UNITED STATES

DEPARTMENT OF THE INTERIOR

GEOLOGICAL SURVEY

CURRENT METER OBSERVATIONS WITHIN LOWER COOK INLET, ALASKA, 1978 - 1979 FROM THE R/V SEA SOUNDER, PACIFIC-ARCTIC BRANCH, U.S. GEOLOGICAL SURVEY

BY

M. L. Rappeport

U.S. Geological Survey
OPEN-FILE REPORT
81-49

This report is preliminary and has not been reviewed for conformity with U.S.Geological Survey editorial standards and stratigraphic nomenclature. Any use of trade names is for descriptive purposes only and does not imply endorsement by the U.S.G.S.

INTRODUCTION

The U.S. Geological Survey under contract to the U.S. Bureau of Land Management conducted geo-environmental hazard studies within lower Cook Inlet, Alaska from 1975 through 1979 (Bouma and Hampton,1976; Bouma and others, 1977 a,b, 1978 ; Hampton and Bouma 1979). As part of this effort the U.S. Geological Survey research vessel, R/V SEA SOUNDER, conducted two cruises in 1978 and one cruise in 1979 (Table 1). A number of stations were occupied for various periods of time (Fig. 1) during which tidal current speed and direction data was recorded. Some 1978 data was obtained concurrently with bottom boundary layer experiments conducted with a large instrumented tripod system referred to as GEOPROBE (Cacchione and Drake, 1979)

In 1978, observations were conducted in three small areas of the inlet (Fig. 2). In 1979, area 3 was revisited and new data obtained. Area 1 is a region of large sand waves with heights of 7-8 meters and wave lengths of 300 - 700 meters. This area is located on the eastern floor of the principal glacial trough of lower Cook Inlet (Cook Trough). Area 2 is located on the steep eastern flank of a prominant reentrant into the eastern shelf region of the inlet. Sand waves in this area have heights to 2-4 meters and are composed of coarser sands than those of the central trough (Orlando, 1980). Area 3 is a region of large sand waves at the mouth of Cook Trough also along its eastern side. Area 3 is a region that has been extensively studied by the Pacific-Arctic Branch of the U.S. Geologcial Survey as a representative site for observations and measurements of large tidally dominated sand waves. It has a complex bathymetry (Fig. 3) and a complete range of bedform sizes including micro,meso and macro scale bedforms (Rappeport, 1979).

Single stations were occupied in areas 1 and 2 while six stations were occupied within area 3. These stations are referred to as stations 324 and 005 in areas 1 and 2 respectively and stations 002,003,009,313,314 and 406 in area 3. The unadjusted positions of the individual lowerings within area 3 are shown in figure 4 and are listed for all lowerings in Table 2. The times for the lowerings are listed in Table 3.

INSTRUMENTATION

Current meter

All measurements were obtained with a HYDRO-PRODUCTS model 950-S Savonius rotor-type continuous profiling current meter system. This instrument system consisting of a model 906 container module coupled with a 951-S sensor and meter (current speed), a 952-S sensor and meter (direction), and a 902-S depth sensor, measures depth, mean velocity and direction (degrees magnetic) transmitting this data to a shipboard readout. Current direction has a system error of +/- 6°. Current speed has a system error of 3% full scale with two scale settings (0-300 cm/s and 0-50 cm/s) based upon a water temperature range of -10°C to 50°C. Lastly, depth has an overall system error of 1.4% full scale (scale range 0-300 m). The shipboard readout requires visual estimation of depth, velocity and direction from needle-type meters as well as manual transcription of the data. The system is calibrated yearly by the manufacturer as well as by marine electronic technicians of the marine support group (MARFAC) of the Pacific-Arctic Branch. The current meter is rated for current speeds between 0.05 and 7.0 knots (3 - 360 cm/s) and current directions from 0° - 360° magnetic.

Overall system accuracy taking operator error into consideration is estimated to be +/- 5 cm/s (speed), +/- 10°(direction) and +/- 2 meters (depth). Often large velocity flucuations and directional variations were observed over short periods of time. These variations are probably the result of large-scale turbulent eddies passing through the water column in the deployment area or some disturbance to the meter. Post-cruise data analysis suggests that the current meter systematically undermeasured water depth.

Navigation

Navigation was extremely precise. An integrated Magnavox satellite-Loran C and separate Motorola Mini-Ranger system were standard navigational equipment. Analysis of post-cruise positional plots based upon Mini-Ranger fixes suggests that there is a maximum 20 meter error in position within area 3. This error value was determined by analysis of the time-sequence position of the vessel while at anchor in area 3 during several 24 hour periods. This error value includes the intrinsic error of the Mini-Ranger system when operating at large distances, calibration error and the error induced by the spatial displacement of the Mini-Ranger antenna as the vessel rolls.

Attachments

For lowerings while at stations 002,003,005 009 and 406 the current meter was suspended on cable from the aft A-frame with a 36 Kg weight attached to the base of the instrument for stabilization. Lowerings at stations 313,314 and 324 were conducted with the current meter supported within a large vaned steel tripod consisting of welded uni-strut. The frame was designed such that the rotor elements of the current meter were at a height of one meter from the base and facing forward with an unobstructed current entrance.

Bathymetry

A Raytheon TR-73A transducer coupled with a Raytheon PTR 12 KHz transceiver was used to obtain precise bathymetric data during these studies. The transducer was hull-mounted at midship approximately 3 meters below the sea surface. Real-time display of the data was available through use of graphic recorders (EPC 4100 recorders) and a CRT display. The bathymetric data was recorded on magnetic tape for later analysis. The detailed bathymetric map shown in figure 3 was constructed from data obtained by digitization of 12 KHz echo sounding records and incorporates both transducer depth correction as well as a correction for tidal height. Tidal height correction is discussed in the following procedures section.

PROCEDURES

Sampling

Velocity measurements were made at 10 m depth intervals during lowering until the bottom was approached at which time a smaller interval was employed. At each step, the needle meters in the shipboard readout were allowed to steady up prior to recording values. Once slack wire was observed the sampling was stopped and the current meter retrieved. On some lowerings measurements were taken both going down and on the way up. In most lowerings careful attention was placed in obtaining near bottom measurements and in particular during series 313,314 and 324 during which the vaned tripod frame was employed.

The time interval between initial current meter deployment and retrieval varied between 12 and 32 minutes. For any lowering, current speeds and directions were not synoptic. Since tidal currents are not likely to vary significantly over a within area 3 are shown in figure 6. These positions were subjectively estimated by evaluating the relative position of the current meter based upon ship's heading, surface and bottom current directions and speeds, and the spatial offsets as discussed. These adjustments ranged from 0 - 50 m. In addition to these corrections to the current meter bottom positions another element in repositioning required a comparison of profiling current meter recorded depths, the 12 KHz echo-sounder depths and depths determined from the bathymetric map.

Depth corrections

Prior to analysis the various depth measurements available at each lowering were in partial disagreement. For each lowering there were four available values for water depth. These were (1) depth as reported on sample log, (2) measured depth from high resolution echo-sounding seismic system (usually 12 KHz), (3) depth measured by the pressure sensor of the current meter system, (4) depth determined from bathymetric map (Fig. 3.). Depths determined from the map required tidal height corrections since the bathymetric map is adjusted to mean sea level. It also involves the spatial adjustments. Of the four values the reported depth often was the most significantly in error. This was most likely due to operator difficulty in determining the 0 level on the high resolution seismic record as well as failure to account for the 3 m transducer depth adjustment. Some of these errors were easily corrected during analyis. A plot of water depth values as measured from the map and adjusted for tide but not spatially versus the uncorrected measured depths from the high resolution seismic records is shown in figure 7. On the same graph is plotted the unadjusted current meter measured depths versus the depths measured from the seismic records. The plot shows an even distribution around the 0 deviation line for the measurements from the map and the depths measured from the seismic small time interval, the measurements are considered quasi-synoptic. Only during phases of the tide when rapid decceleration or acceleration of the tidal current occurs is this assumption inapplicable. The majority of the measurements were obtained during times when this assumption was valid.

Spatial corrections

During occupation of a station the R/V SEA SOUNDER was moored by a single bow anchor and was thus free to rotate around the anchor position as a function of the tidal currents. The surface tidal current ellipse is essentially rotary within the central part of the inlet, while the eastern and western shelf regions of the inlet are characterized by tidal ellipses that are more elongated. An analysis of the path of the R/V SEA SOUNDER while on station 314 shows this typical rotary pattern (Fig. 5). The estimated semi-major axis of the path of the vessel while on anchor was approximately 100 meters while the semi-minor axis averaged about 60 meters. The overall orientation of the tidal current ellipse as shown by the movement of the vessel is elongated slightly in at north-northeast to south-southwest direction.

On the R/V SEA SOUNDER, there is a 22 m offset between the central mast where the Mini-ranger antenna is located and the aft A-frame boom. In addition there is an added 4 m lateral offset when the A-frame is lowered into operating position. To adjust the bottom position of each current meter lowering it was considered neccessary to correct for the above 26 meter offset. For some lowerings when the currents were particularily swift it was also necessary to correct for any offset of the meter due to the meter not remaining directly under the vessel during sampling. The final bottom positions of the current meter system for each lowering records. However, the depths measured by the current meter appear to be systematically offset towards the low side. This observation leads to the conclusion that the depths recorded by the profiling current meter are likely systematically low in the order of 2 to 3 meters.

Tidal height corrections

A requirement for precise bottom positioning is a detailed bathymetric map. A location specific bathymetric map was constructed by initial computer contouring of digitized 12 KHz echo-sounding data followed by manual interpretation and adjustment. In the process of compiling the data base for the contouring it was necessary to adjust the data to mean sea level. This correction was determined by analysis of tidal data from the C.O.S.T. well of Arco Petroleum company which was situated just north northwest of area 3 and from depths measured by the pressure transducer incorporated in the GEOPROBE bottom boundary layer measurement tripod during one of three deployments in area 3 . The C.O.S.T. data suggested that the times of high water were equal to the reported times of high water at the Seldovia, Alaska tidal station plus one hour and 2 minutes while the maximum tidal height was equal to Seldovia's listed high tide height less 2.9 feet (in: Tidal current tables- Pacific Coast of North America, 1978, U.S. Department of Commerce). The time of slack water was reported for the C.O.S.T well site as equal to the reported time for slack water at Wrangle Narrows . Correction factors determined from the GEOPROBE data together with the reported correction factors for the C.O.S.T well suggests that for area 3 the times of high and low water range from 1 hour 5 minutes to 1 hour 12 minutes later than the times for high and low water at Seldovia ,Alaska tidal station. The tidal height differences from Seldovia were determined to be approximately -2.9 feet for high tide and 0.0 feet for low tide.

For a first order approach to adjustment of water depth a constant correction of + 1 hour 10 minutes was used as well as a -2.9 foot correction for tidal height adjustment. These corrections were then applied to all high and low tide times for the period of the current meter lowerings. Corrections for individual lowerings were then obtained by linear interpolation between the calculated high and low water heights based upon time differences. This approach yielded tidal height variations that were close to those measured by the GEOPROBE pressure transducer at the equivalent times. A sinusoidal fit to the tidal height data was felt to be inappropriate in light of the overall errors in corrections for depth.

Final corrections

Table 4 lists for each lowering the corrected current meter recorded depth, the best estimated depth, the reported depth , the measured depth from seismic records and the spatially and tidally adjusted map depth for the bottom position of the current meter. The overall fit of all these sources of data is now much more in agreement. This is especially evident when best estimated depth (based upon measured, map, reported and recorded) is plotted against map depth based upon corrected position (Fig. 8). Here the correlation is striking and supports the validity of the correction methodology and the overall accuracy of the bathymetric map.

The estimated error for the final positions is of comparable magnitude to the error in Mini-ranger positioning but it is felt that the final positions (Fig. 6) represent the best estimate of bottom position for each lowering. Lateral error is considered less than 50 meters maximum and between 15 and 30 meters on the average.

DATA

Raw data

Appendix A contains plots of current speed versus depth and current direction versus depth for all 59 lowerings taken in lower Cook Inlet. These plots are raw data plots without depth adjustment. The bottom shown is only for reference and is not intended to represent the actual recorded bottom depth. Downgoing observations are indicated by solid connecting lines while measurements taken while coming up are connected by dashed lines.

Adjusted data

Appendix B contains quasi-synoptic plots of corrected depth (plotted on semilog scale) versus current speed (plotted on linear scale). The values are spatially and temporally averaged. Plots were constructed only for those profiles where the current directions were relatively unidirectional from near-surface to the bottom. In general, directional differences in excess of 100° constituted justification for not plotting a profile in the semi-log format. A plot in the semi-log format is only useful for flow analysis when there is steady flow (no large accelerations or deccelerations in the flow) and unidirectionality. Forty plots are presented in which these requirements are approximately met.

Bouma, A.H. and Hampton, M.A., 1976, Preliminary report on the surface and shallow subsurface geology of lower Cook Inlet and Kodiak shelf, Alaska: U.S. Geological Survey, Open-File Report 76-695, 36p.

Bouma, A.H., Hampton, M.A., Wennekens, M.P., and Dygas, J.A, 1977a, Large dunes and other bedforms in lower Cook Inlet ,Alaska : Ninth Offshore Technology Conference, Paper 2737, p. 79-85.

Bouma, A.H., Hampton, M.A. and Orlando, R.C., 1977b, Sand waves and other bedforms in lower Cook Inlet, Marine Geotechnology, v. 2, p. 291-308.

Bouma, A.H., Hampton, M.A., Rappeport, M.L., Whitney, J.W., Teleki, P.G., Orlando, R.C. and Torresan, M.E., 1978, Movement of sand waves in lower Cook Inlet, Alaska : Tenth Offshore Technology Conference, Paper 3311, p. 2271-2284

Bouma, A.H., Rappeport, M.L., Cacchione, D.A., Drake, D.E., Garrison, L.E.,Hampton, M.A., and Orlando, R.C.,1979, Bedform characteristics and sand transport in a region of large sand waves, lower Cook Inlet, Alaska, Eleventh Offshore Technology Conference, Paper 3485.

Cacchione, D.A., and Drake, D.E., 1979, Bottom and near-bottom sediment dynamics in lower Cook Inlet: Annual Report RU 430, Outer Continental Shelf Environmental Assessment Program (OCSEAP), 41 p.

Hampton, M.A. and Bouma, A.H., 1979, Notes on the acquisition of high resolution seismic reflection profiles, side-scanning sonar records, and sediment samples from lower Cook Inlet and Kodiak Shelf, R/V SEA SOUNDER Cruise S8-78-WG, August 1978., U.S. Geological Survey, Open-File Report, 79-1311.

Orlando, R.C., in press, Compilation and parameters for analyzed sediment samples collected from Lower Cook Inlet, Alaska 1976 through 1979, U.S. Geological Survey, Open-File Report, 80-xxx.

Rappeport, M.L, Cacchione, D.A., Bouma, A.H., and Drake, D.E., 1979, Seafloor microtopography, tidal current characteristics and bottom boundary layer time-series data, Cook Inlet, Alaska, (abs.): EOS, American Geophysical Union, Transactions, v. 60., no. 18., p. 285.

TABLE 1

CRUISE	DATE(Julian)/HR-MIN(Greenwich)
S7-78-WG	205/1756 -- 212/1810
S8-78-WG	214/1539 -- 234/0153
S8-79-WG	210/1700 -- 217/2015

TABLE 1

CRUISE	DATE(Julian)/HR-MIN(Greenwich)
S7-78-WG	205/1756 -- 212/1810
S8-78-WG	214/1539 -- 234/0153
S8-79-WG	210/1700 -- 217/2015

Table 1. Start and end dates for cruises within lower Cook Inlet 1978-1979 in which current meter data was recorded.

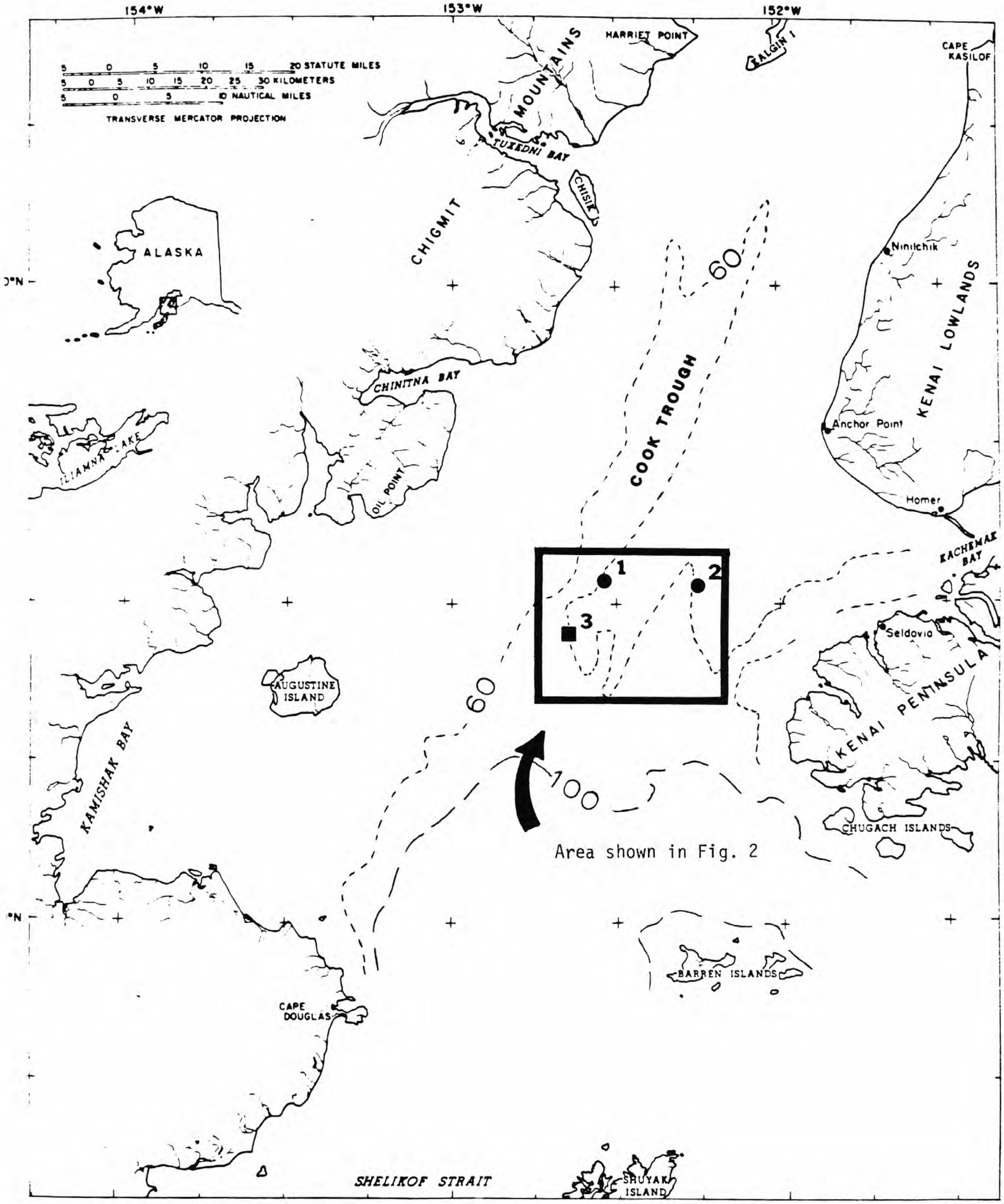


Figure 1. Sites within lower Cook Inlet where current meter observations were conducted 1978-1979. Areas are referred to by number in text.

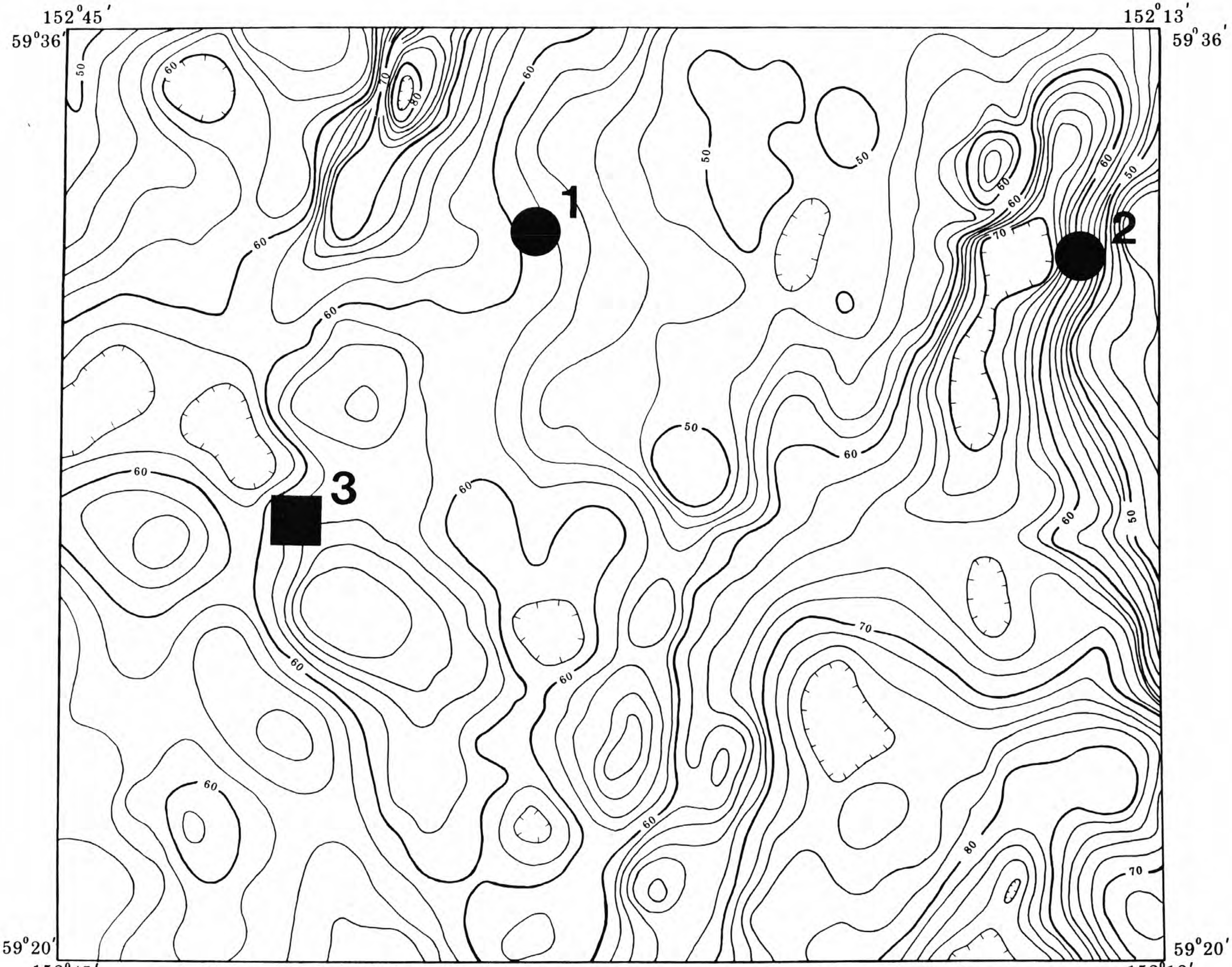


Figure 2. Detailed bathymetry of portion of lower Cook Inlet with site locations.

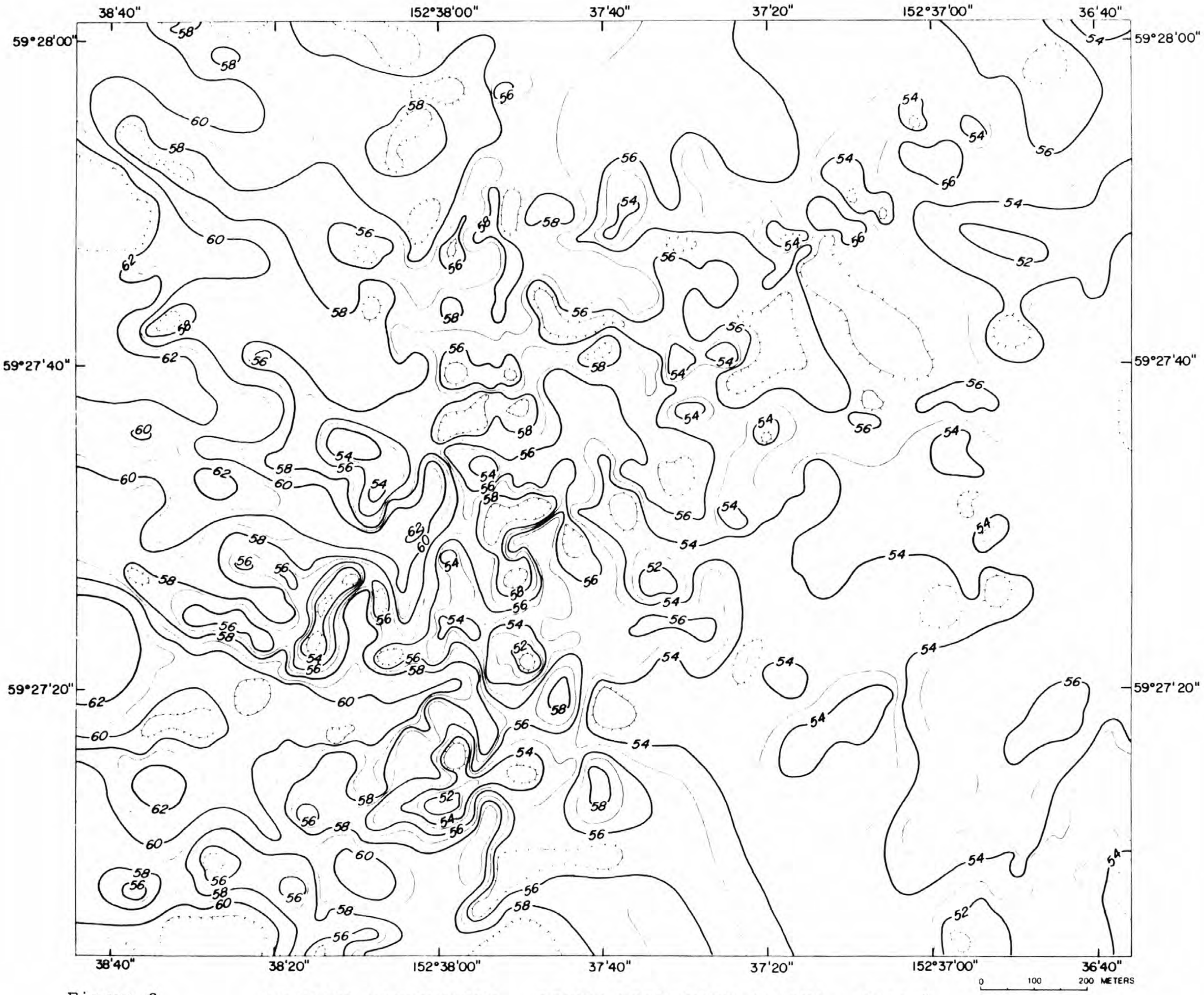


Figure 3. **DETAILED BATHYMETRY - LOWER COOK INLET, ALASKA** - Area 3

CONTOUR INTERVAL 1 METER

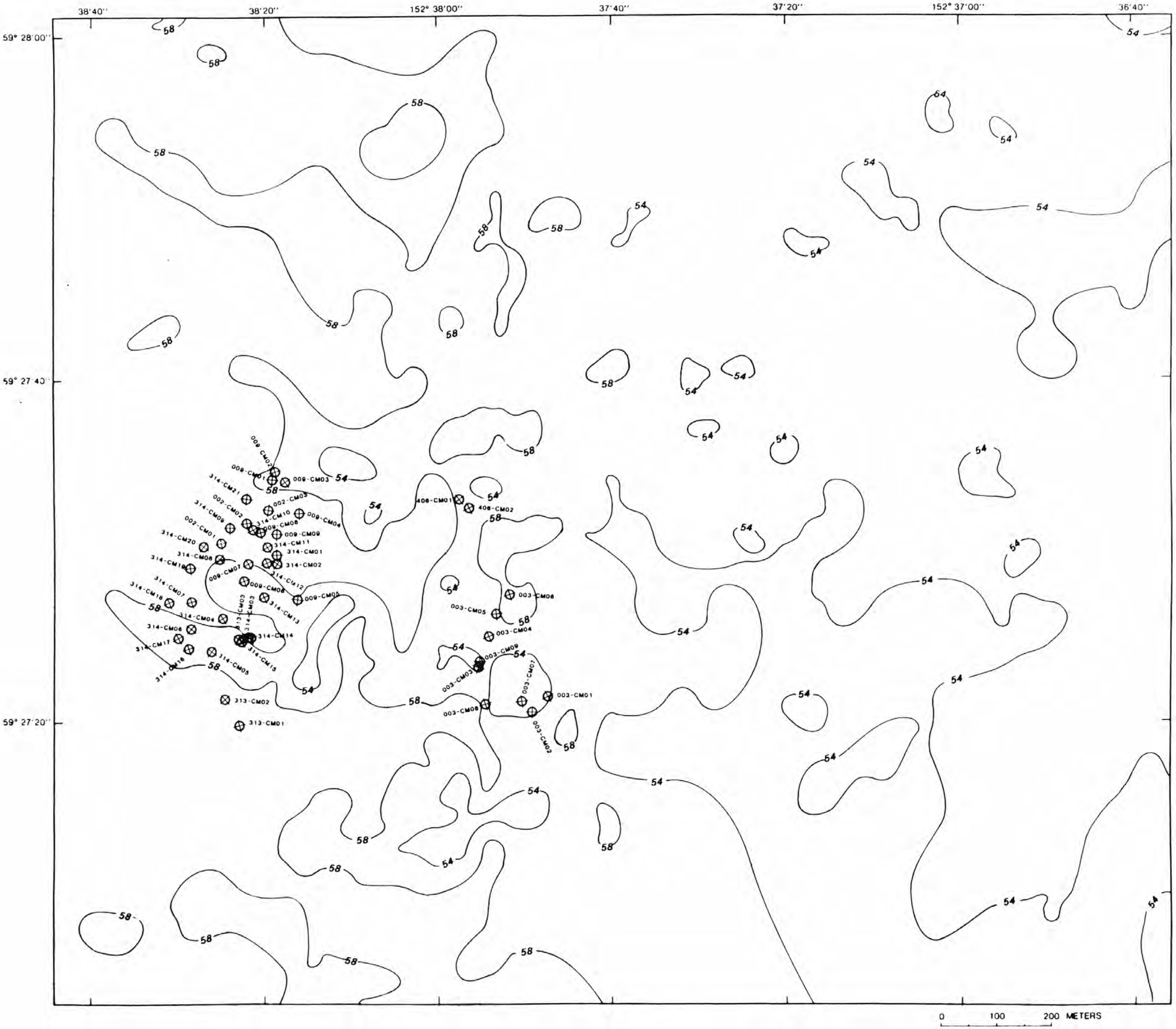


Figure 4. Unadjusted positions of lowerings - area 3.

Table 2. Latitude and longitude of each lowering of current meter within lower Cook Inlet 1978-1979.

002-CM01	59°27'30.56"	152°38'25.01"
002-CM02	59°27'31.71"	152°38'22.09"
002-CM03	59°27'32.51"	152°38'19.72"
003-CM01	59°27'21.53"	152°37'47.35"
003-CM02	59°27'20.45"	152°37'49.12"
003-CM03	59°27'23.22"	152°37'55.34"
003-CM04	59°27'24.98"	152°37'54.16"
003-CM05	59°27'26.32"	152°37'53.44"
003-CM06	59°27'27.47"	152°37'51.67"
003-CM07	59°27'21.13"	152°37'50.41"
003-CM08	59°27'20.95"	152°37'54.66"
003-CM09	59°27'23.54"	152°37'55.27"
005-CM01	59°32'04.13"	152°15'49.82"
005-CM02	59°32'04.06"	152°15'52.31"
005-CM03	59°32'05.32"	152°15'51.19"
005-CM04	59°32'09.31"	152°15'51.16"
005-CM05	59°32'11.36"	152°15'52.27"
005-CM06	59°32'11.11"	152°15'52.59"
005-CM07	59°32'06.22"	152°15'53.68"
009-CM01	59°27'34.24"	152°38'19.36"
009-CM02	59°27'34.70"	152°38'18.96"
009-CM03	59°27'34.06"	152°38'17.70"
009-CM04	59°27'32.36"	152°38'16.22"
009-CM05	59°27'27.29"	152°38'16.40"
009-CM06	59°27'28.26"	152°38'22.38"
009-CM07	59°27'27.94"	152°38'21.88"
009-CM08	59°27'31.28"	152°38 20.36
009-CM09	59°27'31.14"	152°38'18.71"

313-CM01	59°27'20.02"	152°38'21.84"
313-CM02	59°27'21.35"	152°38'24.50"
313-CM03	59°27'24.91"	152°38'22.99"
314-CM01	59°27'29.92"	152°38'18.71"
314-CM02	59°27'29.36"	152°38'19.19"
314-CM03	59°27'26.19"	152°38'22.04"
314-CM04	59°27'25.65"	152°38'23.98"
314-CM05	59°27'24.71"	152°38'25.82"
314-CM06	59°27'25.60"	152°38'28.03"
314-CM07	59°27'28.15"	152°38'28.79"
314-CM08	59°27'29.98"	152°38'25.26"
314-CM09	59°27'31.25"	152°38'21.41"
314-CM10	59°27'31.54"	152°38'21.88"
314-CM11	59°27'30.74"	152°38'19.86"
314-CM12	59°27'29.20"	152°38'19.71"
314-CM13	59°27'27.29"	152°38'20.69"
314-CM14	59°27'25.02"	152°38'21.95"
314-CM15	59°27'24.77"	152°38'22.67"
314-CM16	59°27'24.01"	152°38'28.21"
314-CM17	59°27'25.24"	152°38'30.64"
314-CM18	59°27'27.04"	152°38'31.52"
314-CM19	59°27'29.02"	152°38'29.47"
314-CM20	59°27'30.24"	152°38'27.64"
314-CM21	59°27'33.21"	152°38'23.39"
324-CM01	59°32'27.31"	152°31'05.02"
324-CM02	59°32'30.08"	152°31'01.20"
324-CM03	59°32'32.24"	152°30'55.19"
324-CM04	59°32'32.40"	152°31'04.20"
324-CM05	59°32'52.20"	152°30'44.40"
406-CM01	59°27'25.20"	152°38'02.40"
406-CM02	59°27'25.10"	152°38'02.20"

Table 3. List of representative bottom times for all current meter lowerings

TABLE 3

LOWERING	Representative Bottom Time
	1978
002-CM01	207/0009
002-CM02	207/0212
002-CM03	207/0340
003-CM01	207/0803
003-CM02	207/1006
003-CM03	207/1234
003-CM04	207/1343
003-CM05	207/1529
003-CM06	207/1715
003-CM07	207/2045
003-CM08	207/2235
003-CM09	208/0100
005-CM01	208/2043
005-CM02	208/2304
005-CM03	209/0100
005-CM04	209/0314
005-CM05	209/0513
005-CM06	209/0703
005-CM07	209/0905
009-CM01	210/0408
009-CM02	210/0607
009-CM03	210/0805
009-CM04	210/1005
009-CM05	210/1216
009-CM06	210/1410
009-CM07	210/1604
009-CM08	210/1805
009-CM09	210/2010
313-CM01	217/1840
313-CM02	217/2011
313-CM03	217/2145
314-CM01	218/0112
314-CM02	218/0240
314-CM03	218/0425
314-CM04	218/0542
314-CM05	218/0711
314-CM06	218/0808
314-CM07	218/0910
314-CM08	218/1031
314-CM09	218/1142
314-CM10	218/1240
314-CM11	218/1344
314-CM12	218/1443
314-CM13	218/1549
314-CM14	218/1638
314-CM15	218/1718

314-CM16	218/1805
314-CM17	218/1938
314-CM18	218/2042
314-CM19	218/2140
314-CM20	218/2252
314-CM21	219/0002
324-CM01	221/2233
324-CM02	221/2338
324-CM03	222/0036
324-CM04	222/0311
324-CM05	222/0411

1979

406-CM01	213/0559
406-CM02	213/0635

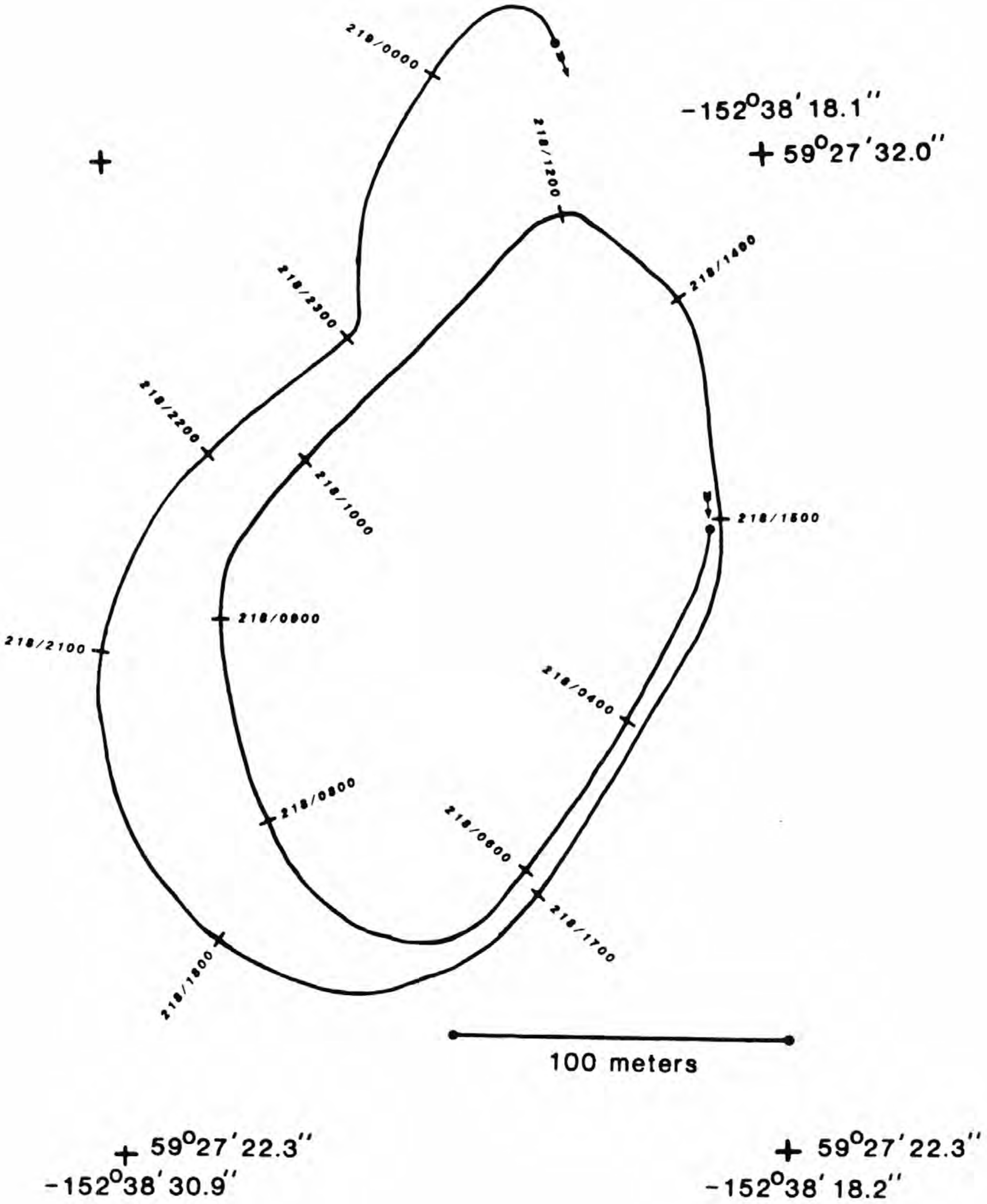


Figure 5. Schematic path of R/V SEA SOUNDER while at anchor at station 314.

