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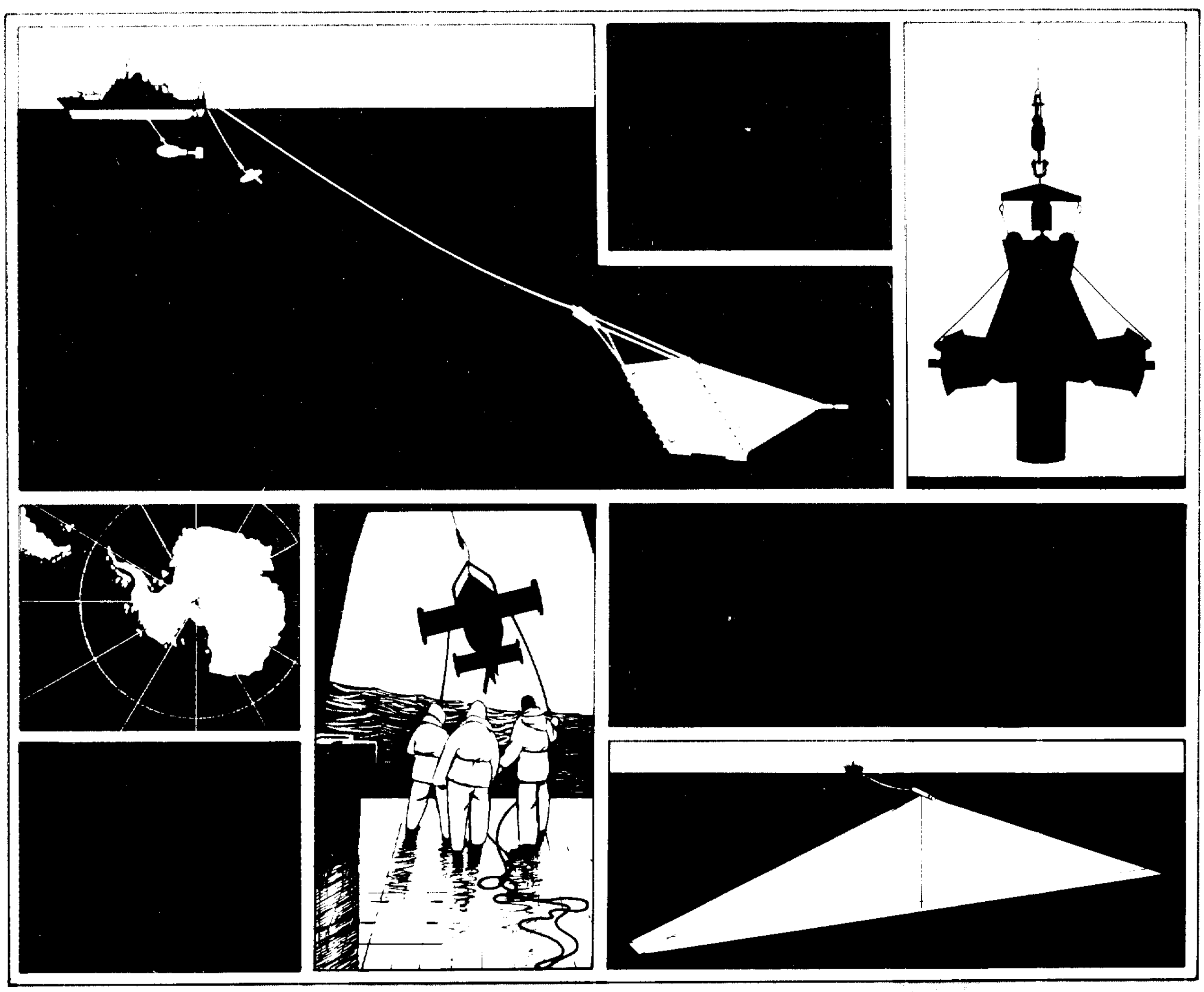
Shipboard ADCP observations during RRS *Charles Darwin* Cruise 62

M C Hartman

Report No 298 1992



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ABSTRACT

During August 1991 *RRS Charles Darwin* Cruise 62 occupied CTD stations in a WOCE Control Volume in the North Atlantic. The RDI 150 kHz ADCP was operating throughout, producing data on water velocity and echo amplitude whilst the ship was under way and whilst on station. This document provides a description of the set up and data processing route used. A summary of the current velocity data collected from the instrument whilst on station.is given as contour plots for each leg of the cruise.

KEYWORDS

ACOUSTIC DOPPLER CURRENT PROFILER (ADCP)
ATLN
"CHARLES DARWIN"/RRS - cruise(1991)(62)
CONTROL VOLUME
CONVEX
CURRENT VELOCITY
NORTH ATLANTIC
RELATIVE ECHO AMPLITUDE
WOCE

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INTRODUCTION

RRS Charles Darwin Cruise 62 commenced on the 1st August 1991, leaving from Barry, Wales and ended on the 3rd September at Troon, Scotland. Its primary objective was to study the gyre scale circulation of the North Atlantic by occupying a series of CTD station grids which made up a Control Volume (WMO, 1988). This was done in accordance with the WOCE implementation plan, (Gould et al., 1992). During the cruise, the Acoustic Doppler Current Profiler (ADCP) ran for over 7500 km, or over 700 hours providing good quality data on station and variable quality under way data (see Data Quality, p.10). Continuous GPS coverage was available throughout the cruise enabling absolute current velocities of the water column to be calculated.

When the *RRS Charles Darwin* set sail at 2100 on the 1st August the ADCP was in bottom tracking mode. The first calibration run was made on the 2nd August between 0515 and 0800 and then on the 3rd, after the first CTD station had been completed, the mode was changed from bottom tracking to water tracking. On the 3rd August Disk C on the ADCP Data Acquisition System PC crashed and the spare PC was used in conjunction with some boards from the original unit and ADCP software version 2.48 was re-installed . A problem with the data stream meant that no data were logged by the shipboard level C computer from 0500 on the 3rd until 1600 on the same day. Some data were lost on the 5th at 0400 due to the PC hard disk crashing and on the 11th due to a problem with the shipboard level ABC computer. On the 19th at 0600 the logging program was altered so that ancillary data were recorded, approximately half an hour of data were lost due to a level ABC crash. On 3rd September at 0746 the ADCP was switched to bottom tracking mode whilst the ship was in shallow water then at 1400 navigation ended.

ADCP INSTALLATION

Whilst in deep water the ADCP recorded 64 bins of length 8 metres, the hull mounted transducers were at a depth of 5 meters and the blank beyond transmit length was set to 4 metres, thus placing the centre of the first bin at 13 metres. A 2 minute sampling interval was used throughout the cruise. Both the water and bottom tracking configurations were similar to those used on *RRS Charles Darwin* Cruise 51, changes that were made are listed in Appendix 1.

The transducer installation is of a 'top hat' configuration mounted forward of the beam and offset on the port side of the centre line. Data from this unit are sent to a signal processing and data acquisition system (DAS) based on an IBM PC-AT. This is where the ADCP configuration is set, the data were transferred from the hard disk to floppy disk regularly so that in the event of the PC crashing there would be minimal data loss.

The DAS is housed in the plot, aft of the wheelhouse, an area that suffers excessive motion during heavy weather. For this reason a video camera was mounted in front of the PC, allowing the screen to be viewed from the main laboratory. The DAS clock drift was noted at least every watch, but usually more often, this was used as input to adpexec1 to correct the data in the level C.

The hard disk on this PC crashed only 3 days after leaving port due to a disc controller error, this was cured by swapping some of the boards with those from another PC. Serial data from the DAS were routed via port 2 on the PC at 9600 baud directly to the shipboard computer system level C, via a (printer) buffer. The new boards required this connection to be changed to port 1 of the PC causing some initial problems with the data stream. It was recommended in the cruise report (Gould et al., 1992) that a spare identical unit is carried in future, forestalling the possible problems caused my mismatched boards. A minor repercussion was that logging of 'Ancillary data', (ship's heading and water temperature) were lost for the week following the event, in terms of the standard processing route these variables are not used.

