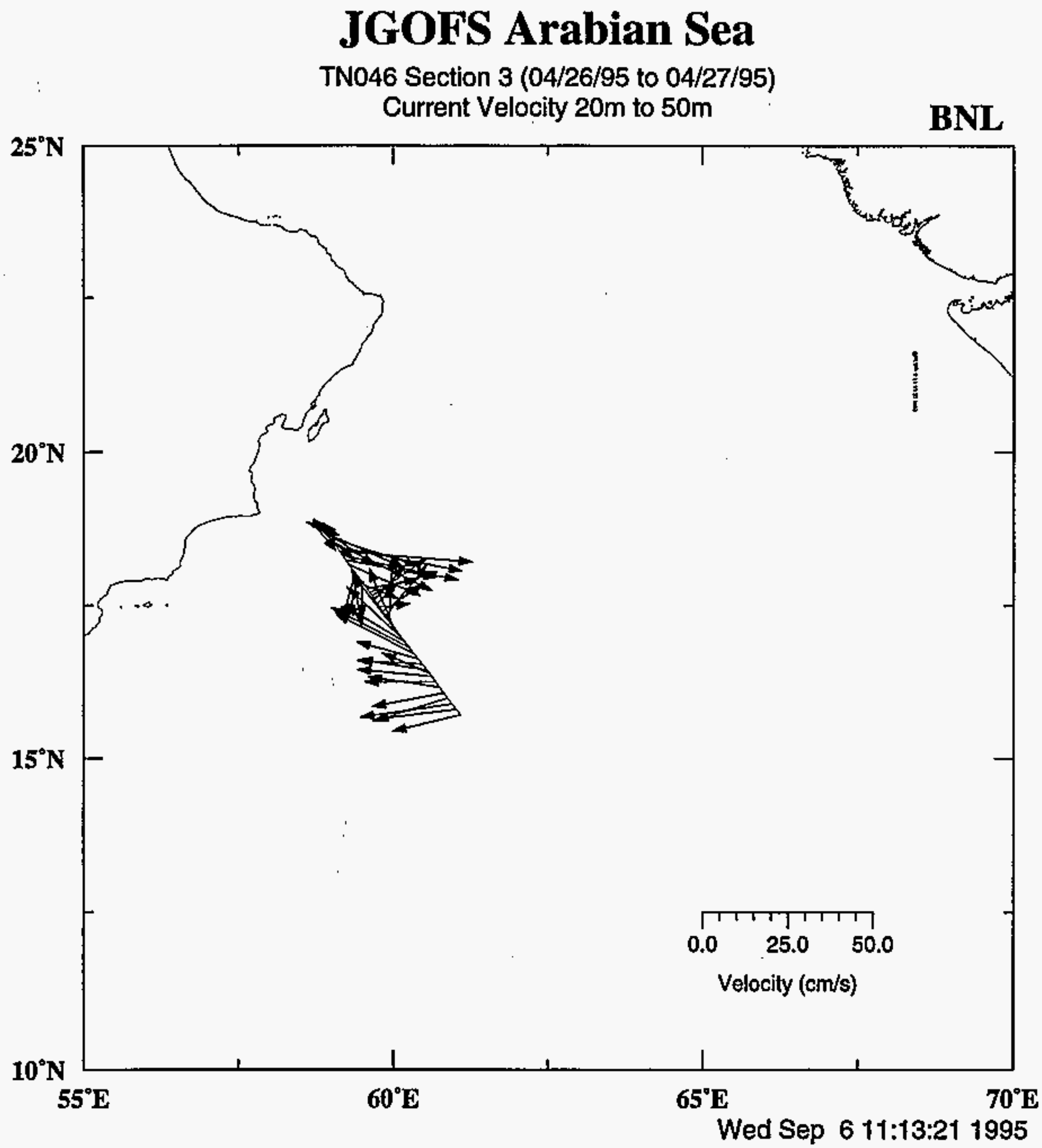


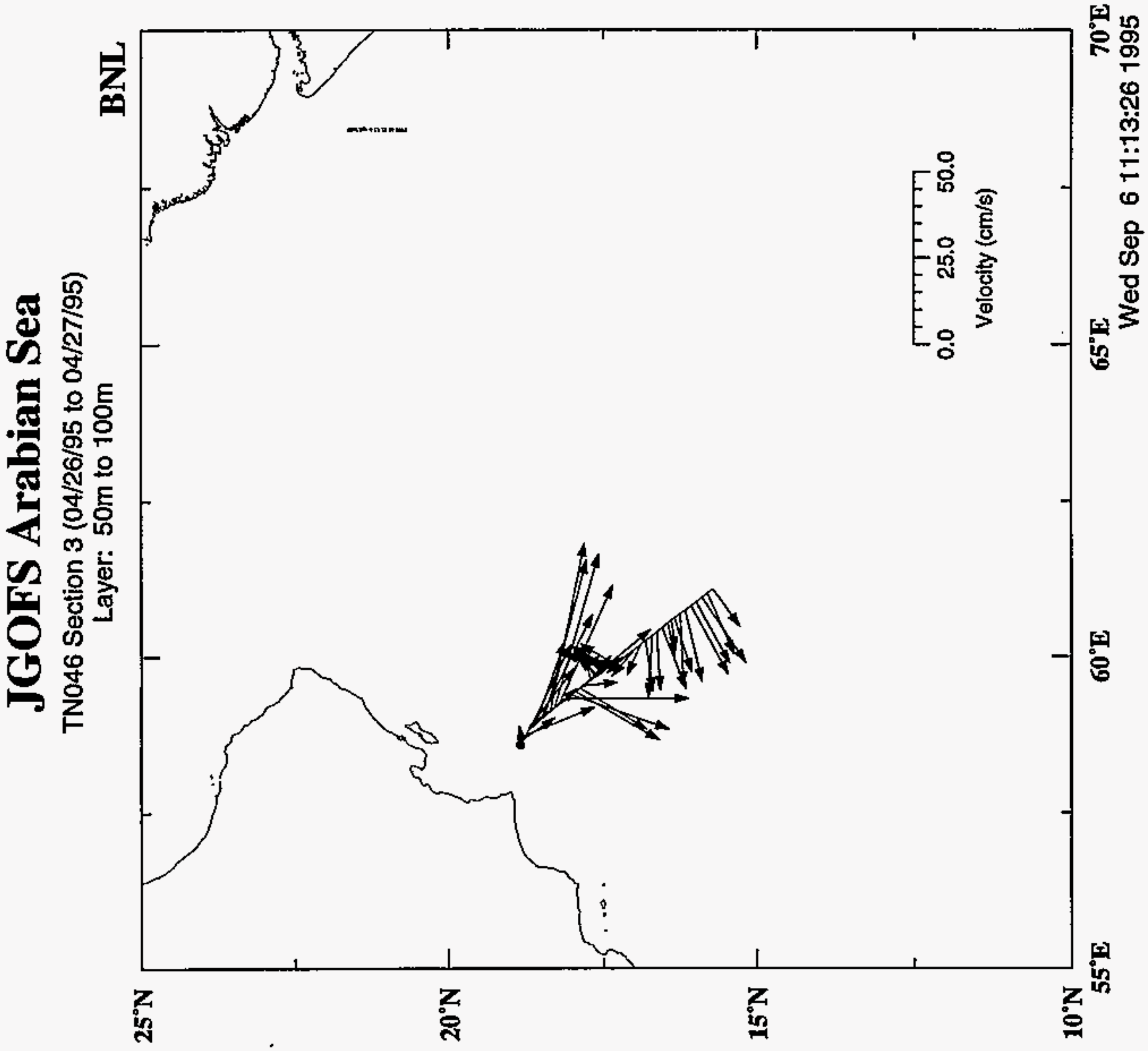
# JGOFS Arabian Sea

TN046 Section 2 (04/16/95 to 04/26/95)
Layer: 100m to 200m




JGOFS Arabian Sea
TN046 Section 2 (04/16/95 to 04/26/95)
Layer: 200m to 300m
BNL
16.0°N
15.5°N
15.0°N
14.5°N
60.8°E
61.3°E
61.8°E
62.3°E
0.0
25.0
50.0
Velocity (cm/s)
Wed Sep 6 11:10:33 1995