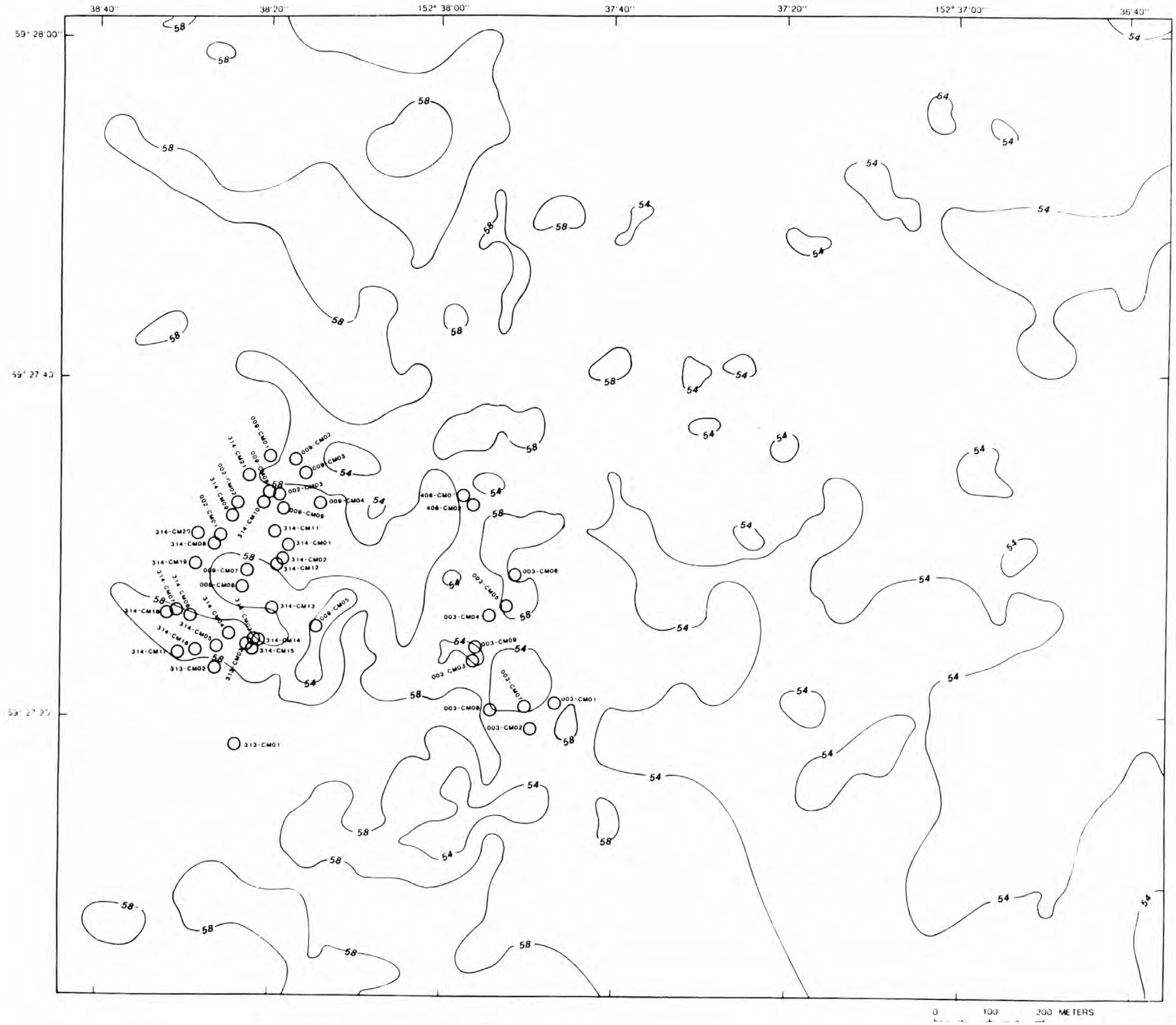


Figure 6. Final adjusted positions for all lowerings within area 3.

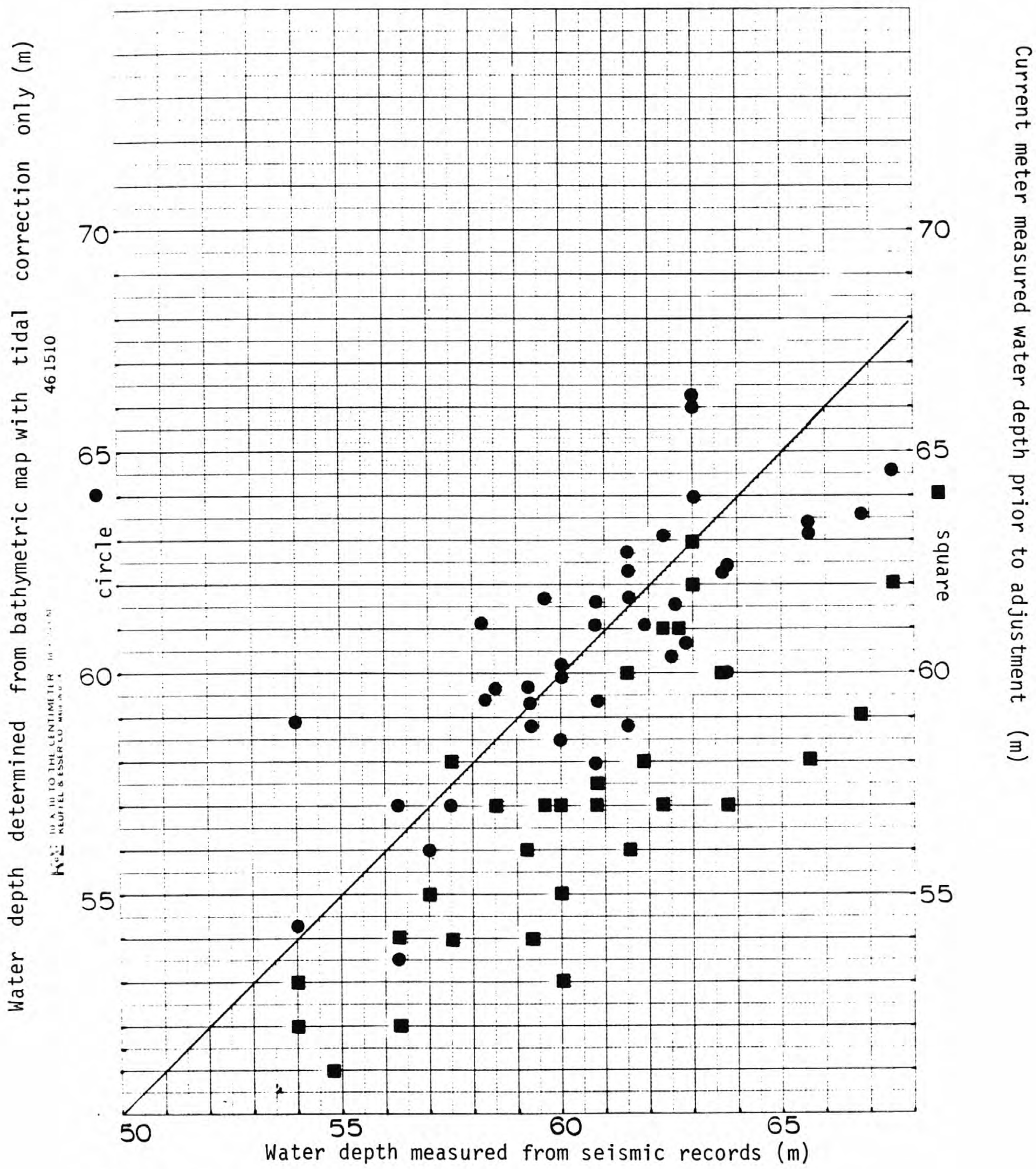


Figure 7. Depth determined from bathymetric map plotted against depth measured from seismic records. Also plotted on same graph are depths recorded by current meter versus seismic record determined depths.

Table 4. Table of various depth measurements for all lowerings.

Lowerings	(1)	(2)	(3)	(4)	(5)	(6)
002-CM01	57		61	61	61.5	62
002-CM02	62		64	64		65
002-CM03	62		64	64		64
003-CM01	52	55-56	56	57	54	58
003-CM02	54		56	55	56	57
003-CM03	54		55			56
003-CM04	57		58	58		59
003-CM05	60		61	55		62
003-CM06	59		59	60		58
003-CM07	55	57-58	57	55		57
003-CM08	57	57-58	57	60		56
003-CM09	52	54-55	56	55		56
009-CM01	57		62	60	63	62
009-CM02	57	60-61	61		62	61
009-CM03	57		61	60	63	60
009-CM04	57	59-60	61	62	64	61
009-CM05	54	54-55	55		54	55
009-CM06	52	57-58	58	55	61	57
009-CM07	55	55-56	58	56	59	59
009-CM08	59	59-60	61	62	65	61
009-CM09	62		64		65	64
313-CM01	58	59	60	57	61	60
313-CM02	59	60	60	59	61	60
313-CM03	58	59	60	56	61	60
314-CM01	63	64	64	65	68	65
314-CM02	61	62	62	64	64	62
314-CM03	58	59	59	57	60	60
314-CM04	55	56	56	55	59	57
314-CM05	55	56	56	54	58	57
314-CM06	56	57	57	56	60	59
314-CM07	57	58	58	58	59	60
314-CM08	62	63	63	60	63	62
314-CM09	64	65	65	65	63	66
314-CM10	64	65	65	64	63	66
314-CM11	63	64	64	65	63	65
314-CM12	61	62	62	62	62	62
314-CM13	57		59	57	62	60
314-CM14	54		58	58	60	59
314-CM15	57		58	56	59	59
314-CM16	57	58	58	54	57	57
314-CM17	56	57	57	54	56	57
314-CM18	54		57	57	59	58
314-CM19	58	59	59	57	60	61
314-CM20	62	63	63	61	62	64
314-CM21	60	61	62		67	63

(1) Lowest recorded depth by current meter

(2) Bottom depth as recorded by current meter

(3) Estimated bottom depth

(4) Reported water depth on sample logs

(5) Measured water depth from seismic log

(6) Water depth determined from bathymetric map after corrections

NUMBER	meter low	meter bottom	estimated	reported	measured	map
324-CM01	52	53	53	50	55	
324-CM02	59	60	60	58	62	
324-CM03	58	59	59	60	62	
324-CM04	61	62	62	61	64	
324-CM05	61	62	62	62	64	
005-CM01	64	66	66		69	
005-CM02	66		67	66	67	
005-CM03	67		67	67	67	
005-CM04	66		67		70	
005-CM05	62	64	66	66	69	
005-CM06	62	65	67	68	68	
005-CM07	62	64	66	66	70	
406-CM01						
406-CM02						

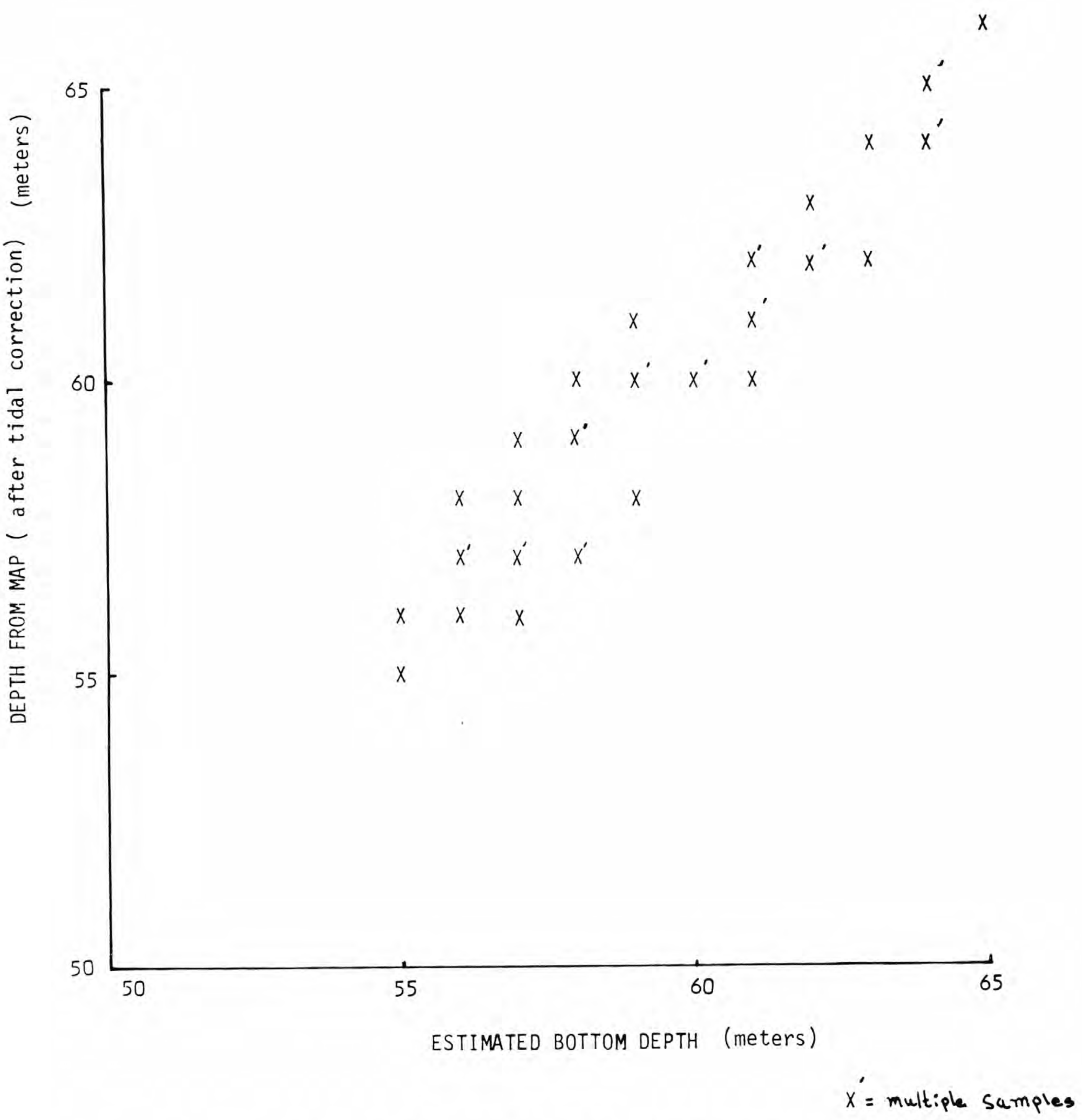


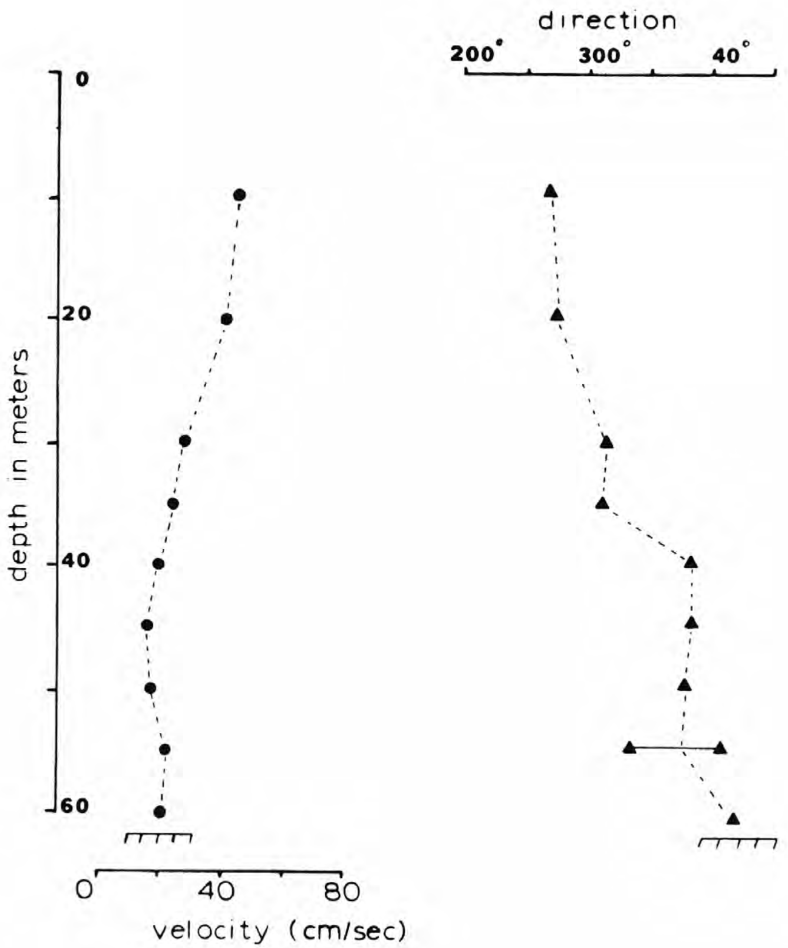
Figure 8. Plot of adjusted depth (spatial and tidal) from map versus final estimated depth for all lowerings.

APPENDIX A

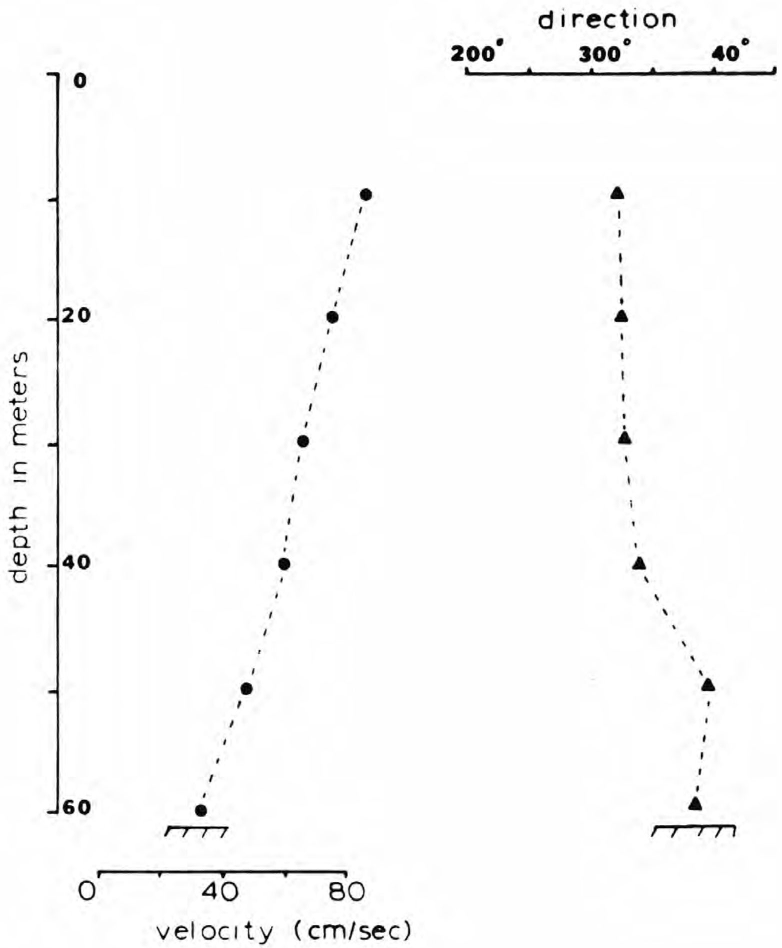
RAW DATA PLOTS

(Current speed and direction versus depth as recorded)