DATA PROCESSING

The data from the PC running the ADCP software were read into the level C of the shipboard computing system then extracted and processed using the Pstar programme library. The bulk processing of data was achieved using execs (Unix scripts); these are command files that run a series of Pstar programmes, with some parameters supplied by the user, others are set automatically. A summary of the execs used on this cruise follows below.

The data were split into two types of file, 'on station data' and 'under way data'. The periods of acceleration and deceleration of the ship led to erroneous current vectors so data from these periods were deleted. Initially this was achieved by plotting out the navigation data to find when the ship had been on station or under way, then running adpexec0 through 4 for each file. Later on in the cruise, 12 hour segments of data were processed using the execs, then these were split into individual files afterwards using pheadr and pcopya. The processing method was changed to reduce the amount of time spent on it, the later method was less time consuming but much more care was needed to prevent misnaming files. Filenames were allocated according to the number of the CTD cast for example adp62010 was recorded during the tenth station and adp62210 was recorded between the tenth and eleventh stations.

SHIPBOARD PROCESSING

The following execs (adpexec0 through 4) were the same as those used for the processing of ADCP data for cruise CD51(Griffiths, G. et al 1992) and subsequently on Vivaldi (CD58 and CD59, G.Griffiths pers.comm.)

adpexec0

Reads ADCP data from RVS format file, writes to a Pstar format file, data selected on time, split into two files ; one with gridded the other with non-gridded data.

adpexec1

Corrects the ADCP clock drift recorded from the difference between the ADCP time and the ship's clock time.

adpexec2

Averages the data to 15 minutes and then adds a pointing angle and amplitude correction determined by the calibration run

adpexec3

Calculates the velocity in each cell relative to a reference layer (user specified) . This was used to plot the averaged ADCP data against the navigation before merging the two. Plots relative current vectors.

adpexec4

Merges the averaged ADCP data with the smoothed navigation file created by navexec0 and navexec1. Absolute velocities are then calculated for each depth cell.

adprl2

This was used to produce the relative backscatter amplitude for each section.

The two following execs were created to produce plots of relative amplitude, percent good and current vectors for a portion of ships track on a single page. Originally created for the CD51 ADCP report, they were used on board to produce plots primarily as a data quality check. These execs work with Uniras version 5.4, but will not work with version 6.0 which is to be used in future. This is because Uniras version 6.0 uses vectors to draw its text instead of a font, so the text is not readily identifiable and cannot be easily edited.

preport

Uses the plotting programs ucontr and parrog to create PostScript files of percent good, relative backscatter amplitude and absolute current velocity vectors

adppage1

Rearranges and does some editing on the PostScript files created by preport so that the three plots for the station or leg are produced on the same page.

LABORATORY PROCESSING

The data are in a state to be archived after adpexec4 has been run on the files and this can be accomplished at sea. However, in order to produce the graphical output in this data report, further processing was necessary. The following section gives the method used in producing the graphical output contained within the report.

Three types of plots are incorporated into this report in order to give an overview of the current velocities obtained and an indication of the data quality throughout the period of observation .

plotxy used to produce a map of the CTD station positions.

The velocity contour plots (Figures 4,5,6,8 and 10) were obtained by selecting the ADCP data corresponding to the periods that the ship was on station during a CTD cast. Currents flowing to the North and to the East are taken to be positive. Then :

allav was used to average all of the variables at each depth level to a single value placing these at the averaged coordinates for the station

papend these files were then appended for each section of the cruise

ucontr was then used to plot the East and North current components for the individual sections.

The two types of data quality plots (Figures 7,9,11) were produced with

ucontr for the section plots of percent good and

plotxy for the error velocity measurements.

DATA QUALITY

An estimate of data quality throughout the cruise is given by the variable percent good; its value depends on how many good 'pings' are returned in an ensemble. Whilst on station 25% good remained below 400 metres for most stations, only rising above 250 metres on 6 stations. Whilst under way the depth of 25% good varied between 150 and 400 metres up to the coast of Greenland, and subsequently deteriorated to between 50 and 250 metres, it remained between these depths for almost all of the rest of the cruise. This could have been caused by bubbles as the sea state was rough for several days off the Greenland coast, however the ADCP transducer unit was bled and no bubbles were found trapped. Plots of averaged percent good for station data are provided in the report for each leg of the cruise. The report also contains a new set of plots that show the spread of error velocities throughout the depth range for each station in the leg. Each point shown is an average of the error velocities at a certain depth over the duration of the station (from allav). A function of having four acoustic beams is that two estimates of vertical velocity are made for the three orthogonal components of the current, the error velocity is the difference between these two vertical velocity estimates. Error velocity can detect errors due to inhomogeneities in the water, as well as errors caused by malfunctioning equipment (RD Instruments 1989). Large absolute values of the error velocity indicate less reliable data.

CALIBRATION

Three calibration runs were made during the cruise, the first in bottom tracking mode, the second in water tracking mode. Whilst performing the third calibration run at the end of the cruise the gyrocompass input jammed and as a consequence there were no navigational data for this period . However, calibration values from the beginning of the next voyage of the *RRS Charles Darwin* (CD62a) have been included for comparison, this cruise commenced almost immediately after CD62. Values from previous cruises are also shown in the table below.

	Date m/y	Amplitude Scaling factor (A)	standard deviation (A)	Pointing angle (ϕ) in degrees	standard deviation (ϕ)
CD 51	7/1990	1.0026	0.005	-0.36	0.16
CD 58	4/1991	0.9956	0.003	-0.68	0.69
CD 59	5/1991	0.9958	0.008	-1.2	0.55
CD 62 Bottom tracking	8/1991	1.005	0.01	-0.4	0.36
CD 62 Water tracking	8/1991	1.005	0.011	0.02	0.48
CD 62a	9/1991	1.012	0.01	-0.73	0.38
Mean		1.0027	0.006		

The mean of the amplitude scaling factor over these 6 calibrations is 1.0027, with a standard deviation of 0.006. This is comparable to the standard deviation of the individual calibrations and from this it seems that there is no real drift in the value of A with time. The pointing angle correction is mainly dependant on gyrocompass drift, the typical drift during a cruise may be $\pm1°$. A list of the differences between star sight readings and corresponding gyro compass readings is given in Appendix 2 although there is a possible inherent error of about 0.5° in the star sight checks themselves .

A preliminary estimate of the GPS positional accuracy was made while the ship was docked. By finding the standard deviation of the 60 second fixes over a period of 21 hours before the cruise and over 19 hours at the end of the cruise, the following results were obtained:-

	Before	After
standard deviation of the latitude estimates /metres	24.2	11.0
standard deviation of the longitude estimates /metres	12.8	11.2

Over a 15 minute interval positional uncertainties with a standard deviation of 24.2 metres lead to an error of 0.05 m/s in the estimation of the ships speed and hence in the speed of the water currents. It is not possible to derive positional accuracy during the cruise without a fixed frame of reference. Selective Availability, the deliberate degradation of GPS accuracy for civilian users was switched on in July 1991, but was not being exercised to any great extent until November 1991, after the cruise. Measurements taken in January 1992 from a fixed location and 24 hours of 1 second fixes gave standard deviation of position of 41 m for X, 21 m for Y. (E. Firing, 1992 pers. comm.).

ACKNOWLEDGEMENTS

This document would be incomplete without acknowledging the following people's contributions. Dr. P. Saunders for his help in calibrating the instrument and producing the averaging program allav. Dr. K. Heywood for her help in processing the data and providing some useful information. G. Griffiths for his time and assistance.

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WMO 1988 World Ocean Circulation Experiment Implementation Plan. Volume II, Scientific Background.
WMO World Climate Research Programme, WCRP-12, 130pp. (WMO/TD No. 243) (WOCE Report No. 21/88)

APPENDIX 1

Changes made to *RRS Charles Darwin* Cruise 51 configuration file CD51DEEP.CNF (water tracking mode) for this cruise.