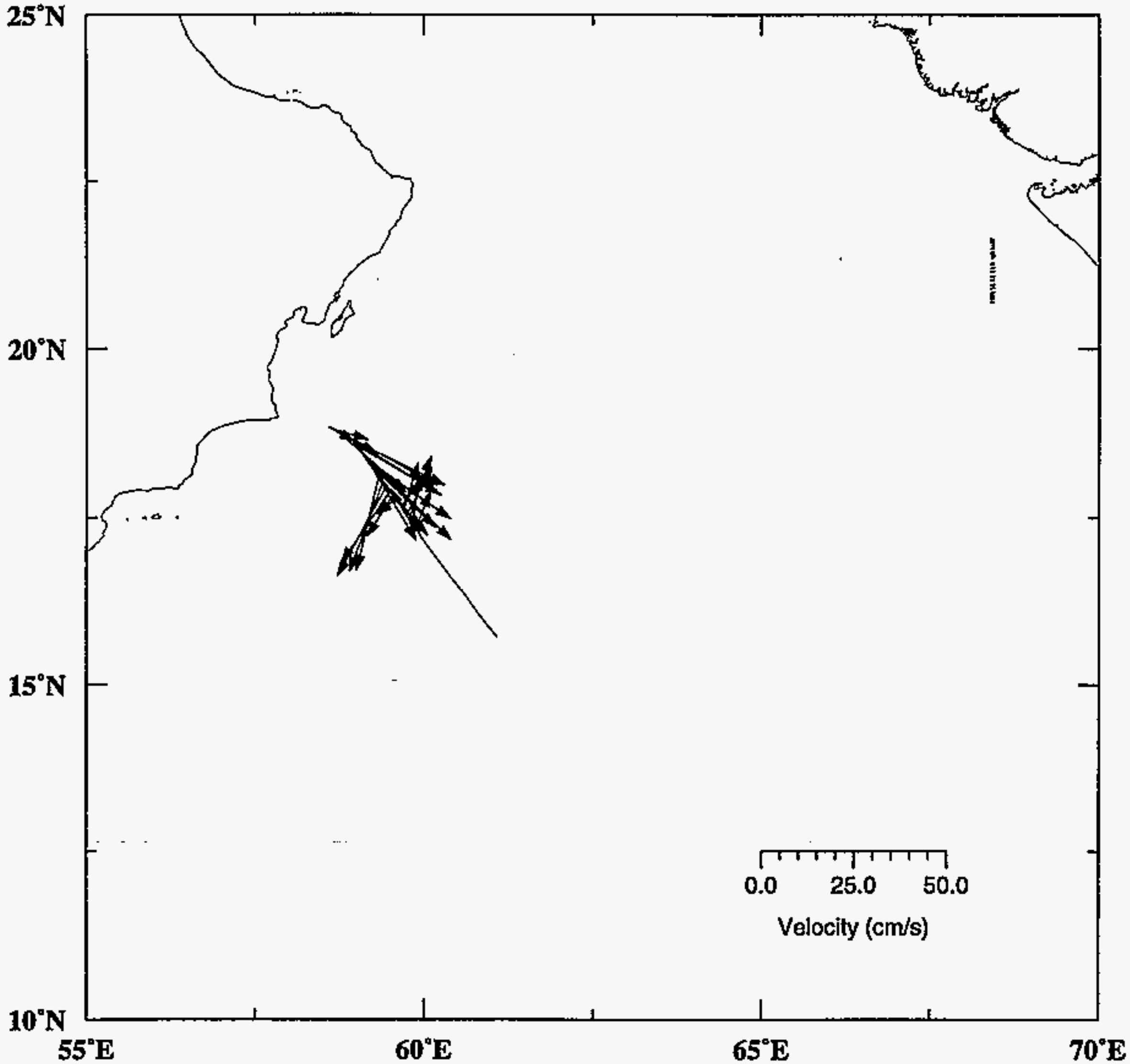

JGOFS Arabian Sea
TN046 Section 3 (04/26/95 to 04/27/95)
Current Velocity 20m to 50m
BNL
25°N
20°N
15°N
10°N
55°E
60°E
65°E
70°E
0.0
25.0
50.0
Velocity (cm/s)
Wed Sep 6 11:13:21 1995


JGOFS Arabian Sea
TN046 Section 3 (04/26/95 to 04/27/95)
Layer: 50m to 100m
BNL
25°N
20°N
15°N
10°N
55°E
60°E
65°E
70°E
0.0
25.0
50.0
Velocity (cm/s)
Wed Sep 6 11:13:26 1995