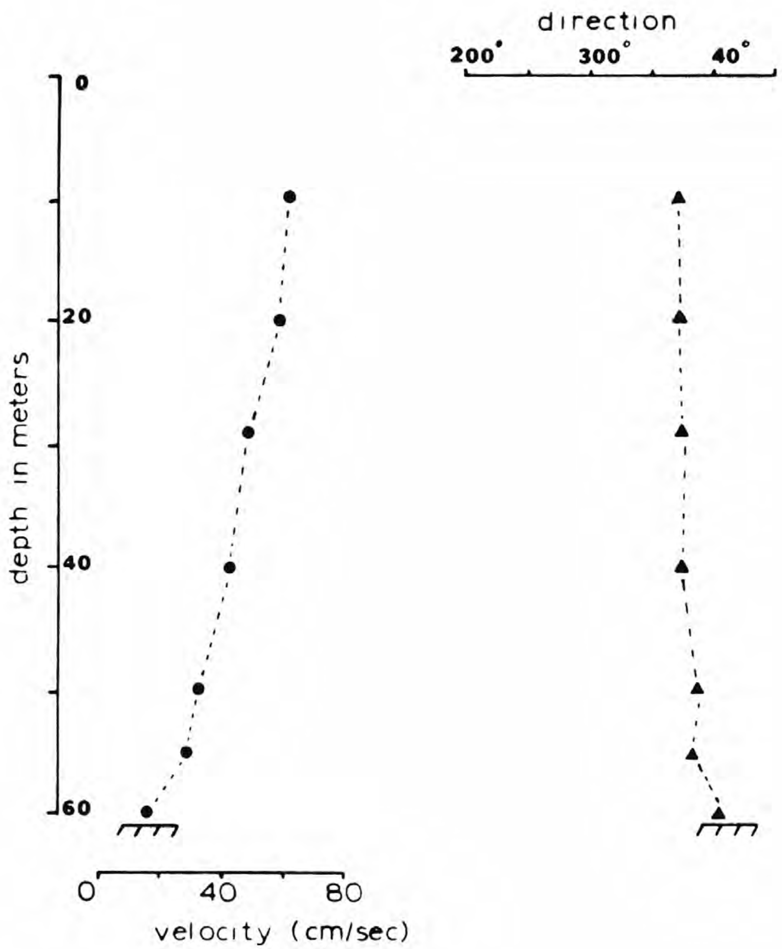
STATION 002 CM-01



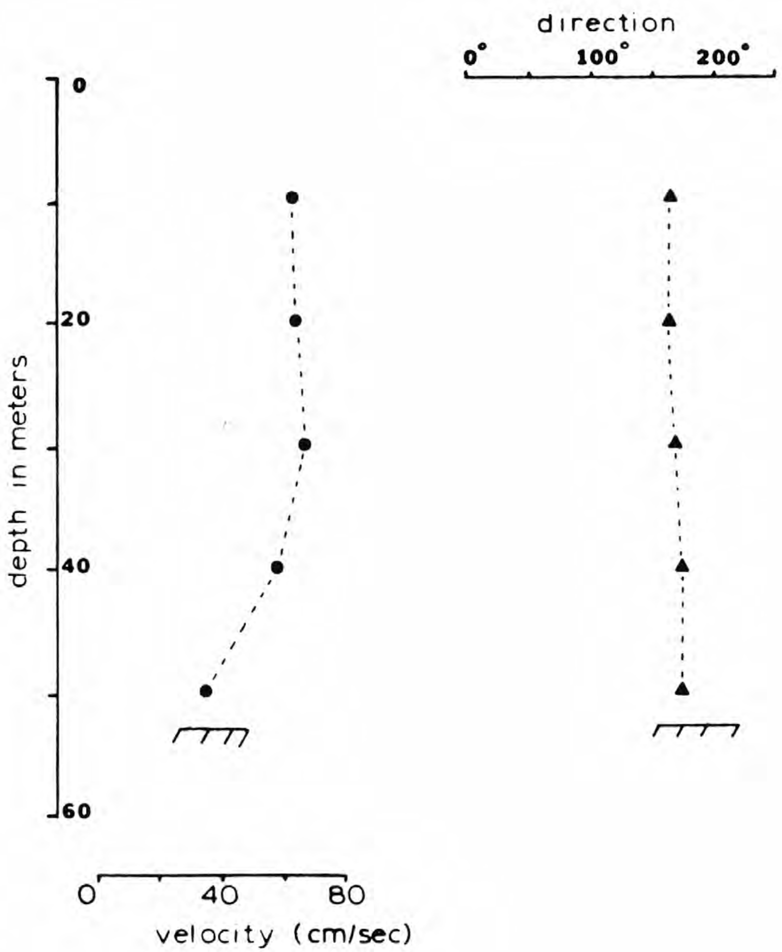
STATION 002 CM-02



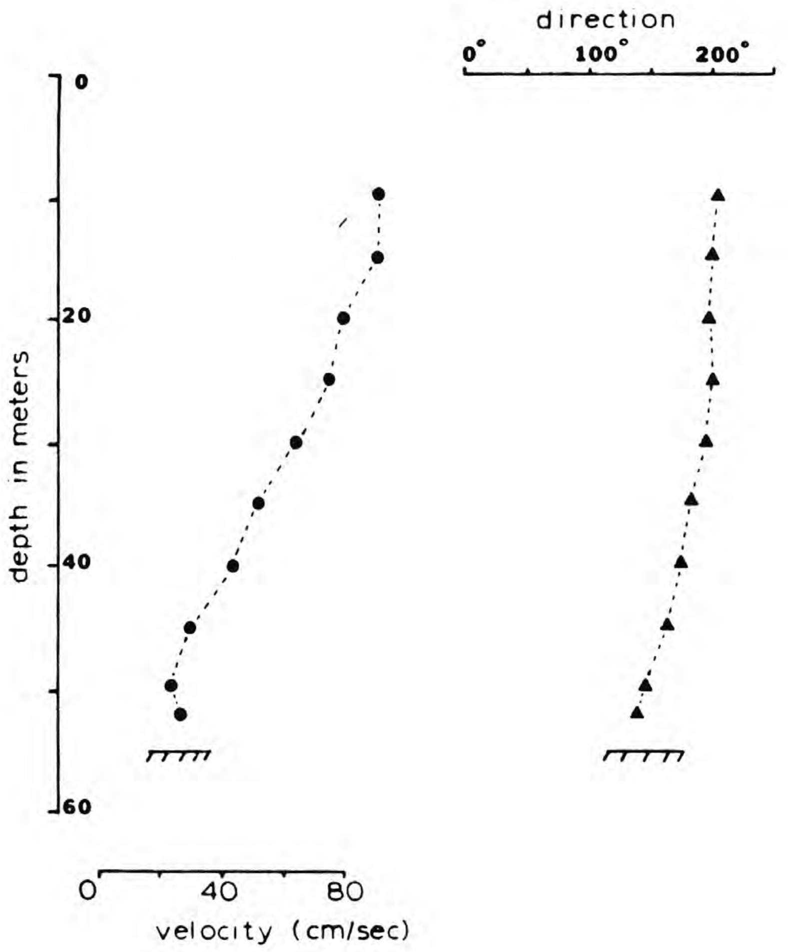
STATION 002 CM-03



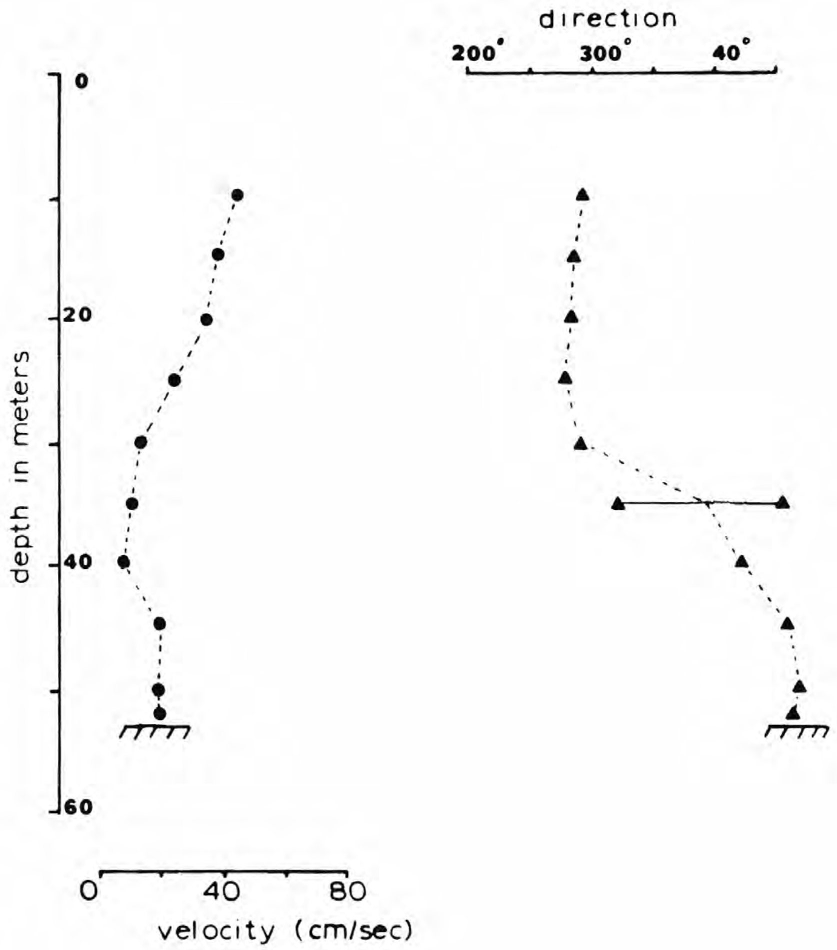
STATION 003 CM-01



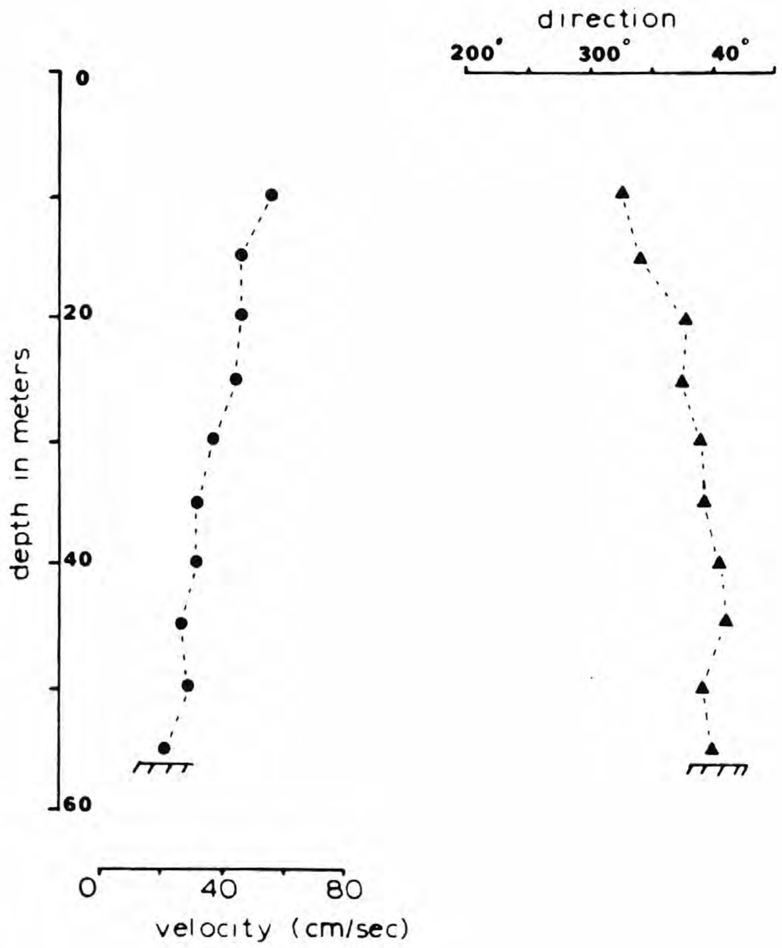
STATION 003 CM-02



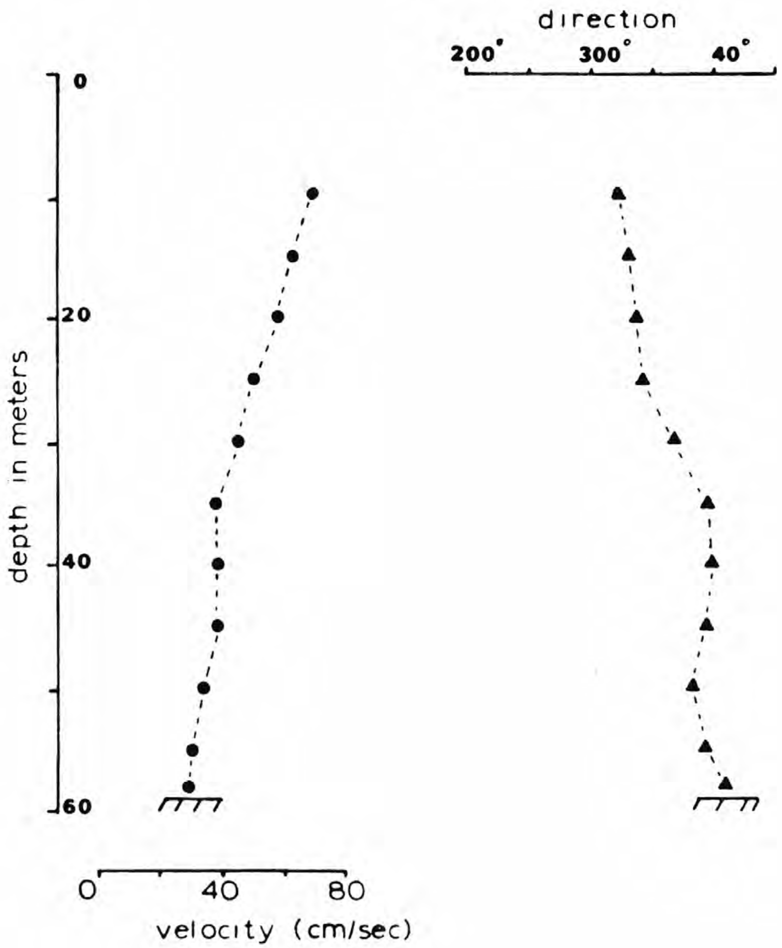
STATION 003 CM-03



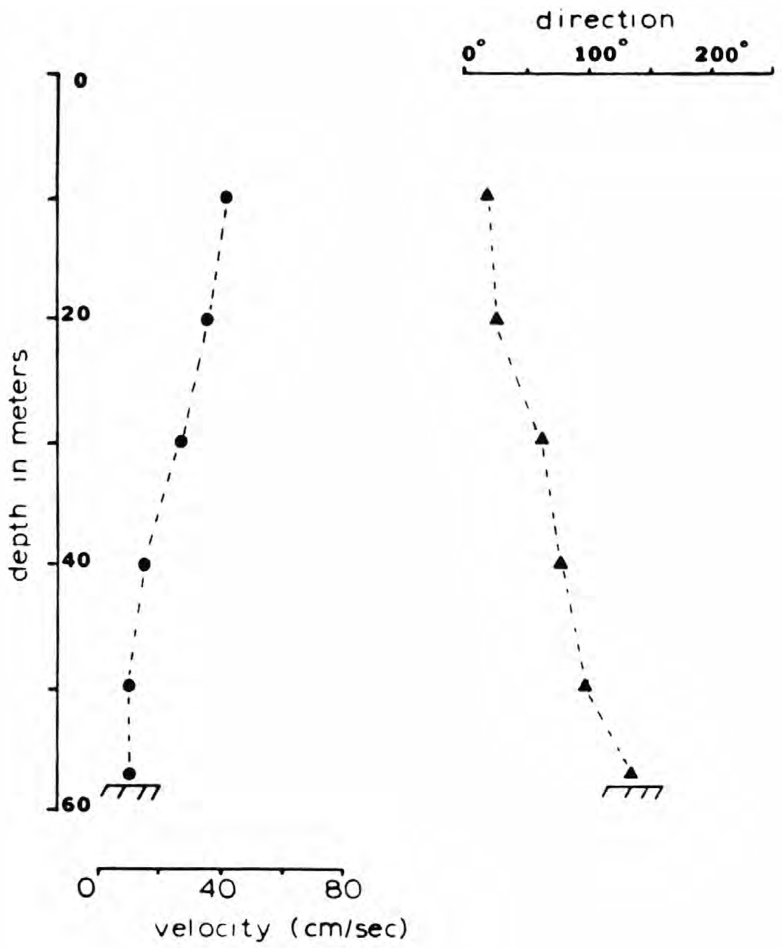
STATION 003 CM-04



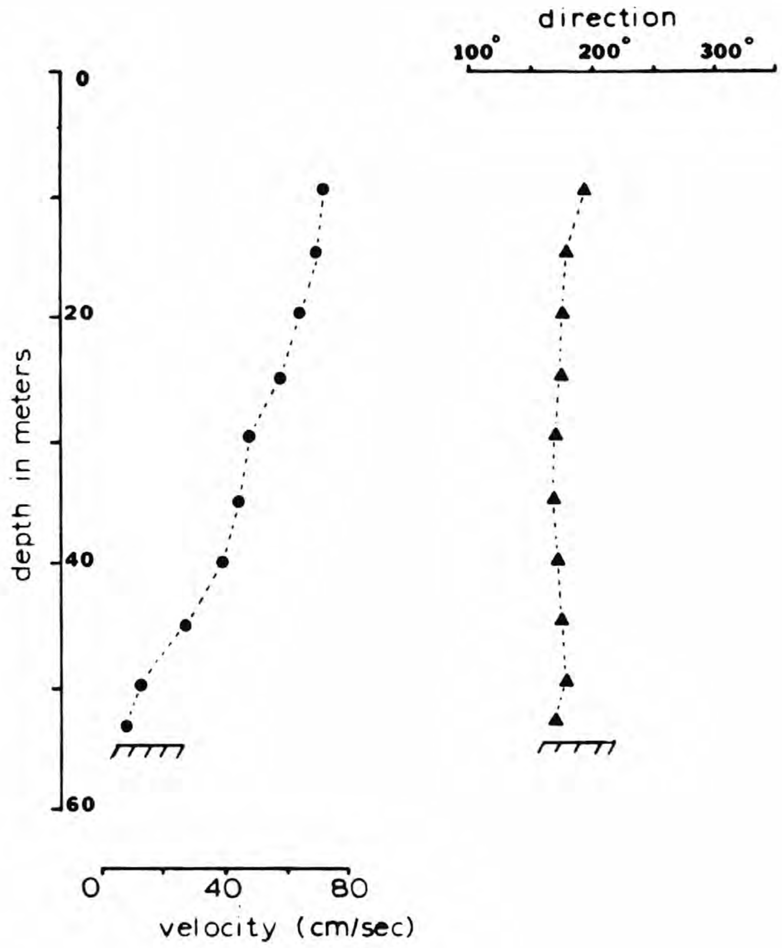
STATION 003 CM-05



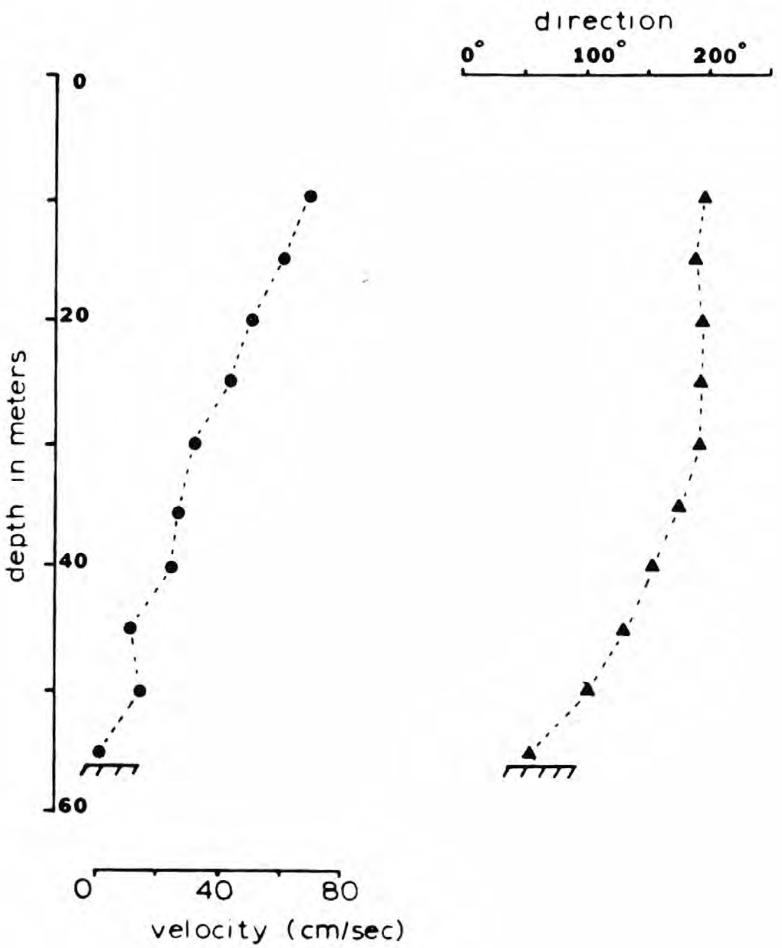
STATION 003 CM-06



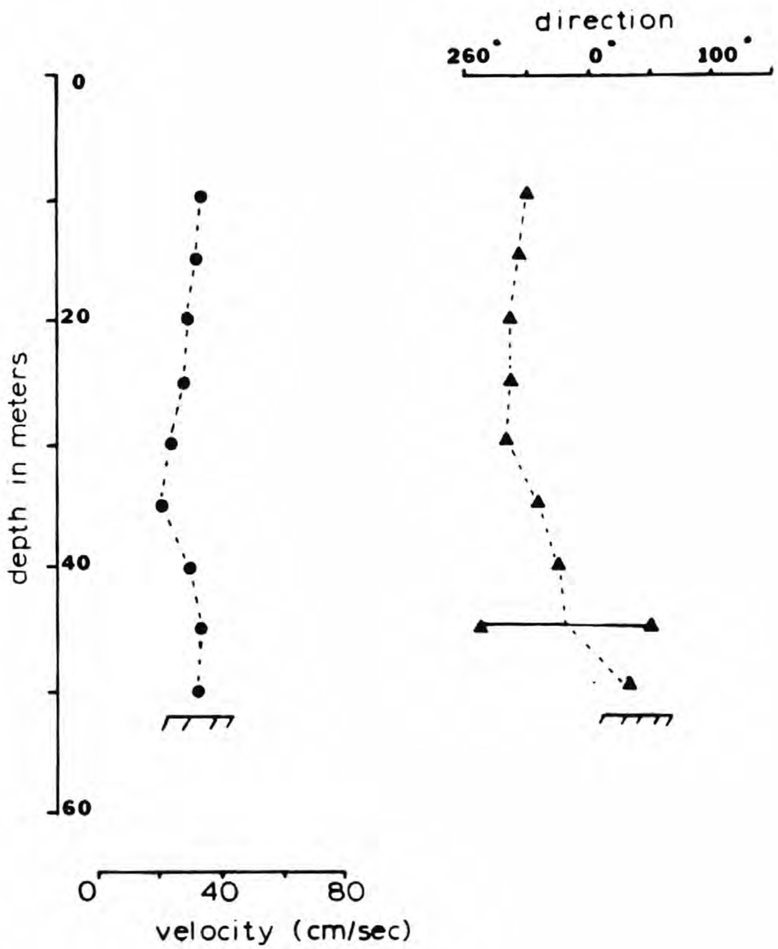
STATION 003 CM-07



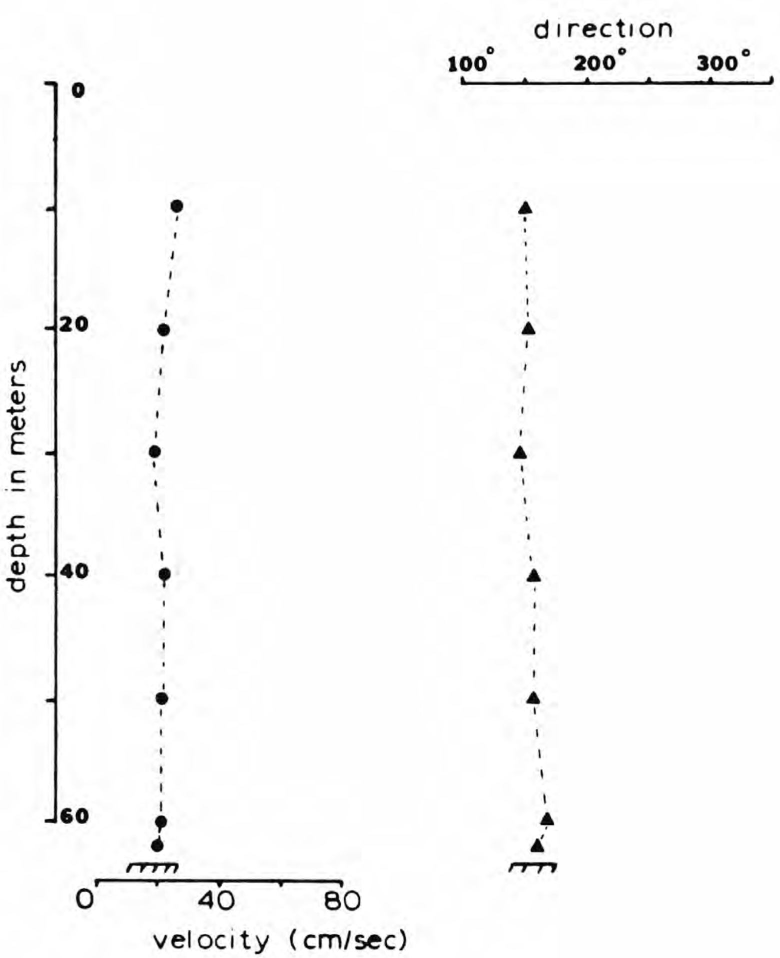
STATION 003 CM-08



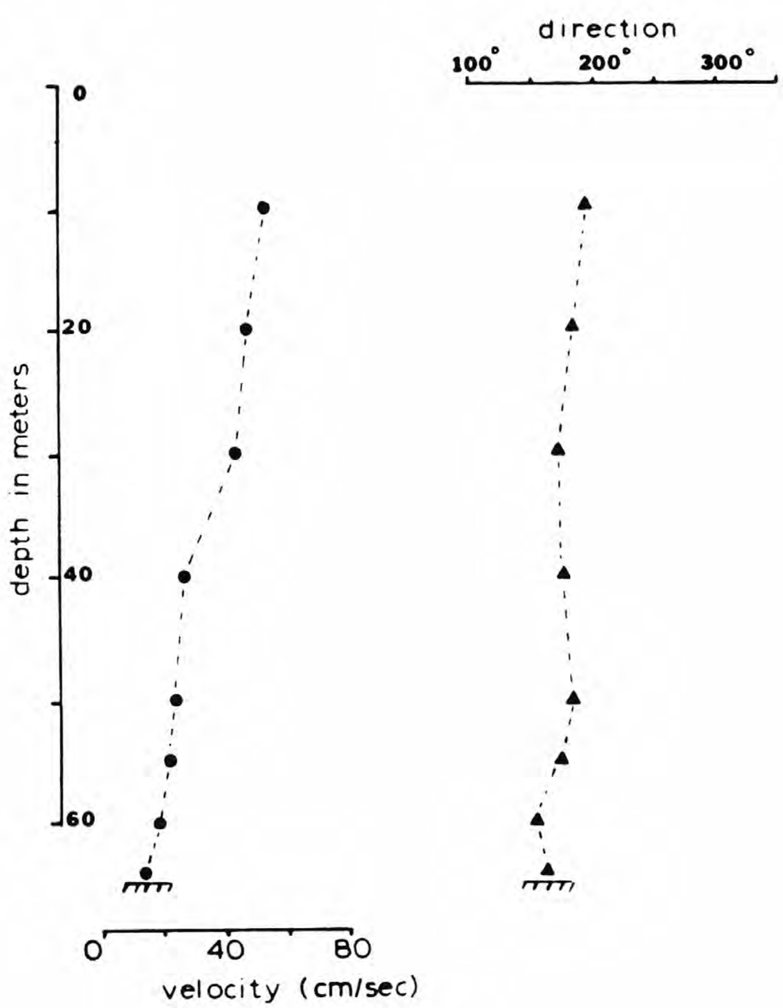
STATION 003 CM-09



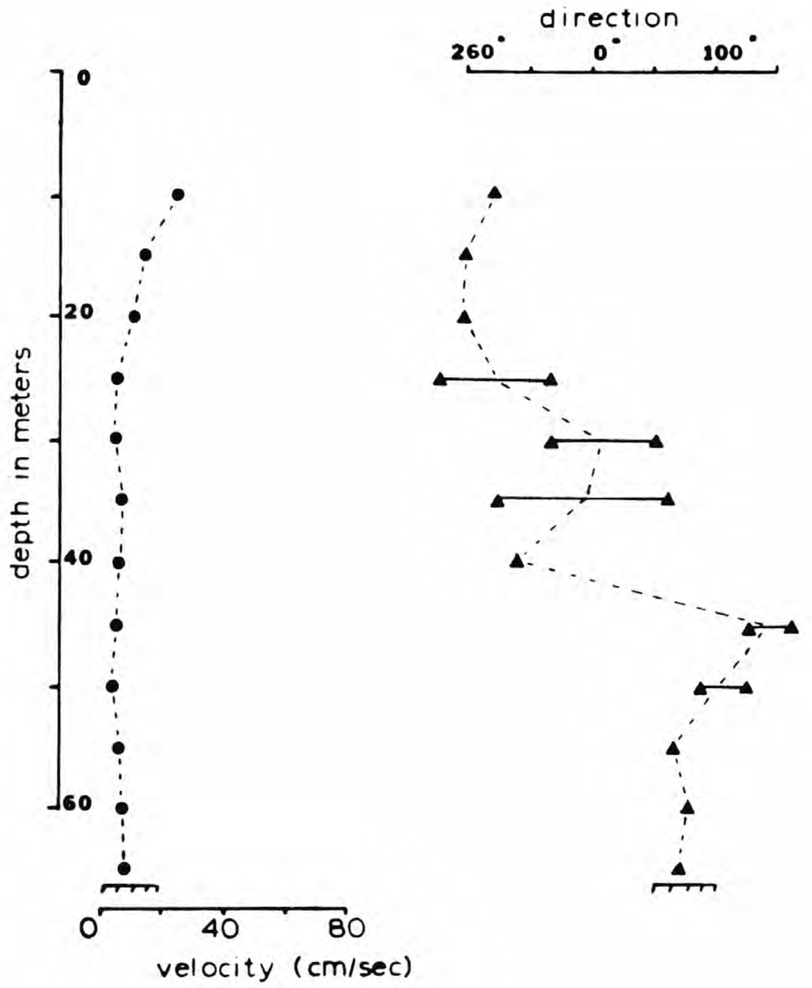
STA 005 CM-01



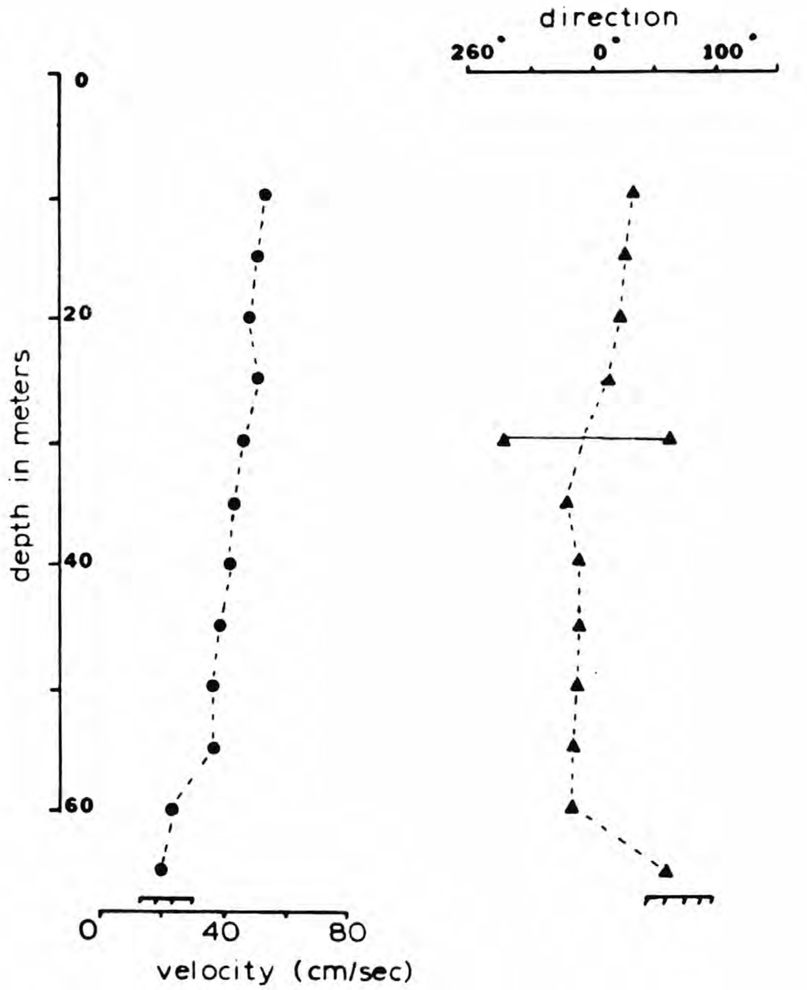
STA 005 CM-02



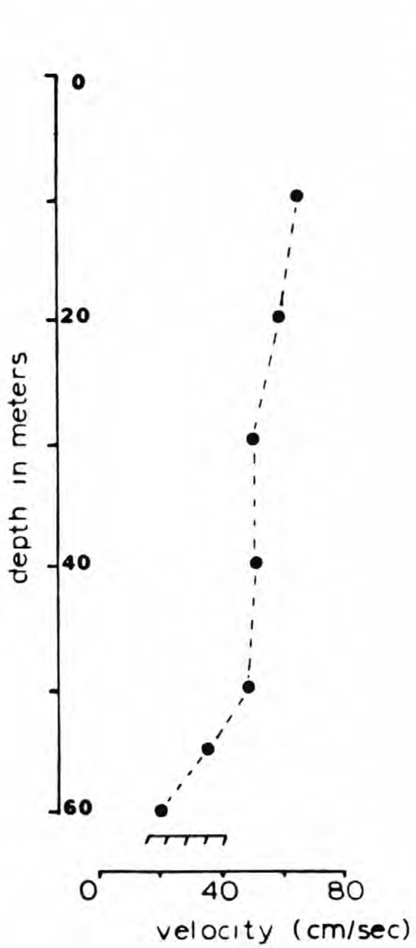
STA 005 CM-03



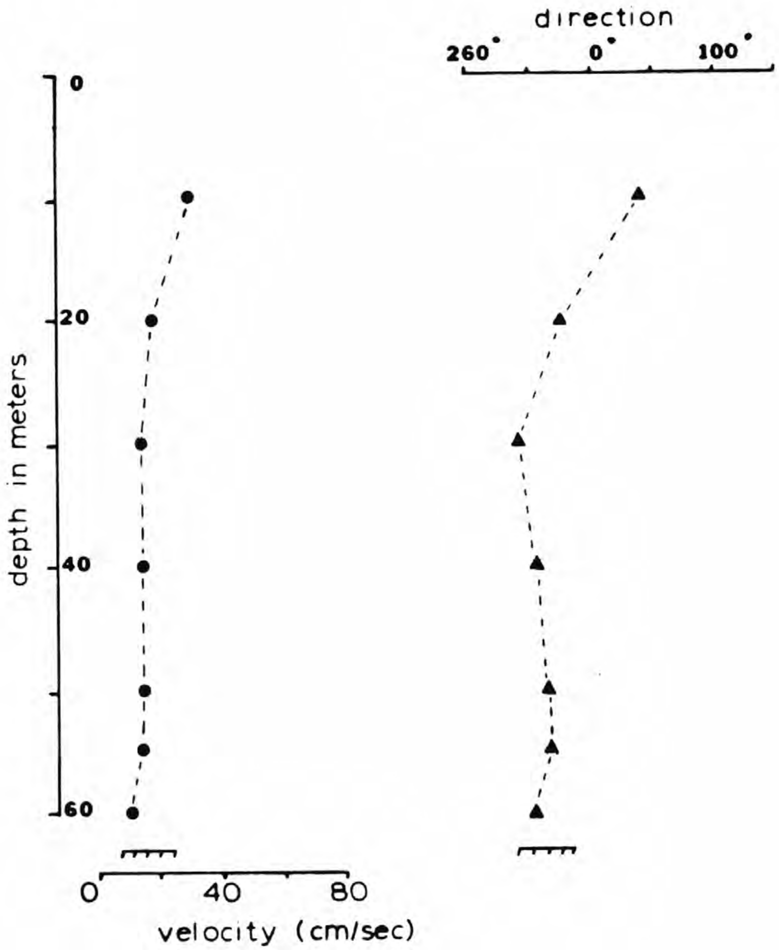
STA 005 CM-04



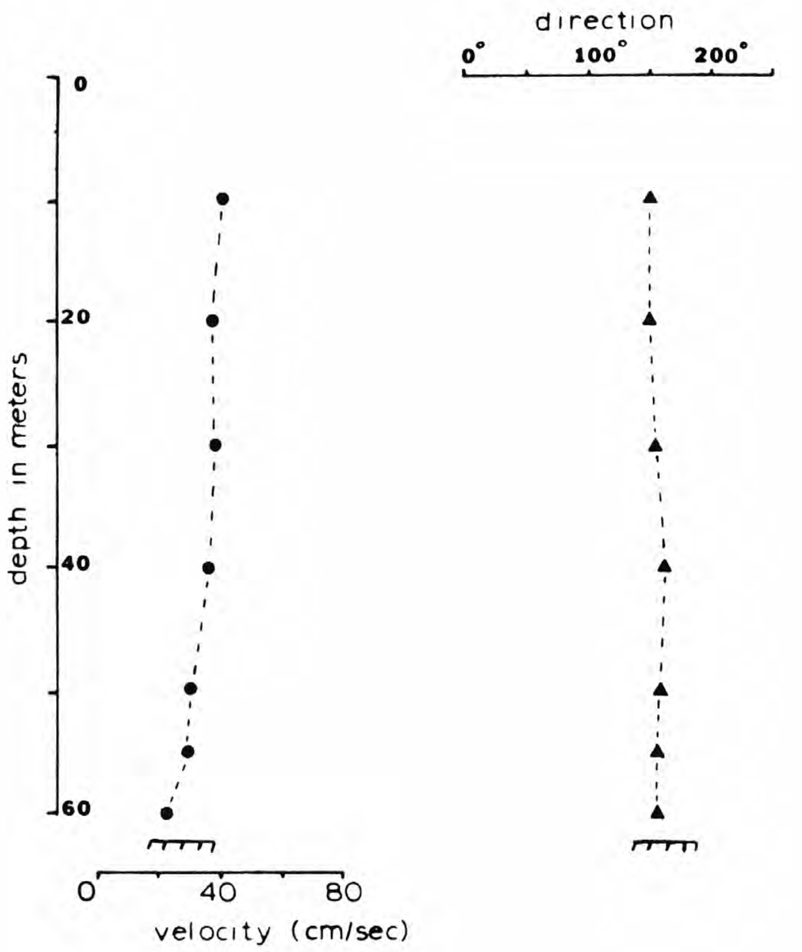
STA 005 CM-05



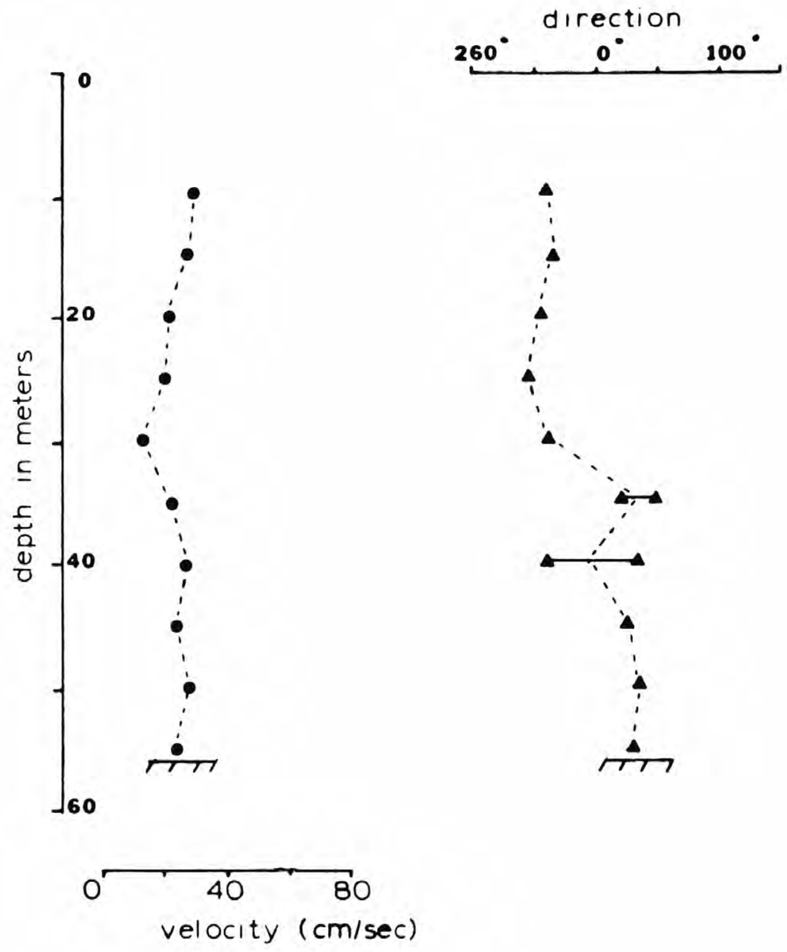
STA 005 CM-06



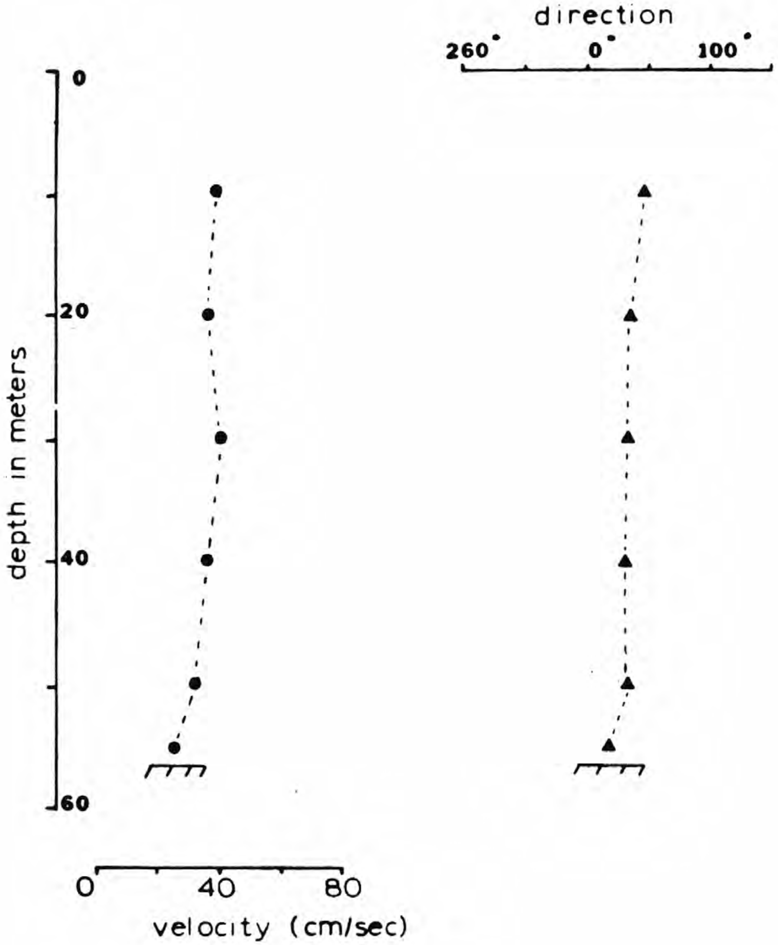
STA 005 CM-07



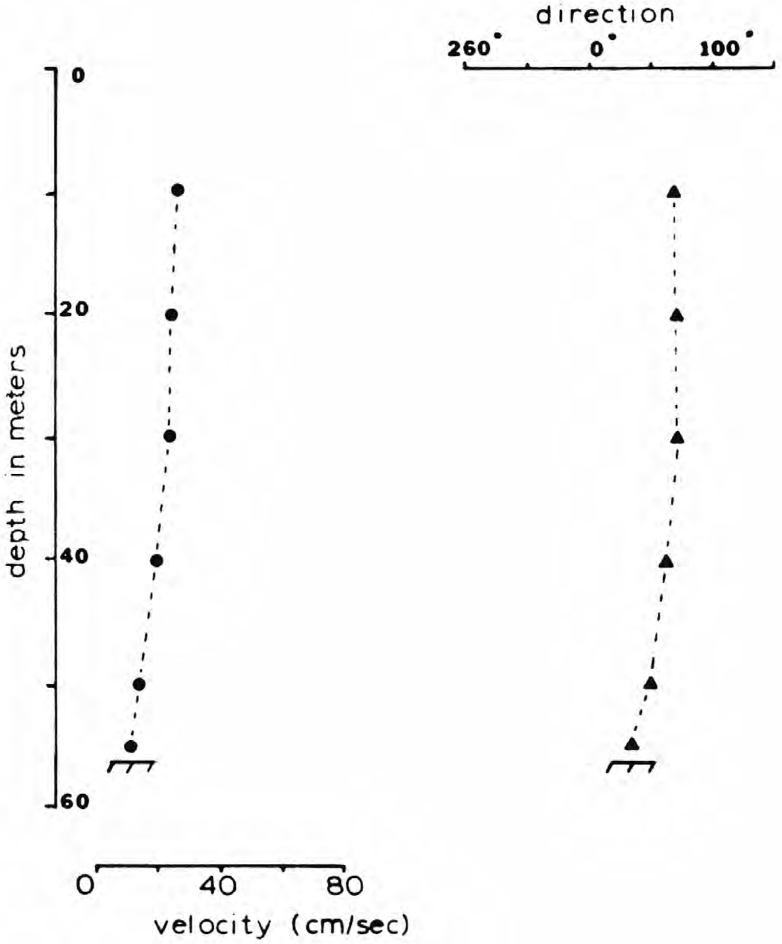
STATION 009 CM-01



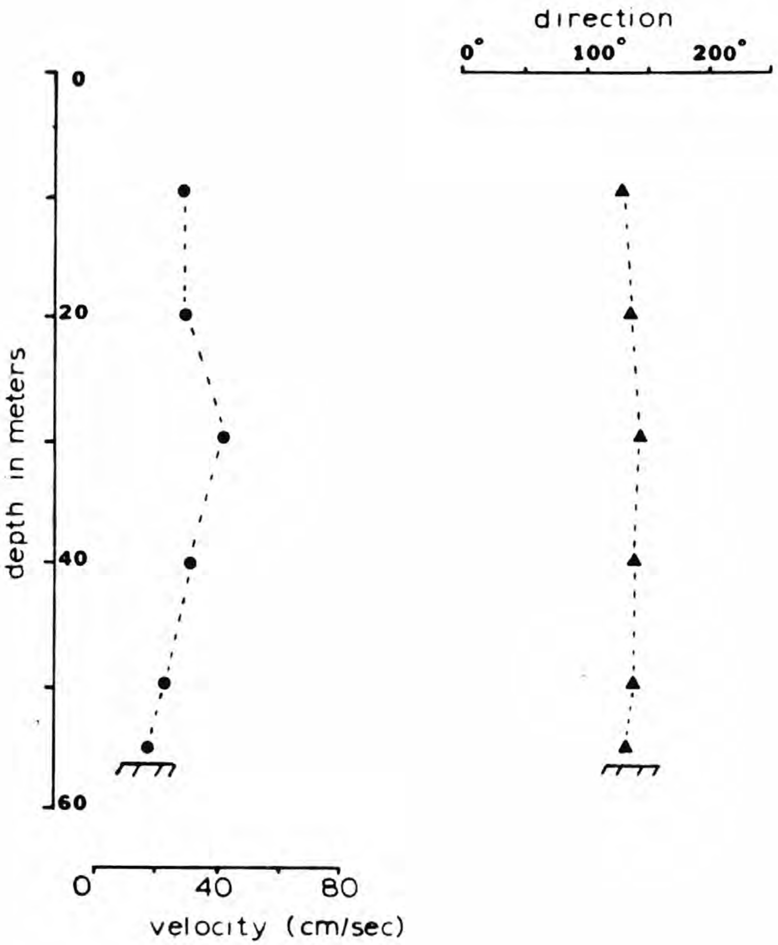
STATION 009 CM-02



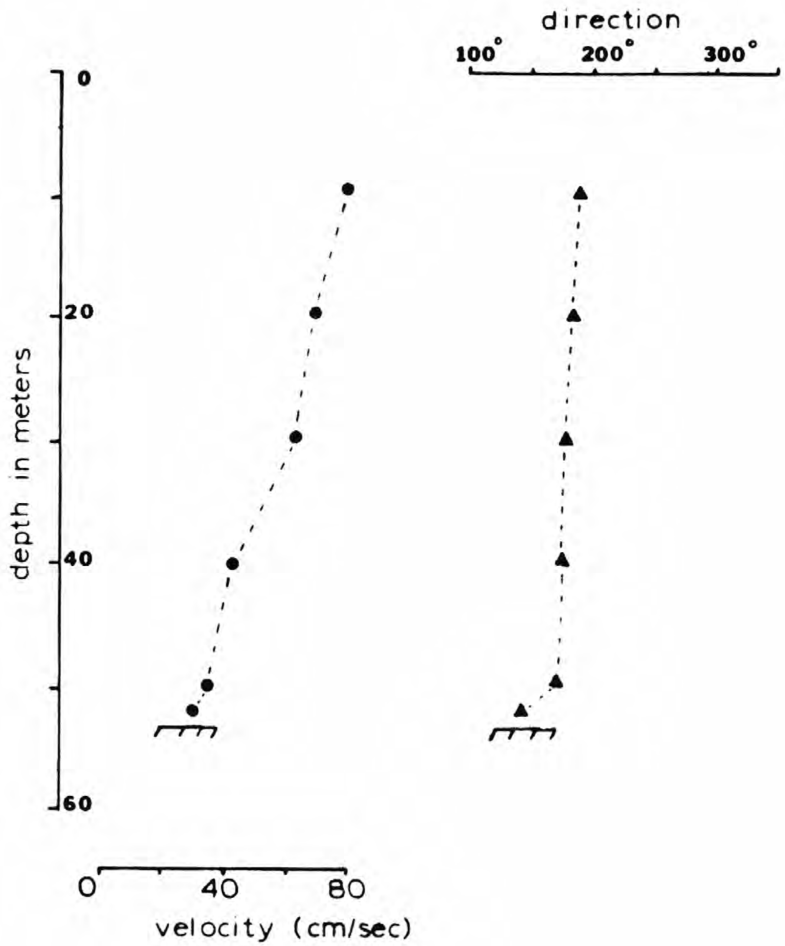