AD,BK,TENTHS	4.0	Blank Beyond Transmit
AD,US,BOOLE	NO	Use Direct Commands on Start Up
DP,VS,BOOLE	YES	Calculate Sound Velocity from TEMP/Salinity
DP,BT,BOOLE	NO	Use Bottom Track
GC,ZV,WHOLE	3	ZERO VELOCITY REFERENCE (S/B/M/L)
GC,DH,WHOLE	600	HIGHEST DEPTHS ON GRAPH
SG,PEV,BOOLE	NO	PLOT ERROR VEL.
AD,DM,BOOLE	NO	USE DMA
DR,RRA,BOOLE	YES	Record last raw AGC
SL,4,ARRAY5	1 1 8	NONE 9600 ENSEMBLE OUTPUT

CI,1,SPECIAL "CHARLES DARWIN 62" CRUISE ID GOES HERE

Changes made to *RRS Charles Darwin* Cruise 51 configuration file CD51SHEL.CNF (bottom tracking mode) for this cruise.

AD,BK,TENTHS	4.0	Blank Beyond Transmit
AD,US,BOOLE	NO	Use Direct Commands on Start Up
DP,VS,BOOLE	YES	Calculate Sound Velocity from TEMP/Salinity
CG,VH,WHOLE	100	HIGHEST VELOCITY ON GRAPH
SG,PEV,BOOLE	NO	PLOT ERROR VEL.
AD,DM,BOOLE	NO	USE DMA
DR,RRA,BOOLE	YES	Record last raw AGC
XX,STD,BOOLE	NO	[SYSTEM DEFAULT, STD]
LR,HB,HUNDREDTHS	0.00	Heading Bias
SL,4,ARRAY5	1 1 8	NONE 9600 ENSEMBLE OUTPUT
SL,5,ARRAY5	0 1 8	NONE 1200 AUX 1

CI,1,SPECIAL "CHARLES DARWIN 62" CRUISE ID GOES HERE
LR,1,SPECIAL " " LORAN FILE NAME GOES HERE

APPENDIX 2

Star sight: gyro compass differences.

Date	Time	Difference
2 August 1991	0106	+ 3.5°
3 August 1991	0116	+ 4.5°
9 August 1991	2330	+ 3.5°
10 August 1991	0134	+ 2°
16 August 1991	0227	+ 2°
16 August 1991	0700	+ 3°
18 August 1991	2226	+ 4.5°
19 August 1991	0206	+ 3°
21 August 1991	0316	+ 4°
22 August 1991	0156	+ 4°
22 August 1991	2121	+ 1.5°
23 August 1991	0032	+ 4°
28 August 1991	2119	+ 3°
29 August 1991	0122	+ 3.5°
29 August 1991	2021	+ 3°

(+ = gyro reads clockwise of true)

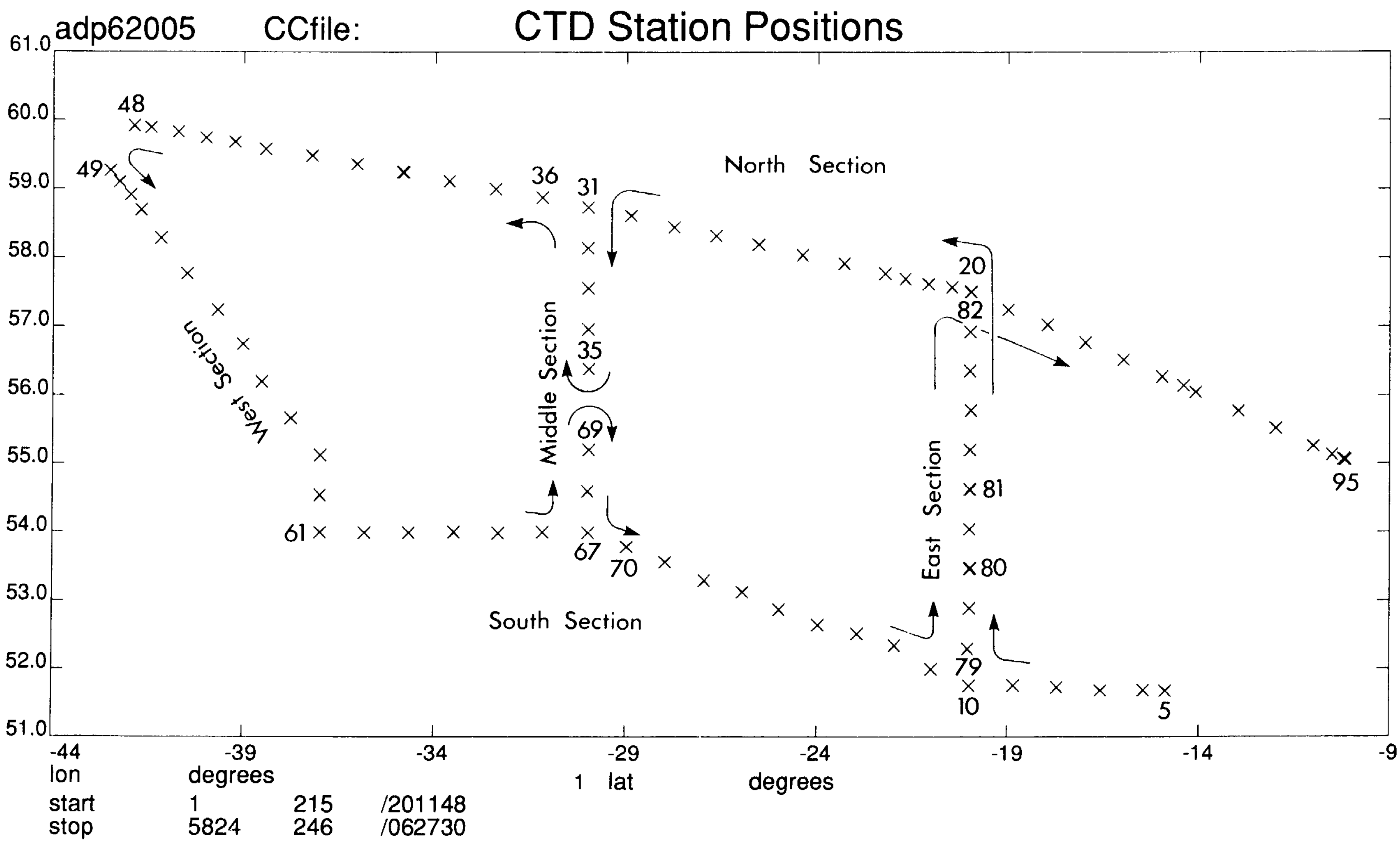
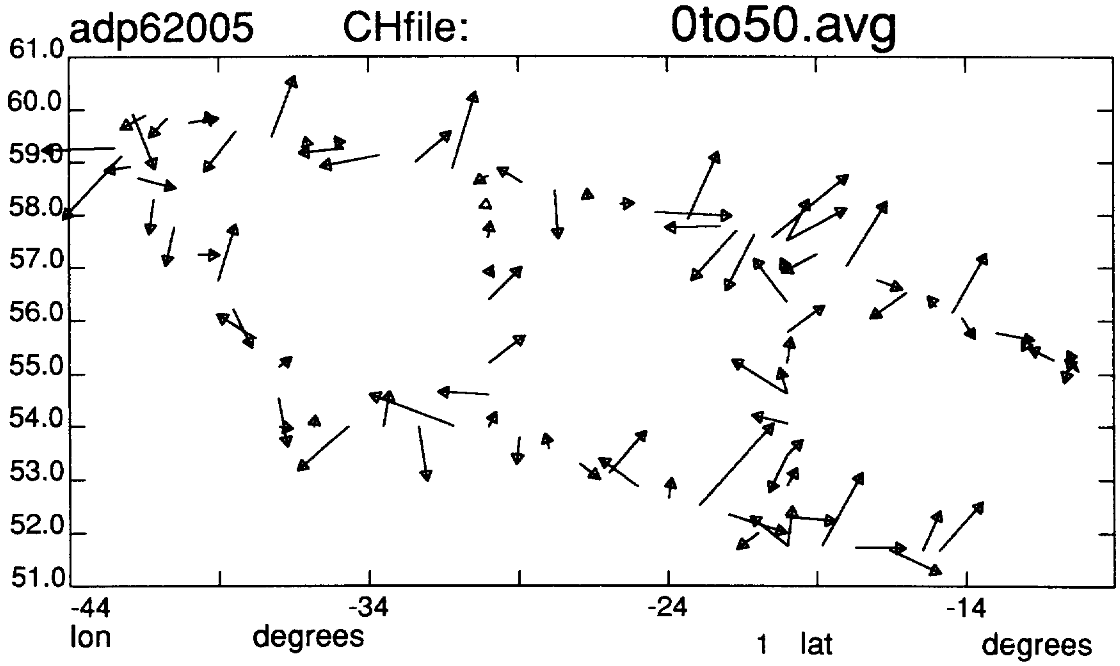


Figure 1. Positions of CTD stations annotated with station number and section names.