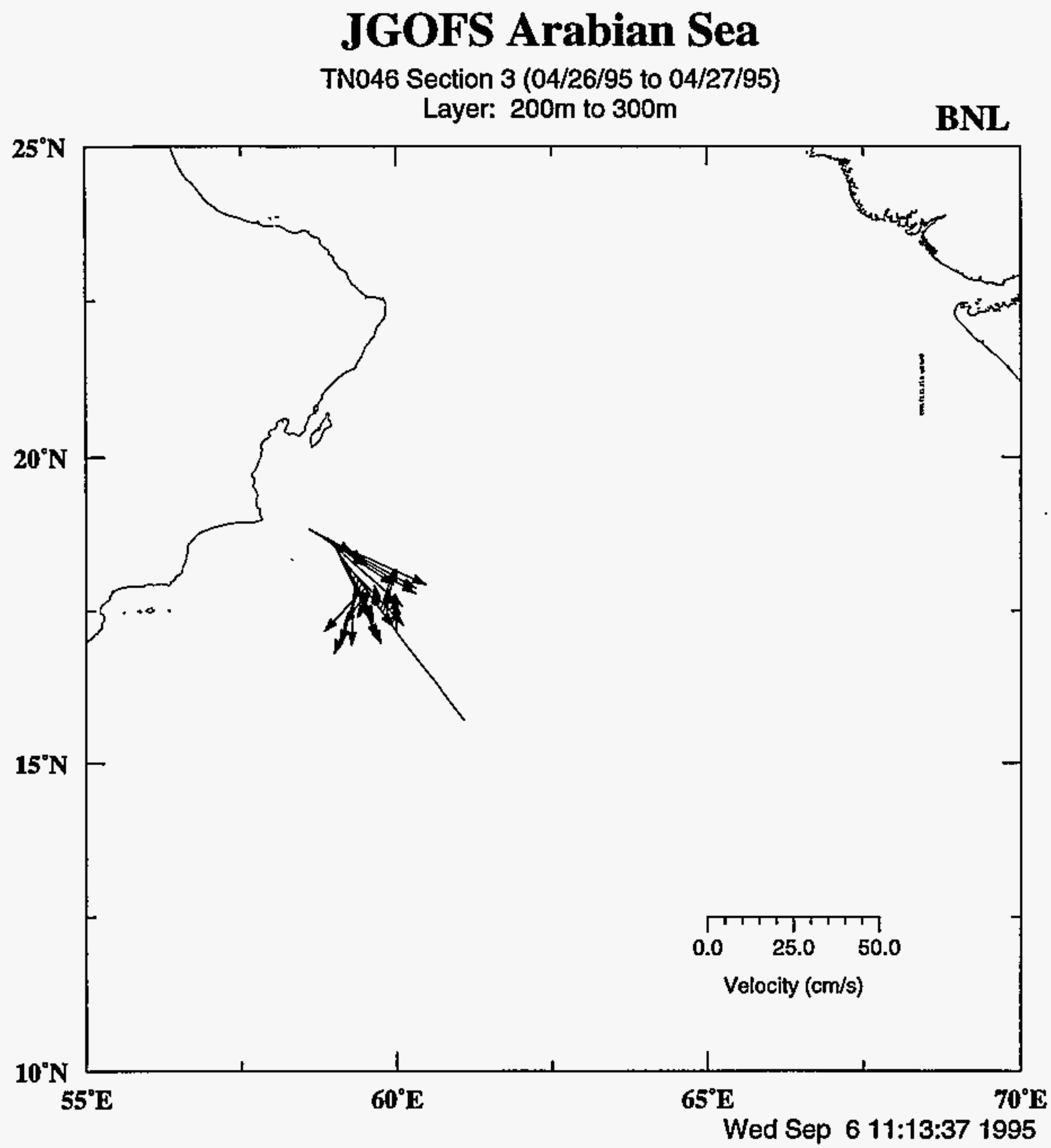
# JGOFS Arabian Sea

TN046 Section 3 (04/26/95 to 04/27/95)
Layer: 100m to 200m

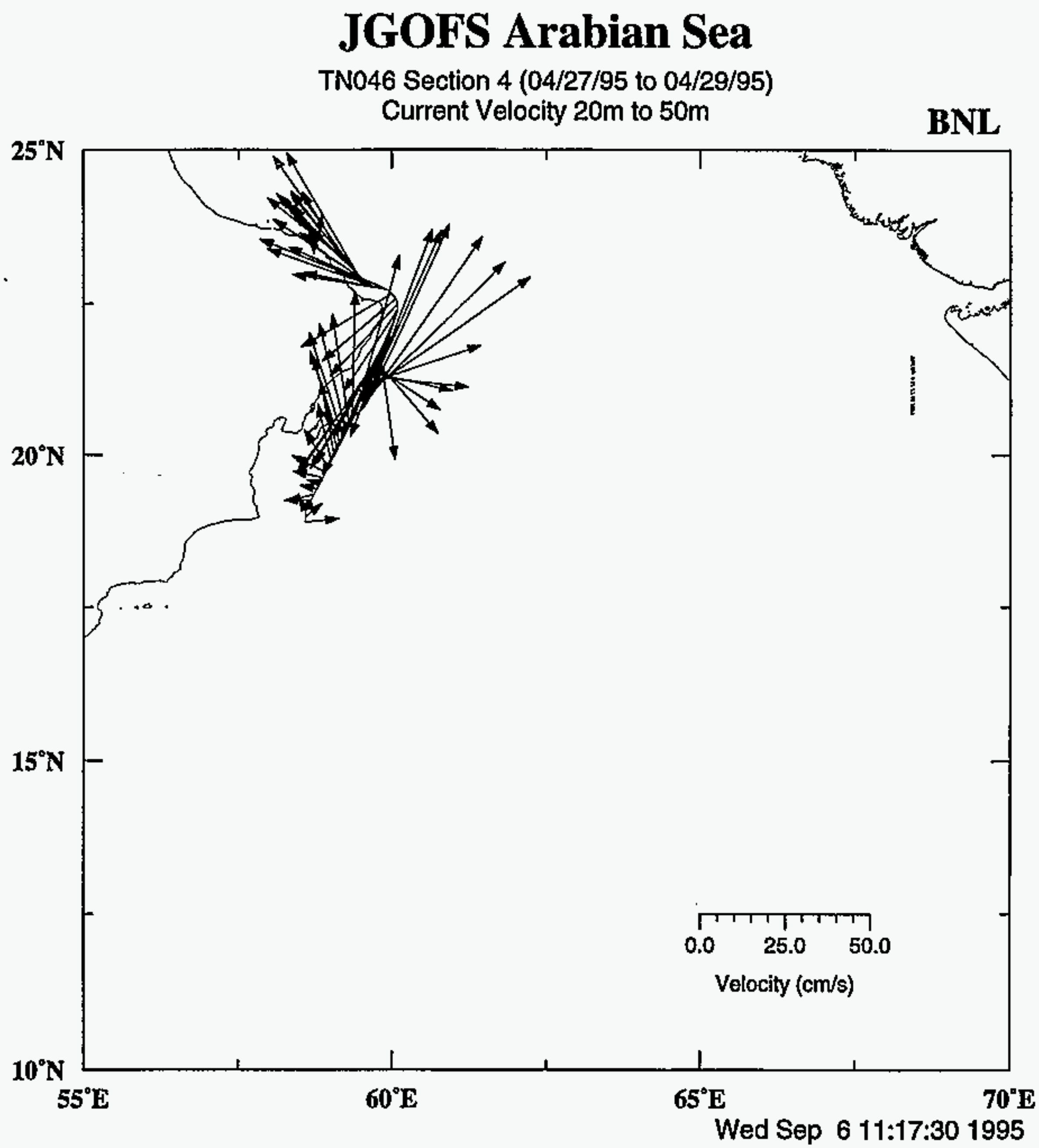
BNL




Wed Sep 6 11:13:31 1995

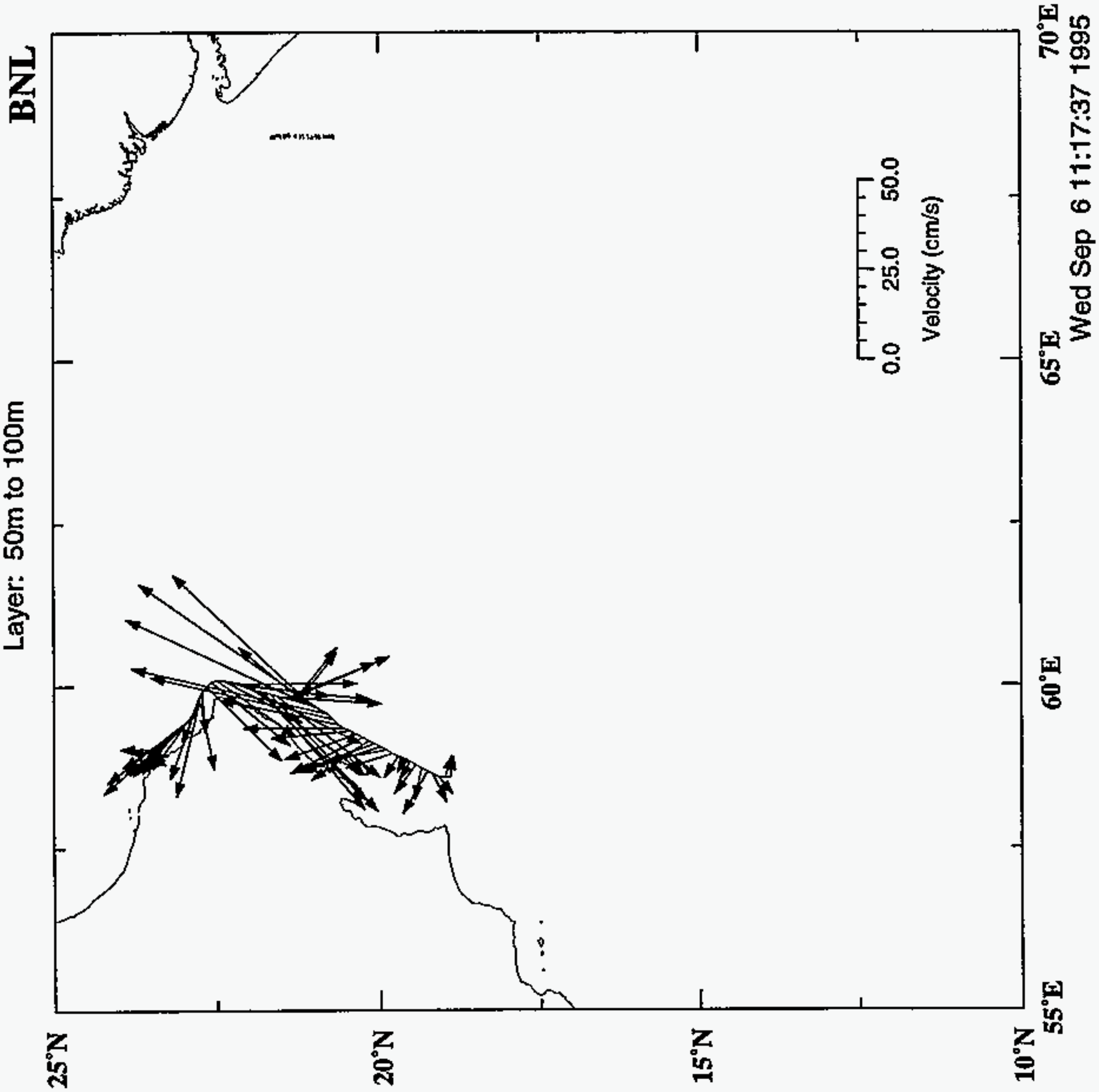


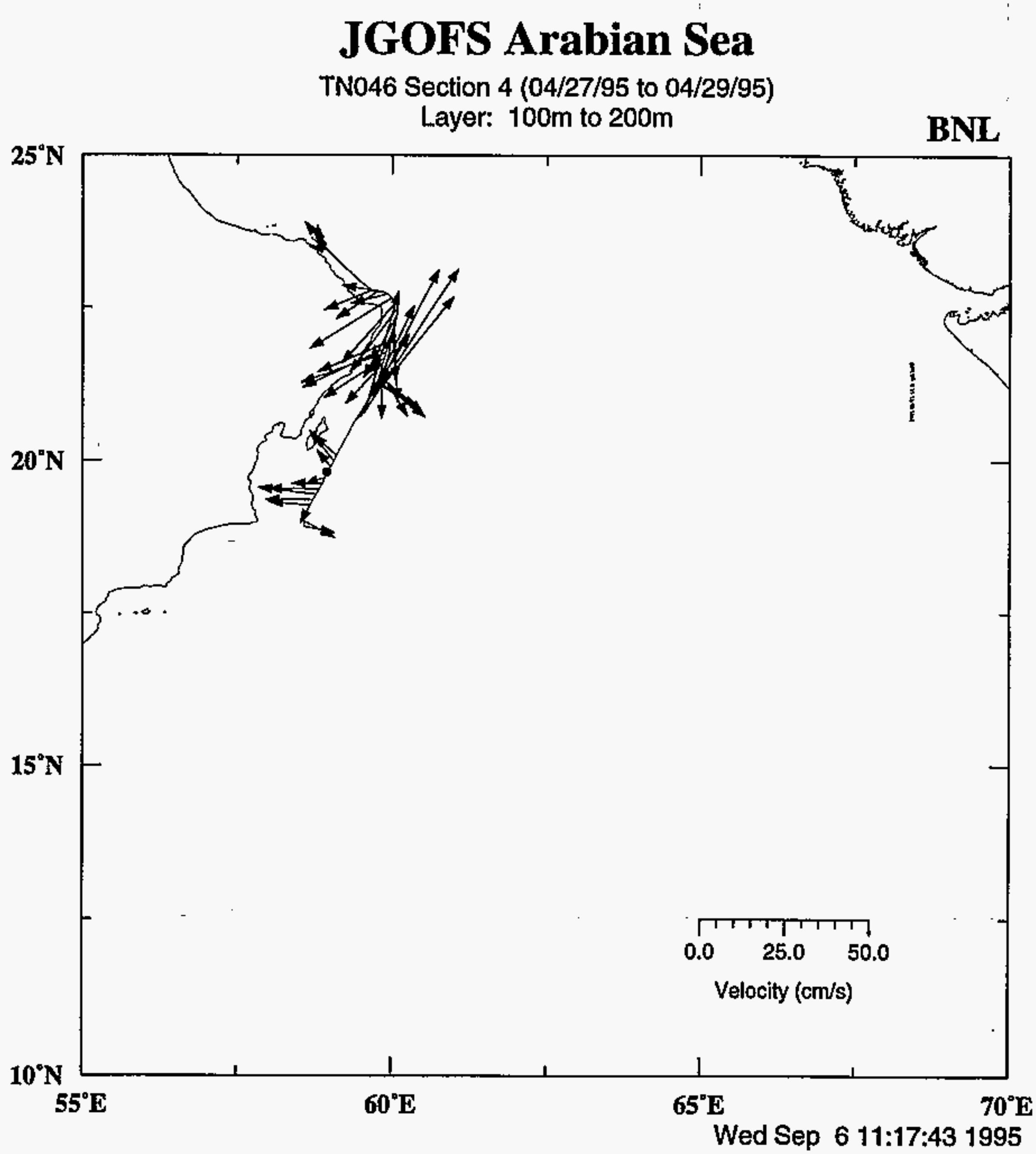
JGOFS Arabian Sea
TN046 Section 3 (04/26/95 to 04/27/95)
Layer: 200m to 300m
BNL
25°N
20°N
15°N
10°N
55°E
60°E
65°E
70°E
0.0
25.0
50.0
Velocity (cm/s)
Wed Sep 6 11:13:37 1995