STATION 009 CM-03



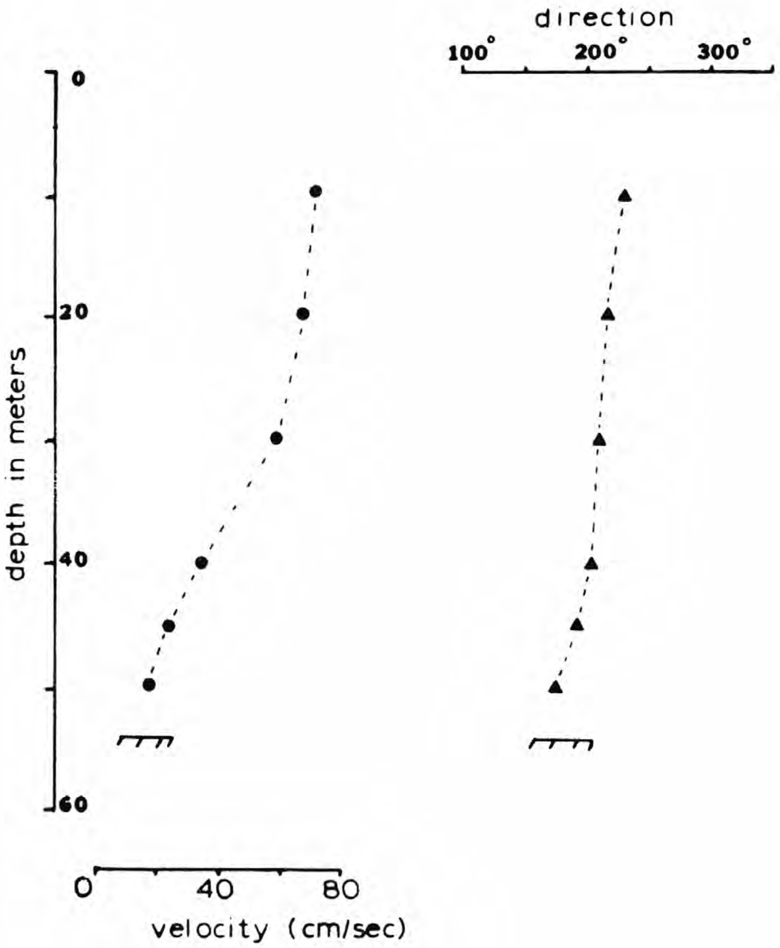
STATION 009 CM-04



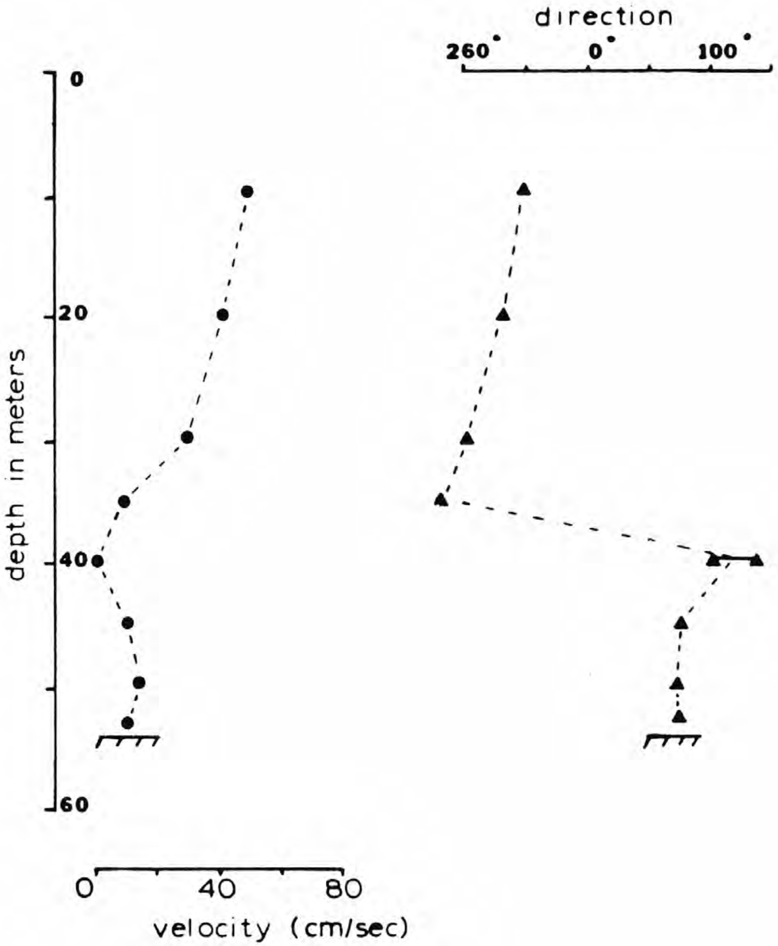
STATION 009 CM-05



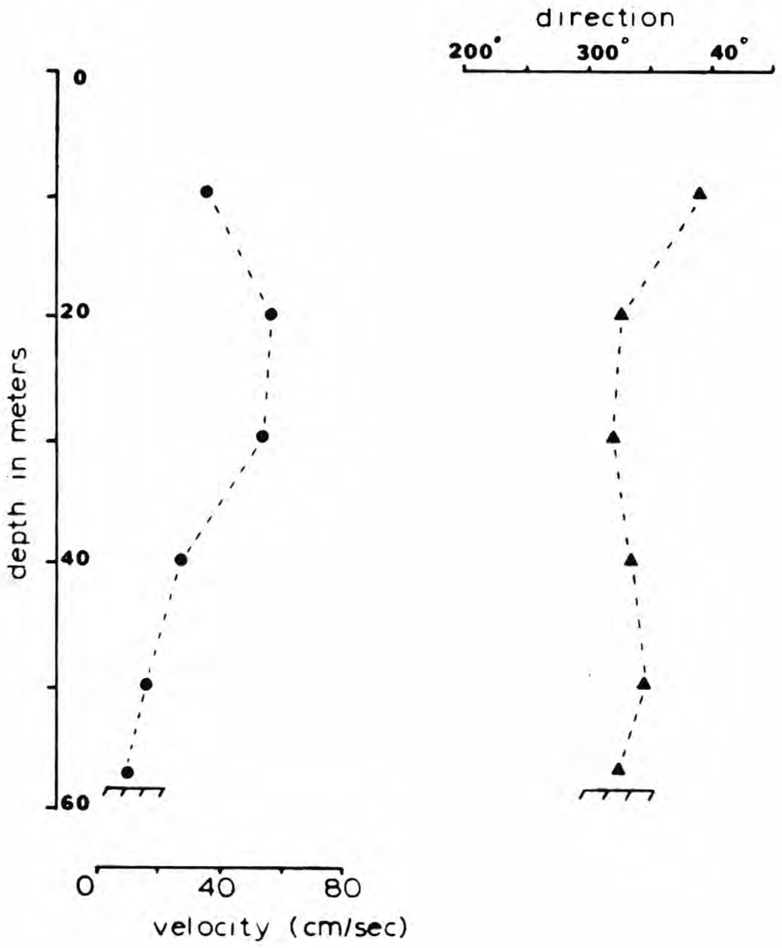
STATION 009 CM-06



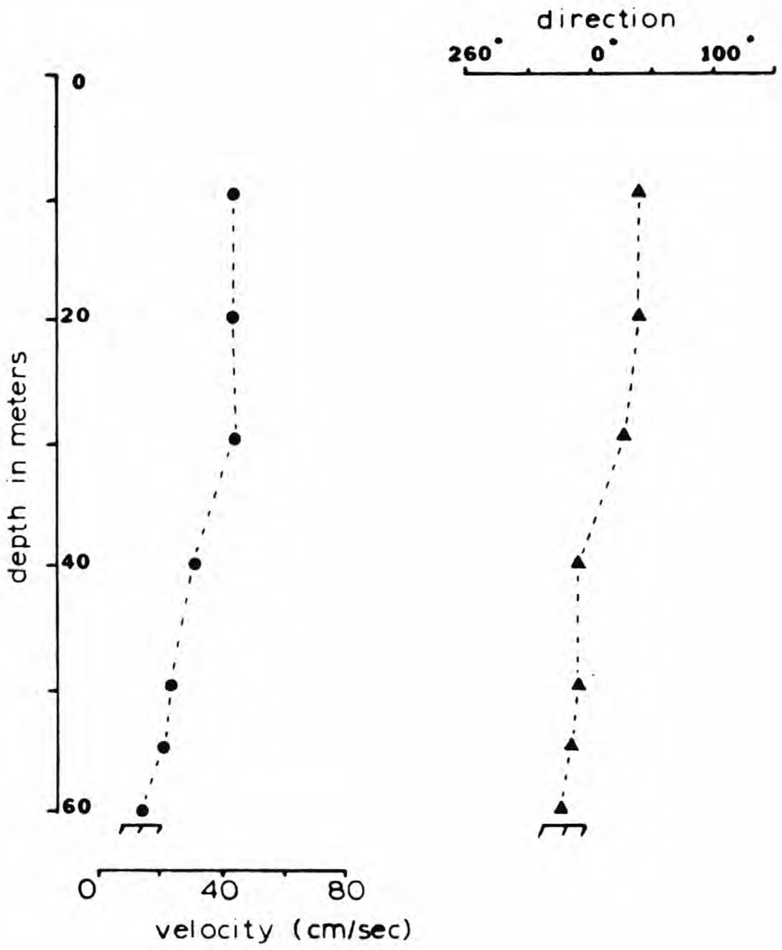
STATION 009 CM-07



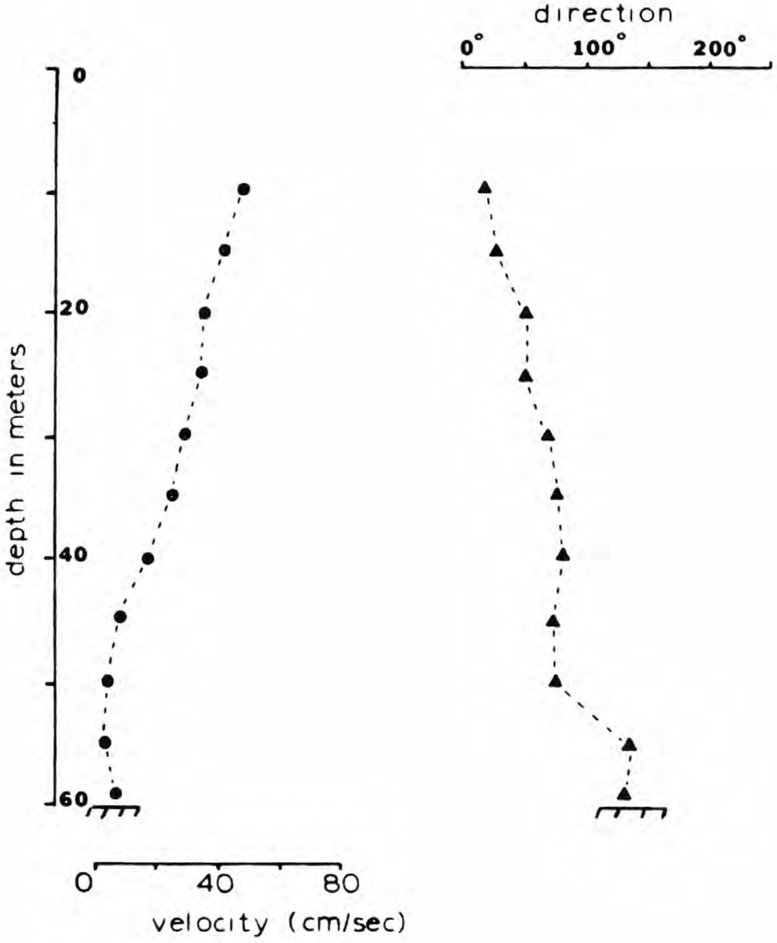
STATION 009 CM-08



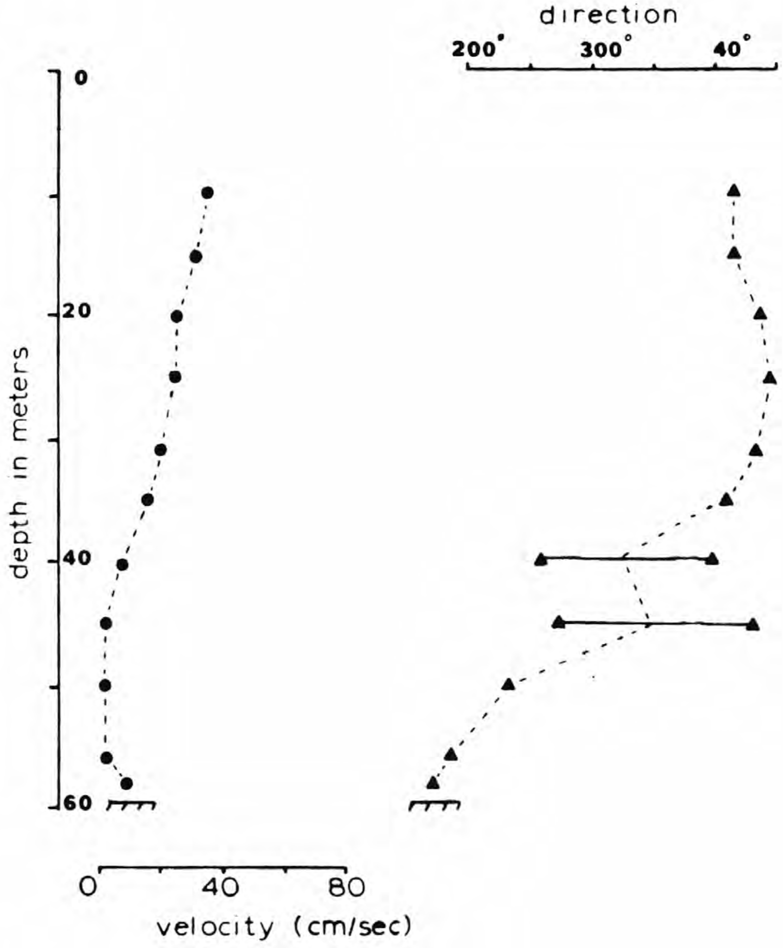
STATION 009 CM-09



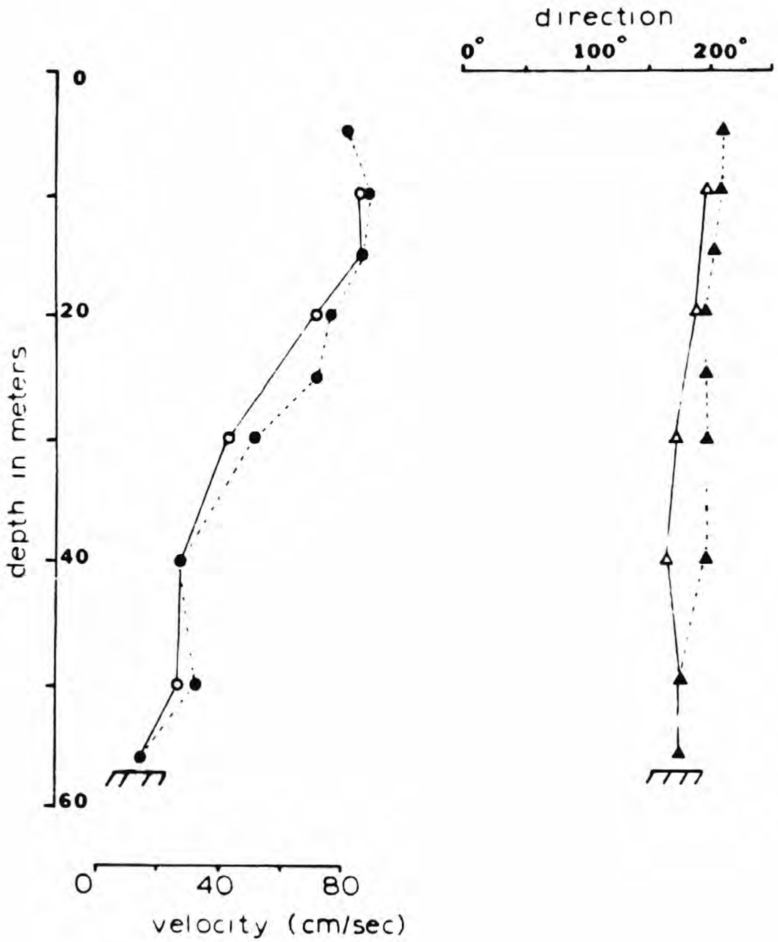
STATION 406 CM-01



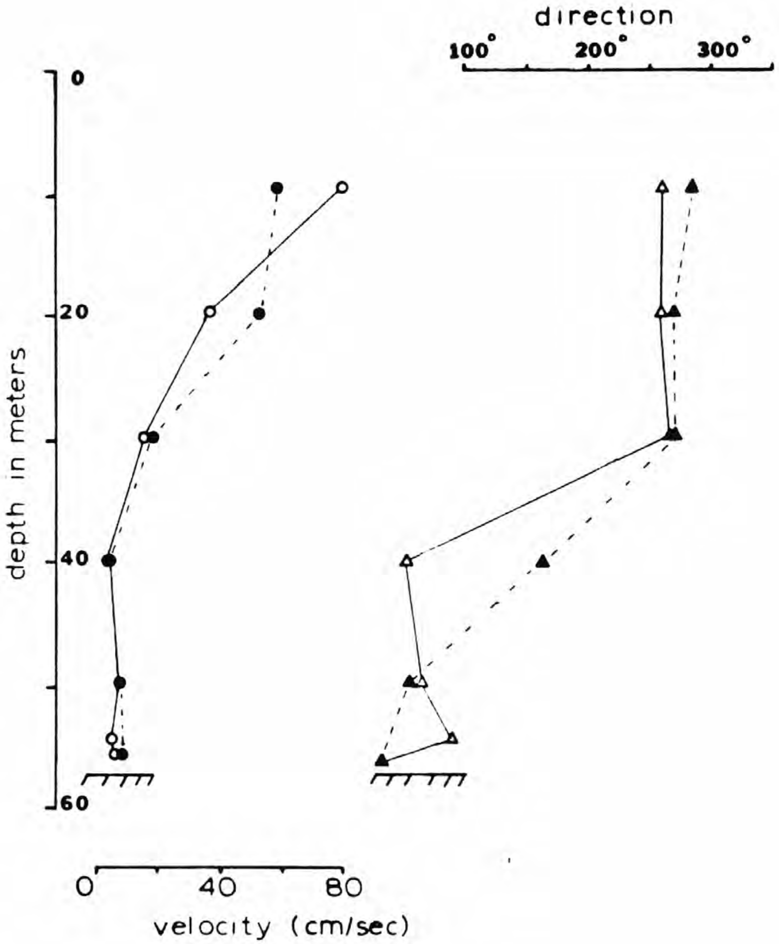
STATION 406 CM-02



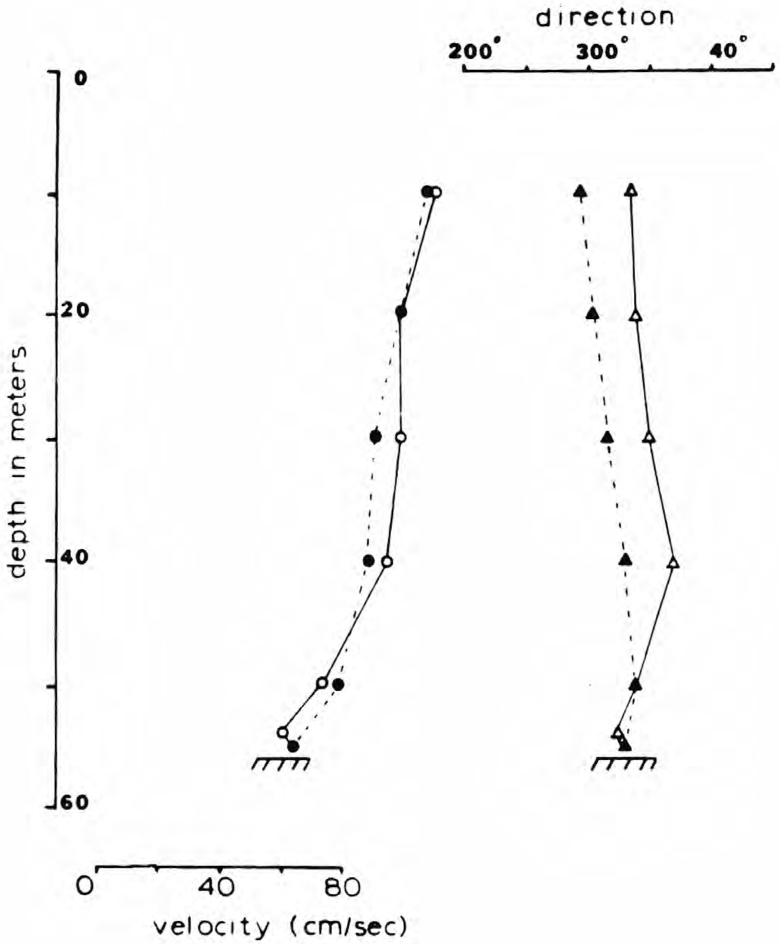
STATION 313 CM-01



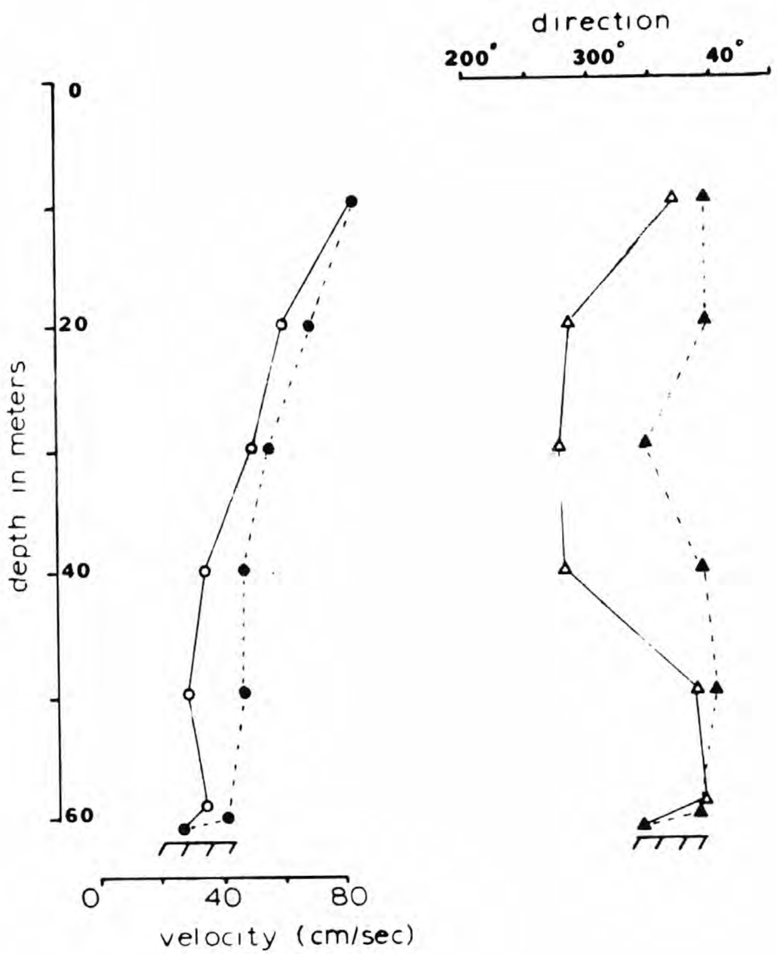
STATION 313 CM-02



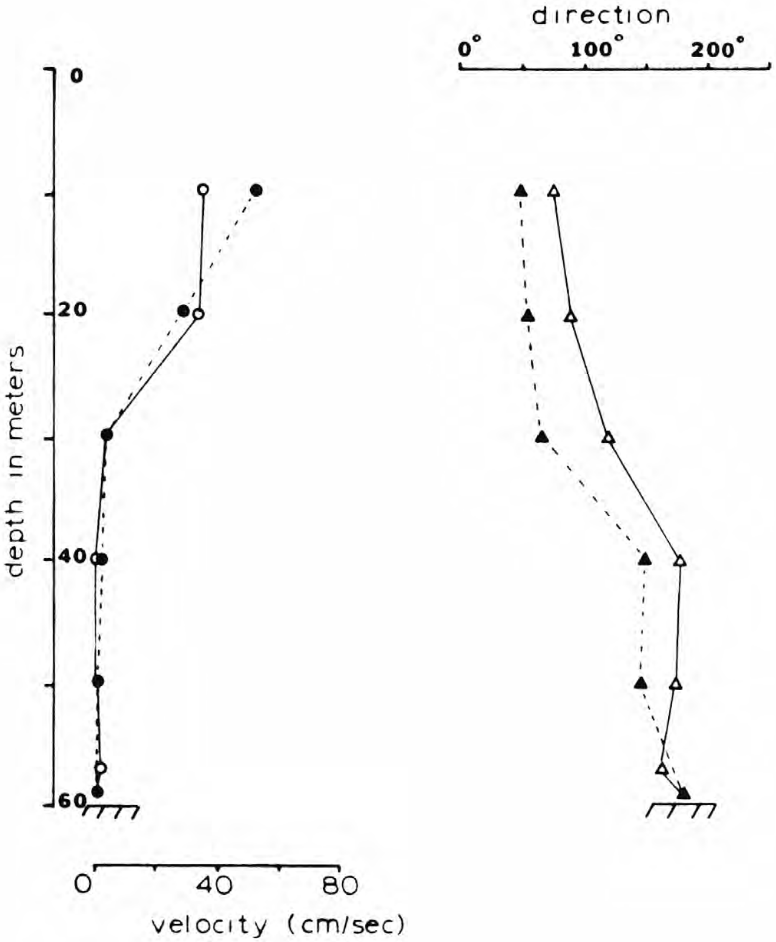
STATION 313 CM-03



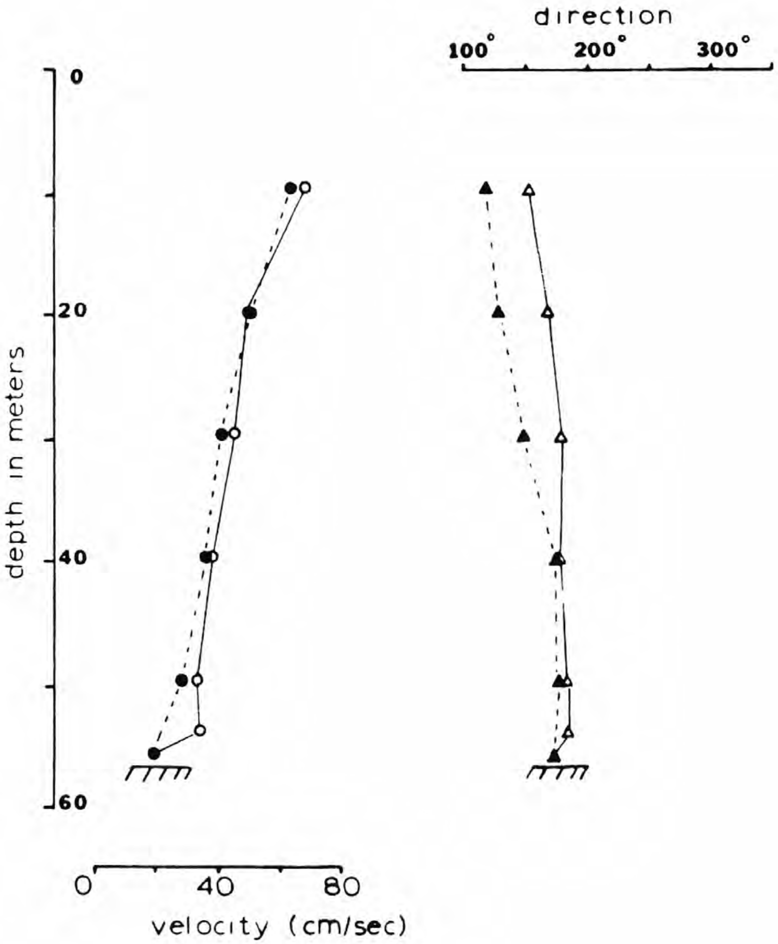
STATION 314 CM-01



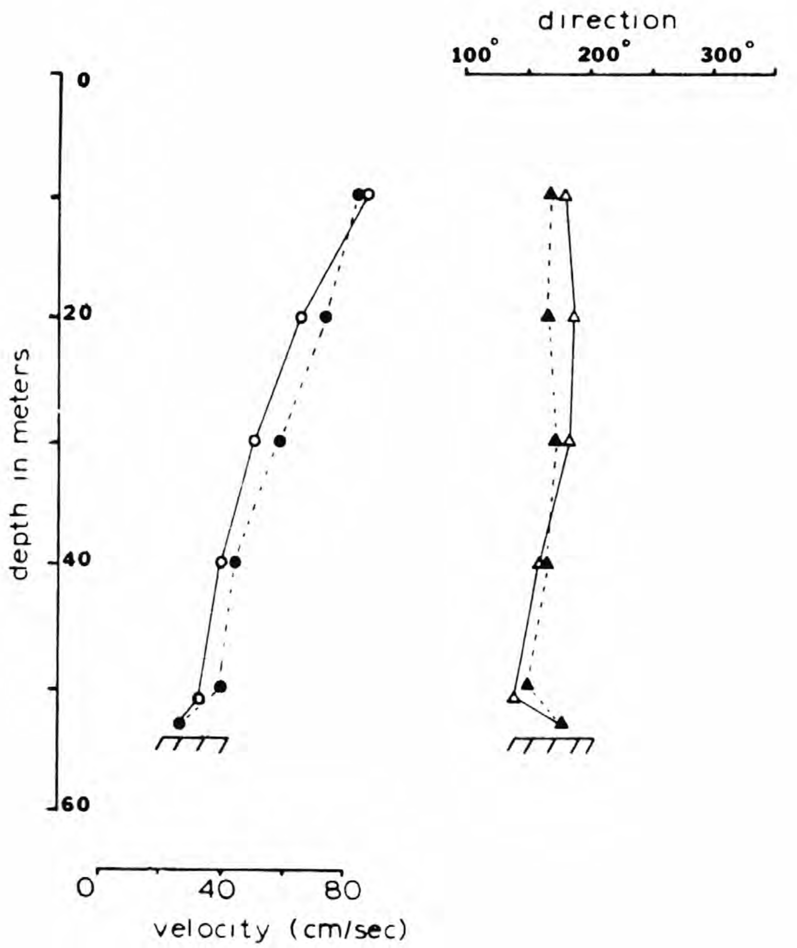
STATION 314 CM-02



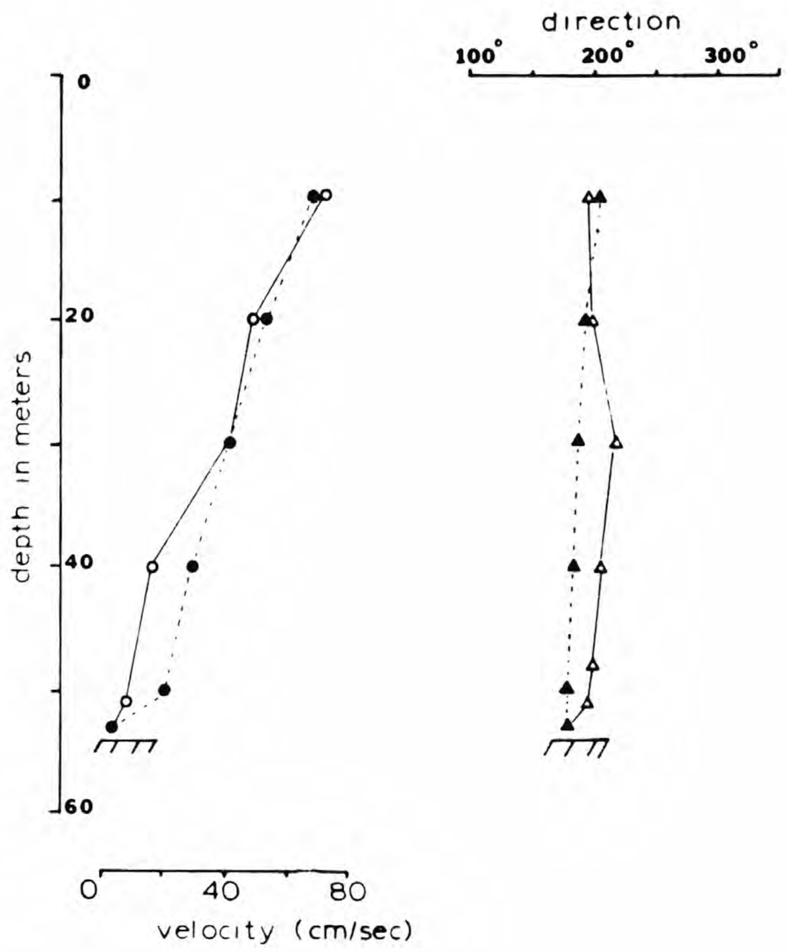
STATION 314 CM-03



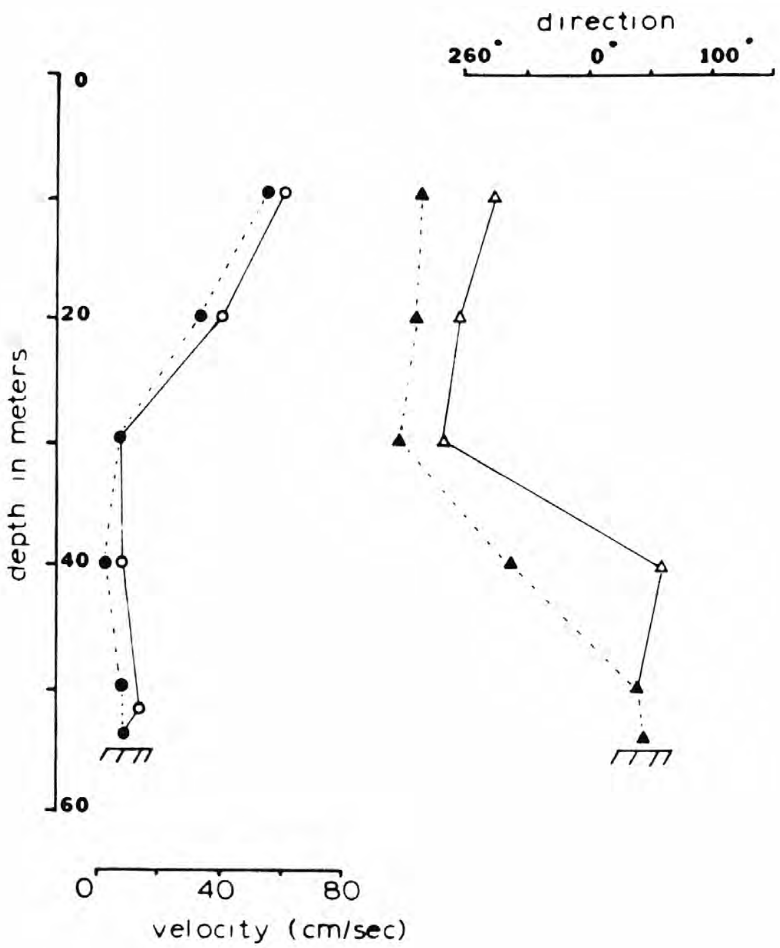
STATION 314 CM-04



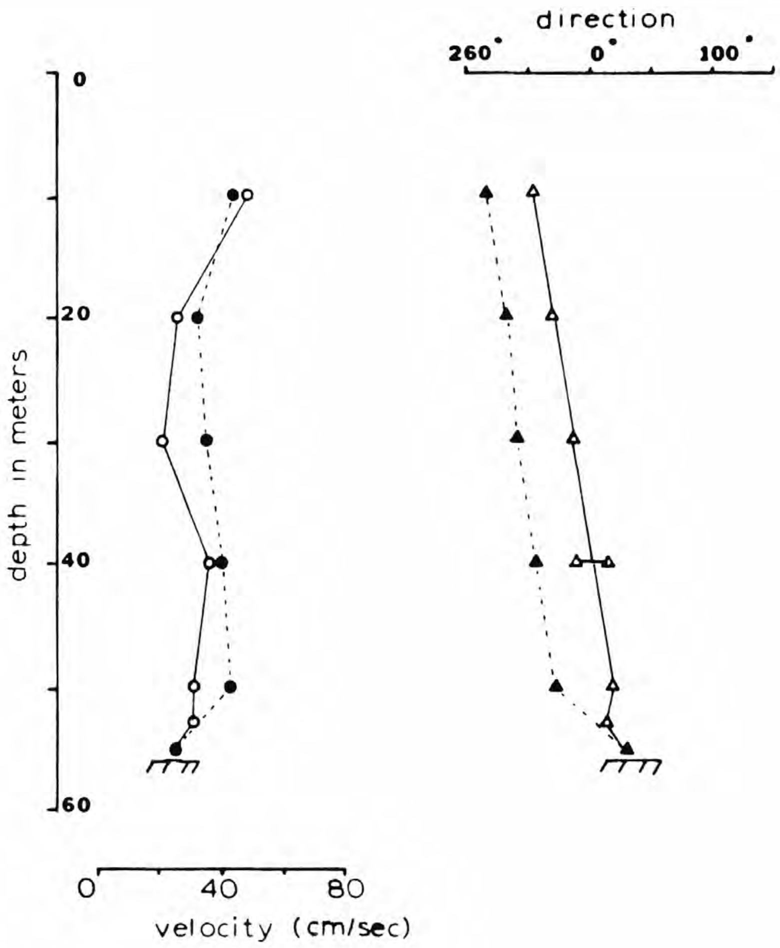
STATION 314 CM-05



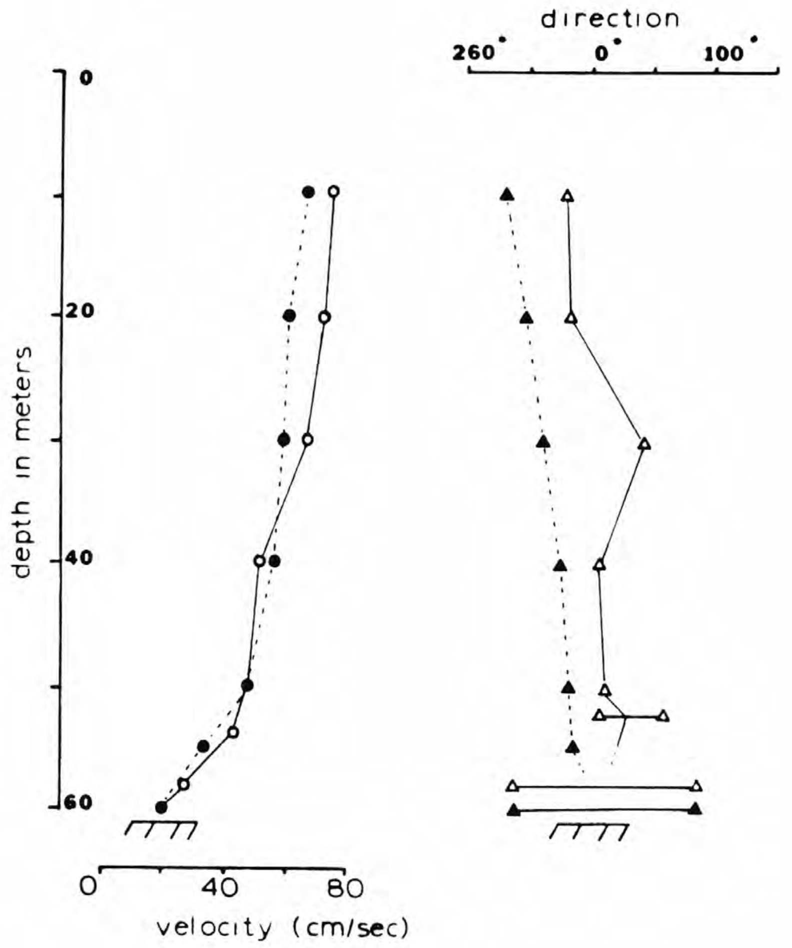
STATION 314 CM-06



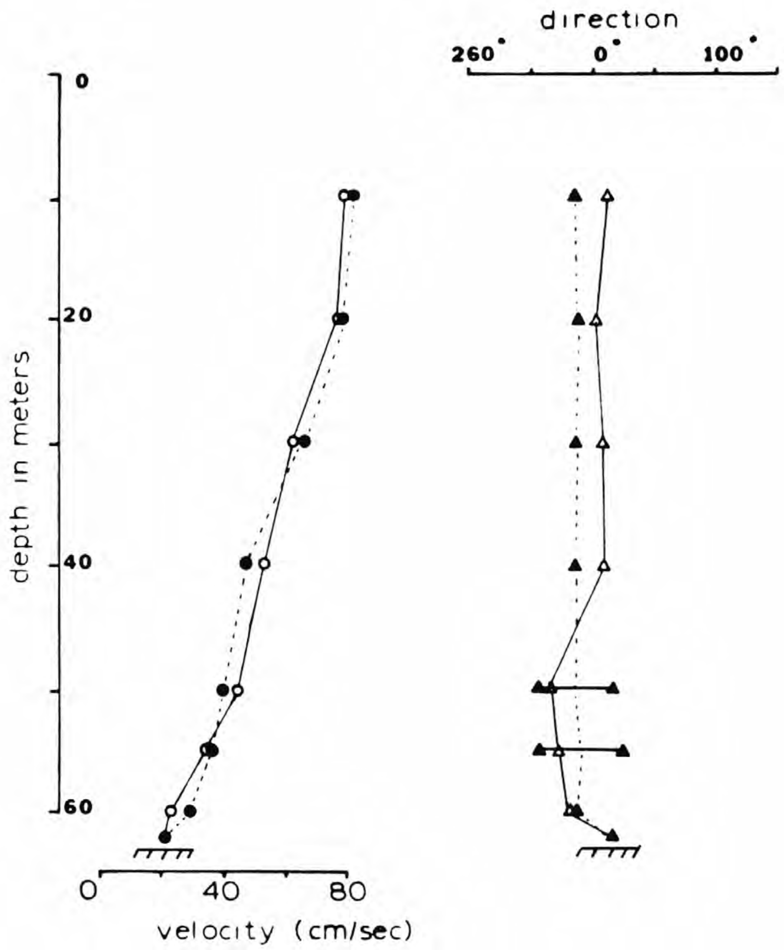
STATION 314 CM-07



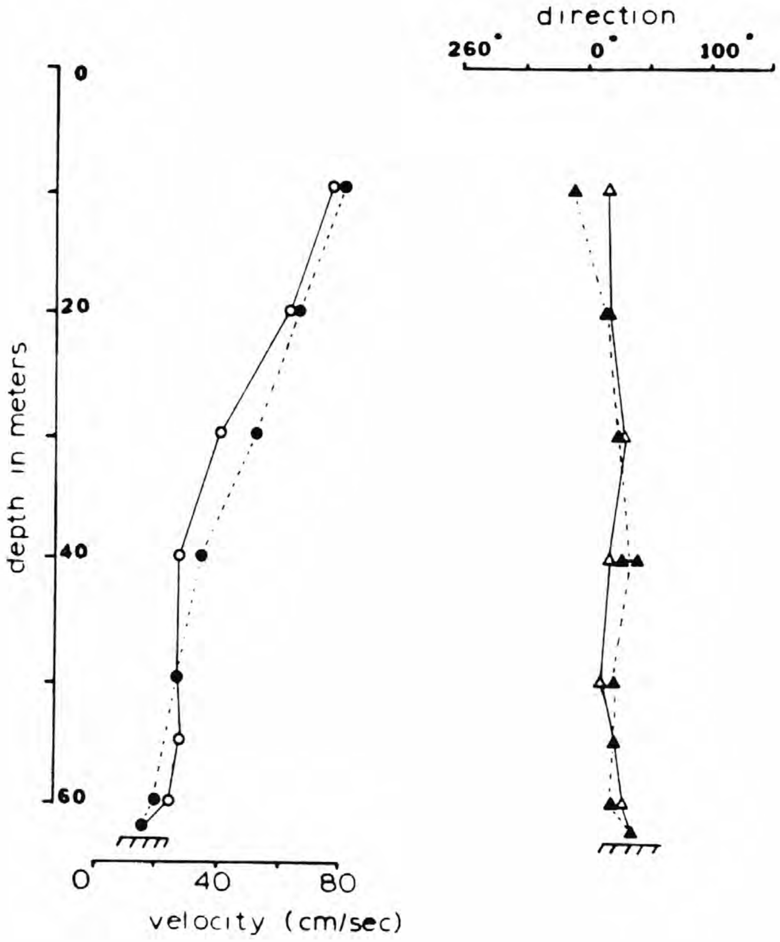
STATION 314 CM-08



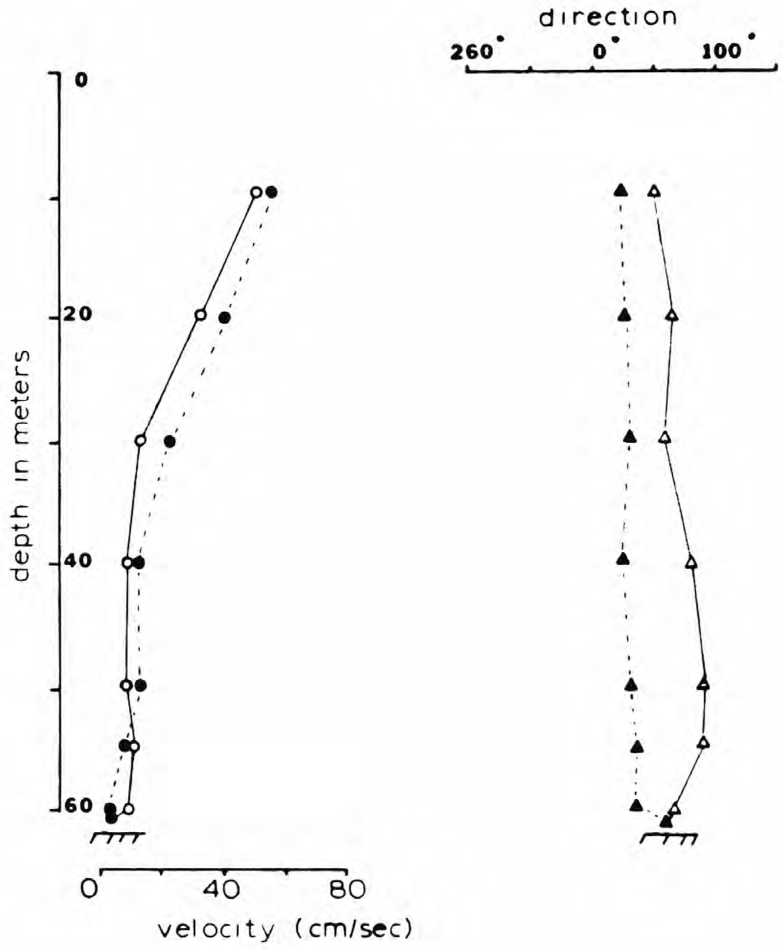
STATION 314 CM-09



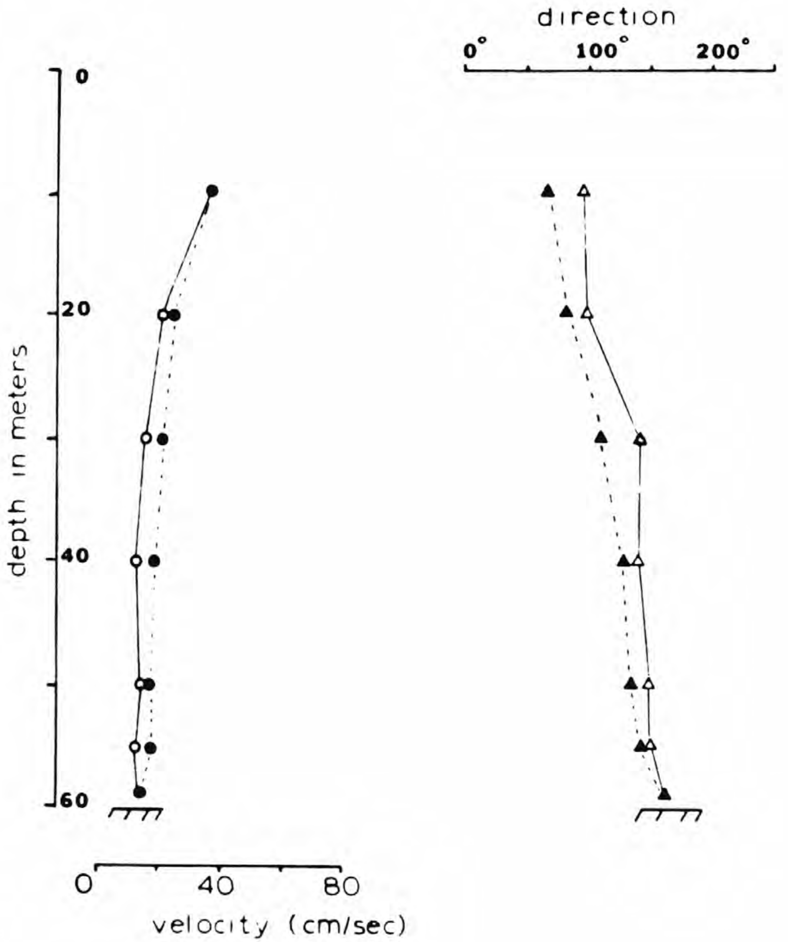