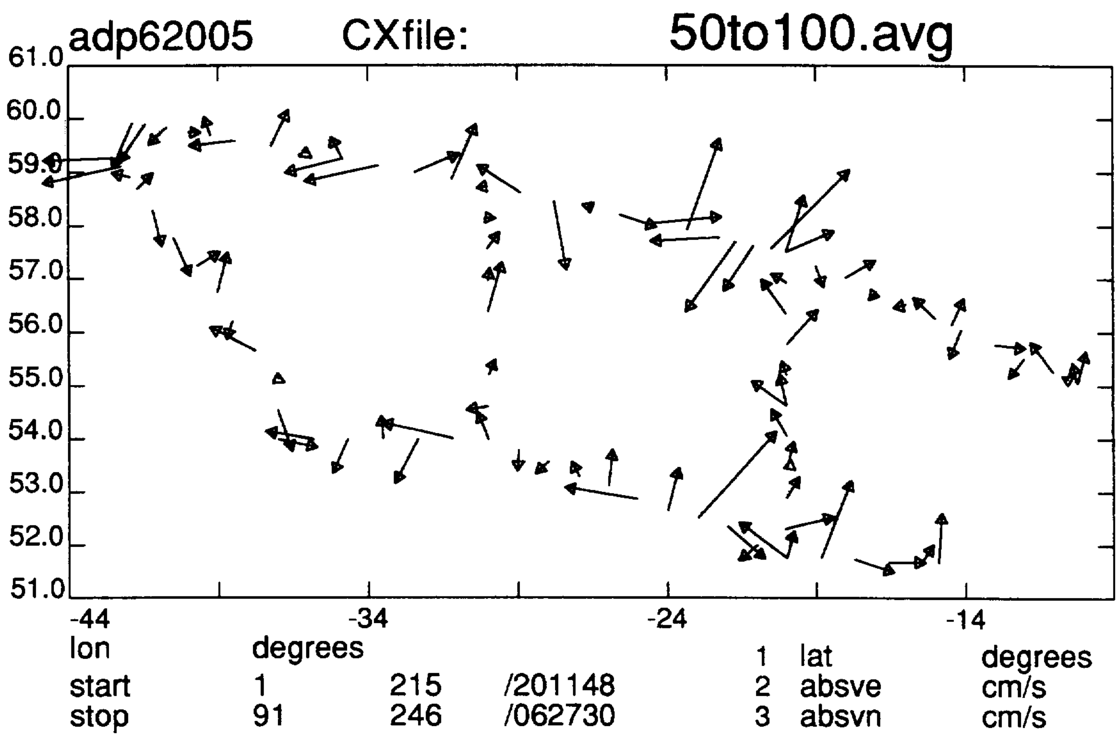
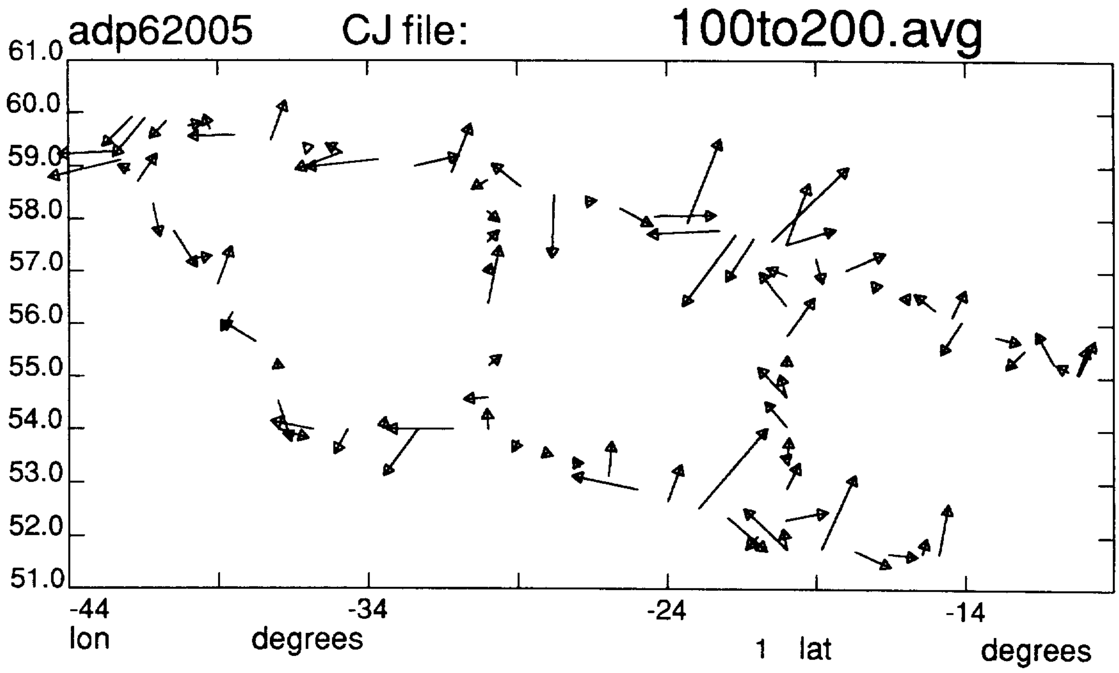


Figure 2. Horizontal maps of 'on station' current vectors averaged over the depth ranges 0 to 50 metres (top) and 50 to 100 metres (bottom). Scale 0.3mm / cms^{-1}



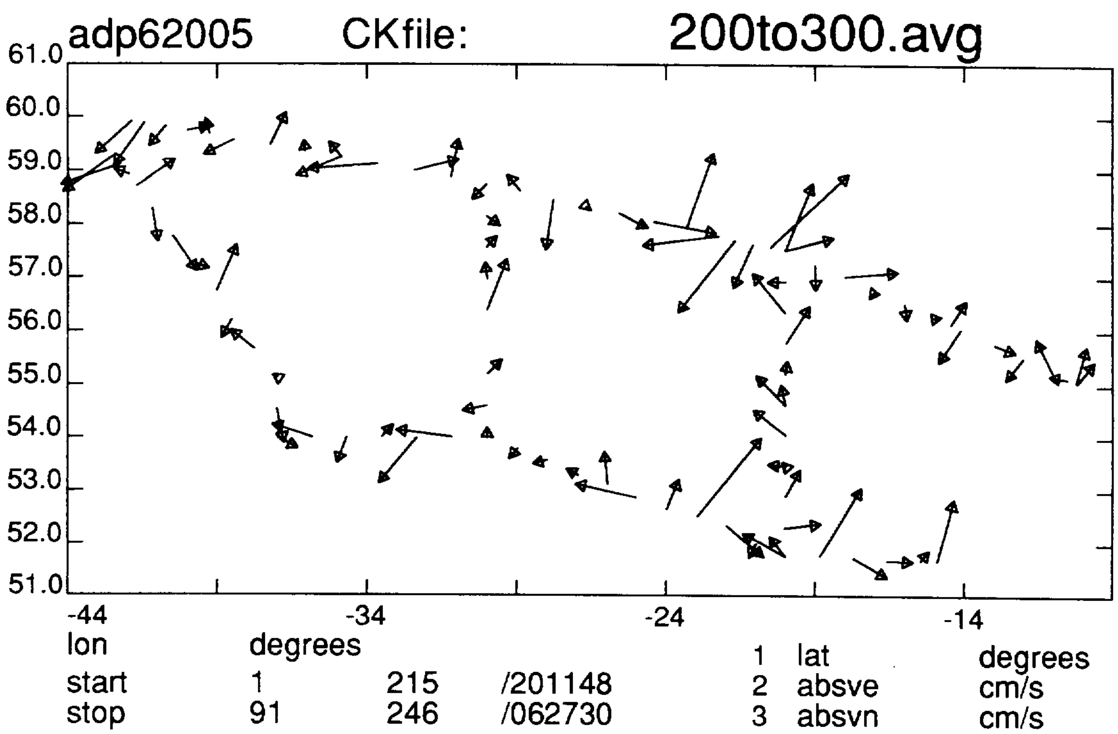
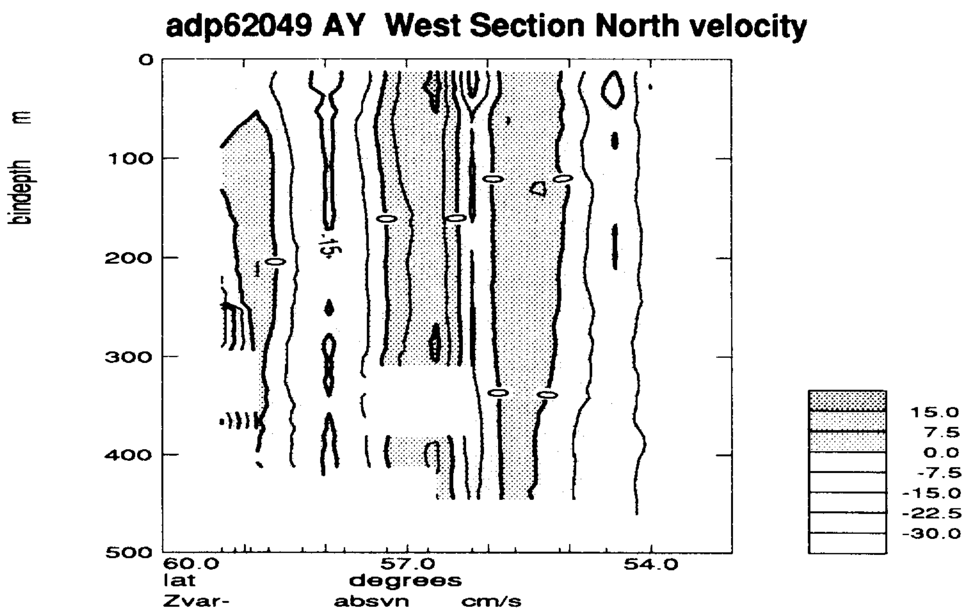