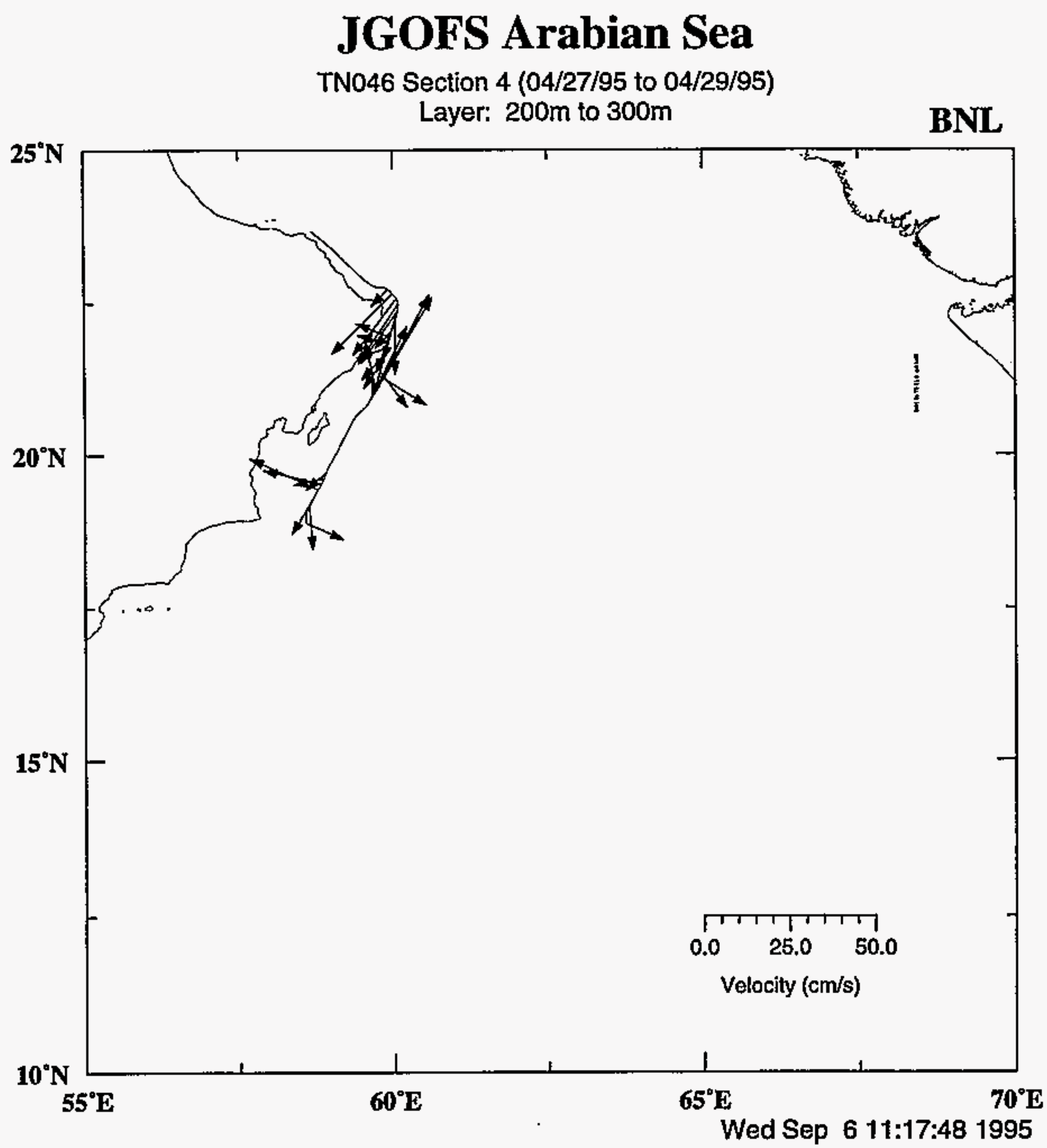

JGOFS Arabian Sea
TN046 Section 4 (04/27/95 to 04/29/95)
Current Velocity 20m to 50m
BNL
25°N
20°N
15°N
10°N
55°E
60°E
65°E
70°E
0.0
25.0
50.0
Velocity (cm/s)
Wed Sep 6 11:17:30 1995

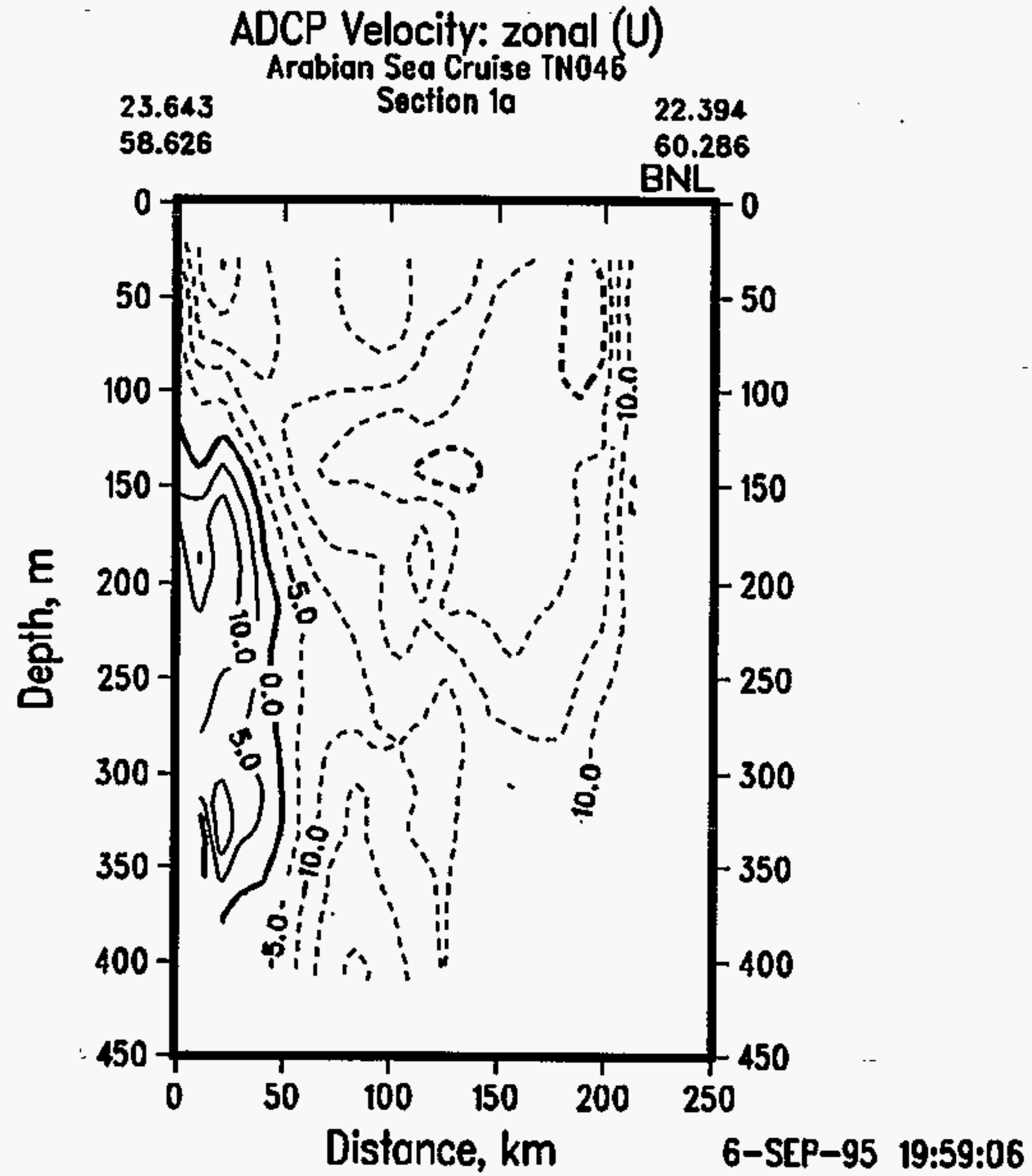
# JGOFS Arabian Sea

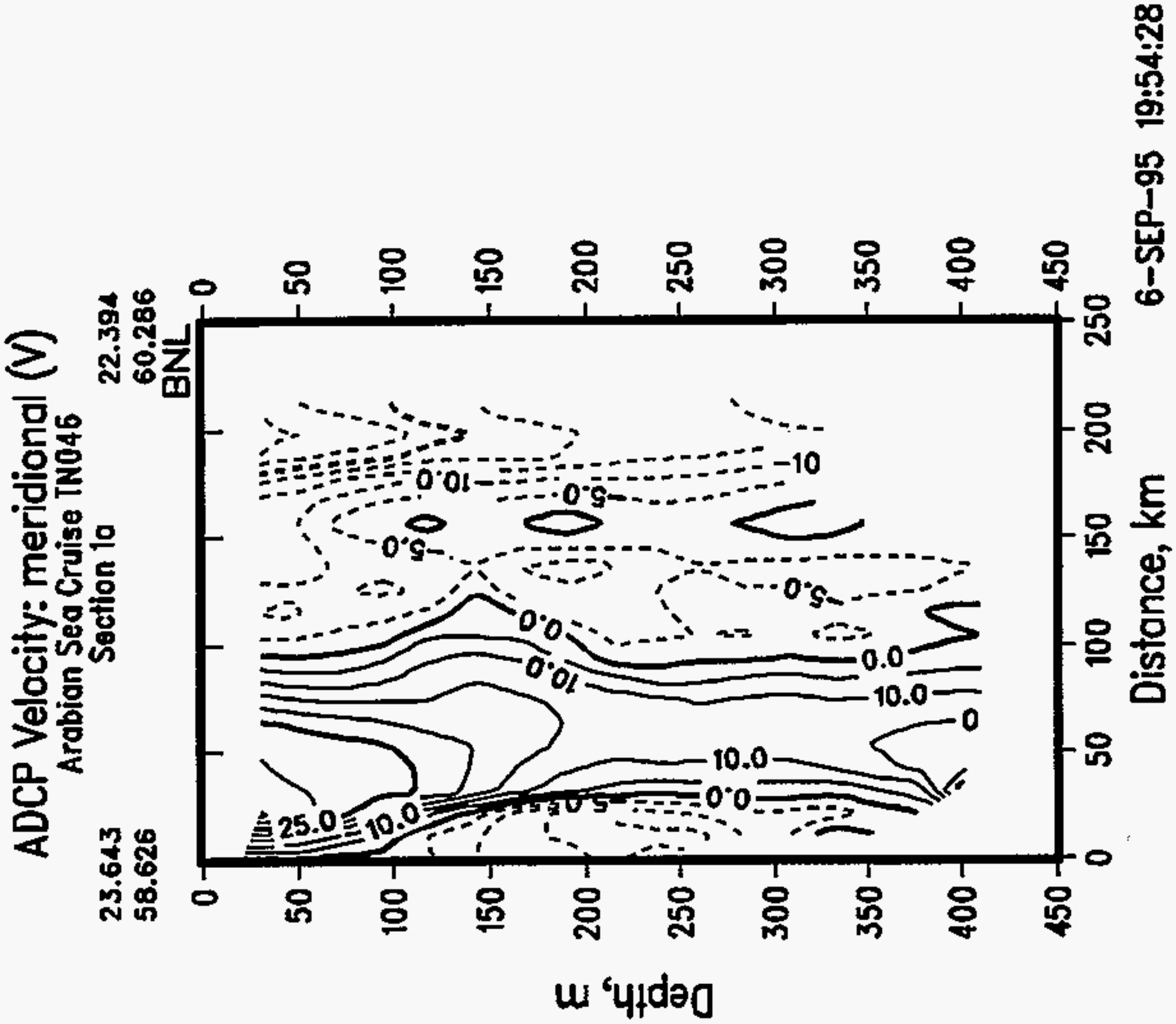
TN046 Section 4 (04/27/95 to 04/29/95)
Layer: 50m to 100m