STATION 314 CM-10



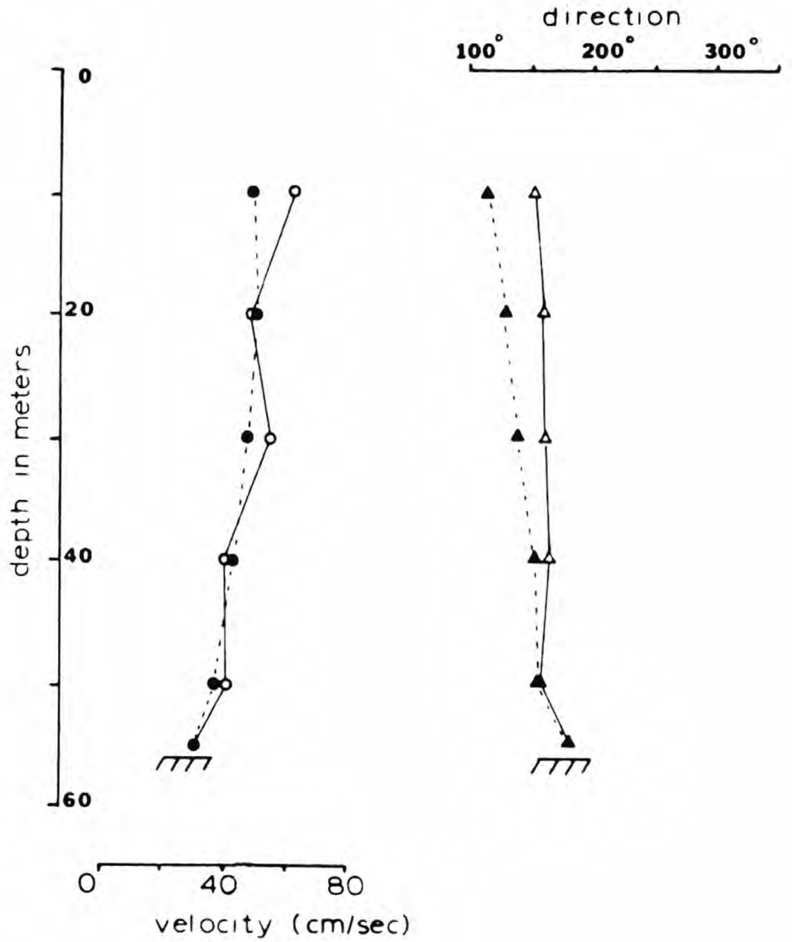
STATION 314 CM-11



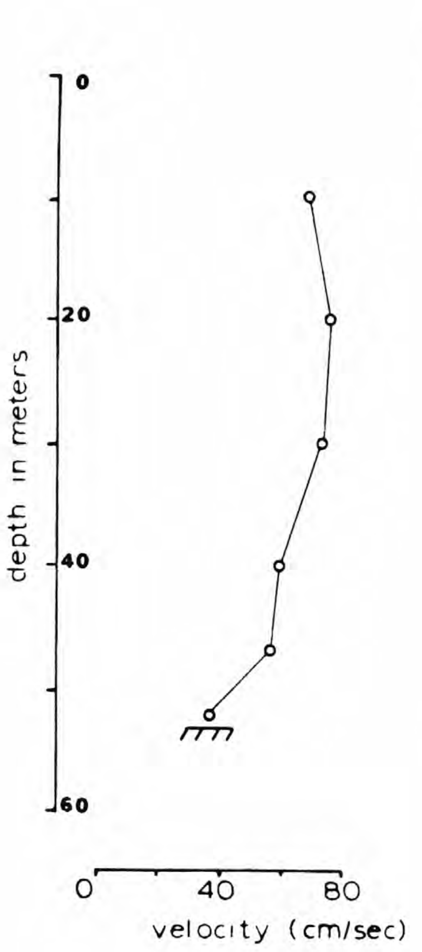
STATION 314 CM-12



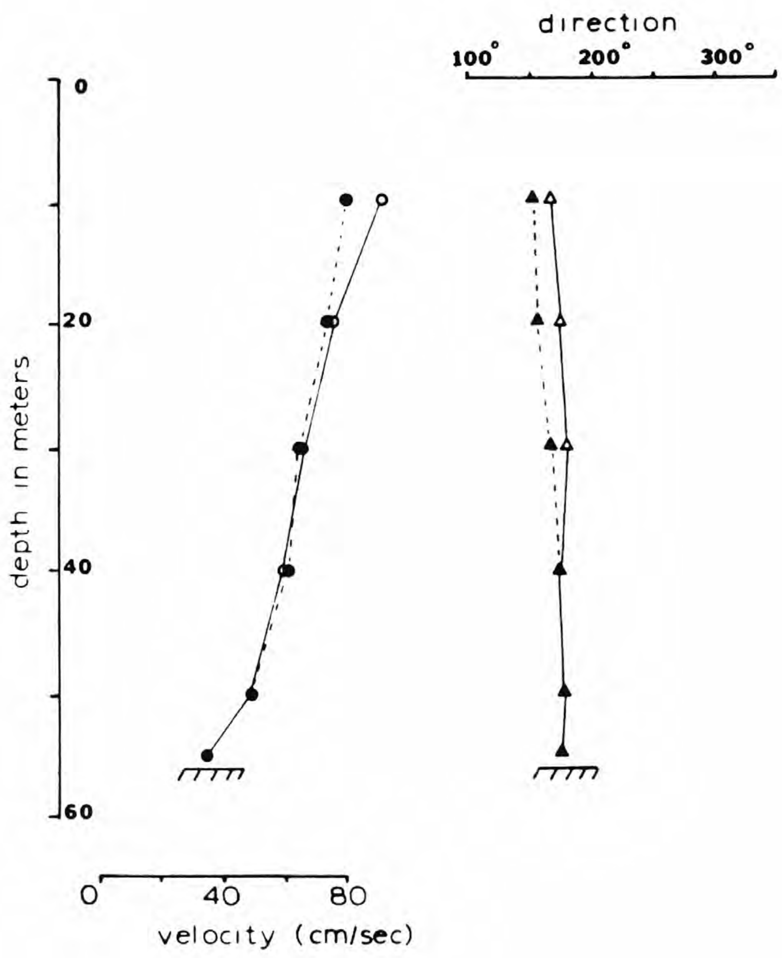
STATION 314 CM-13



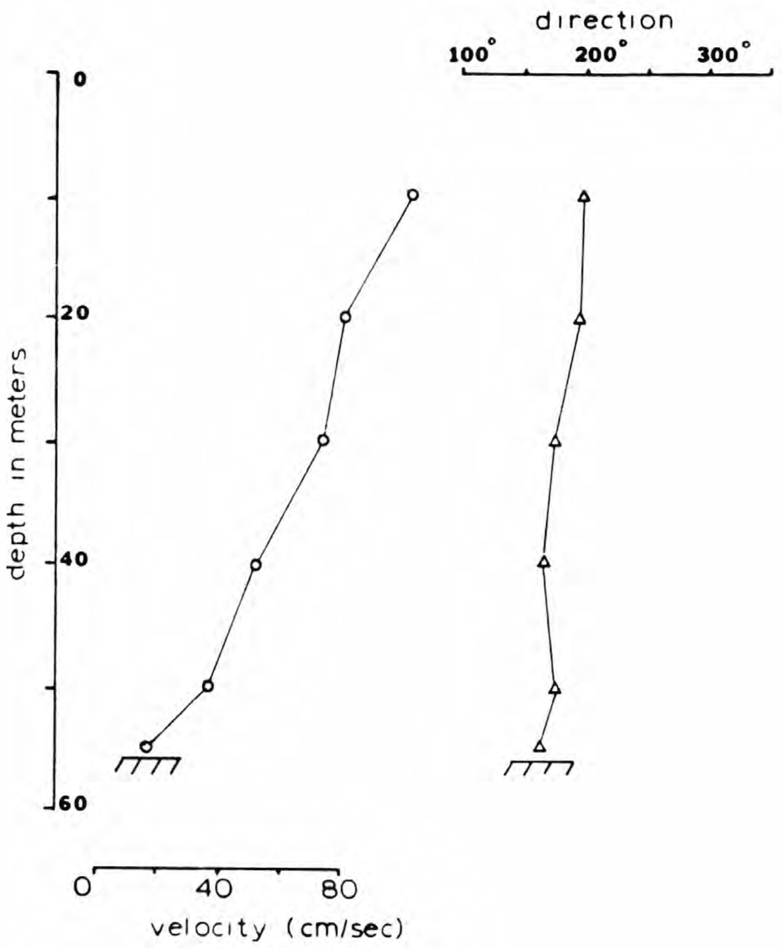
STATION 314 CM-14



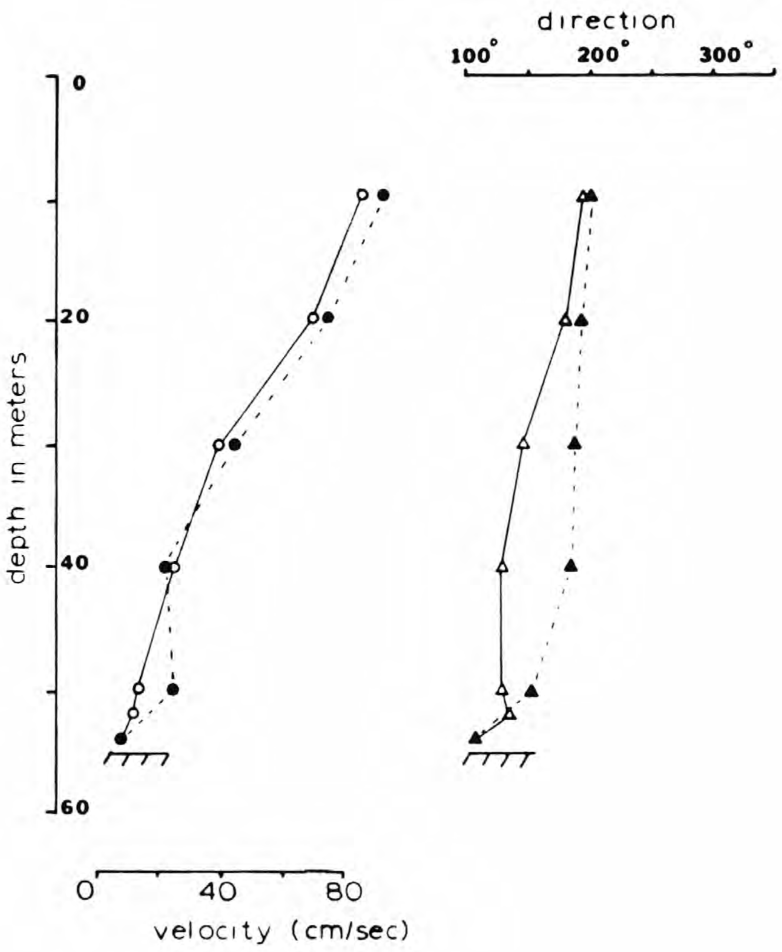
STATION 314 CM-15



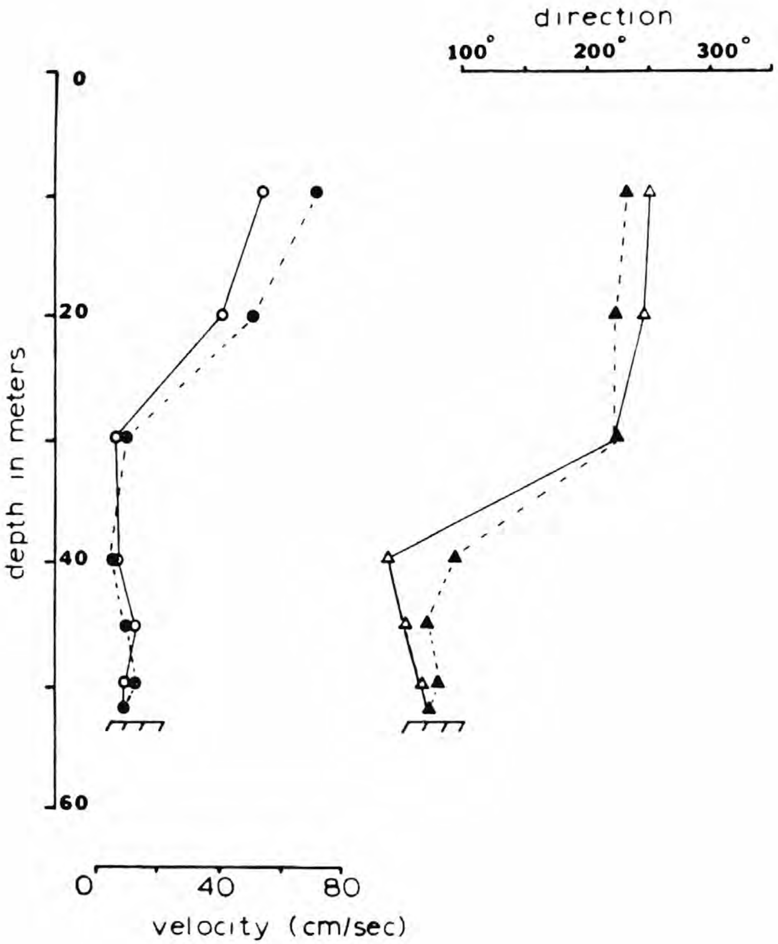
STATION 314 CM-16



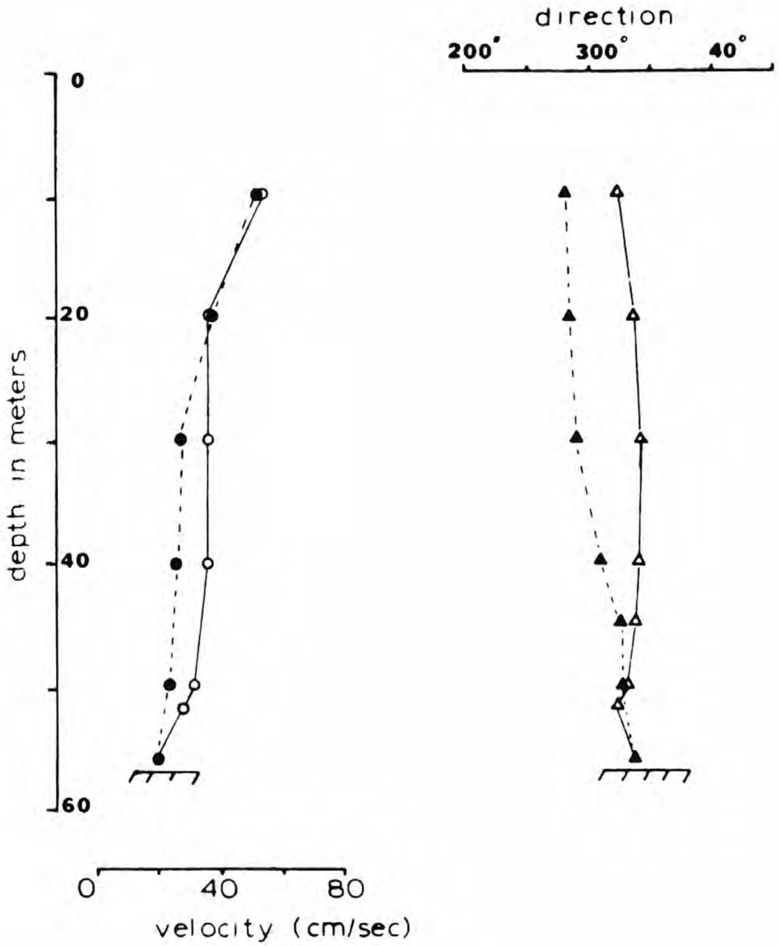
STATION 314 CM-17



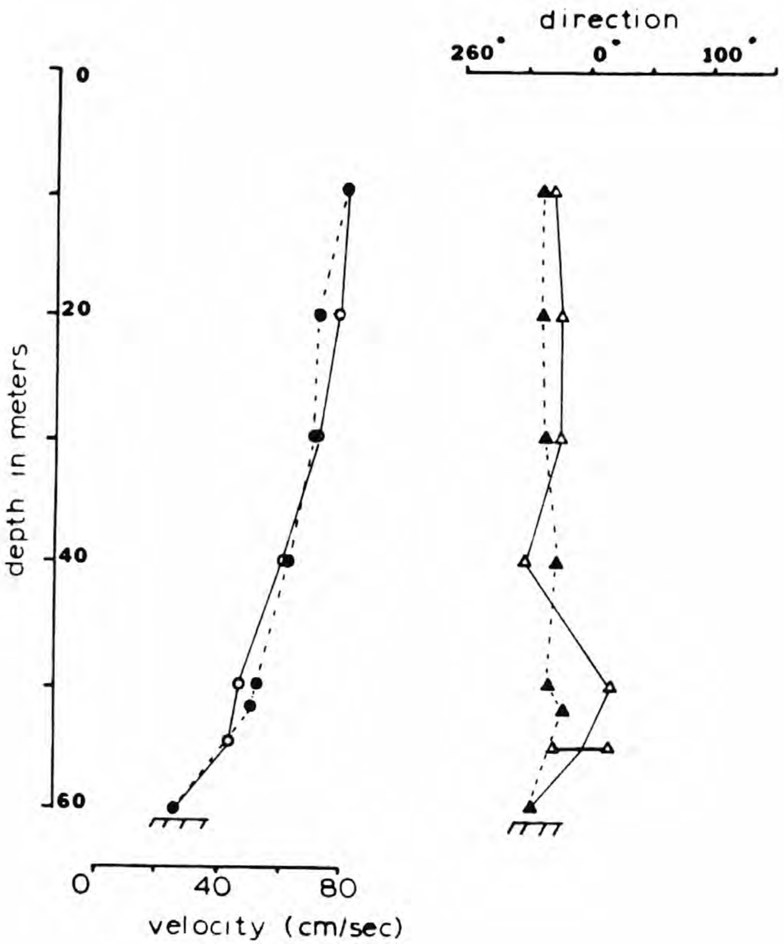
STATION 314 CM-18



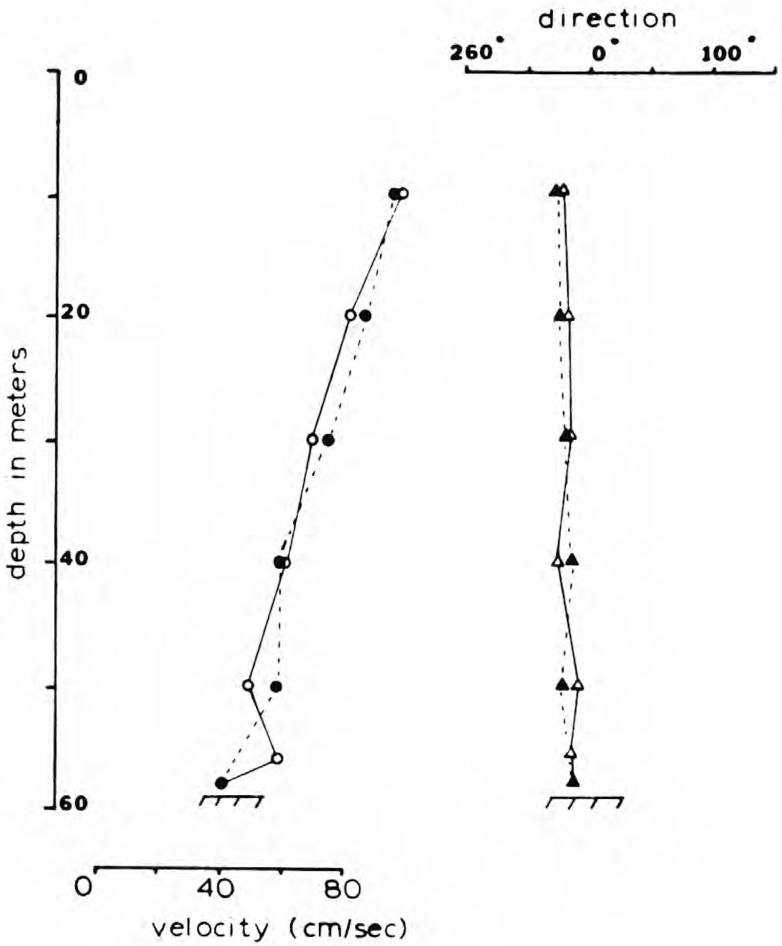
STATION 314 CM-19



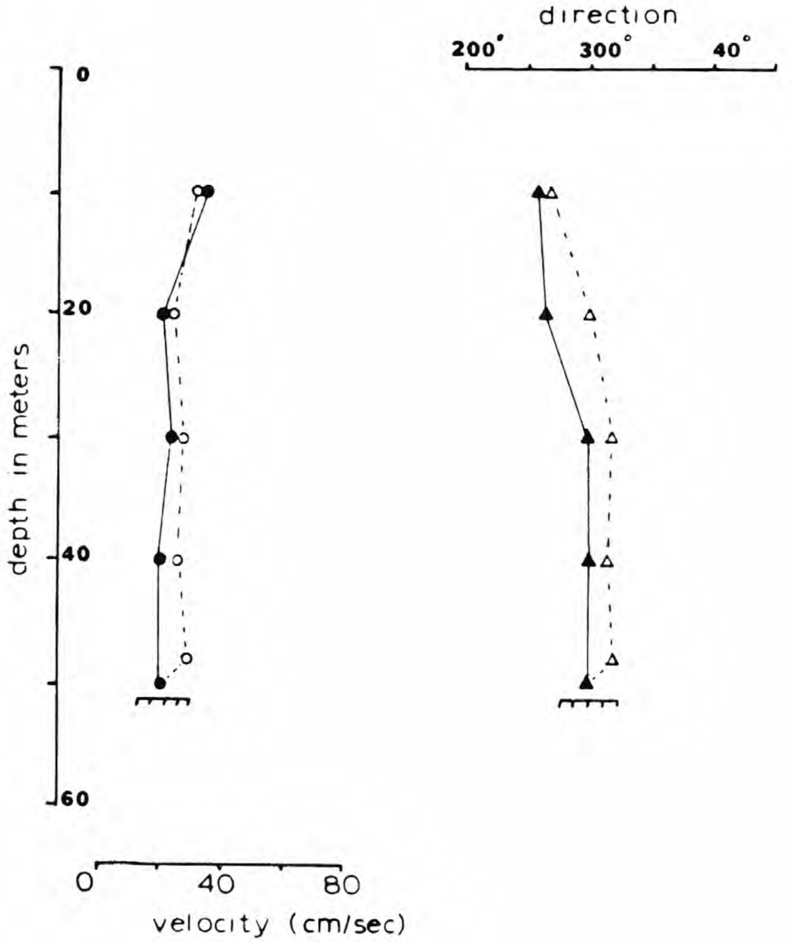
STATION 314 CM-20



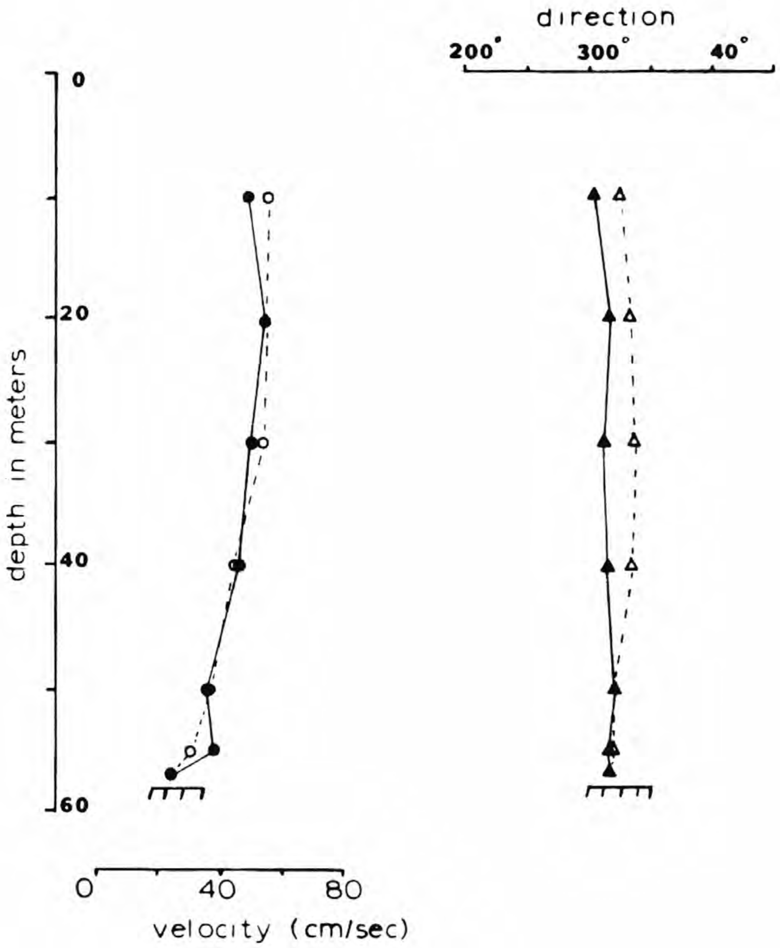
STATION 314 CM-21



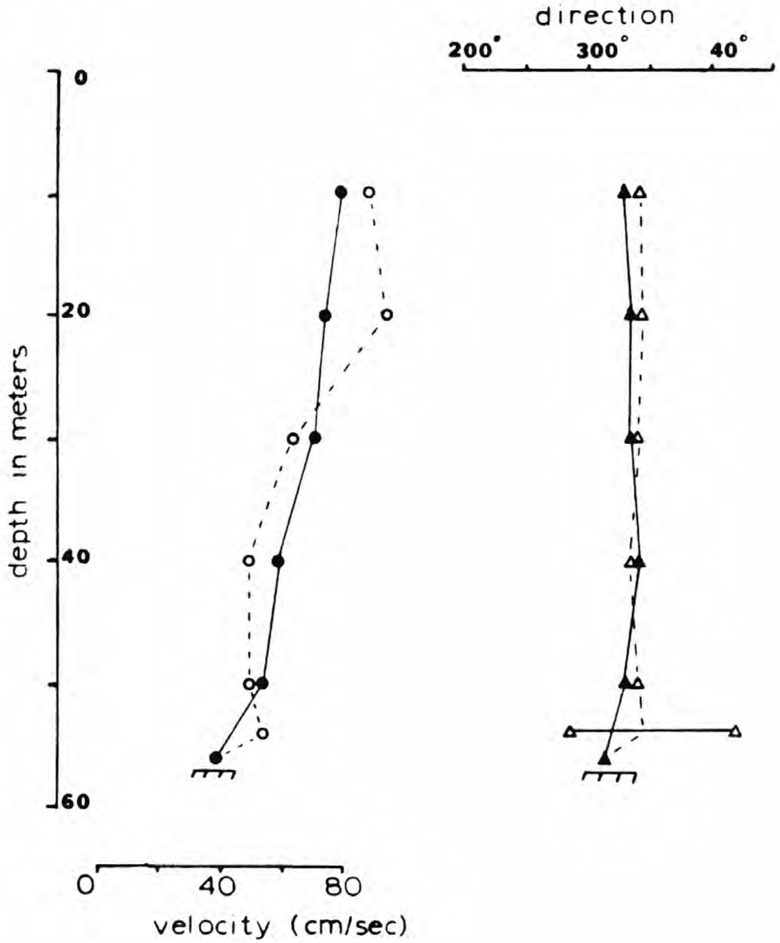
STA 324 CM-01



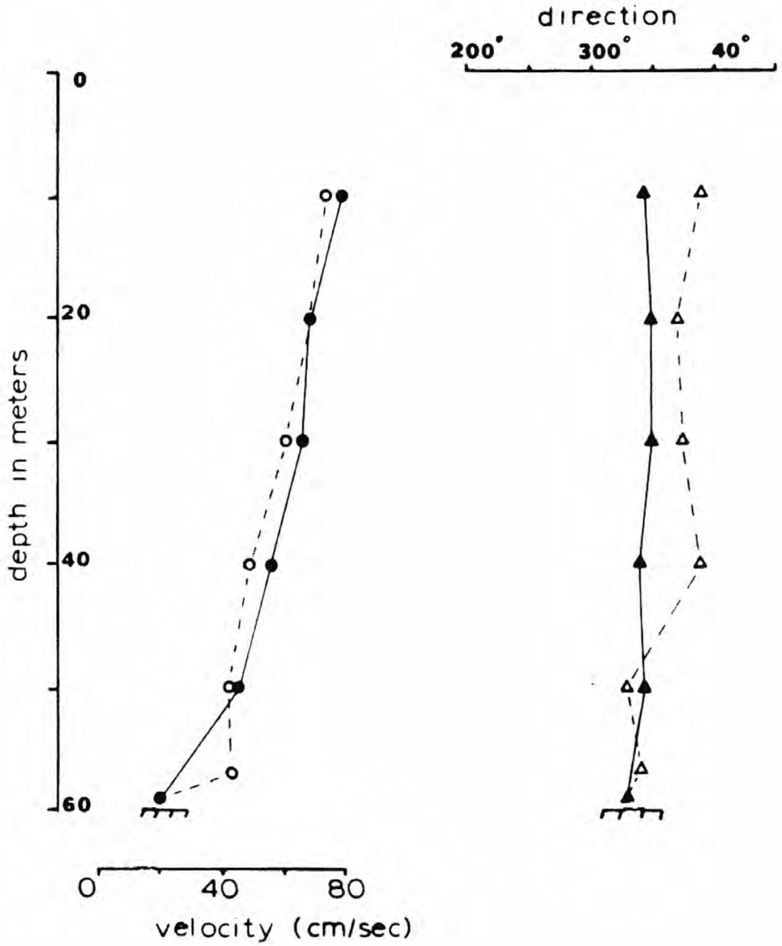
STA 324 CM-02



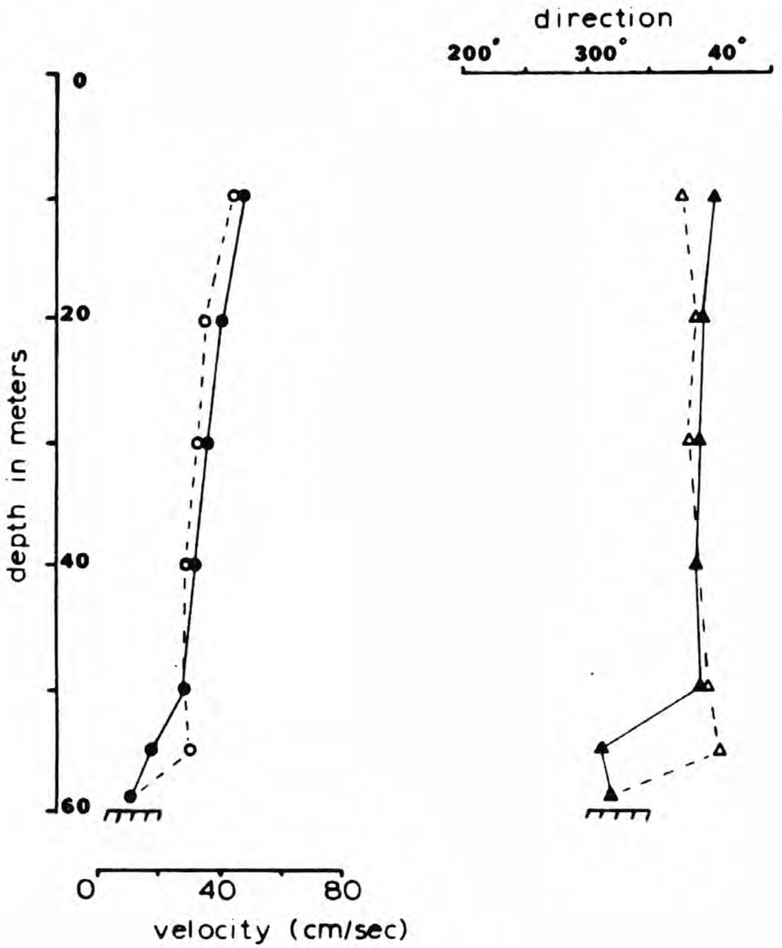
STA 324 CM-03



STA 324 CM-04



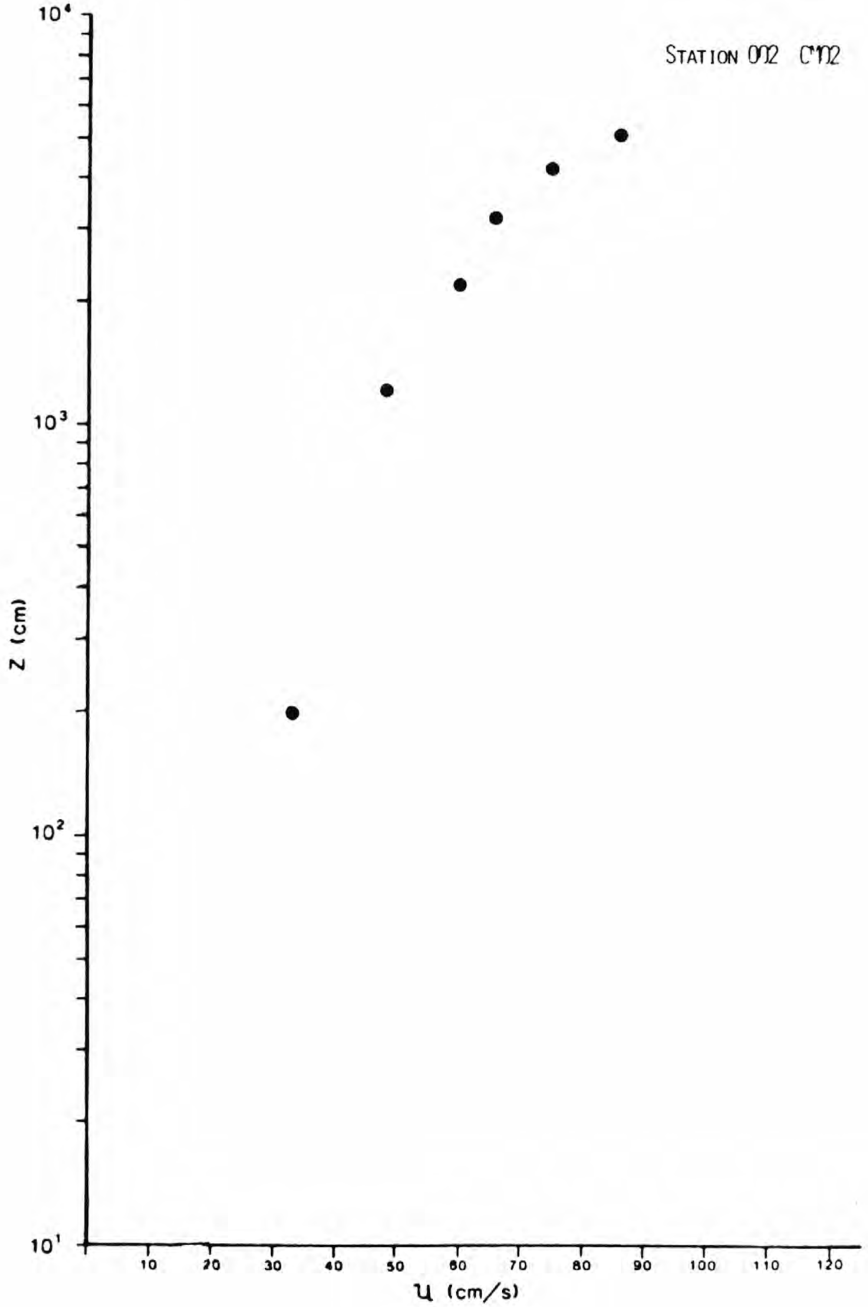
STA 324 CM-05

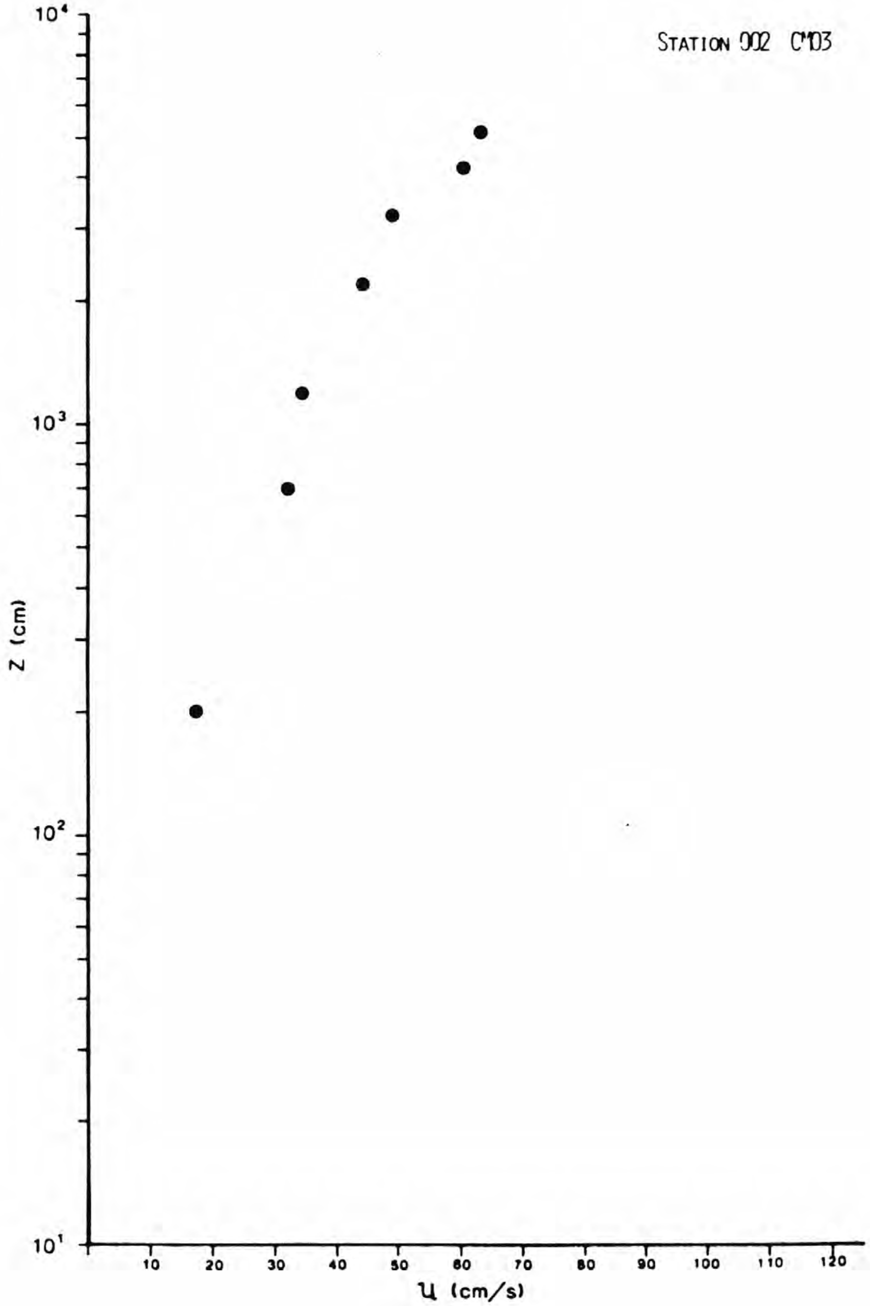

direction
200°
300°
40°
0
20
40
60
depth in meters
0
40
80
velocity (cm/sec)

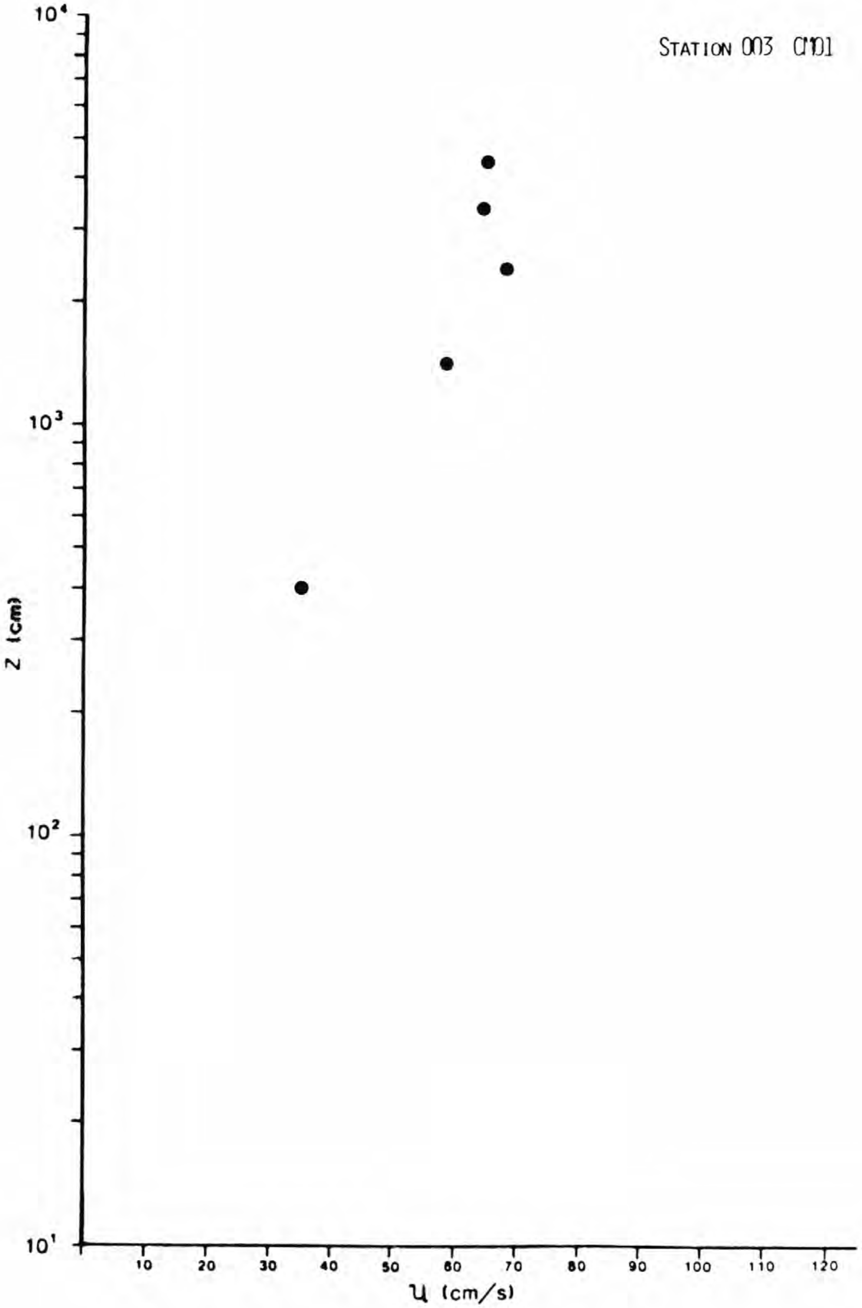
APPENDIX B

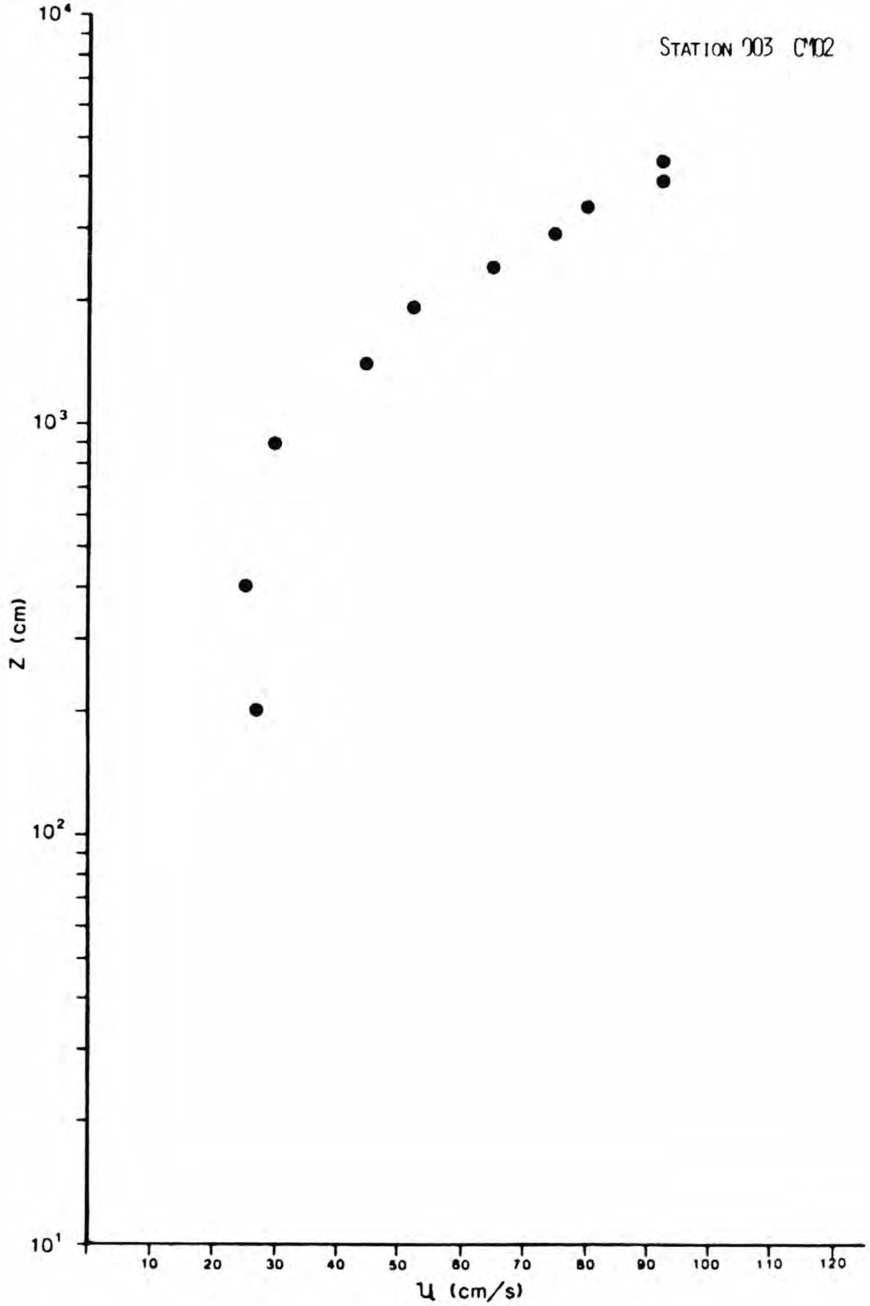
RECAST PLOTS

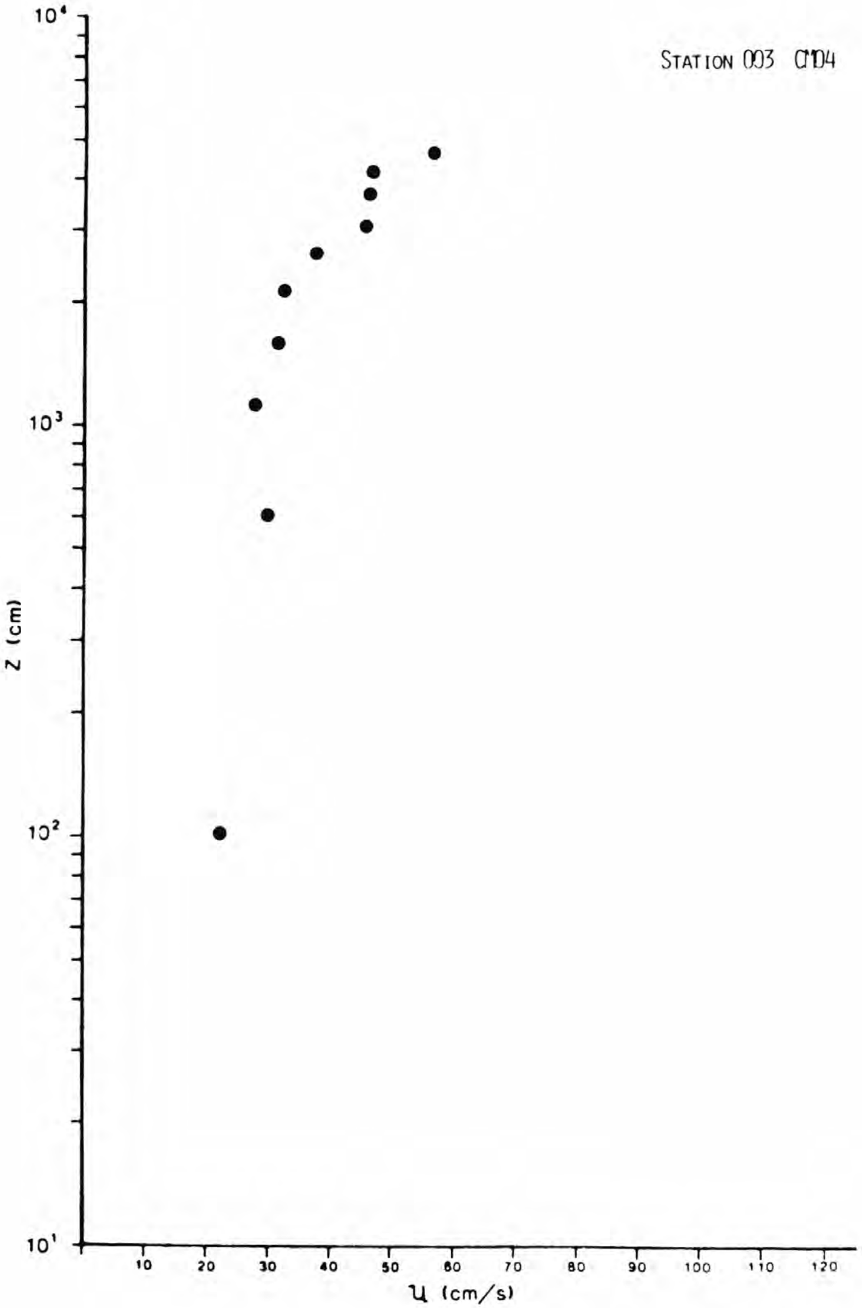
(Plots of current speed(temporally and spatially averaged) versus semilog depth)