Figure 3. Horizontal maps of 'on station' current vectors averaged over the depth ranges 100 to 200 metres (top) and 200 to 300 metres (bottom). Scale 0.3mm / cms^{-1}



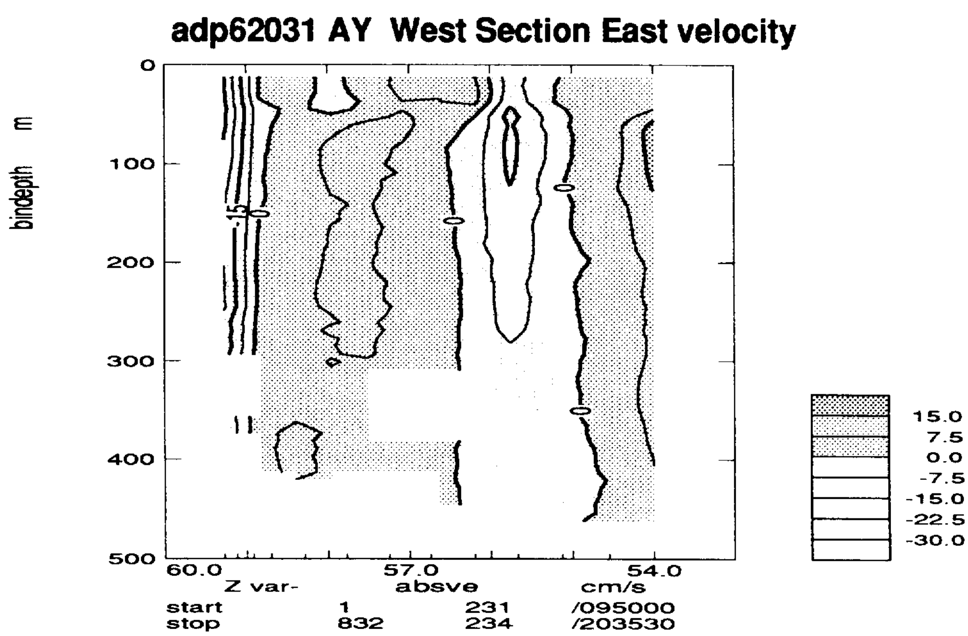
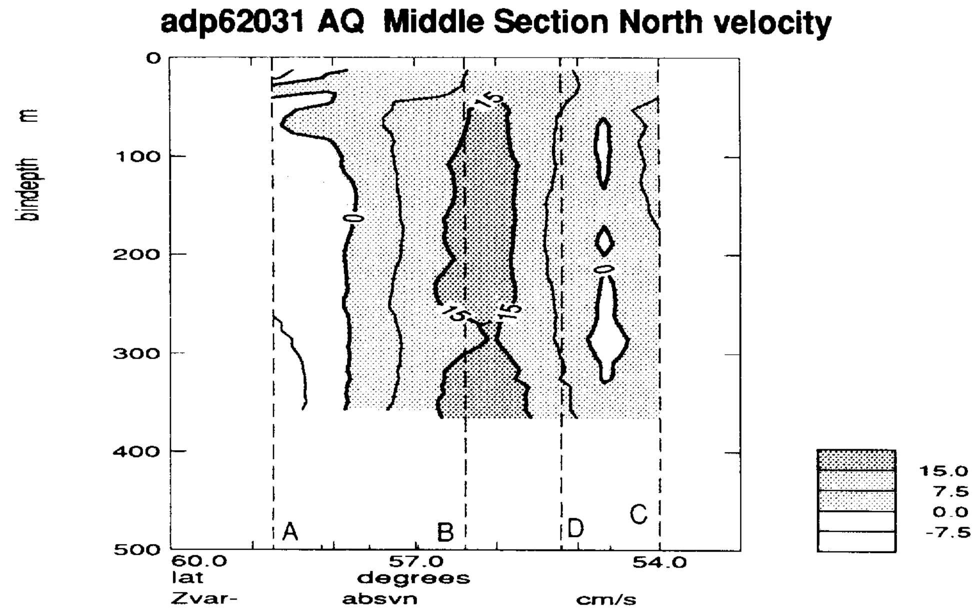


Figure 4. Contour plots showing the North and East velocity components of the currents along the West Section.