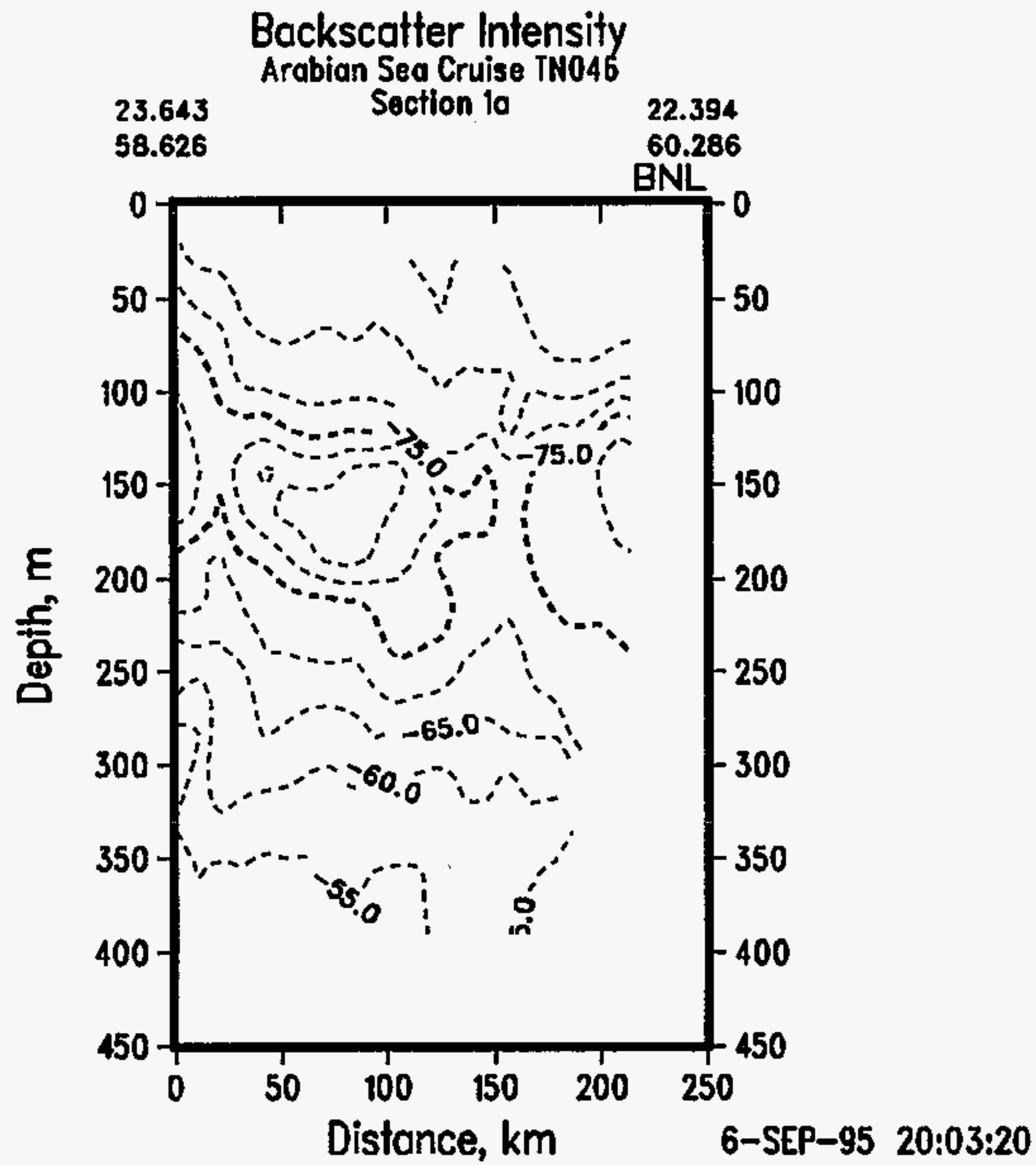



JGOFS Arabian Sea
TN046 Section 4 (04/27/95 to 04/29/95)
Layer: 100m to 200m
BNL
25°N
20°N
15°N
10°N
55°E
60°E
65°E
70°E
0.0
25.0
50.0
Velocity (cm/s)
Wed Sep 6 11:17:43 1995

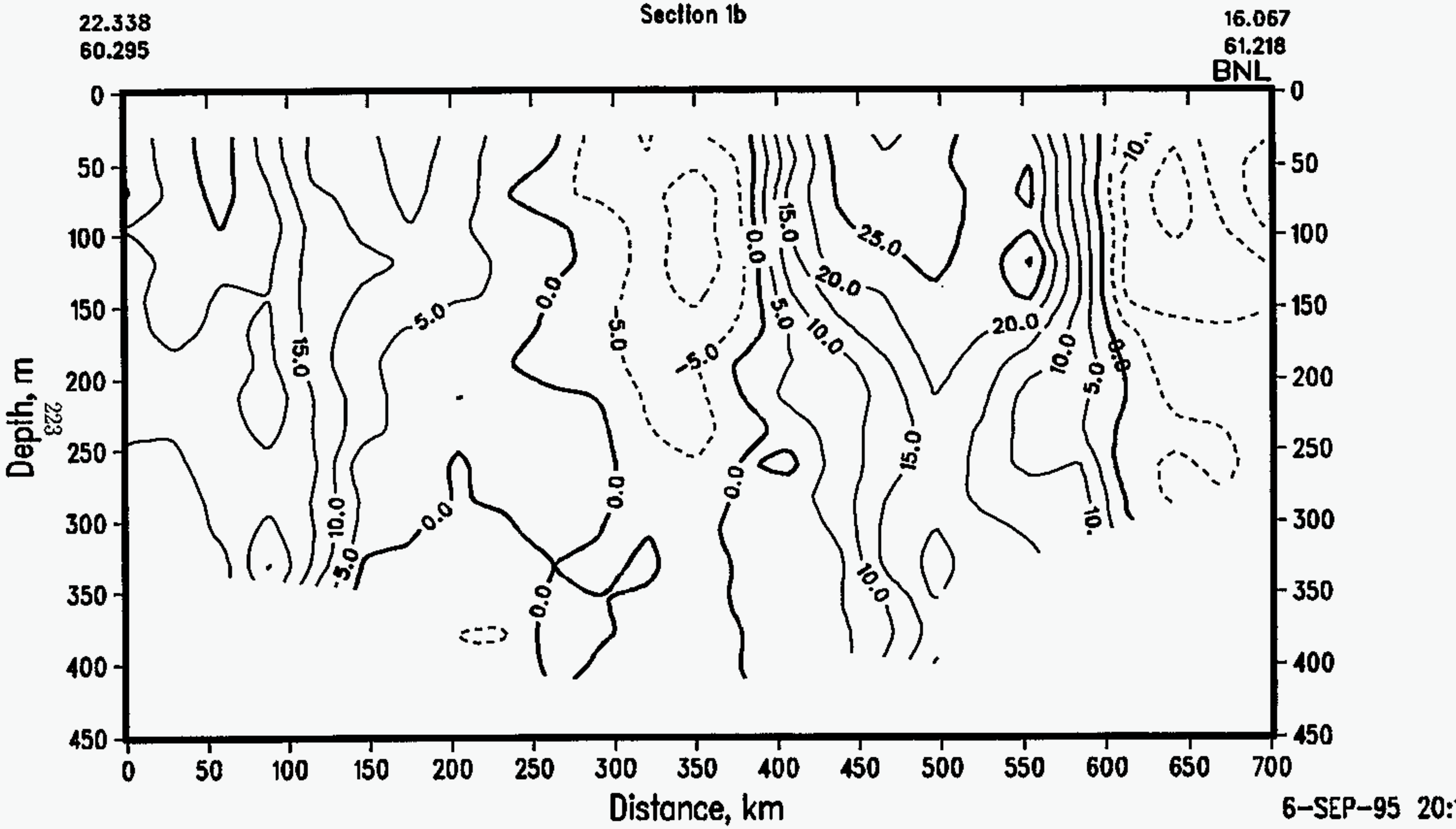

JGOFS Arabian Sea
TN046 Section 4 (04/27/95 to 04/29/95)
Layer: 200m to 300m
BNL
25°N
20°N
15°N
10°N
55°E
60°E
65°E
70°E
0.0
25.0
50.0
Velocity (cm/s)
Wed Sep 6 11:17:48 1995


ADCP Velocity: zonal (U)
Arabian Sea Cruise TN046
Section 1a
23.643
58.626
22.394
60.286
BNL
Depth, m
Distance, km
0
50
100
150
200
250
300
350
400
450
0
50
100
150
200
250
10.0
5.0
0.0
-5.0
-10.0
6-SEP-95 19:59:06