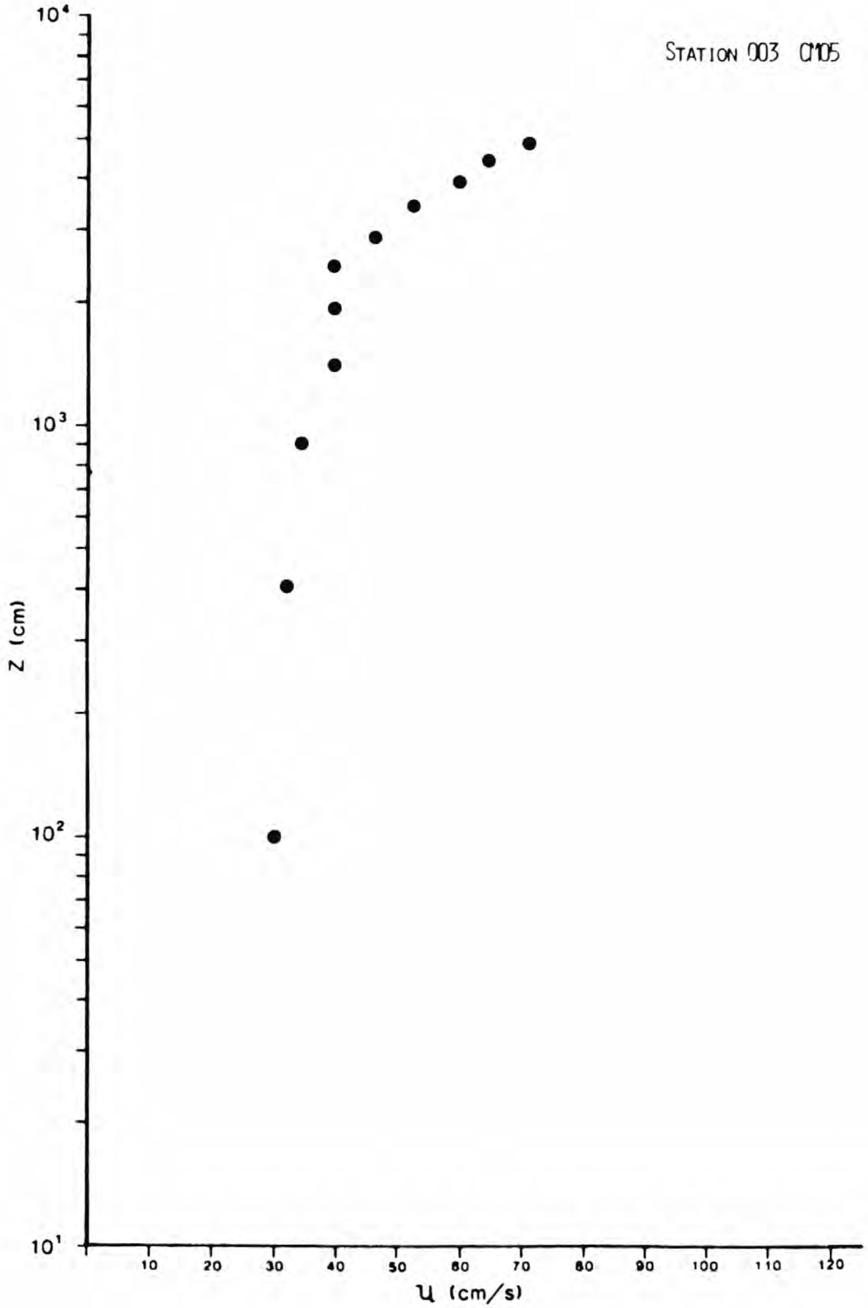

STATION 002 CM02
Z (cm)
U (cm/s)

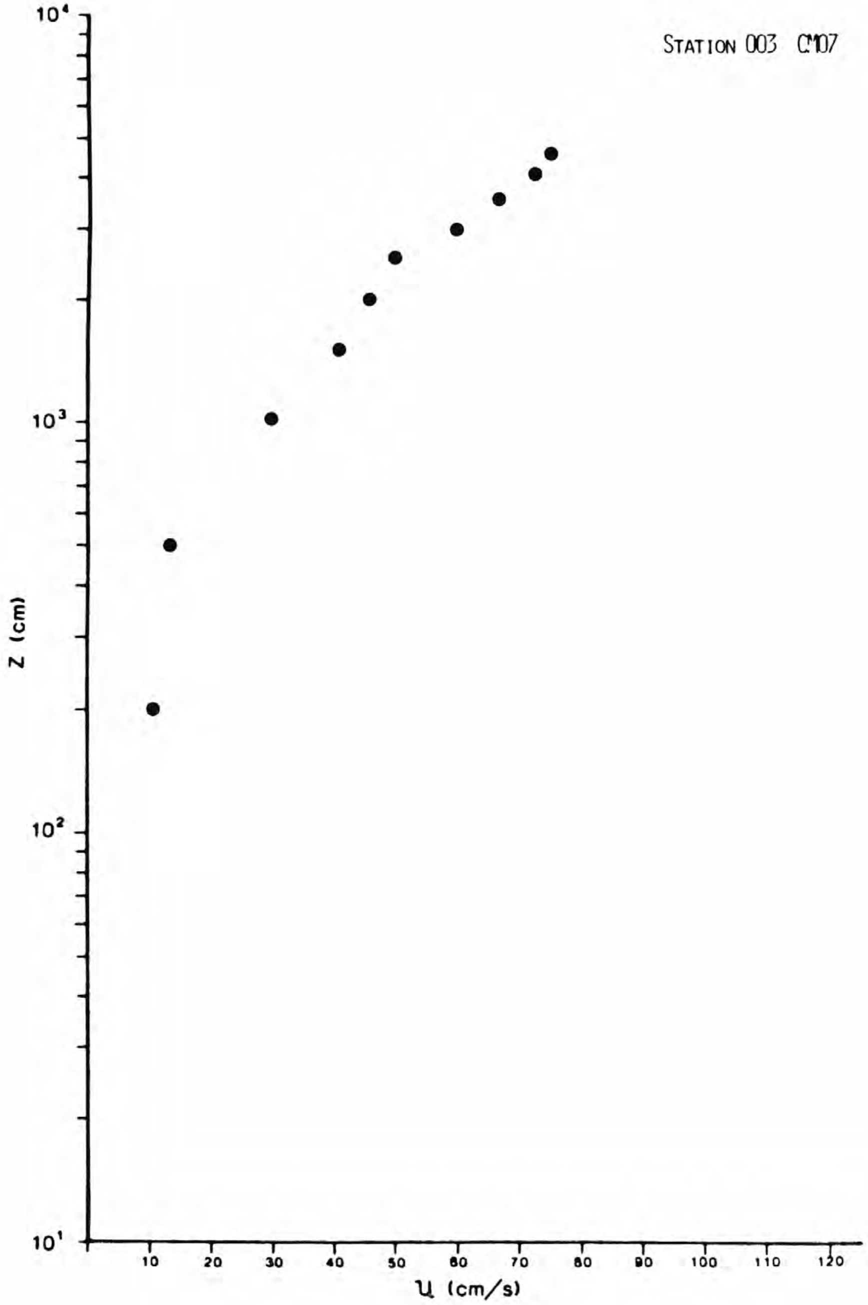

STATION 002 CM03
Z (cm)
U (cm/s)

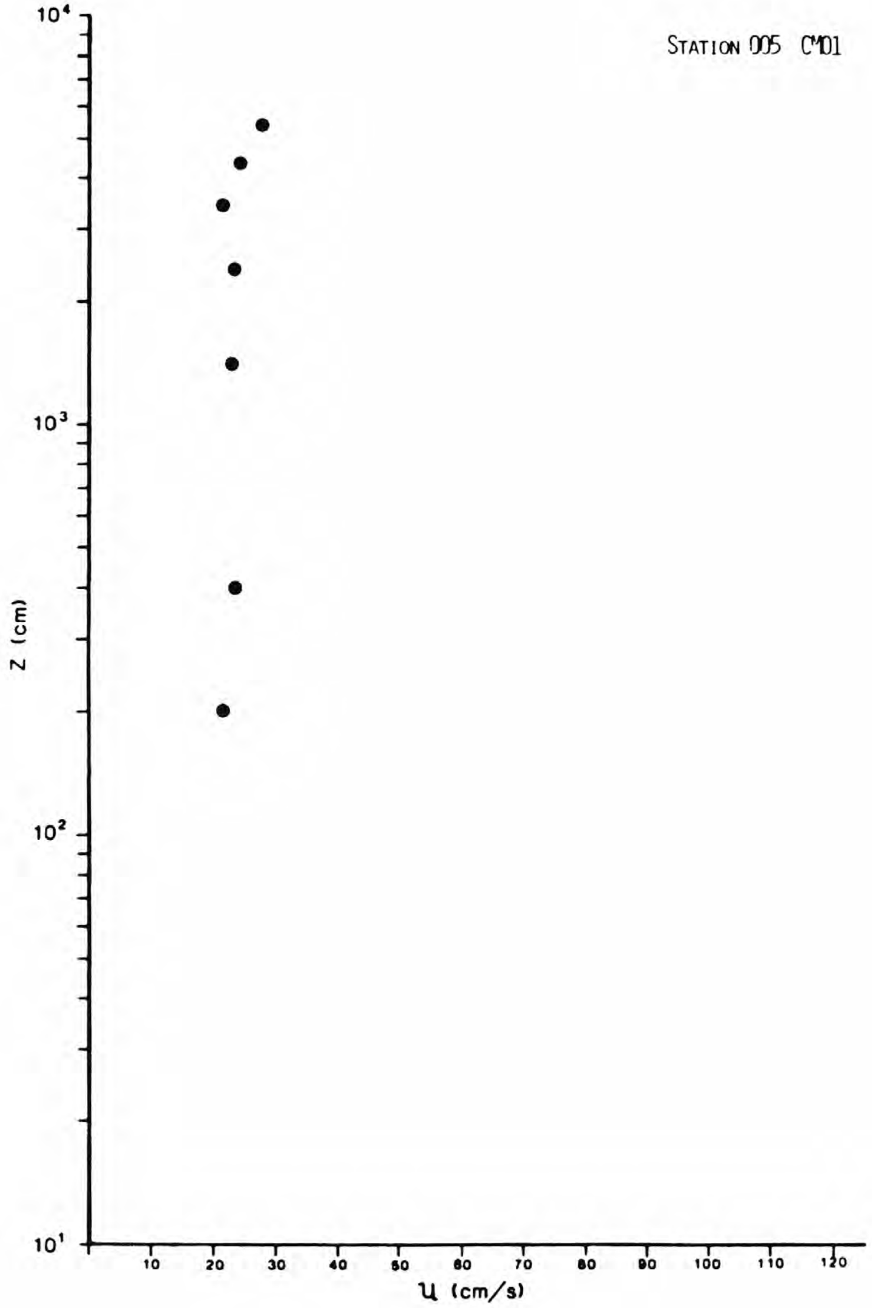

STATION 003 CM01
Z (cm)
U (cm/s)
10 20 30 40 50 60 70 80 90 100 110 120

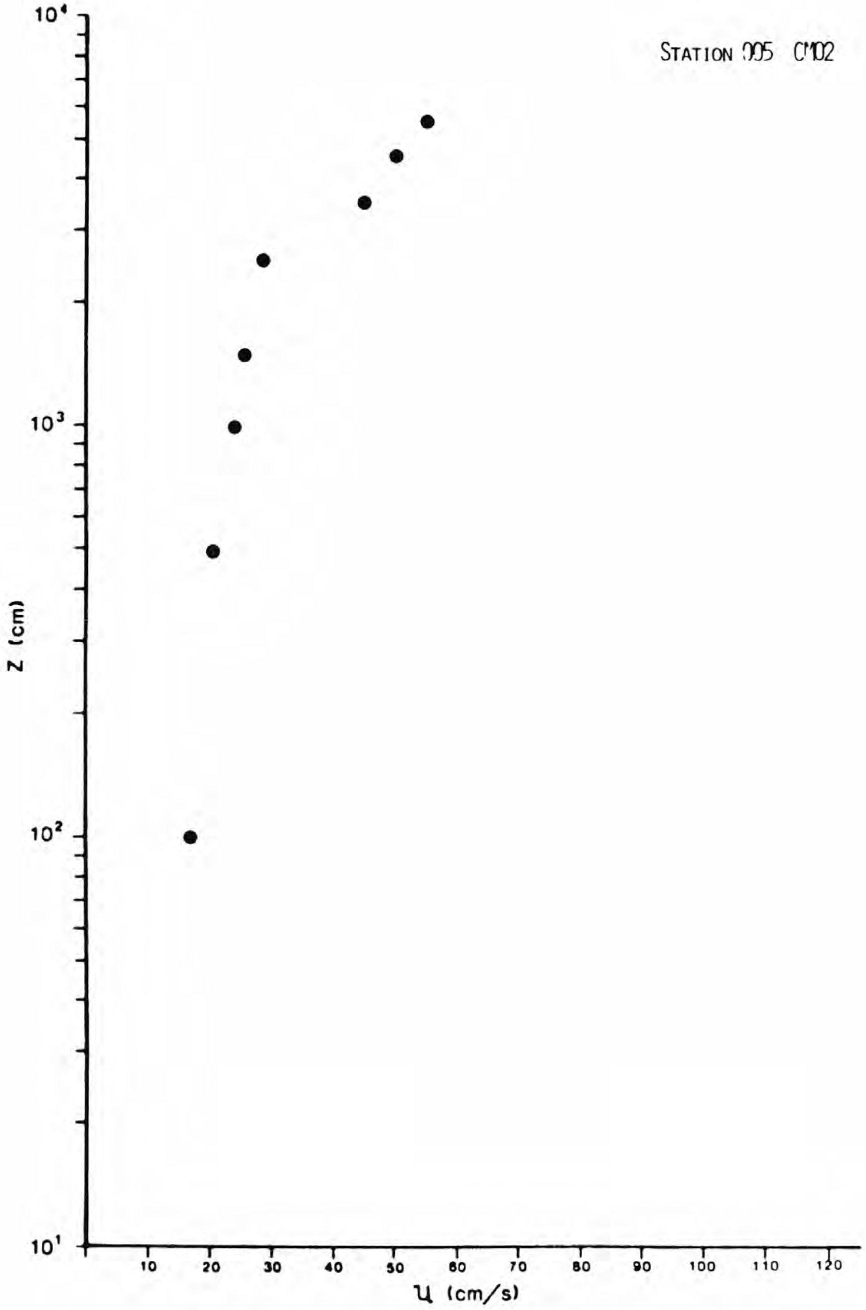

STATION 003 CM02
Z (cm)
U (cm/s)
10 20 30 40 50 60 70 80 90 100 110 120


STATION 003 CM04
Z (cm)
u (cm/s)
10⁴
10³
10²
10¹
10 20 30 40 50 60 70 80 90 100 110 120

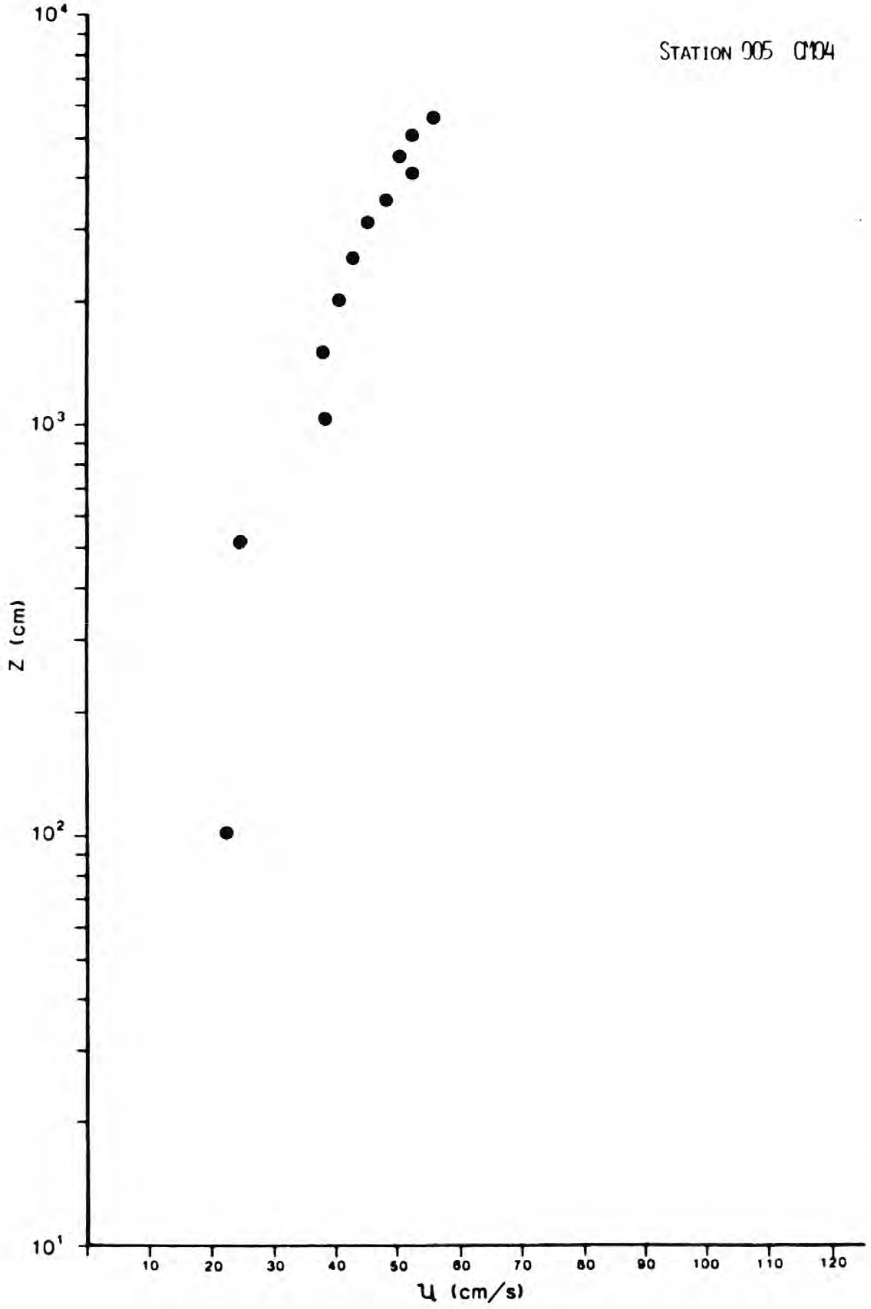

STATION 003 CM05
Z (cm)
u (cm/s)
10⁴
10³
10²
10¹
10 20 30 40 50 60 70 80 90 100 110 120


STATION 003 CM07
Z (cm)
10⁴
10³
10²
10¹
10 20 30 40 50 60 70 80 90 100 110 120
U (cm/s)

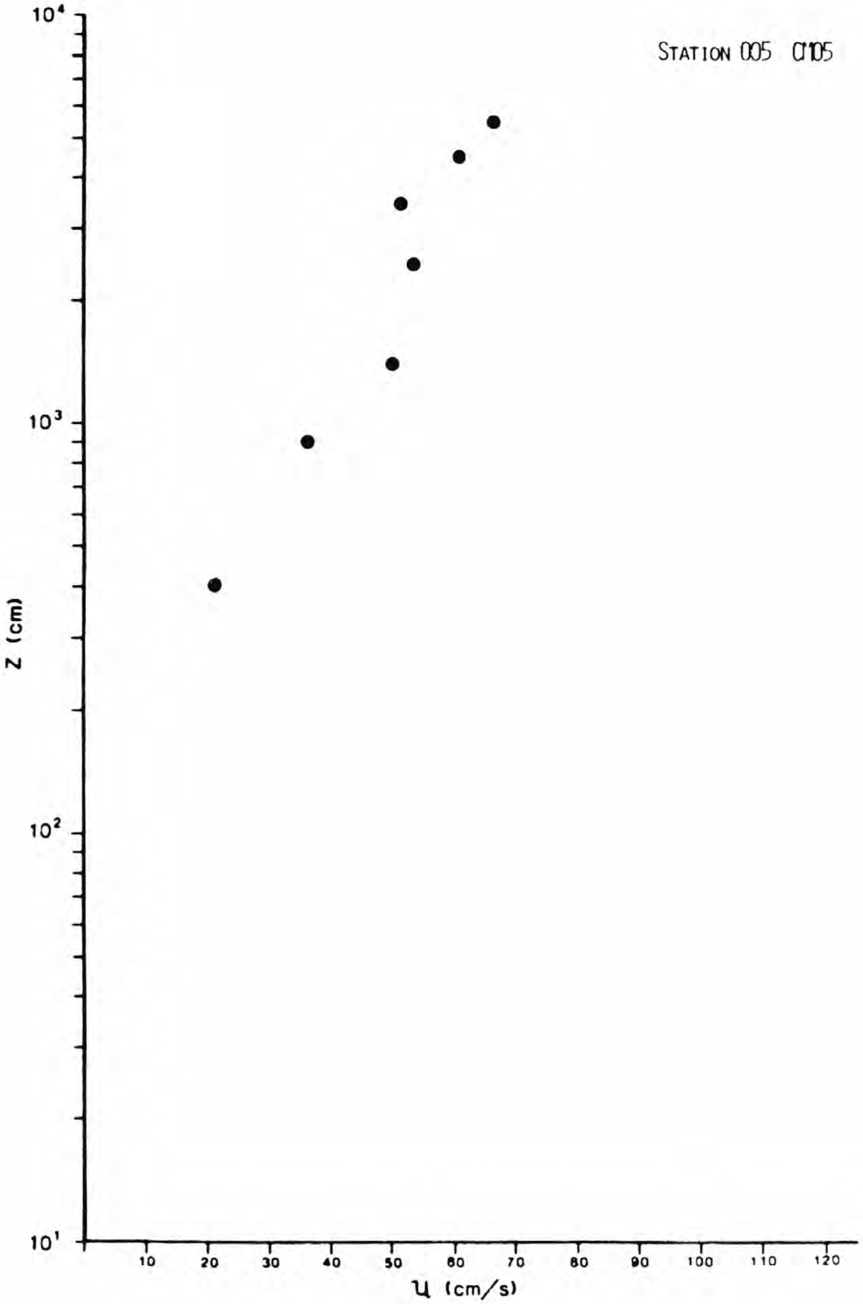

STATION 005 CM01
Z (cm)
10⁴
10³
10²
10¹
10 20 30 40 50 60 70 80 90 100 110 120
U (cm/s)

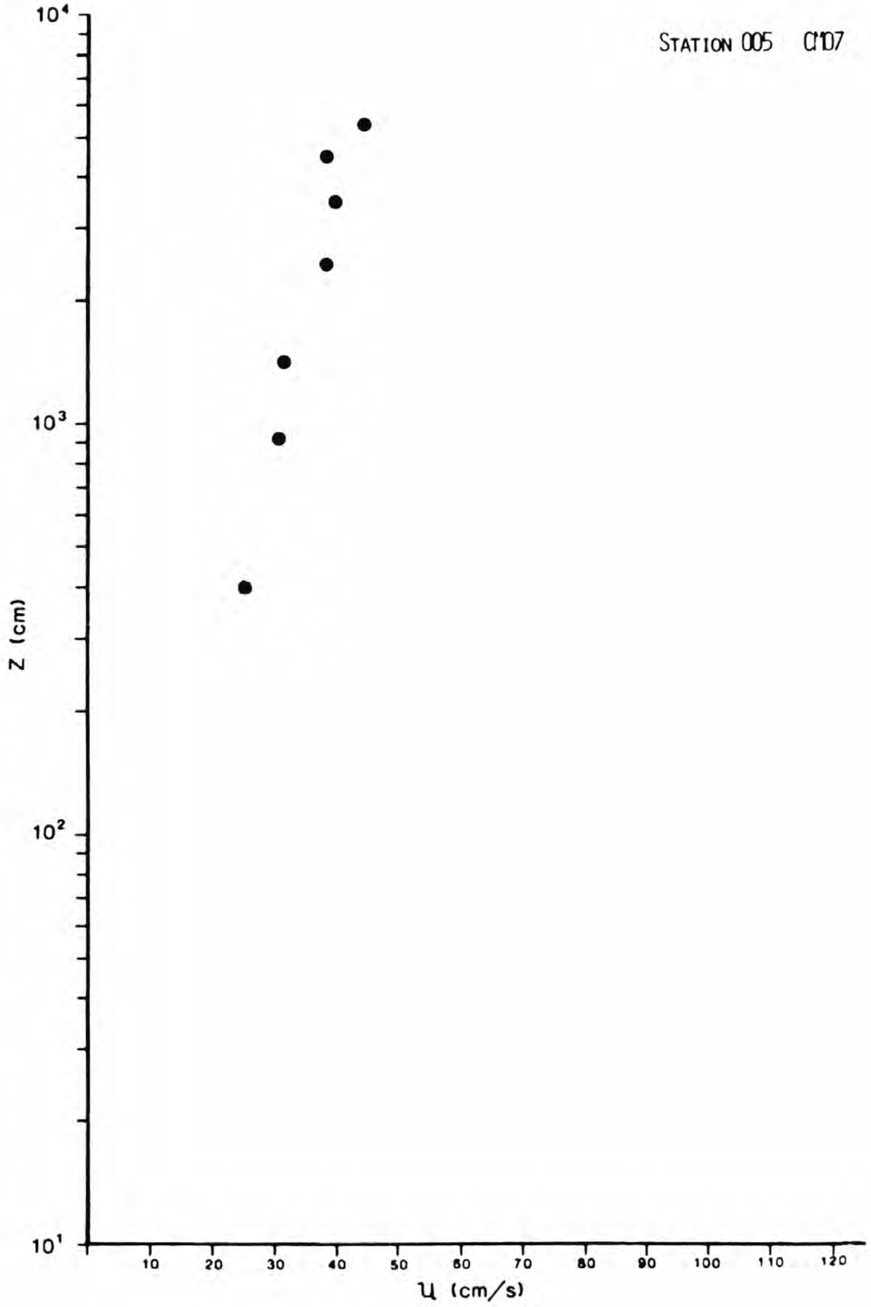


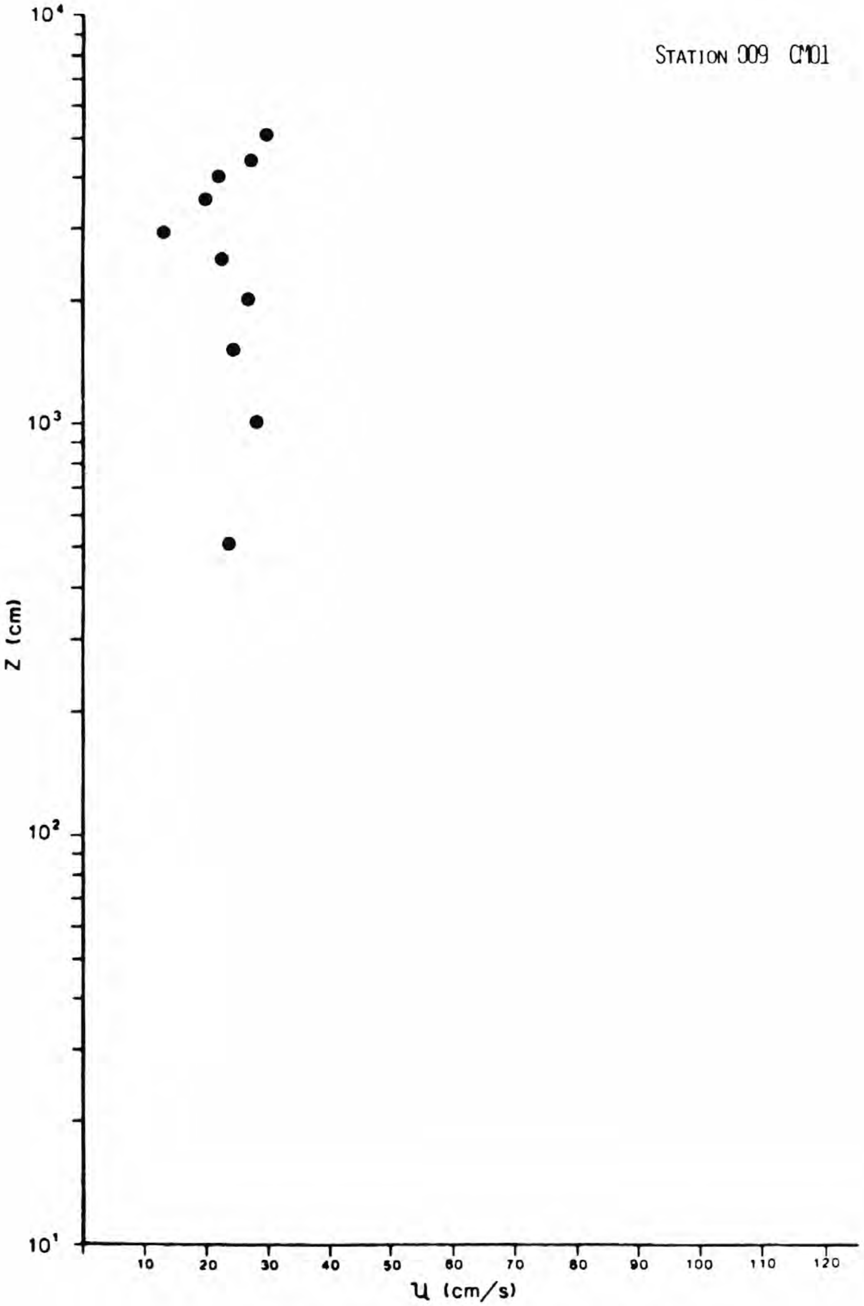
STATION 005 CM02
10⁴
10³
10²
10¹
Z (cm)
10 20 30 40 50 60 70 80 90 100 110 120
U (cm/s)

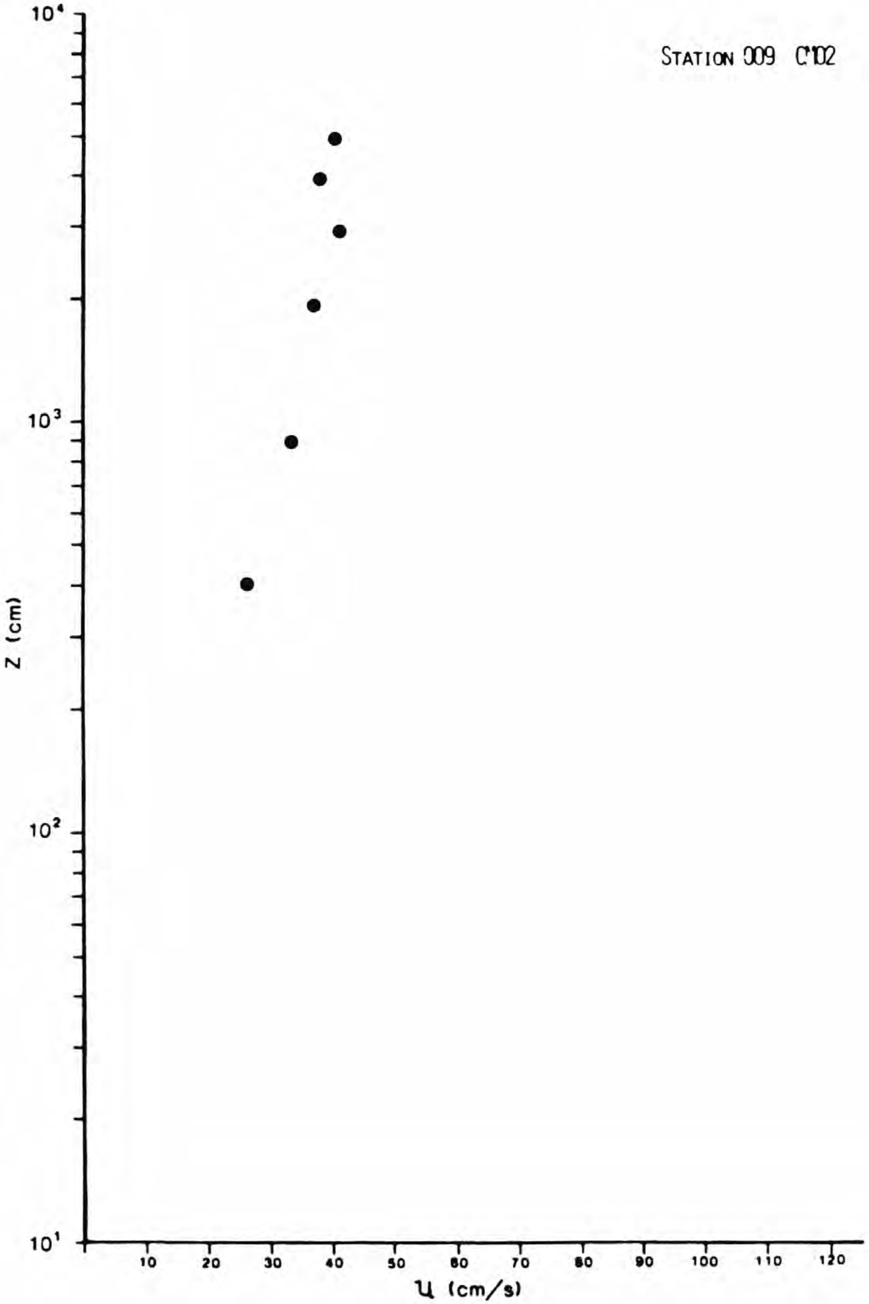


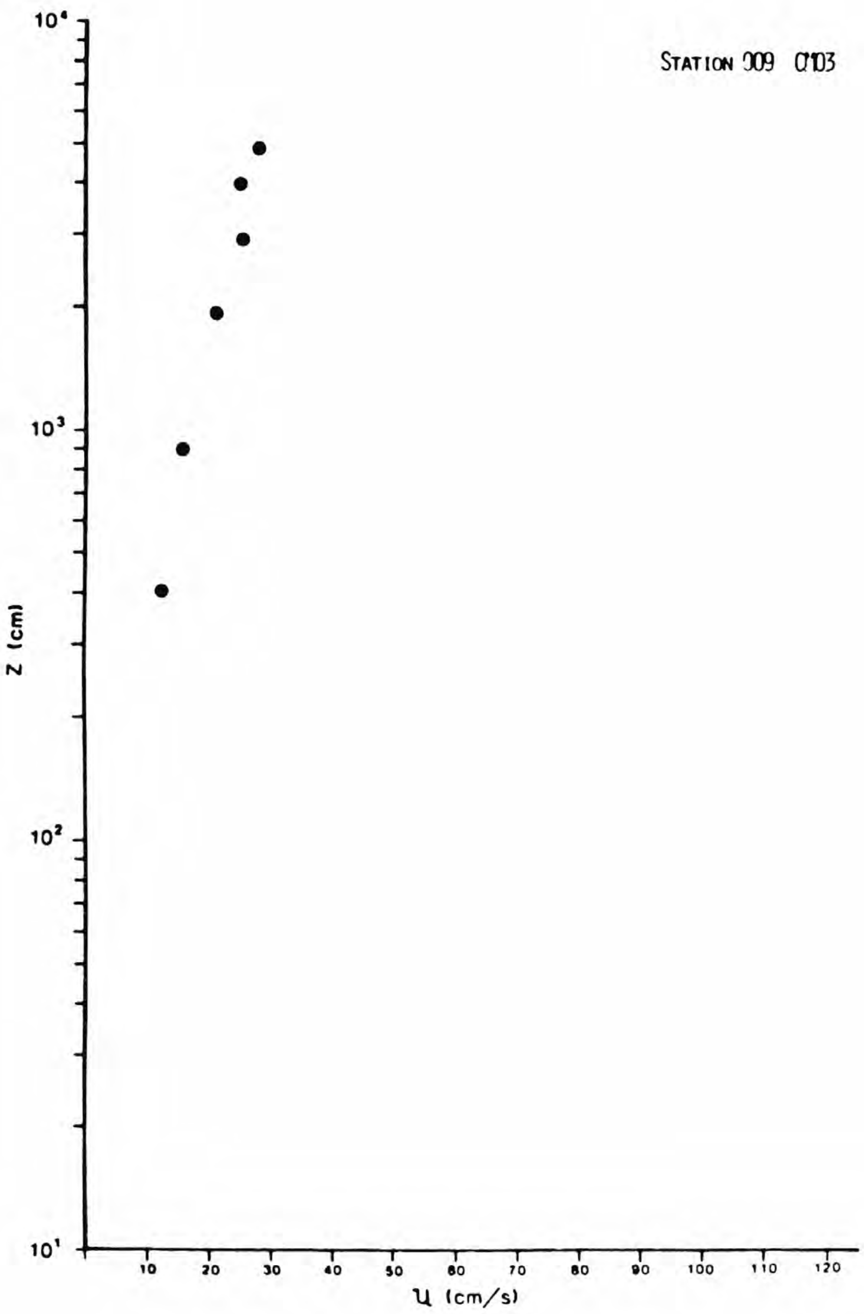
STATION 005 CM04
10⁴
10³
10²
10¹
Z (cm)
10 20 30 40 50 60 70 80 90 100 110 120
U (cm/s)


STATION 005 CM05
Z (cm)
10⁴
10³
10²
10¹
10 20 30 40 50 60 70 80 90 100 110 120
U (cm/s)

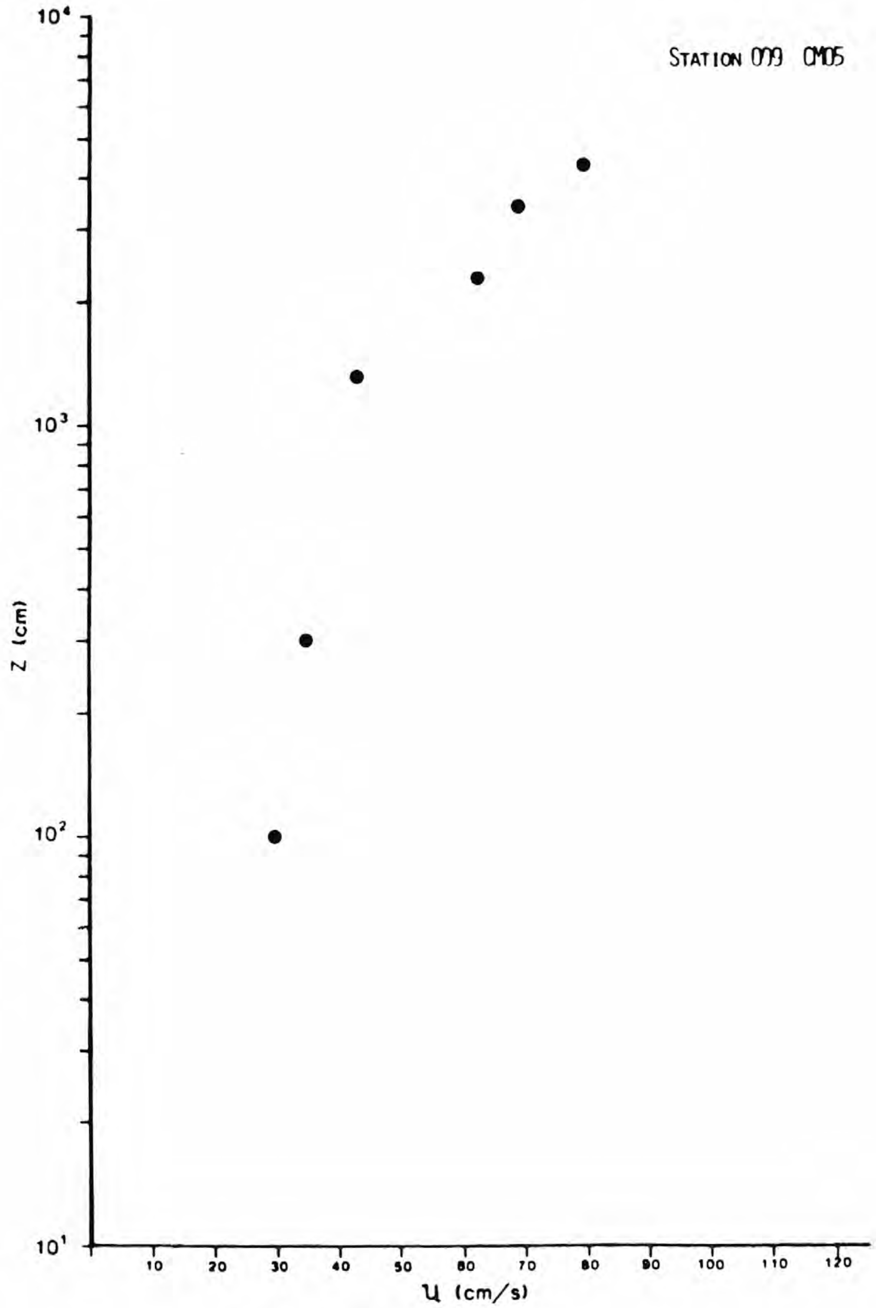

STATION 005 CM07
Z (cm)
10⁴
10³
10²
10¹
10 20 30 40 50 60 70 80 90 100 110 120
U (cm/s)