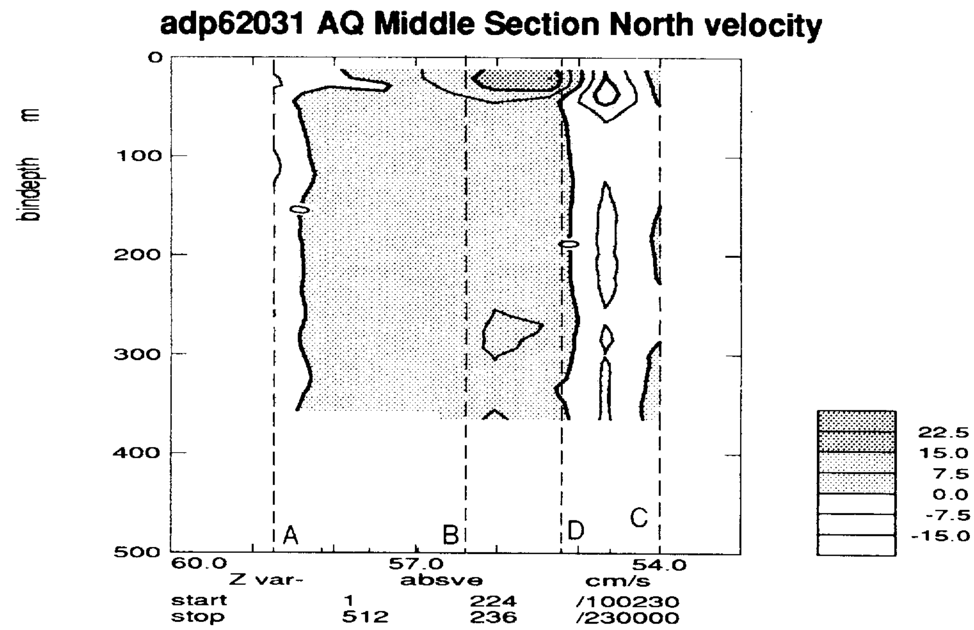
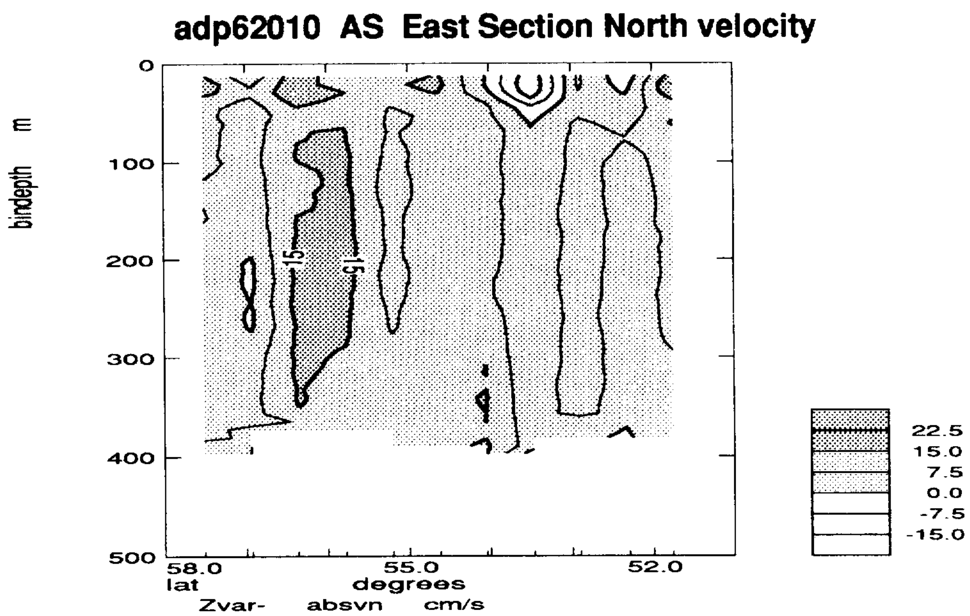


Figure 5. Contour plots showing the North and East components of the currents along the Middle Section. Leg AB runs from jday 224.417 to 225.647, leg CD runs from jday 236..440 to 236.949.



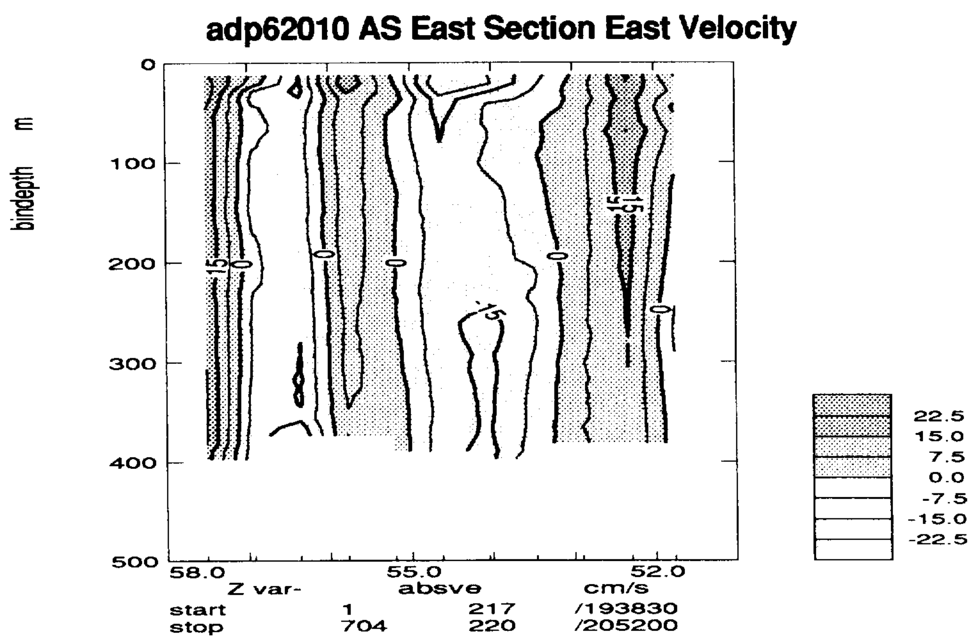


Figure 6. Contour plots showing the North and East velocity components of the currents along the East Section.

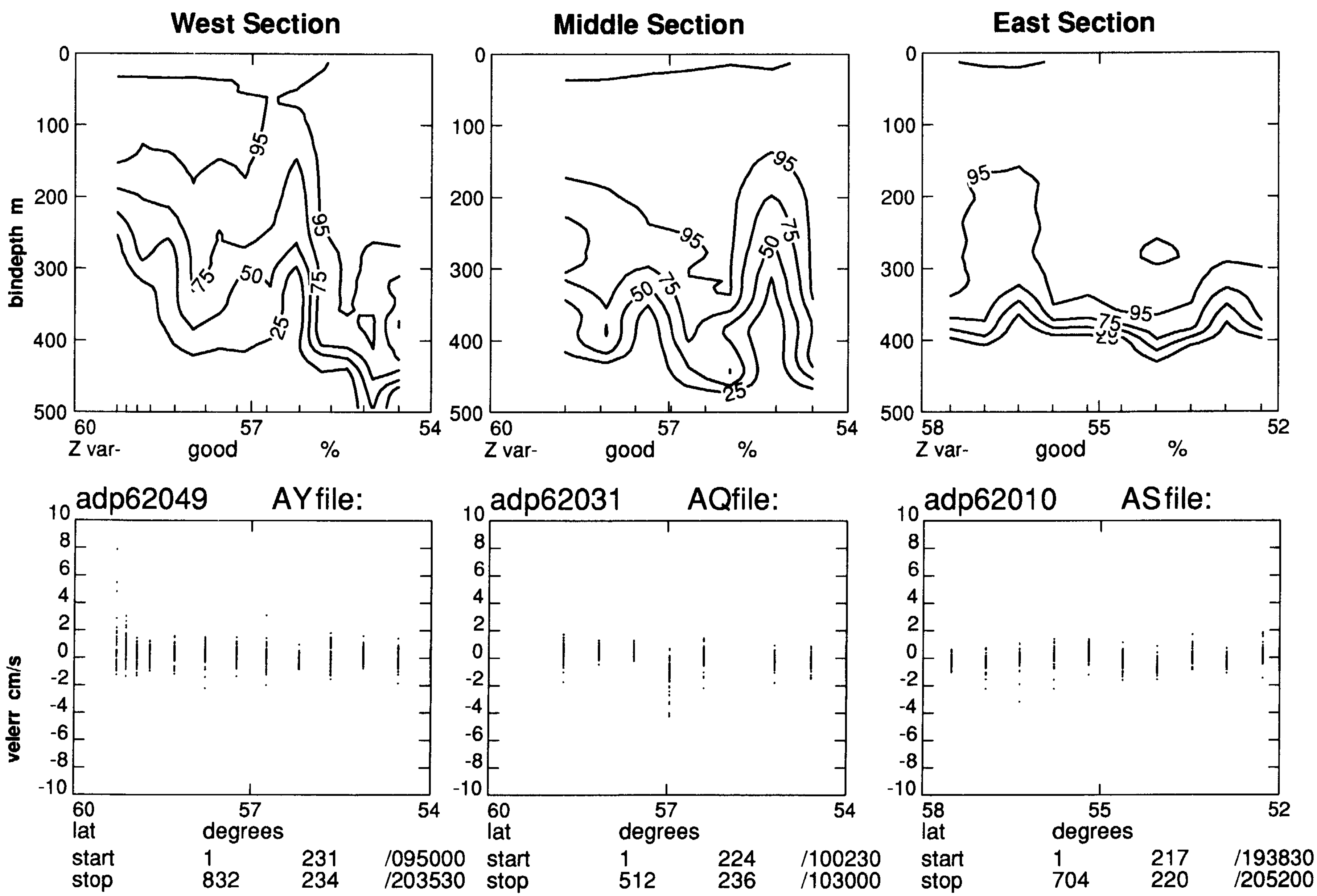


Figure 7. Plots of percent good (top) and error velocity (bottom) for the West, Middle and East Sections.