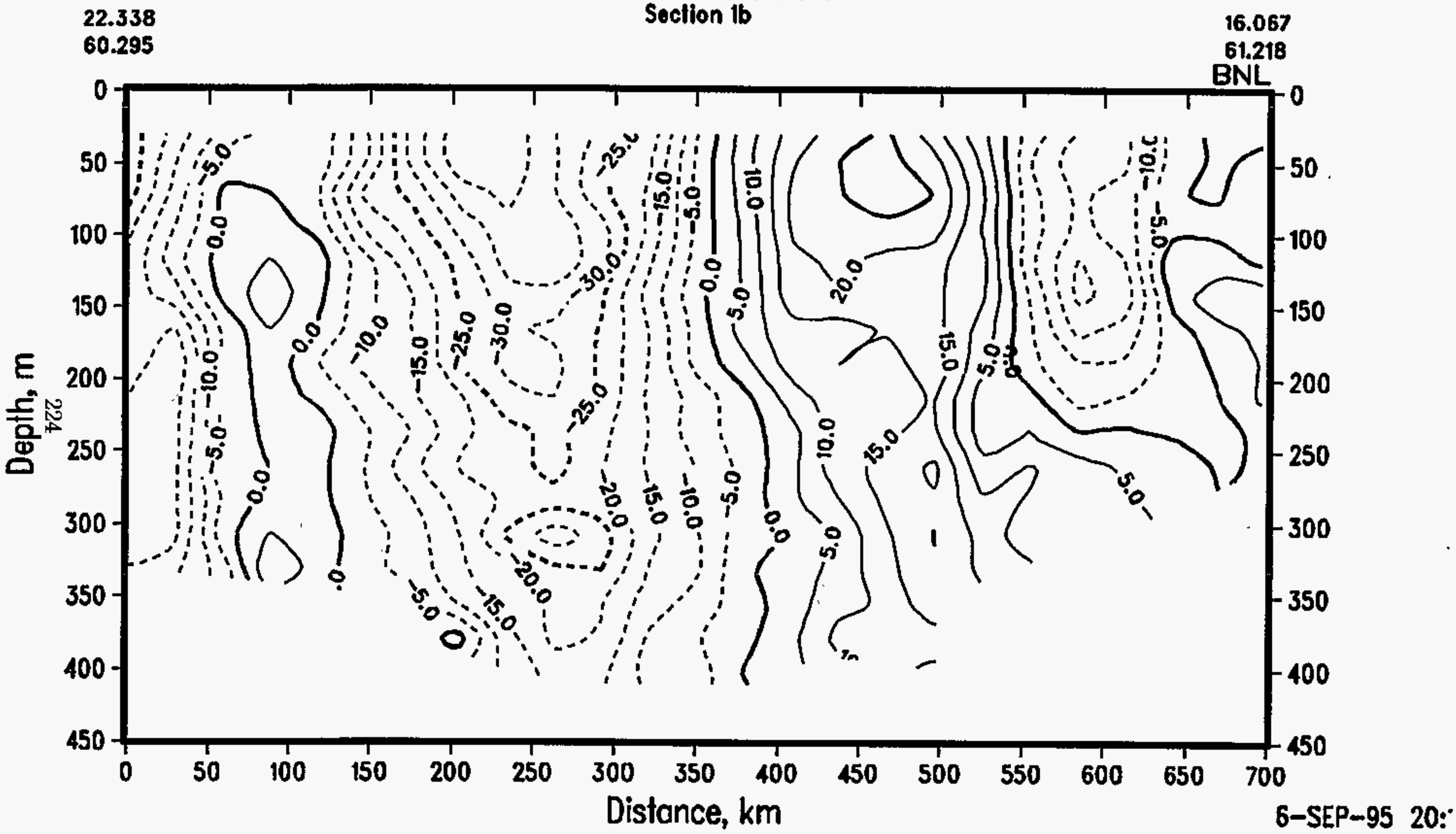

ADCP Velocity: meridional (V)
Arabian Sea Cruise TN046
Section 1a
23.643
58.626
22.394
60.286
BNL
Depth, m
Distance, km
6-SEP-95 19:54:28
25.0
10.0
5.0
0.0
-10
0
0 50 100 150 200 250 300 350 400 450
0 50 100 150 200 250


Backscatter Intensity
Arabian Sea Cruise TN046
Section 1a
23.643
58.626
22.394
60.286
BNL
Depth, m
Distance, km
-75.0
-75.0
-65.0
-60.0
-55.0
6-SEP-95 20:03:20

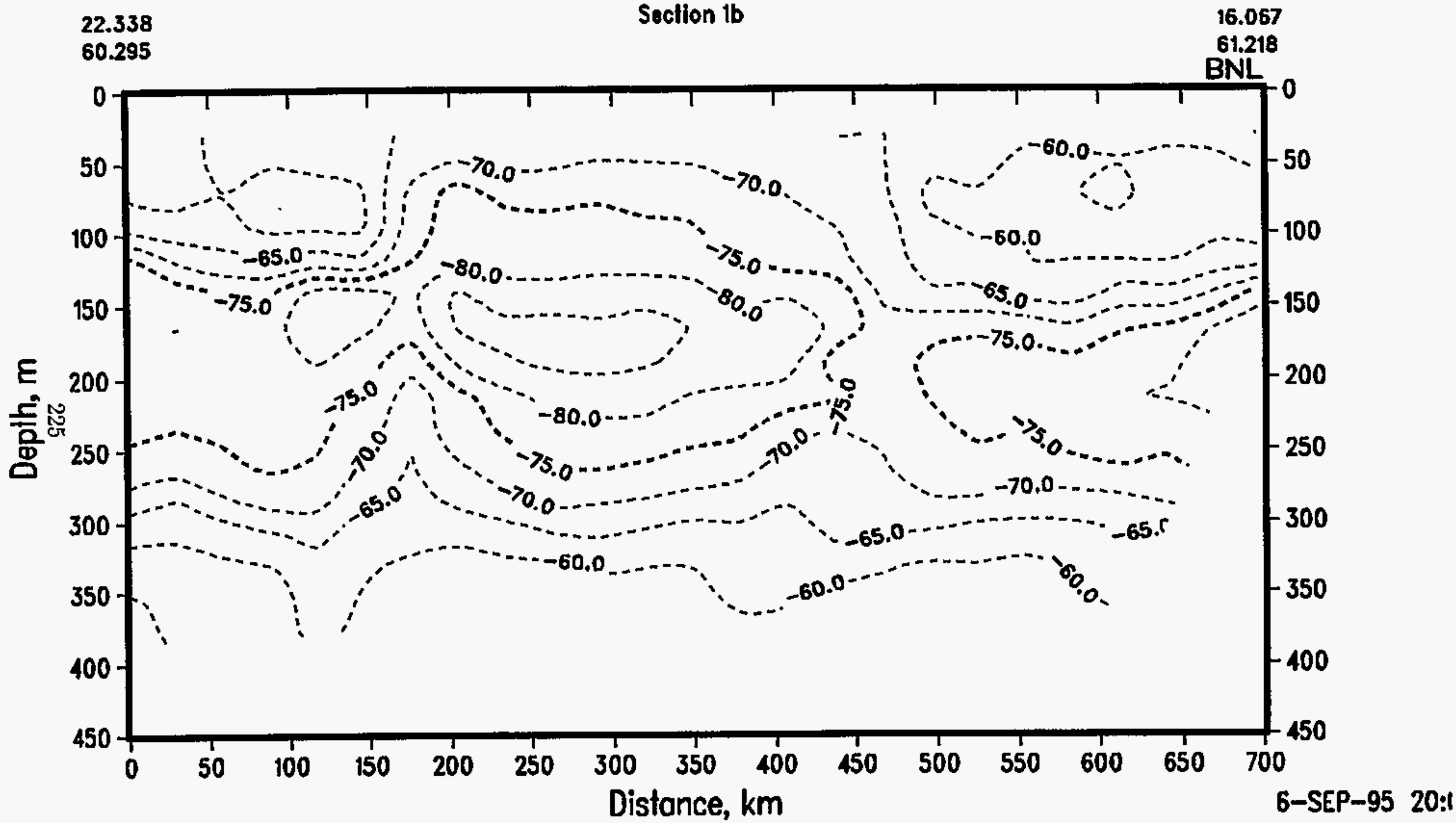
ADCP Velocity: zonal (U)
Arabian Sea Cruise TN046
Section 1b



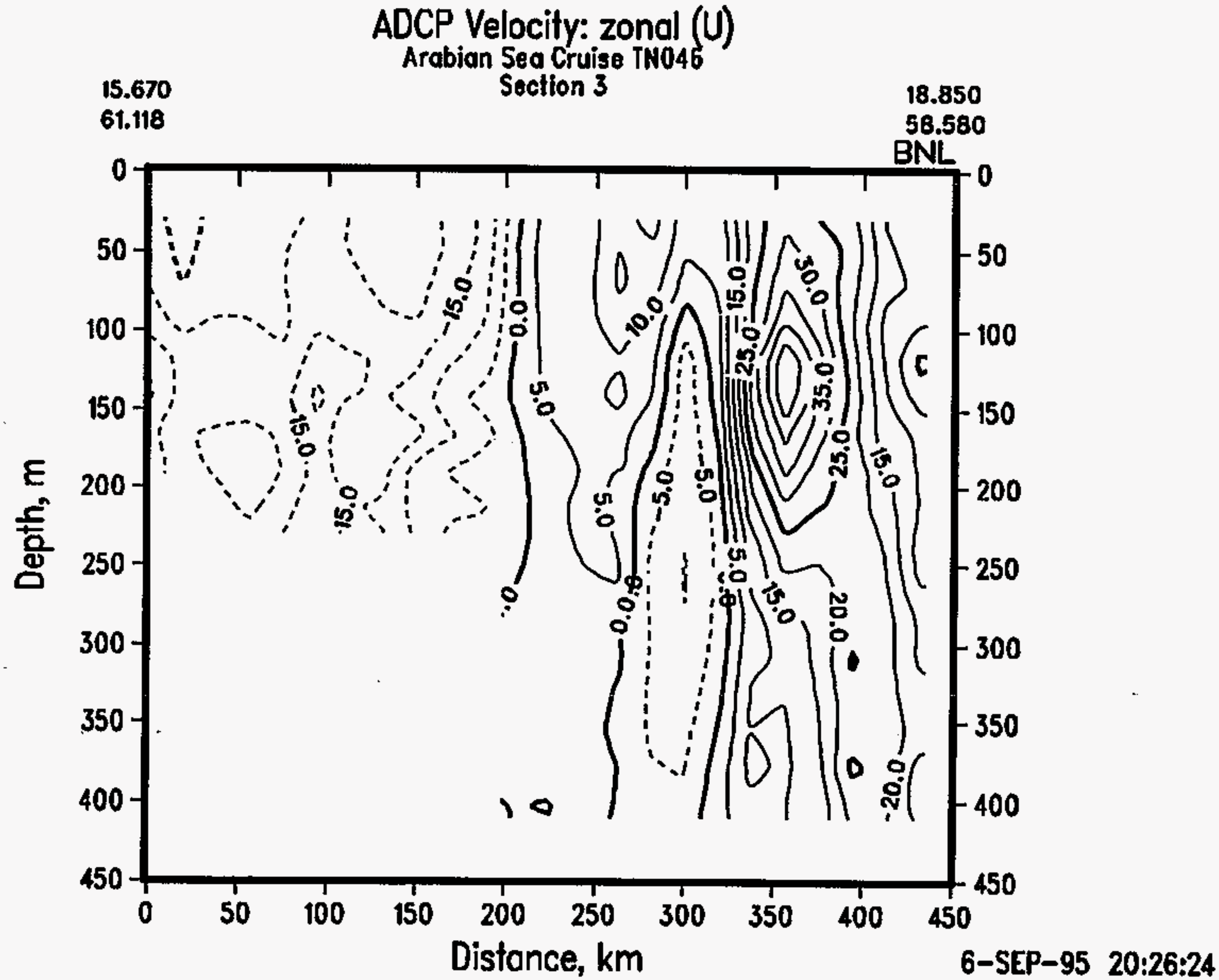
ADCP Velocity: meridional (V)
Arabian Sea Cruise TN046
Section 1b