STATION 009 CM01
10⁴
10³
10²
10¹
Z (cm)
10 20 30 40 50 60 70 80 90 100 110 120
U (cm/s)

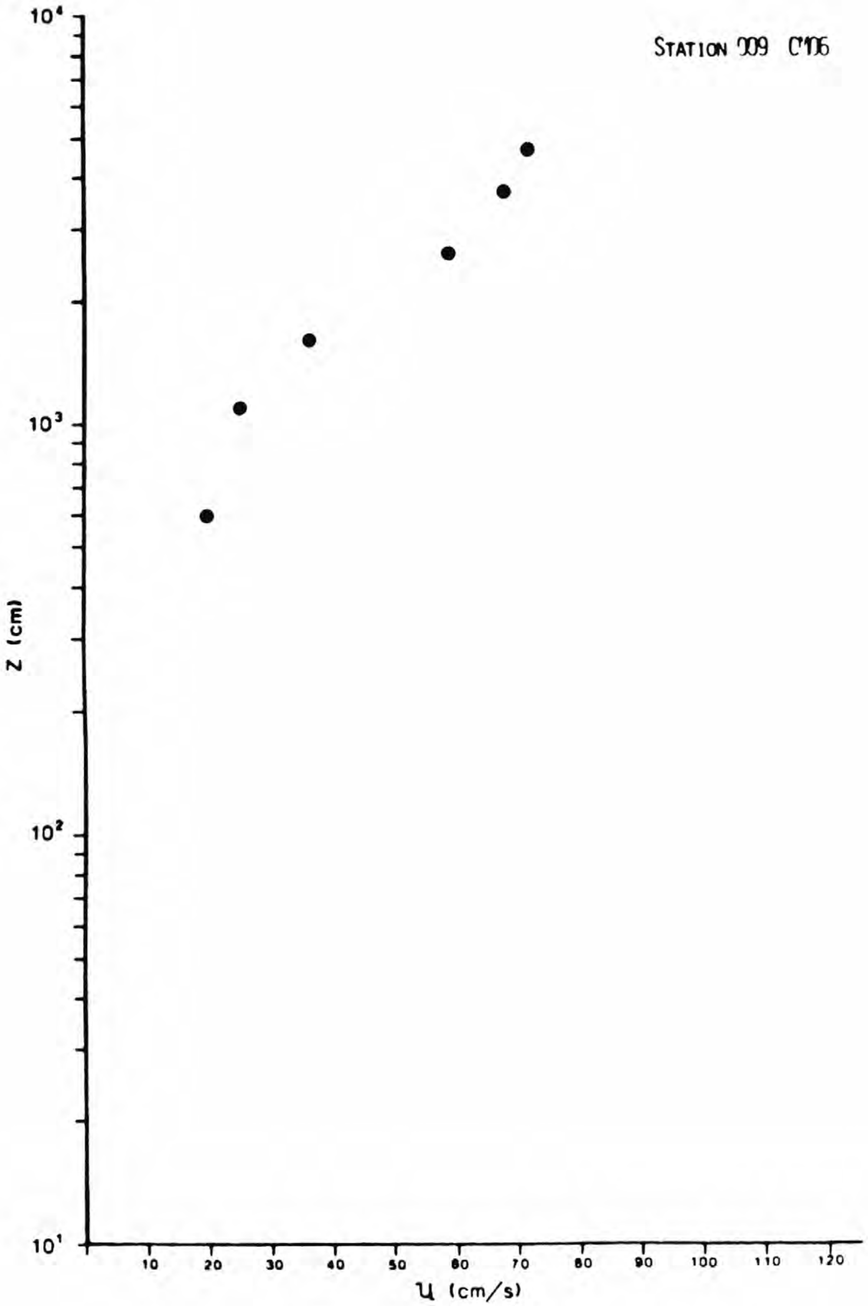

STATION 009 CM02
10⁴
10³
10²
10¹
Z (cm)
10 20 30 40 50 60 70 80 90 100 110 120
U (cm/s)



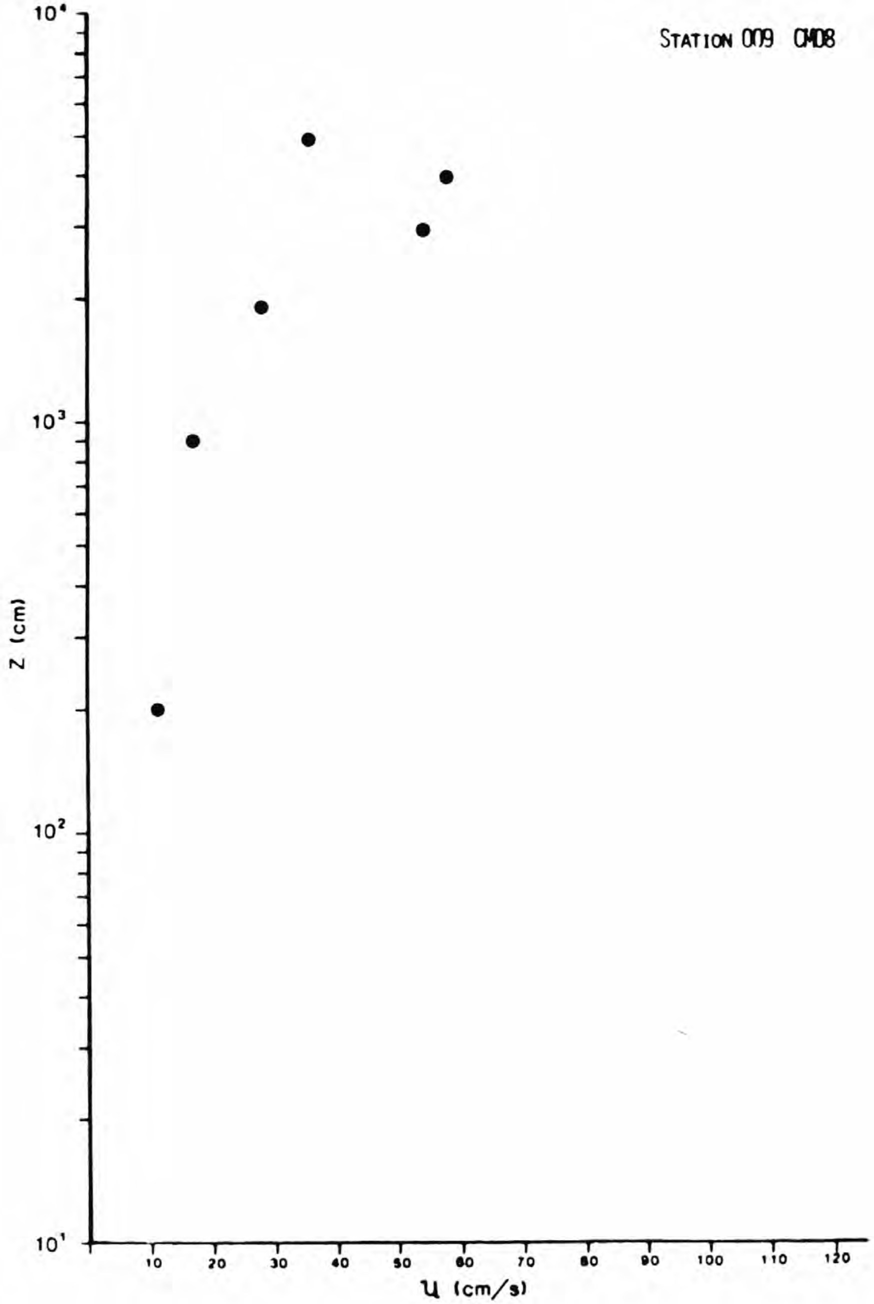
STATION 009 CM03
10^4
10^3
10^2
10^1
Z (cm)
10 20 30 40 50 60 70 80 90 100 110 120
U (cm/s)



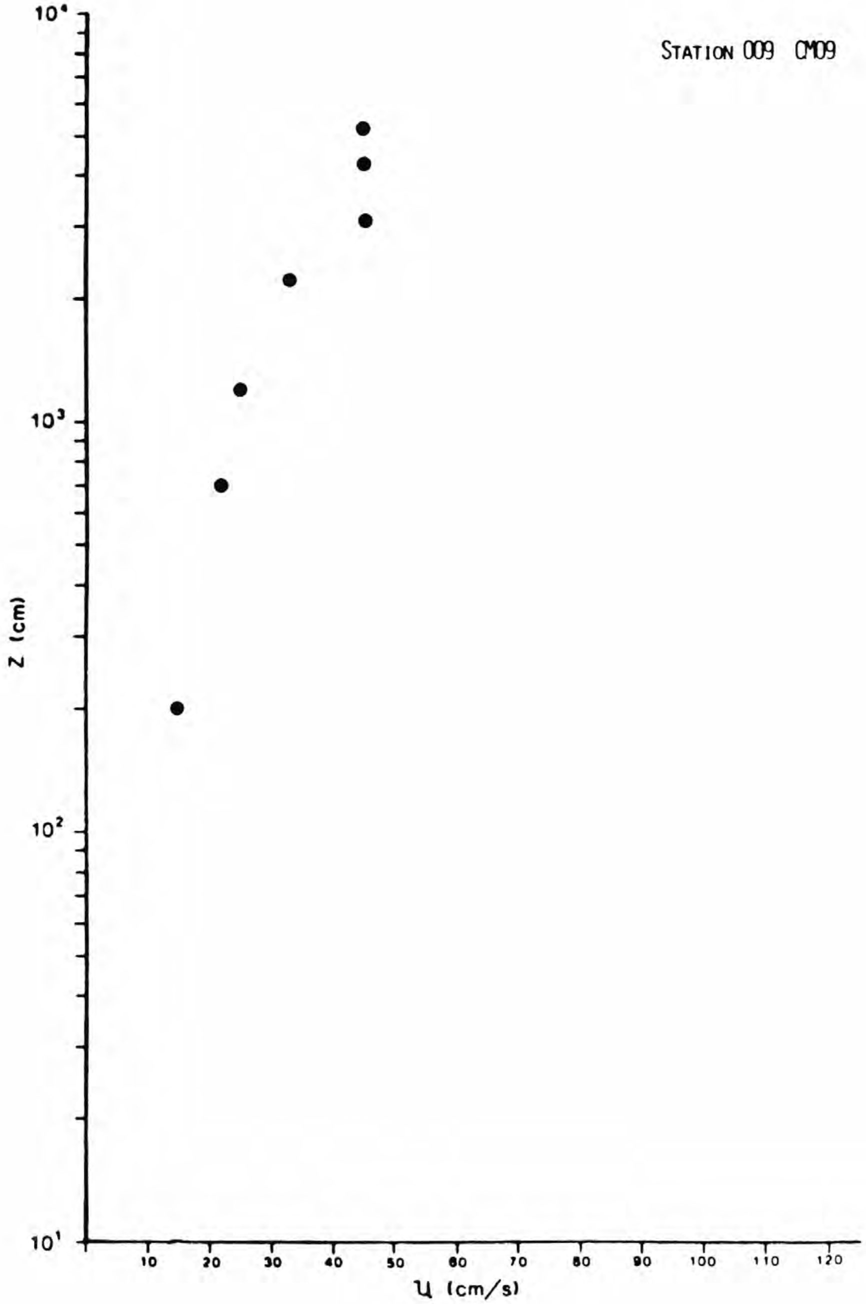
STATION 009 CM05
10^4
10^3
10^2
10^1
Z (cm)
10 20 30 40 50 60 70 80 90 100 110 120
U (cm/s)

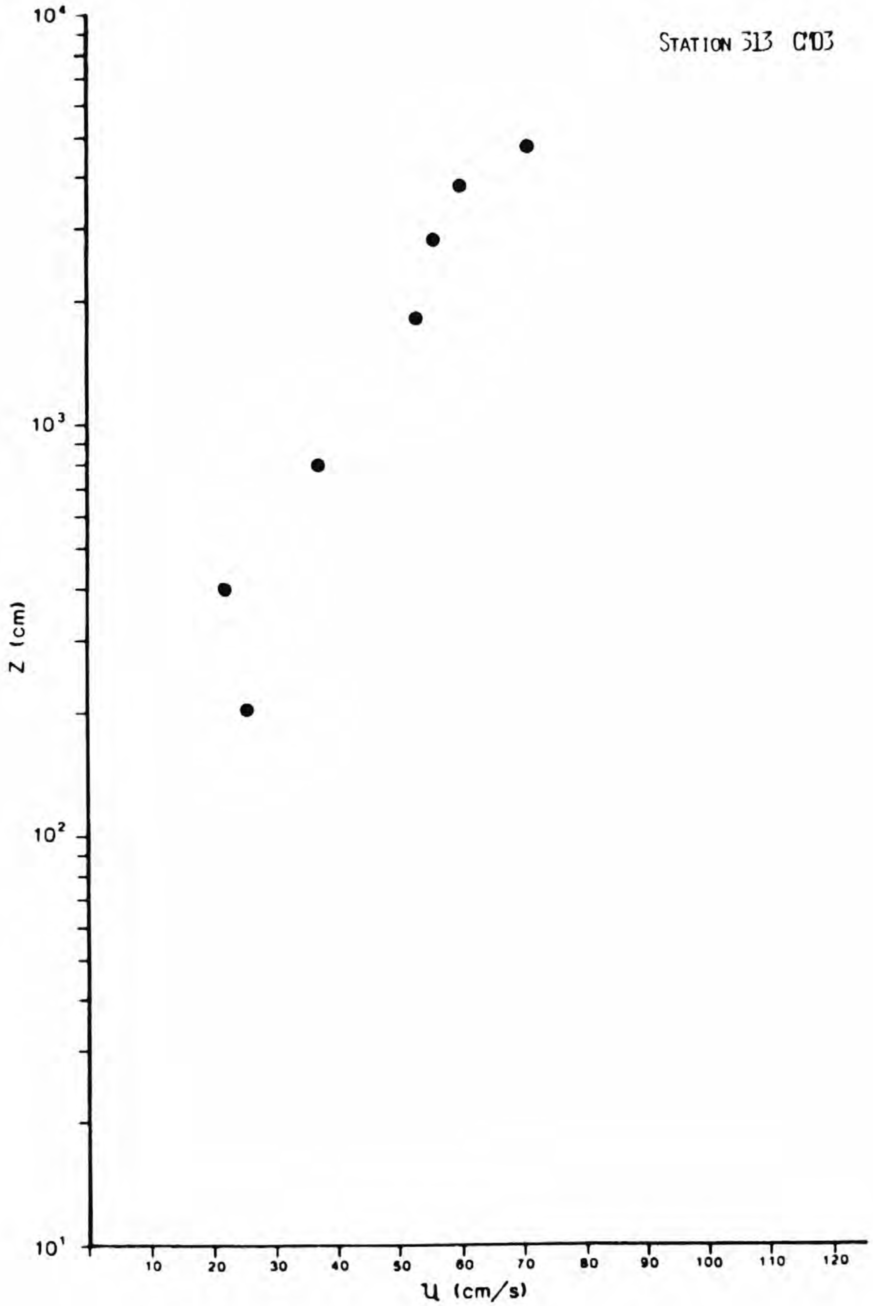


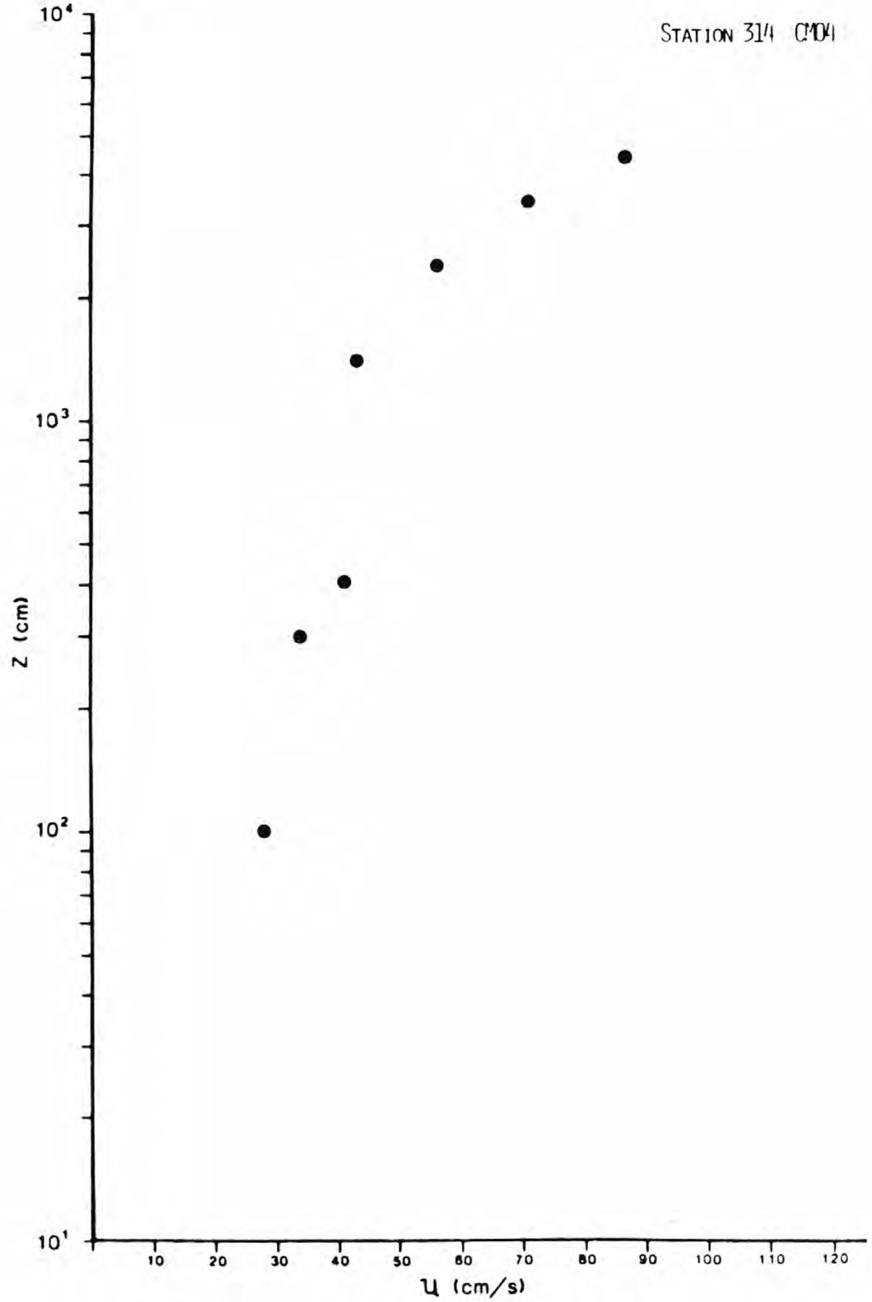
STATION 009 CM06
Z (cm)
10^4
10^3
10^2
10^1
10 20 30 40 50 60 70 80 90 100 110 120
U (cm/s)

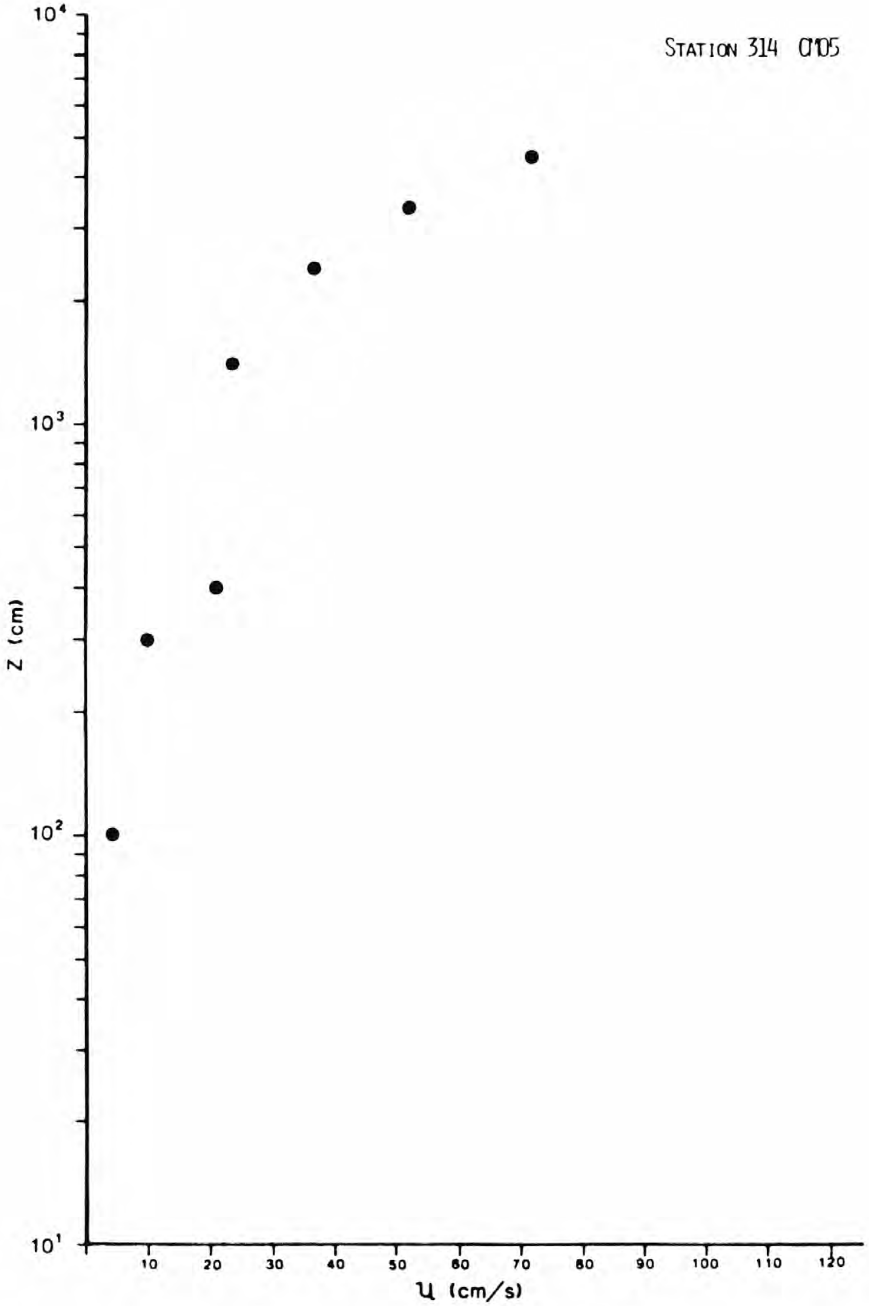


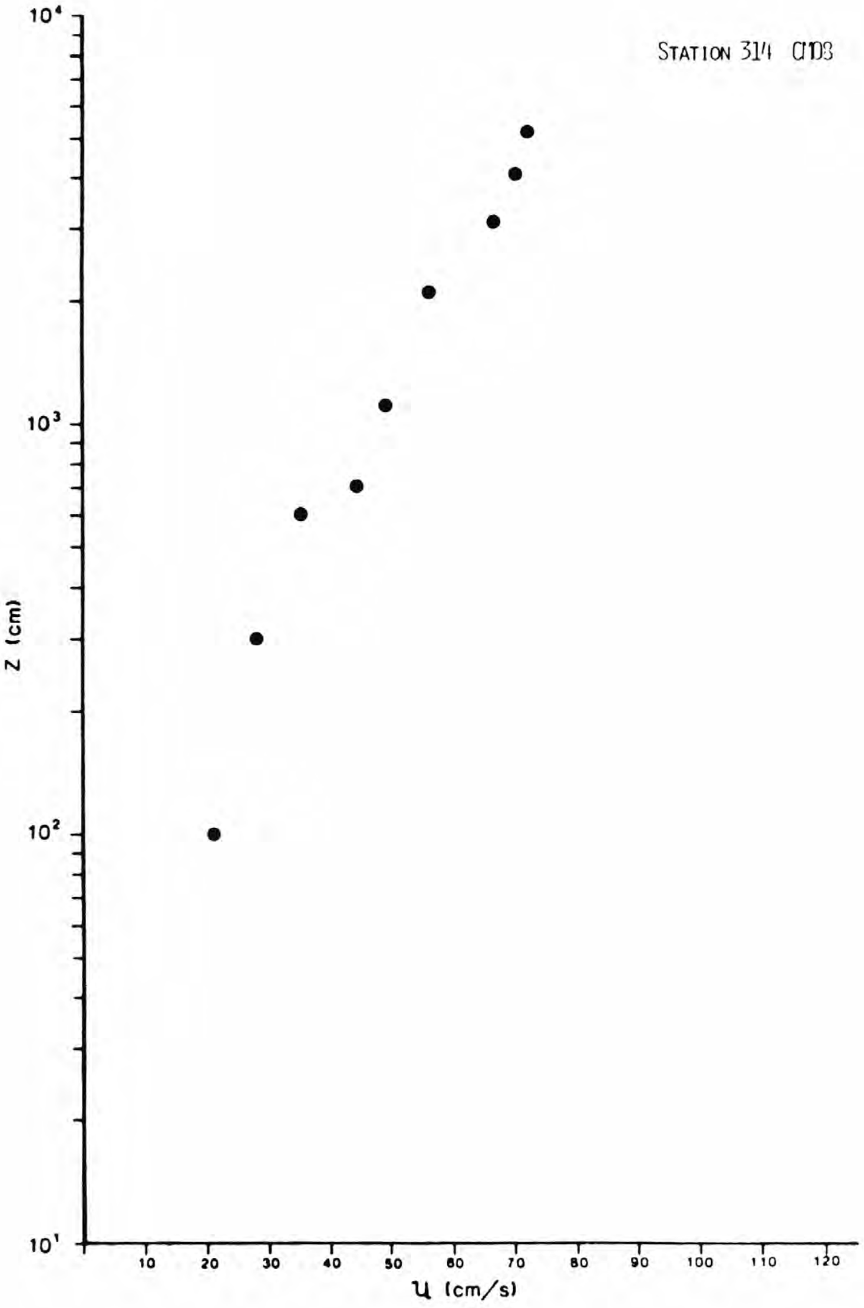
STATION 009 CM08
Z (cm)
10^4
10^3
10^2
10^1
10 20 30 40 50 60 70 80 90 100 110 120
U (cm/s)

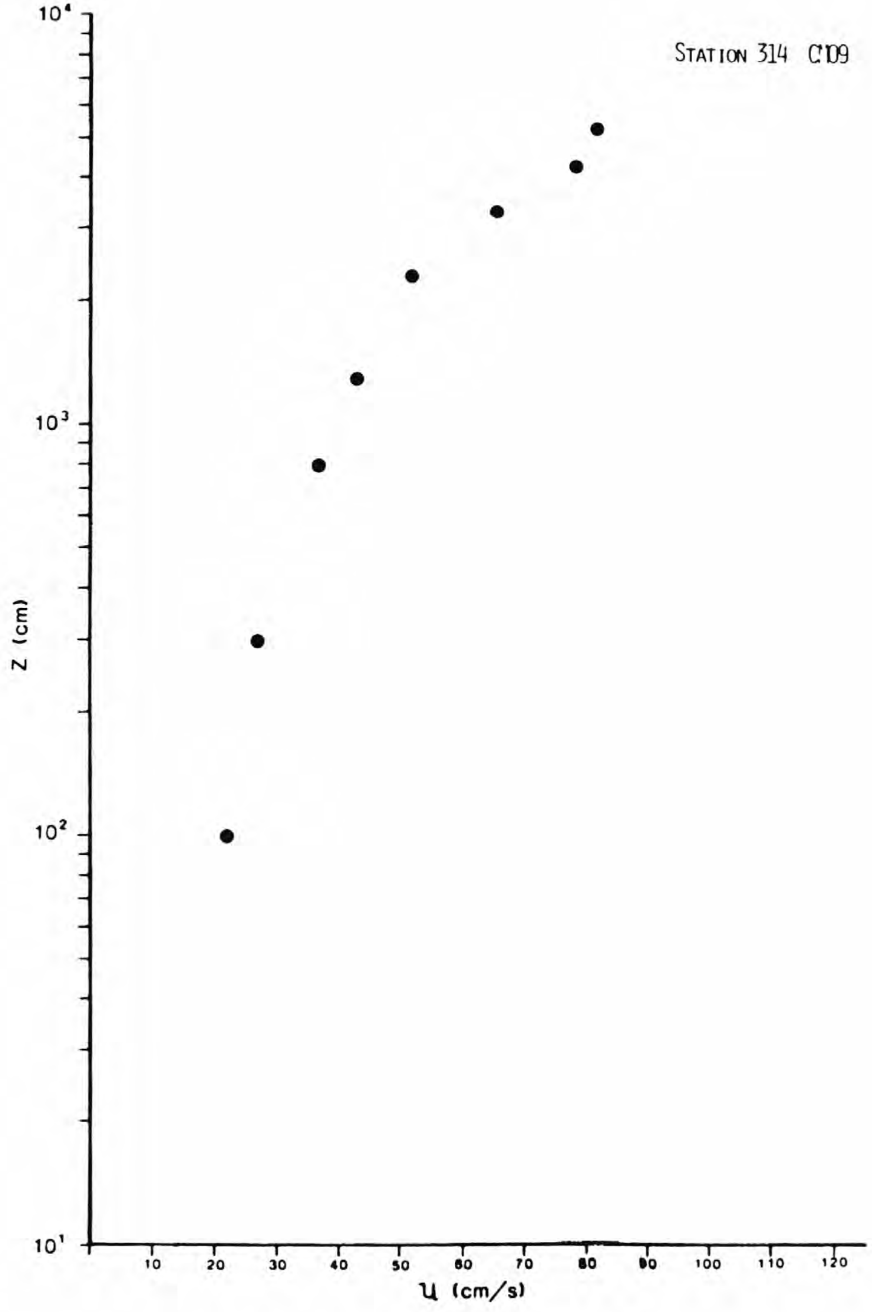

STATION 009 CM09
Z (cm)
U (cm/s)
10⁴
10³
10²
10¹
10 20 30 40 50 60 70 80 90 100 110 120

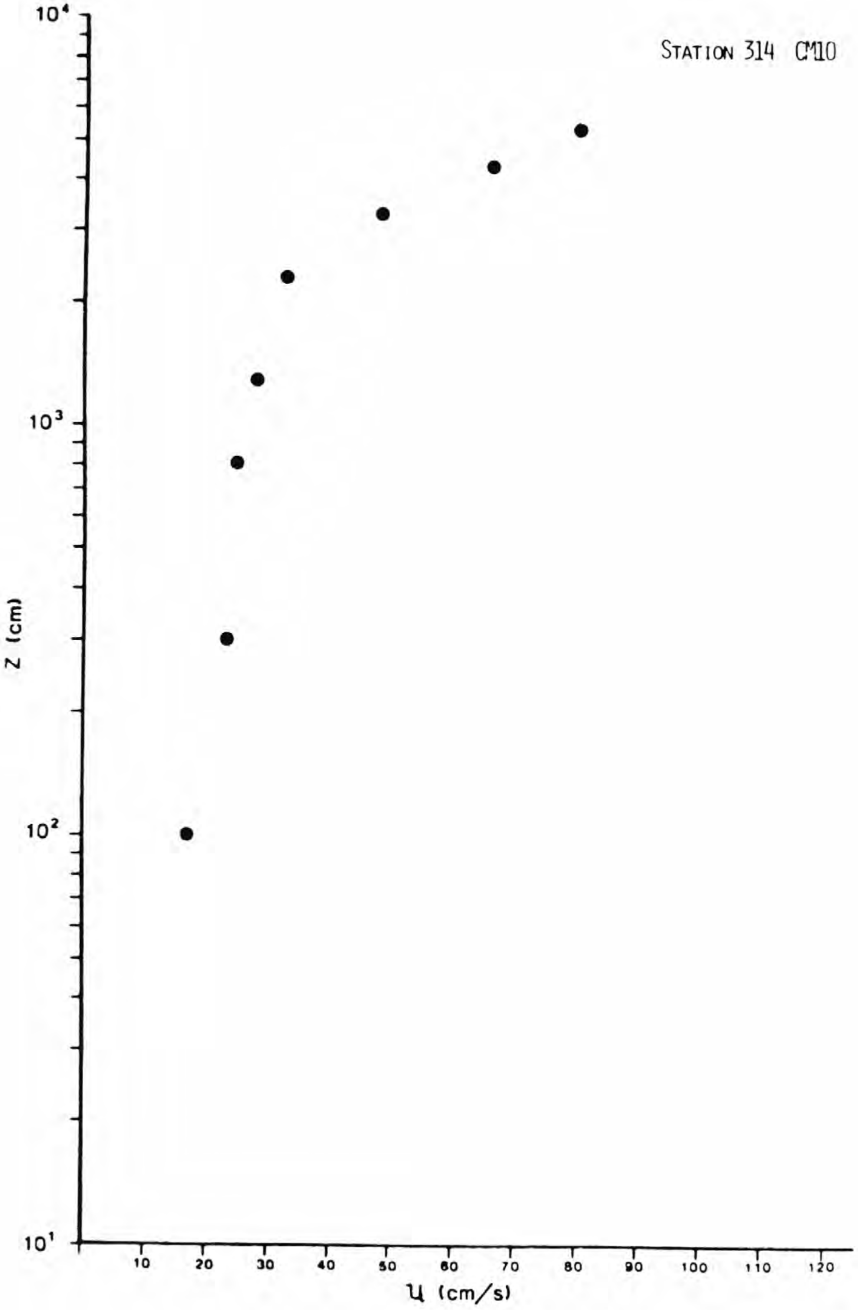

STATION 313 CM03
Z (cm)
U (cm/s)
10⁴
10³
10²
10¹
10 20 30 40 50 60 70 80 90 100 110 120

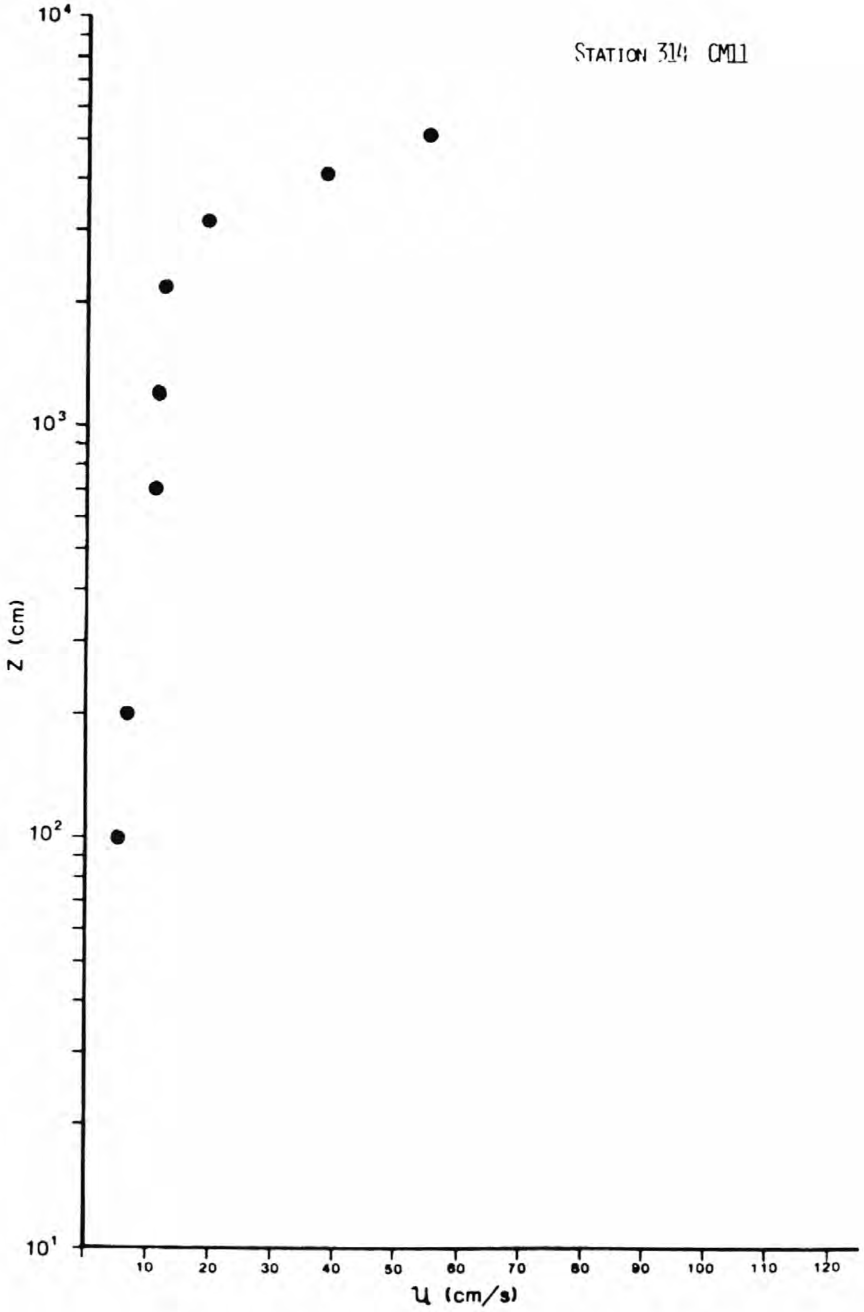

STATION 314 CM04
10^4
10^3
10^2
10^1
Z (cm)
10 20 30 40 50 60 70 80 90 100 110 120
U (cm/s)

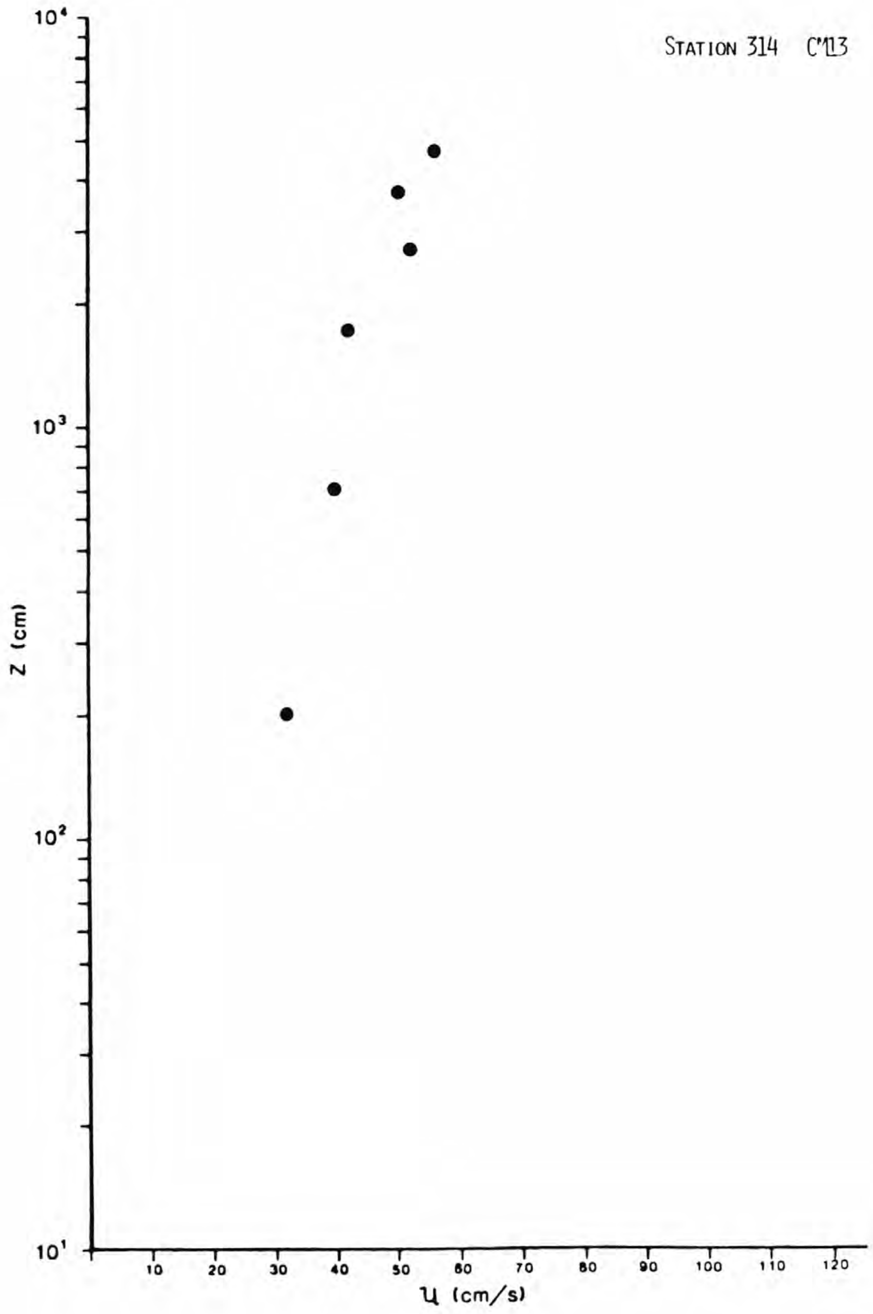

STATION 314 CM05
10^4
10^3
10^2
10^1
Z (cm)
10 20 30 40 50 60 70 80 90 100 110 120
U (cm/s)