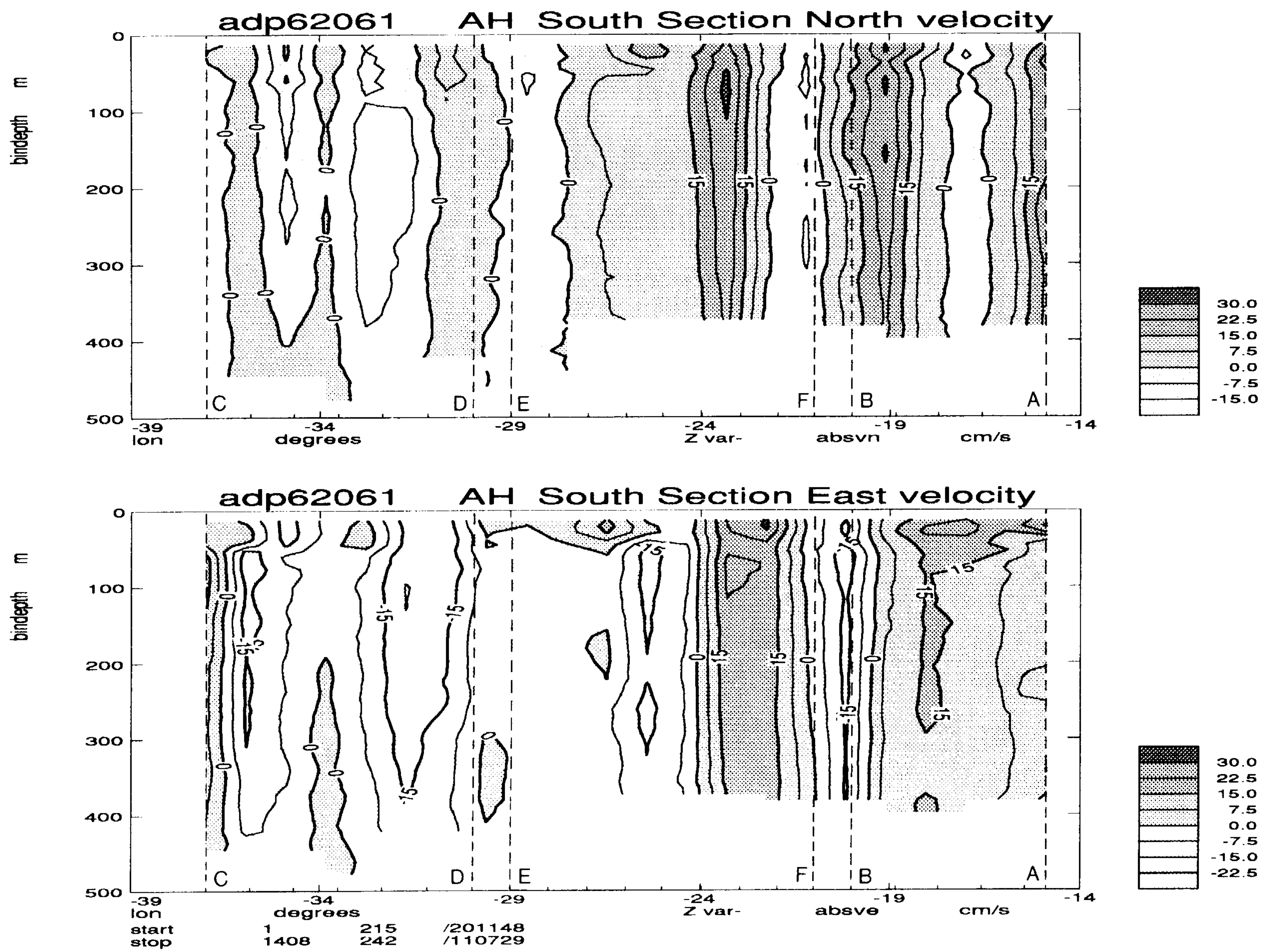
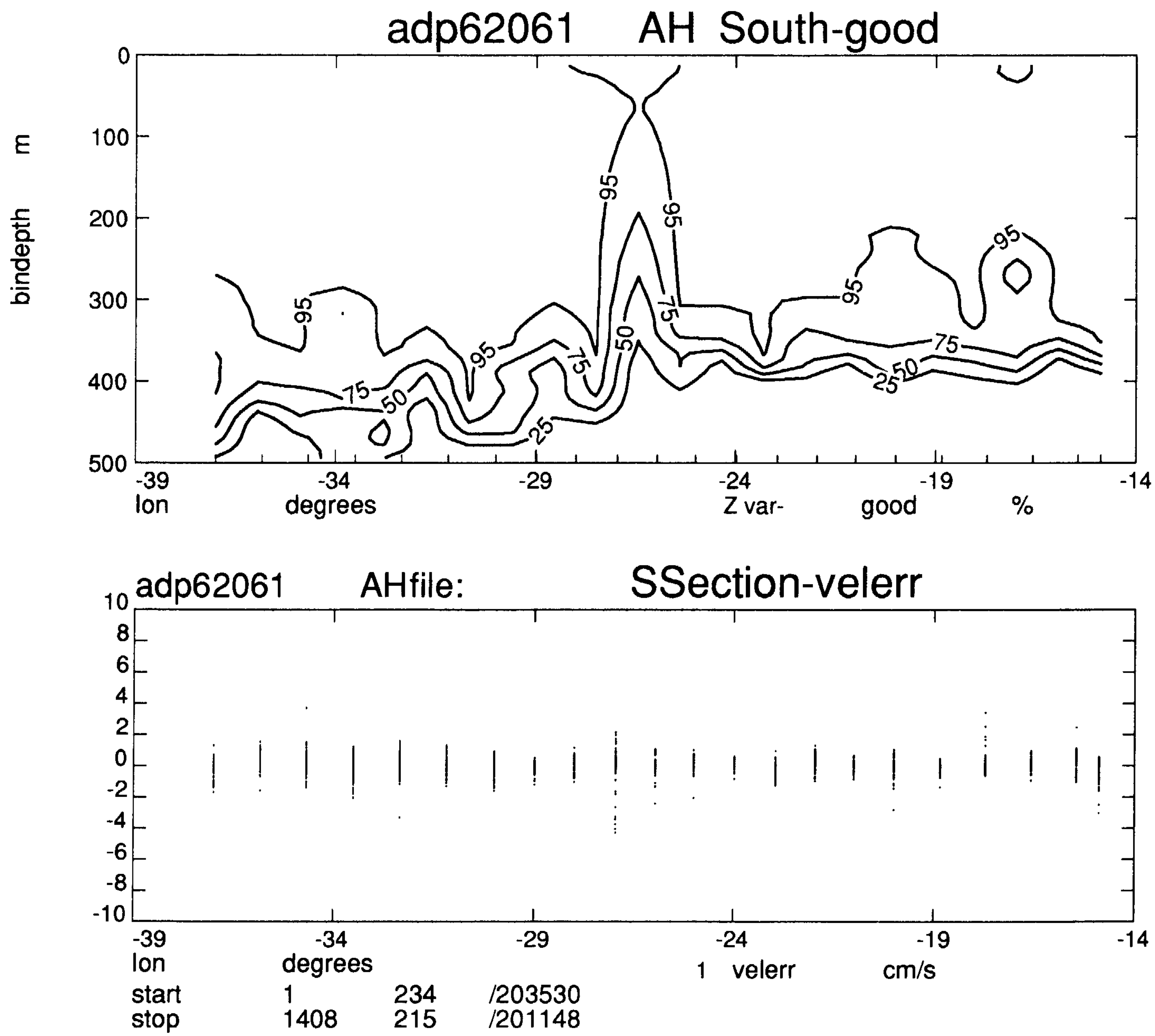


Figure 8. Contour plots showing the North and East velocity components of the currents along the South Section. Leg AB runs from jday 215.836 to jday 217.815, leg CD from jday 234.851 to jday 236.440 and leg EF from jday 239.026 to jday 242.153.