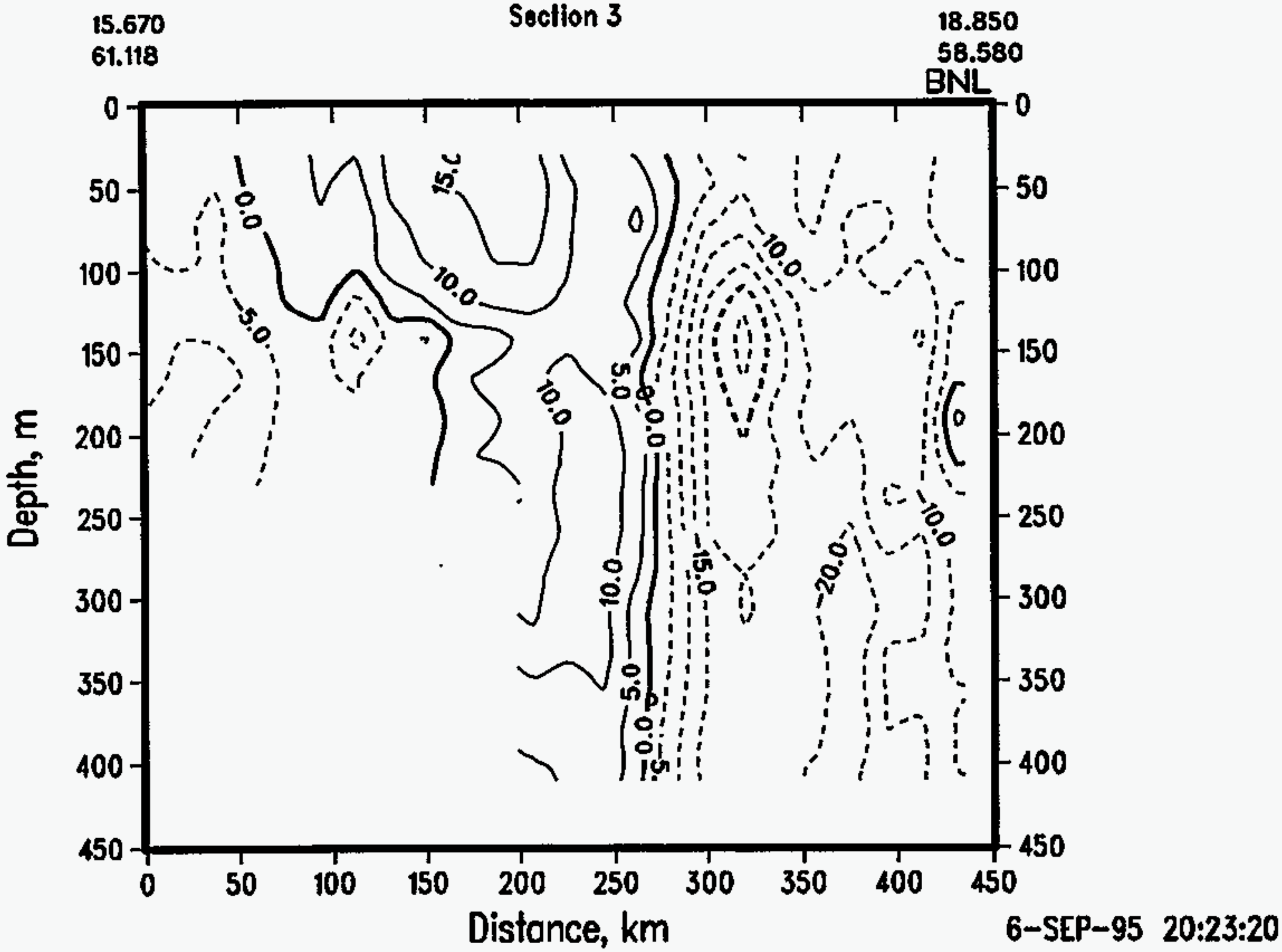
# Backscatter Intensity
Arabian Sea Cruise TN046
Section 1b