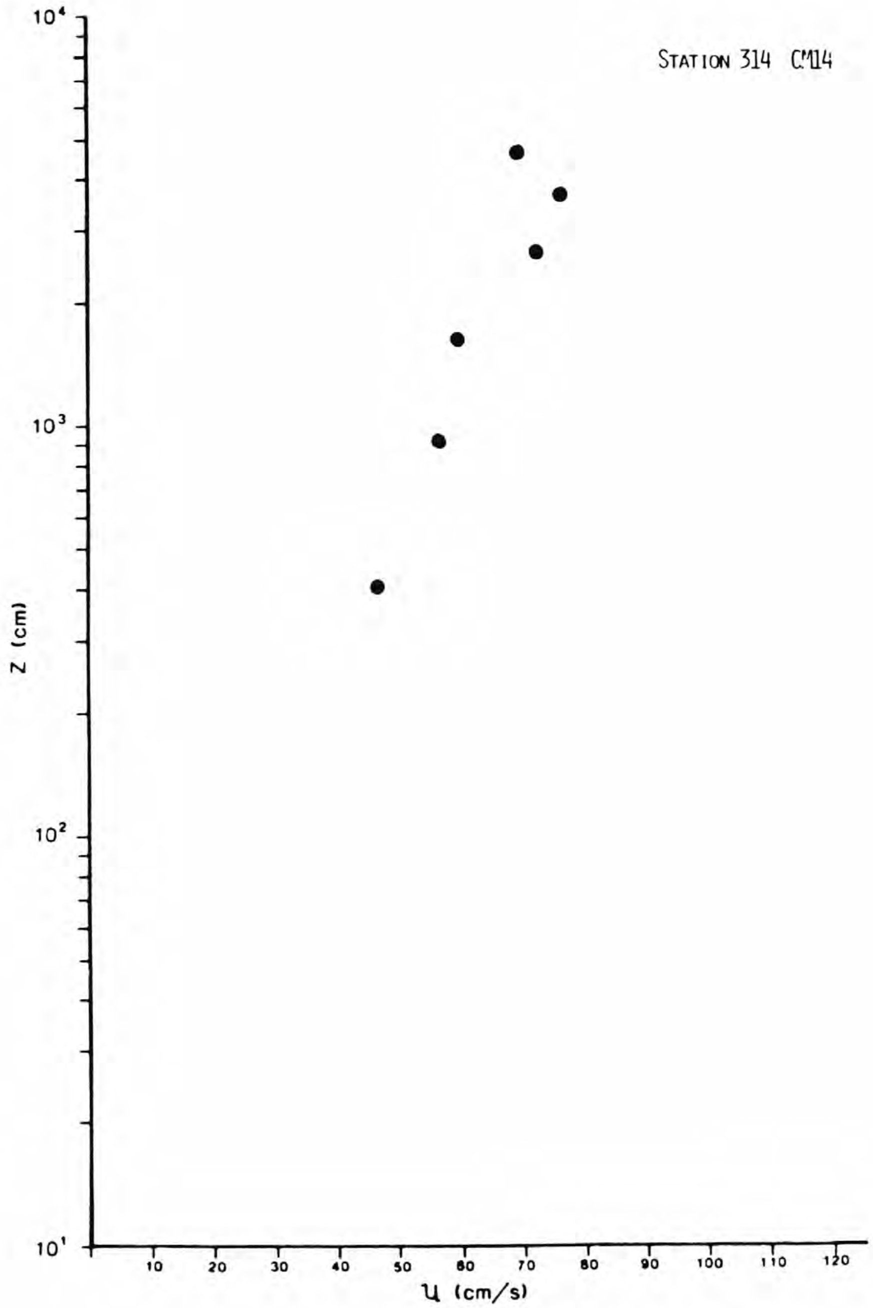

STATION 314 CMD8
Z (cm)
10⁴
10³
10²
10¹
10 20 30 40 50 60 70 80 90 100 110 120
U (cm/s)

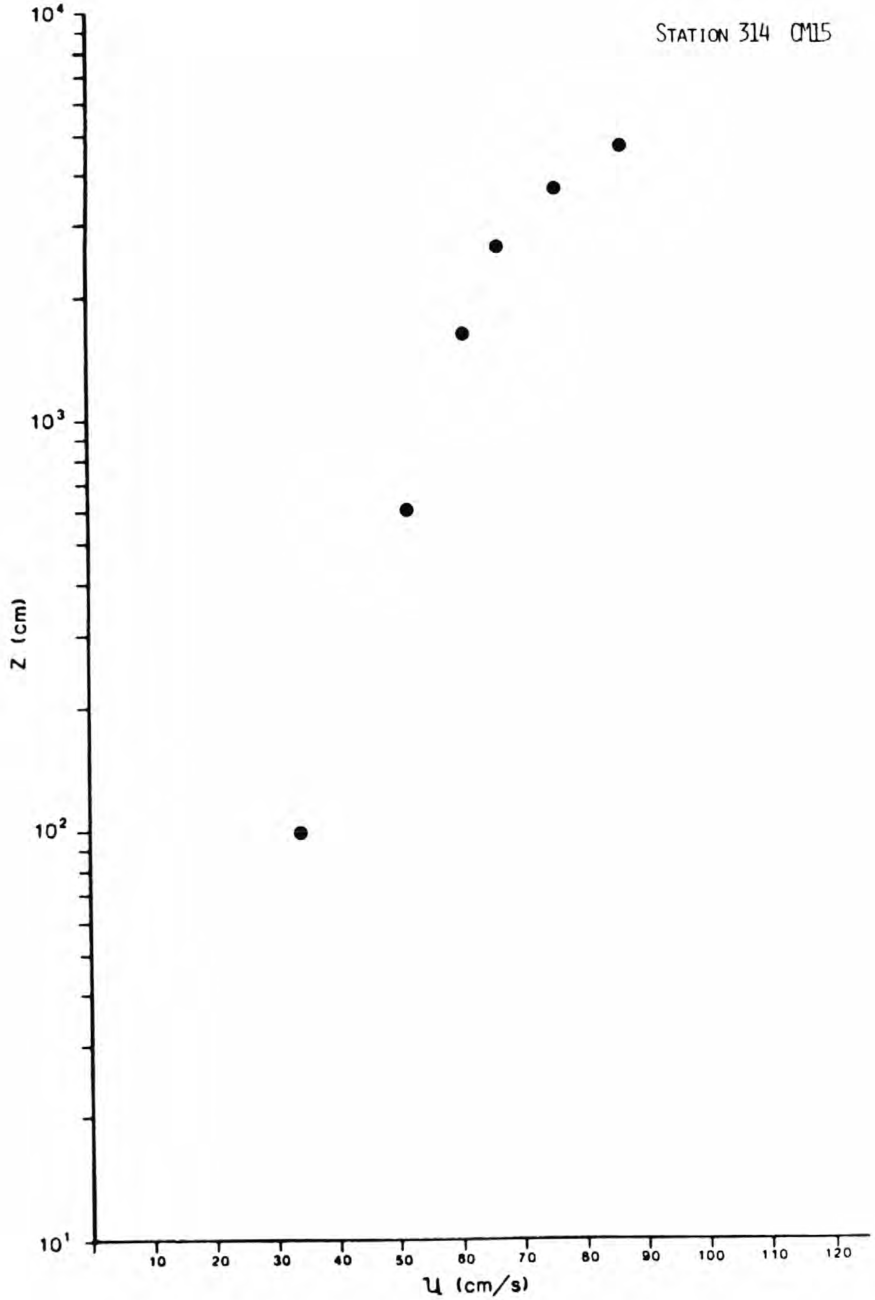

STATION 314 CMD9
Z (cm)
10⁴
10³
10²
10¹
10 20 30 40 50 60 70 80 90 100 110 120
U (cm/s)

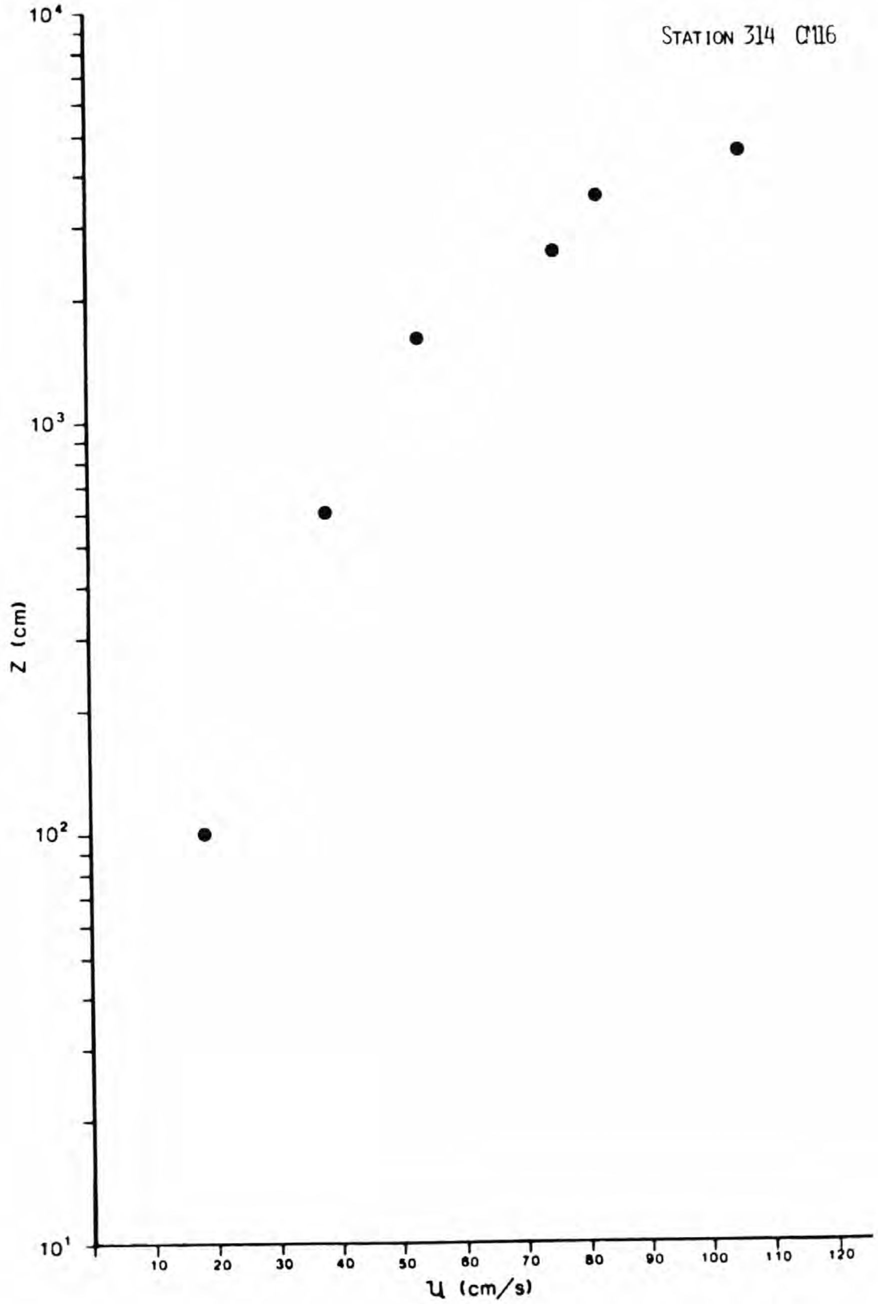

STATION 314 CM10
Z (cm)
10⁴
10³
10²
10¹
10 20 30 40 50 60 70 80 90 100 110 120
u (cm/s)

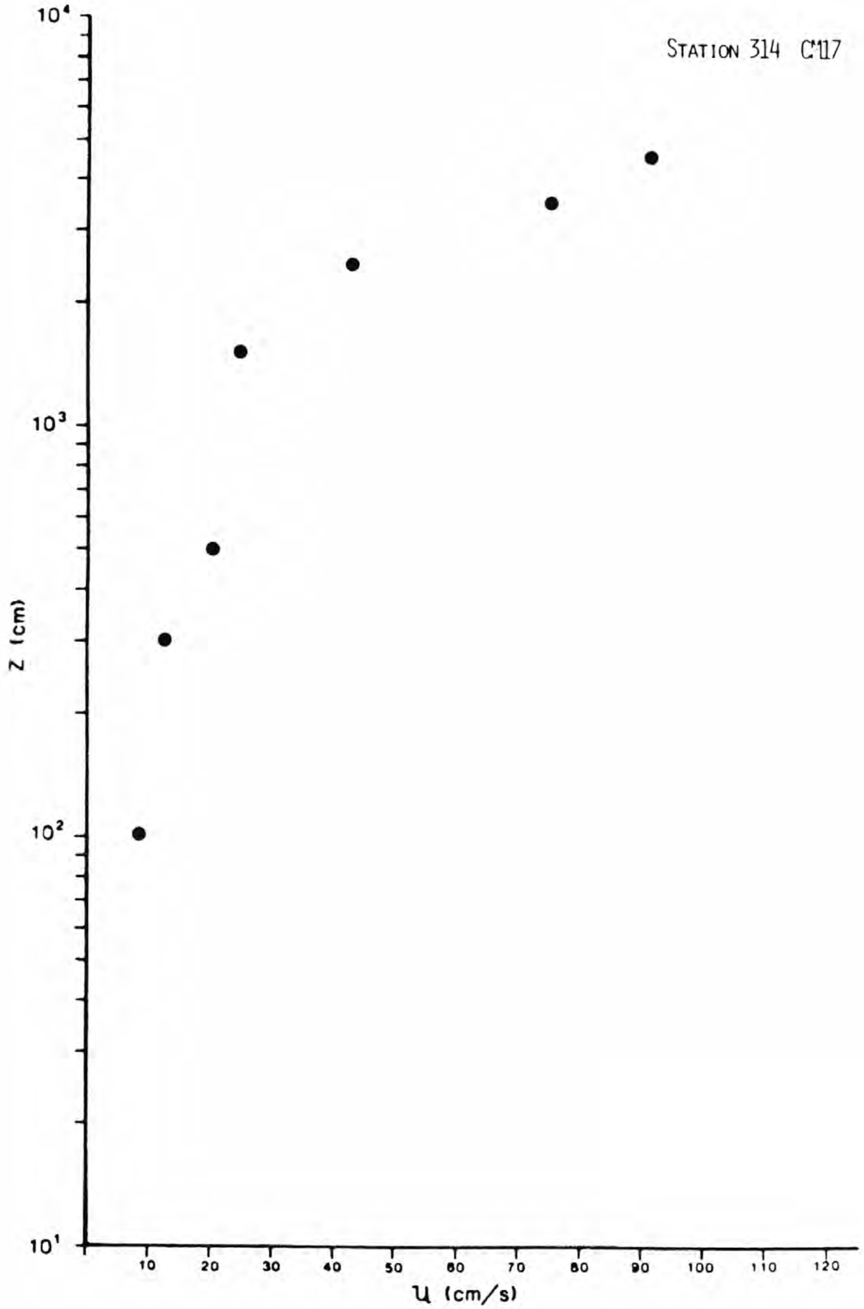

STATION 314 CM11
Z (cm)
10⁴
10³
10²
10¹
10 20 30 40 50 60 70 80 90 100 110 120
u (cm/s)


STATION 314 CM13
Z (cm)
10^4
10^3
10^2
10^1
10 20 30 40 50 60 70 80 90 100 110 120
u (cm/s)

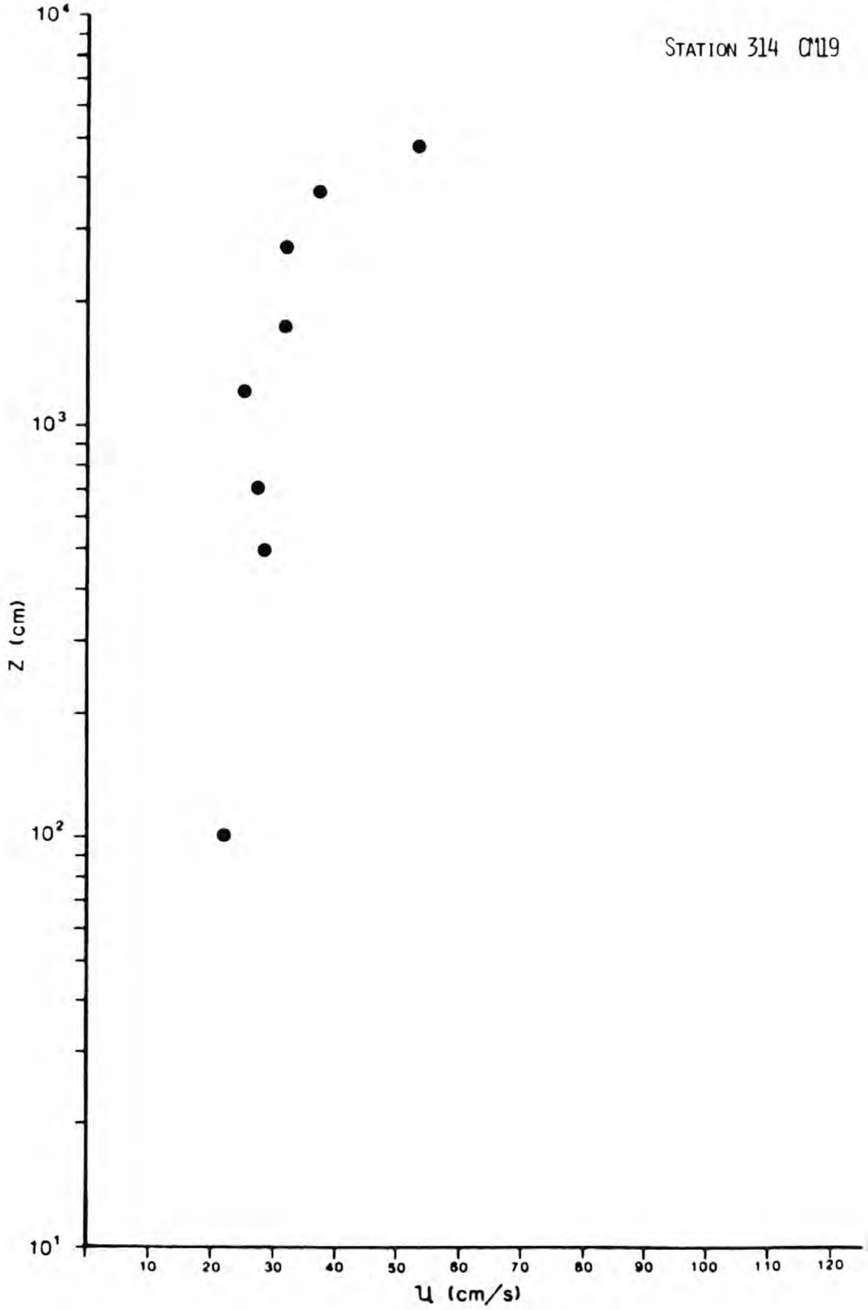

STATION 314 CM14
Z (cm)
10^4
10^3
10^2
10^1
10 20 30 40 50 60 70 80 90 100 110 120
u (cm/s)


STATION 314 CM15
Z (cm)
U (cm/s)
10^1
10^2
10^3
10^4
10
20
30
40
50
60
70
80
90
100
110
120

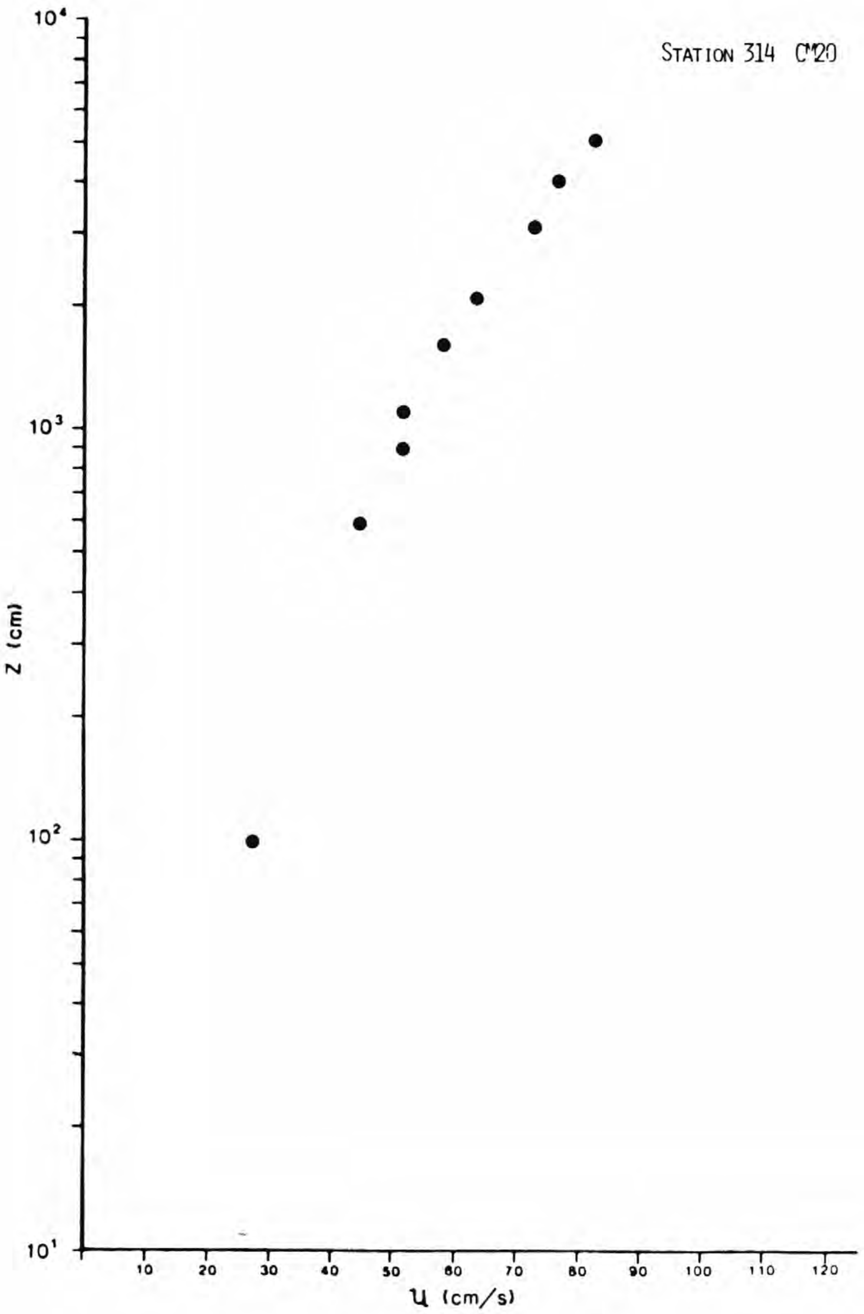

STATION 314 CM16
Z (cm)
U (cm/s)
10^1
10^2
10^3
10^4
10
20
30
40
50
60
70
80
90
100
110
120

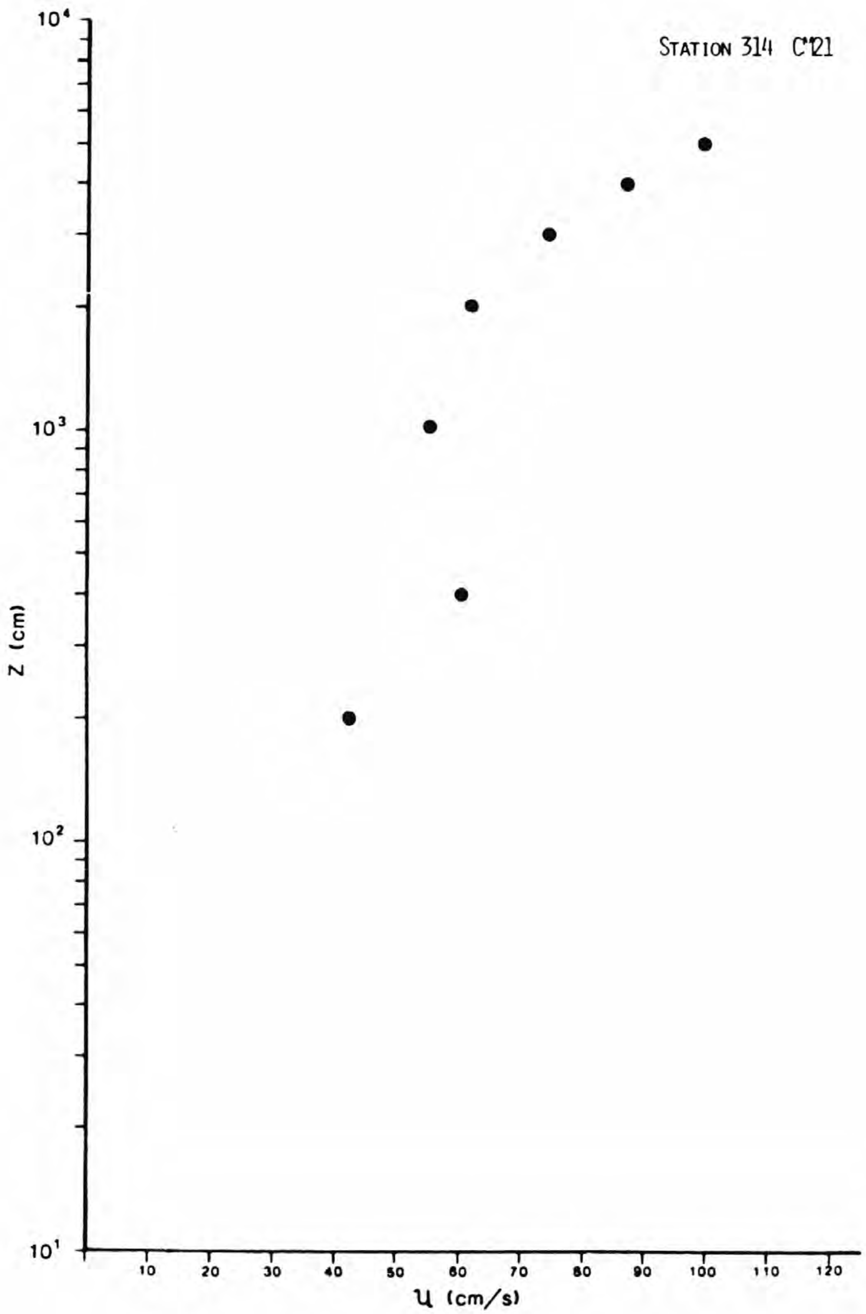


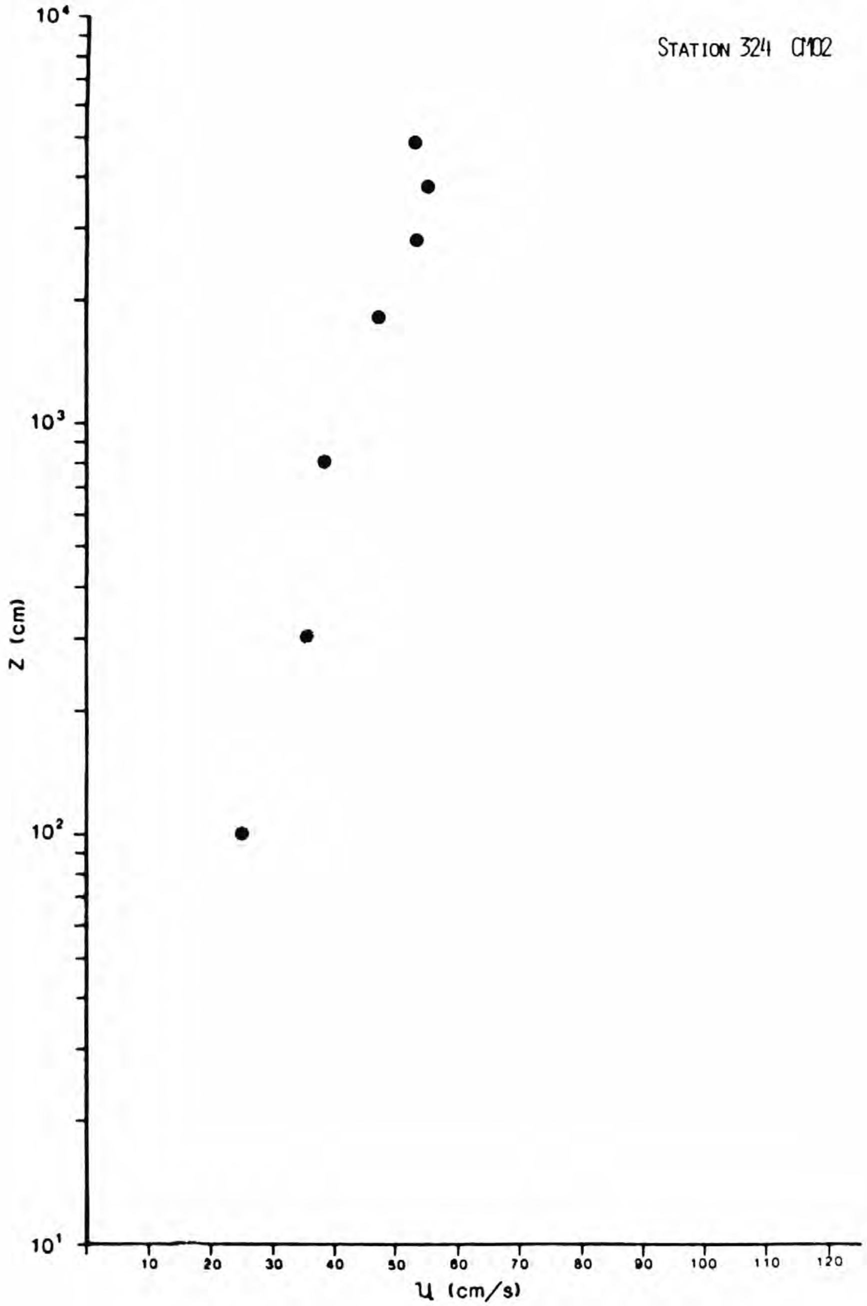
STATION 314 CM17
Z (cm)
10⁴
10³
10²
10¹
10 20 30 40 50 60 70 80 90 100 110 120
U (cm/s)

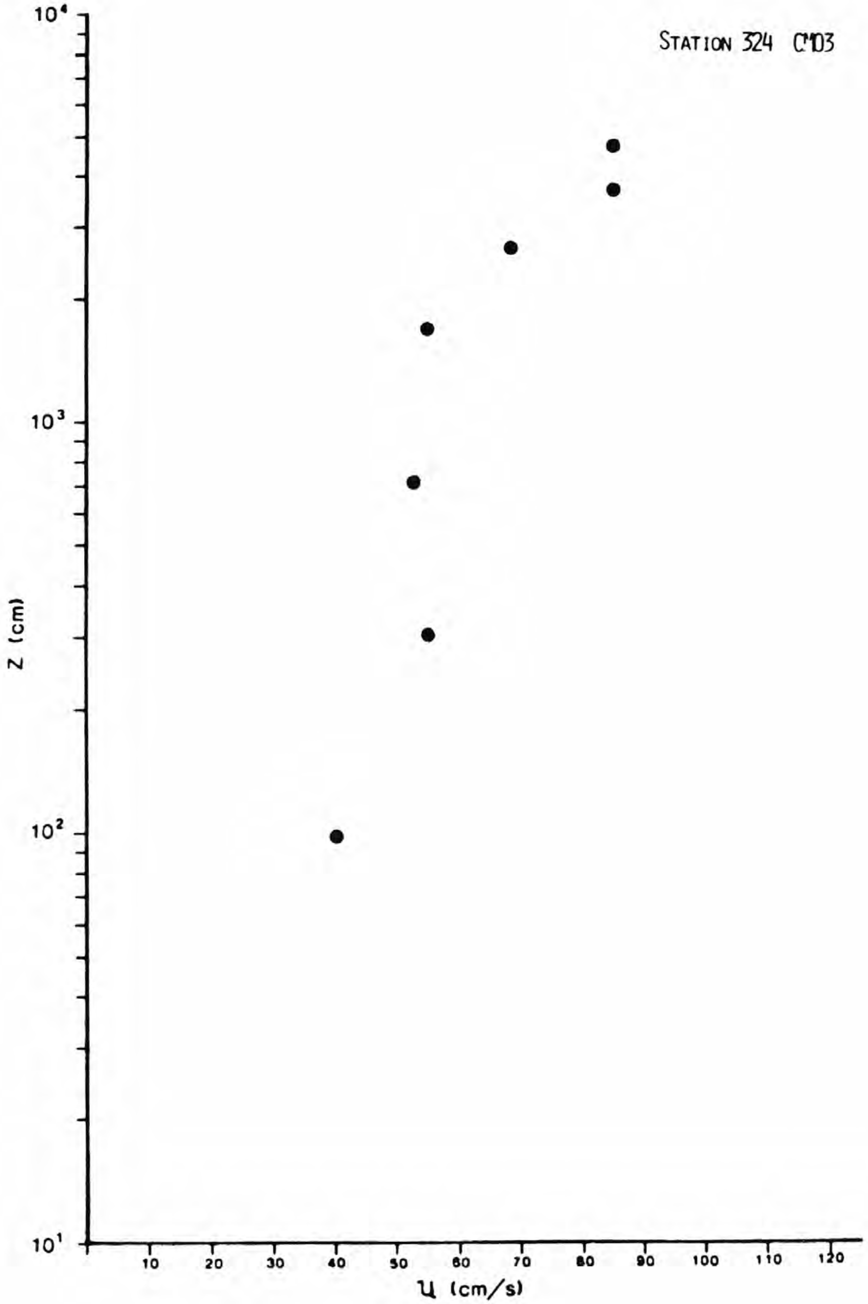


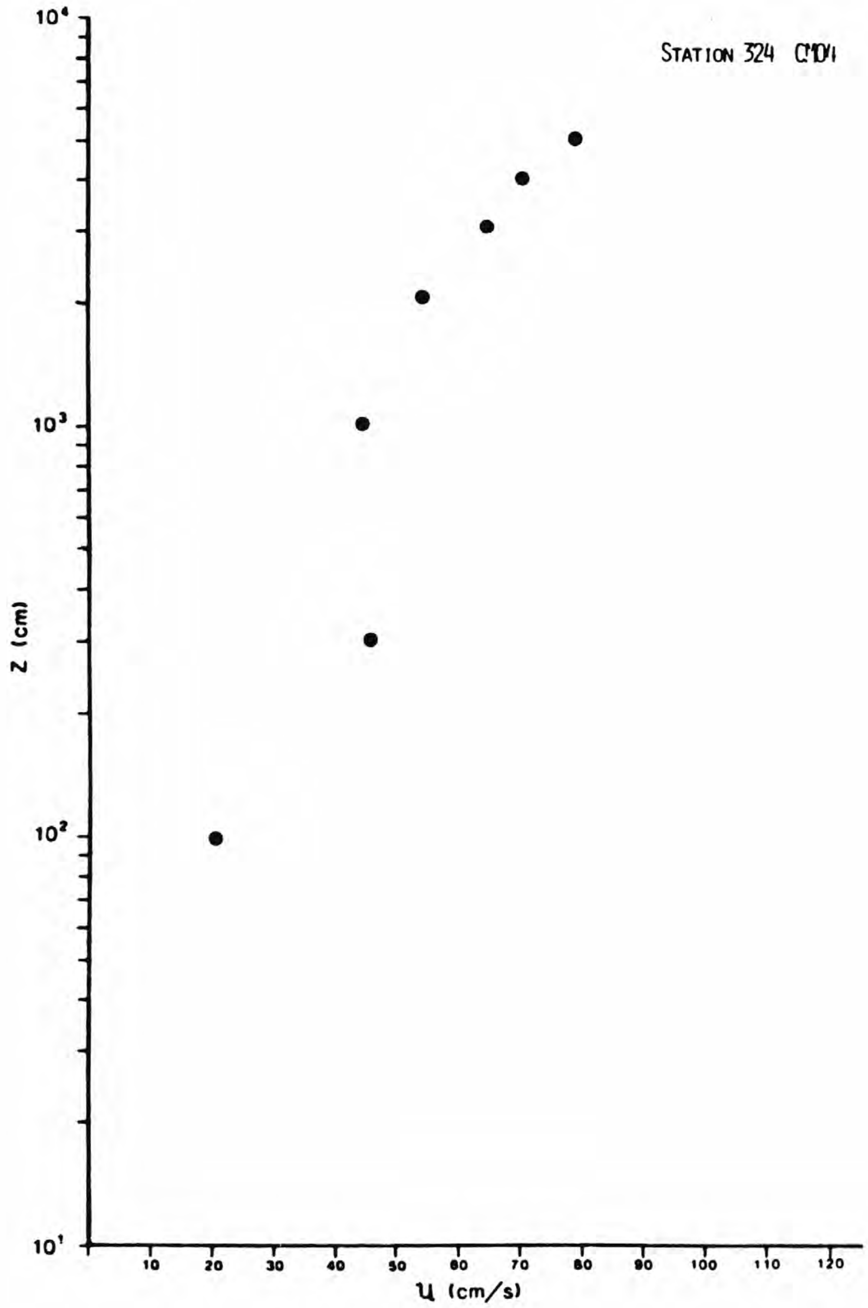
STATION 314 CM19
Z (cm)
10⁴
10³
10²
10¹
10 20 30 40 50 60 70 80 90 100 110 120
U (cm/s)

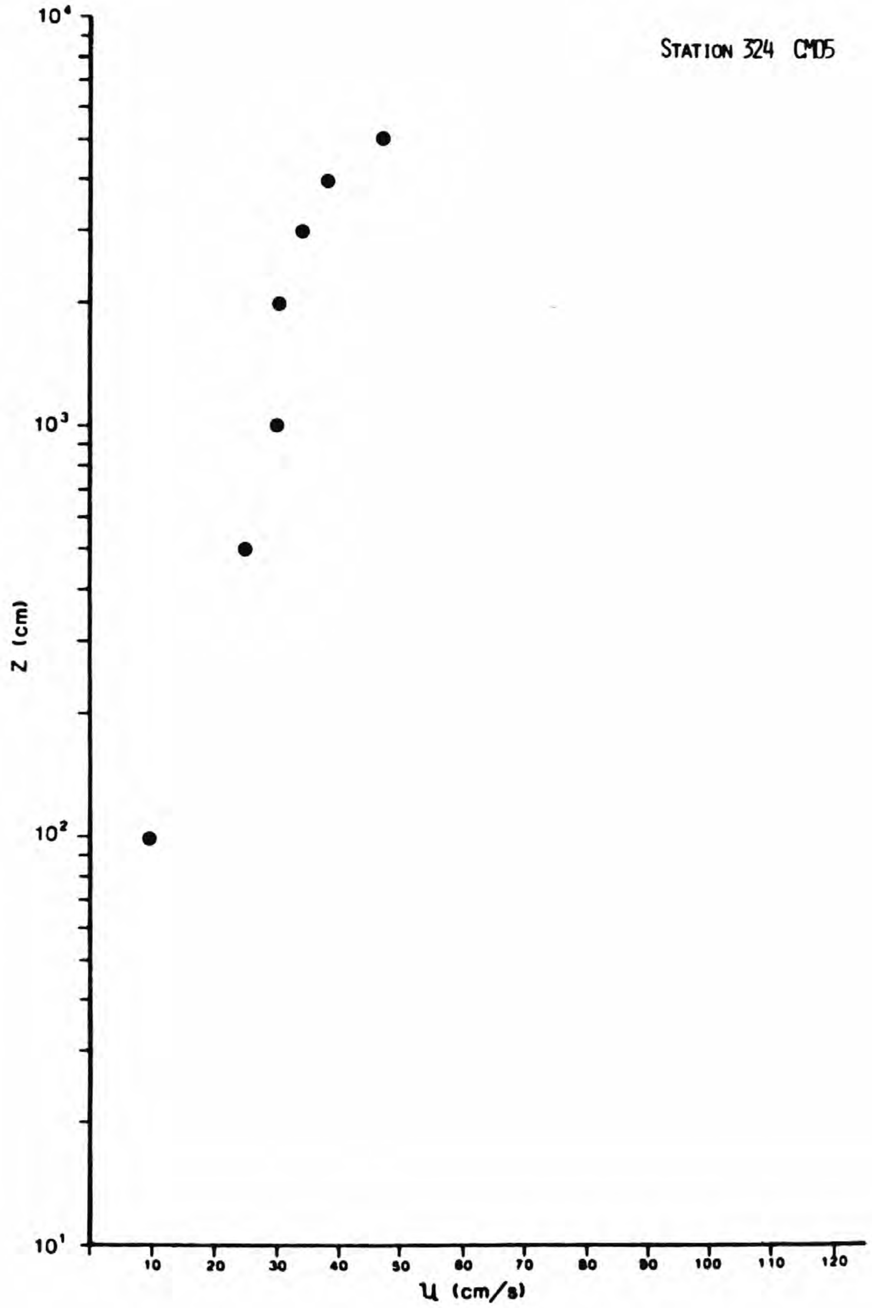

STATION 314 C*20
Z (cm)
U (cm/s)
10⁴
10³
10²
10¹
10 20 30 40 50 60 70 80 90 100 110 120


STATION 314 C*21
Z (cm)
U (cm/s)
10⁴
10³
10²
10¹
10 20 30 40 50 60 70 80 90 100 110 120


STATION 324 CM02
10⁴
10³
10²
10¹
Z (cm)
10 20 30 40 50 60 70 80 90 100 110 120
u (cm/s)


STATION 324 CM03
10⁴
10³
10²
10¹
Z (cm)
10 20 30 40 50 60 70 80 90 100 110 120
u (cm/s)


STATION 324 CM04
Z (cm)
U (cm/s)
10^4
10^3
10^2
10^1
10 20 30 40 50 60 70 80 90 100 110 120


STATION 324 CM05
Z (cm)
U (cm/s)
10^4
10^3
10^2
10^1
10 20 30 40 50 60 70 80 90 100 110 120