✳ Figure 9. Plots of percent good (top) and error velocity (bottom) for the South Section.

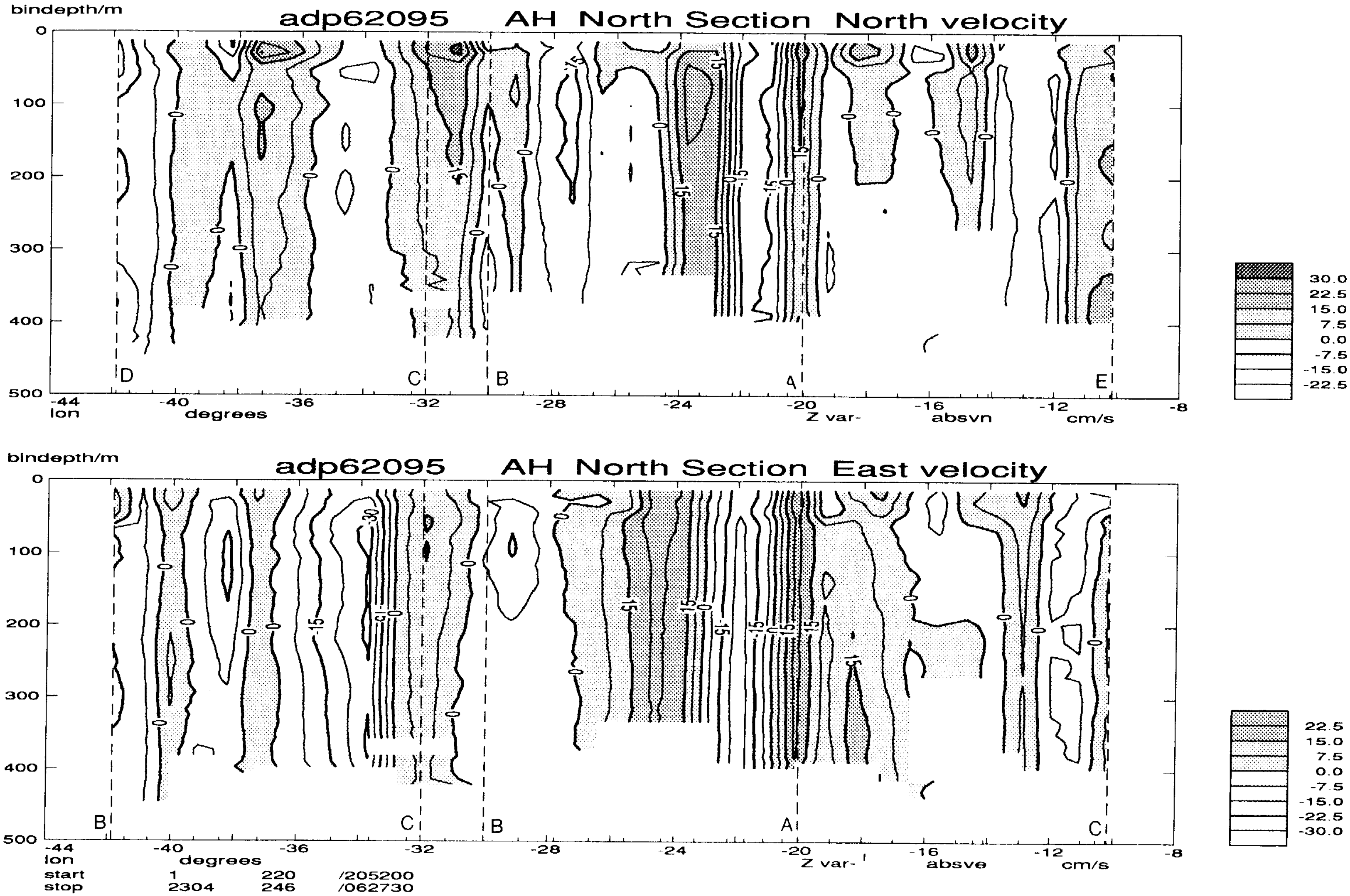


Figure 10. Contour plots showing the North and East velocity components of the currents along the North Section. Leg AB runs from jday 220.851 to 224.417, leg CD runs from jday 226.325 to 229.913 and leg AC from jday 243.953 to 246.257

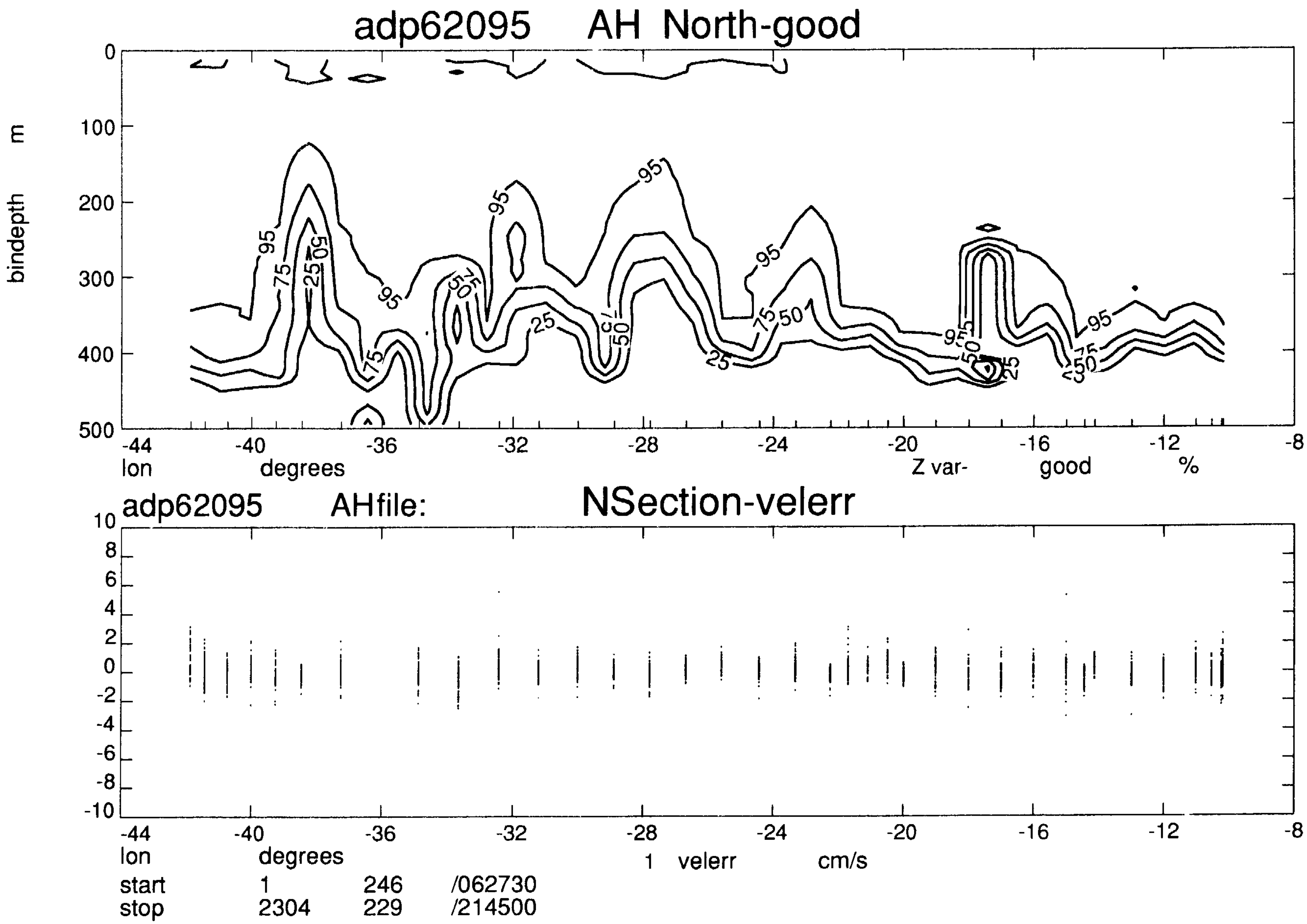


Figure 11. Plots of percent good (top) and error velocity (bottom) for the North Section.