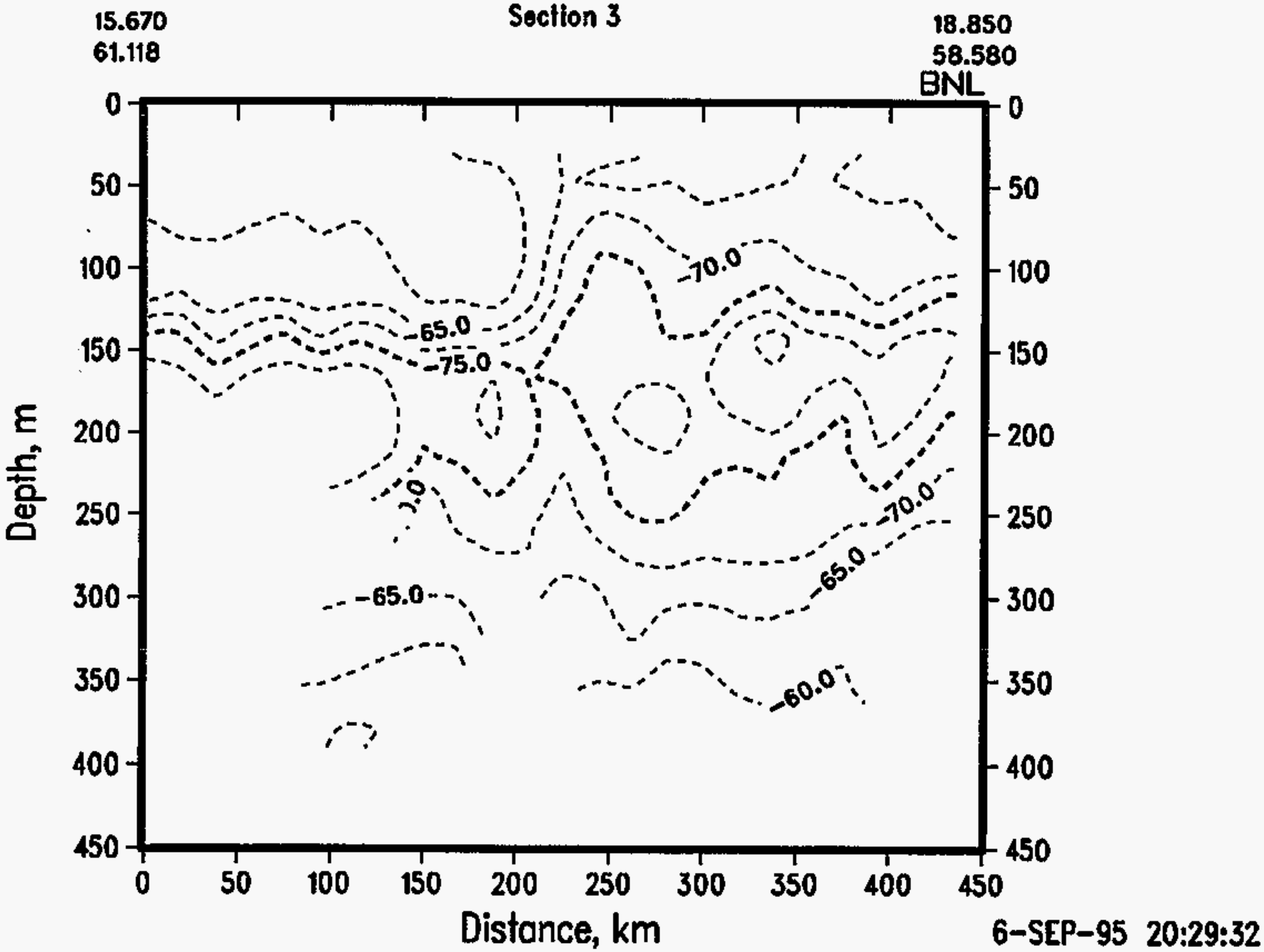

225

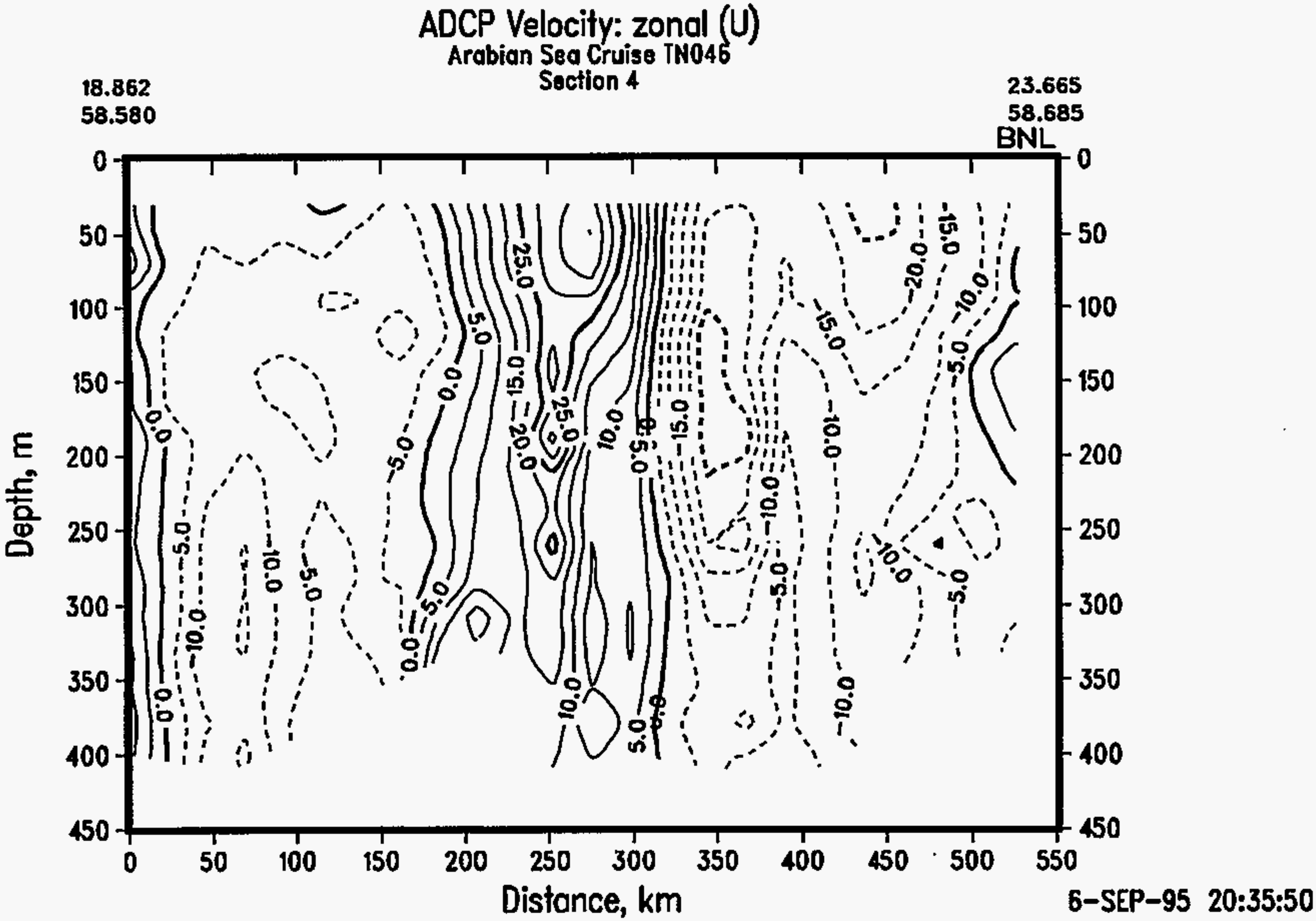

ADCP Velocity: zonal (U)
Arabian Sea Cruise TN046
Section 3
15.670
61.118
18.850
58.580
BNL
Depth, m
Distance, km
6-SEP-95 20:26:24

ADCP Velocity: meridional (V)
Arabian Sea Cruise TN046
Section 3

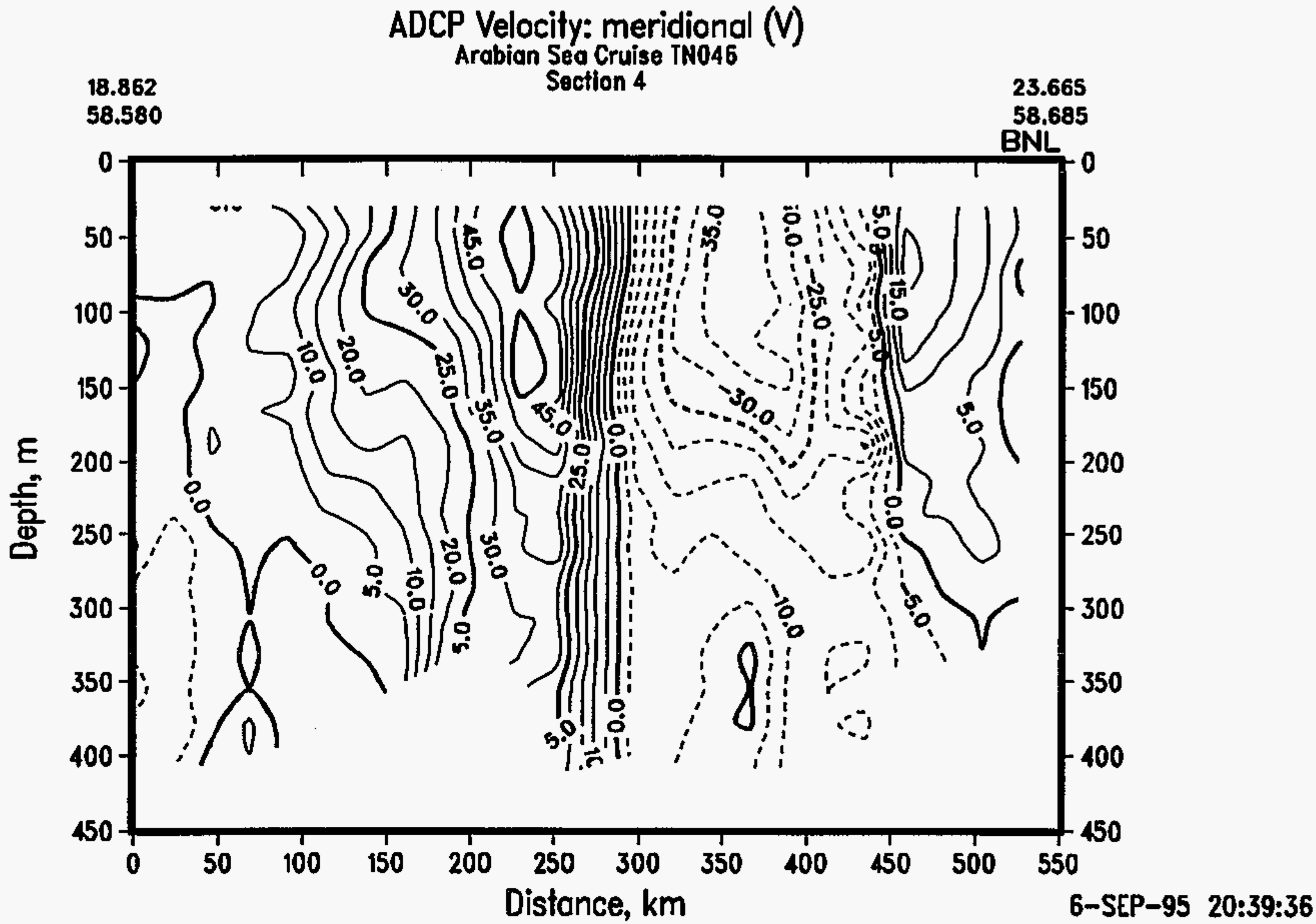


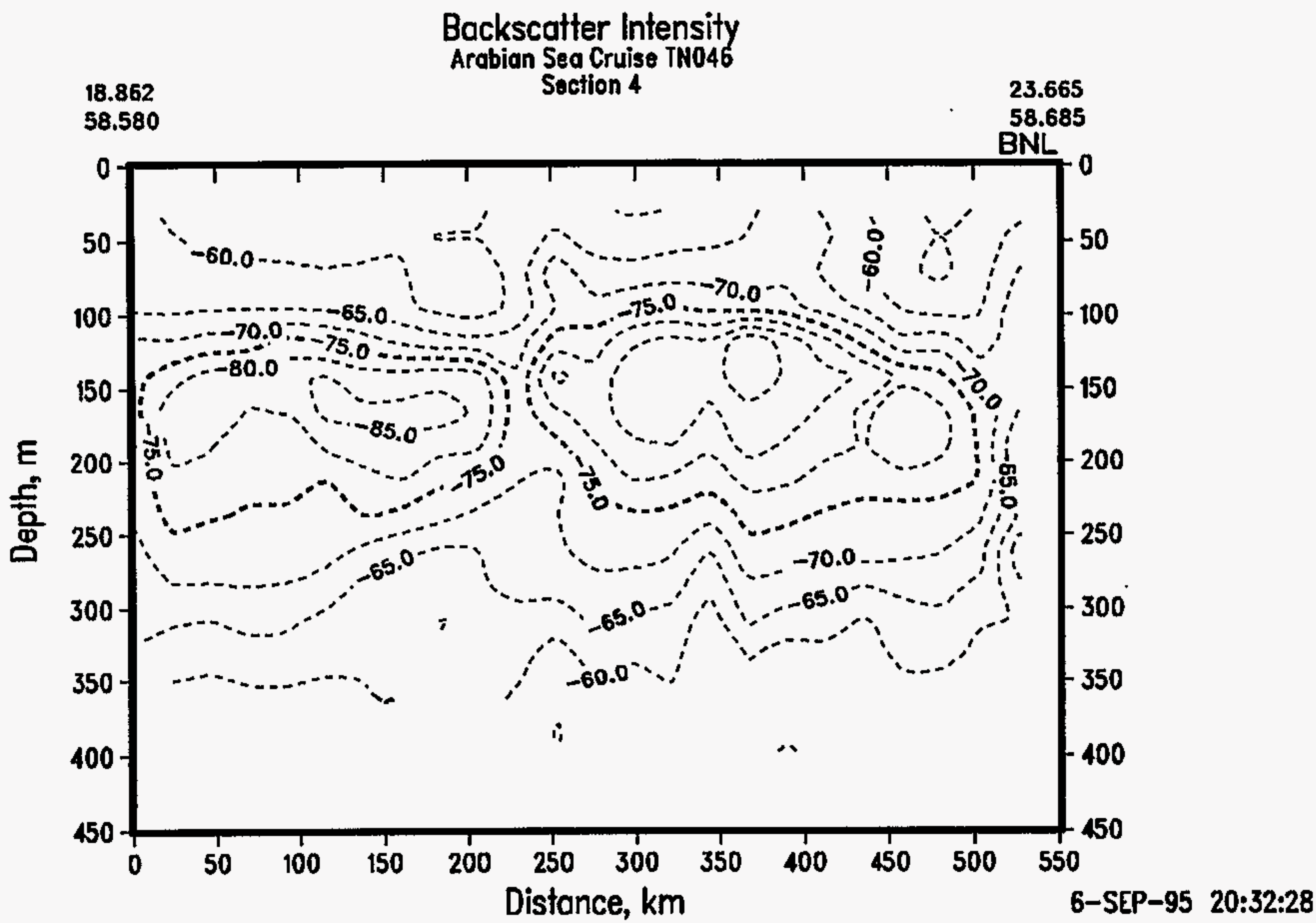
Backscatter Intensity
Arabian Sea Cruise TN046
Section 3





ADCP Velocity: zonal (U)
Arabian Sea Cruise TN046
Section 4
18.862
58.580
23.665
58.685
BNL
Depth, m
Distance, km
6-SEP-95 20:35:50


ADCP Velocity: meridional (V)
Arabian Sea Cruise TN046
Section 4
18.862
58.580
23.665
58.685
BNL
Depth, m
Distance, km
6-SEP-95 20:39:36


Backscatter Intensity
Arabian Sea Cruise TN046
Section 4
18.862
58.580
23.665
58.685
BNL
-60.0
-65.0
-70.0
-75.0
-80.0
-85.0
Depth, m
Distance, km
6-SEP-95 20:32:28