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"RHENO 65" CURRENT METER OBSERVATIONS

BY

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institute of coastal oceanography and tides
NATURAL ENVIRONMENT RESEARCH COUNCIL

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This report was prepared before the
Tidal Institute became the Institute
of Coastal Oceanography and Tides.

"Rheno 65" Current Meter Observations

The Observations

Hourly values of the north and east components of velocity were extracted from the original data, sampled at 5-minute intervals, for the three stations.

A 56°14' N, 04°30' E; depths 11, 36 and 50m.

B 56°46' N, 03°36' E; depths 11 and 52m.

C 56°56' N, 04°46' E; depths 10, 25 and 50m.

The total depth of water in the area is of the order of 60 m. The maximum span of data covered some 31 consecutive days, the minimum covered only 10 days.

The Analysis

Wherever possible the hourly components were subjected to tidal analysis using the flexible program devised by the Tidal Institute. This enables the maximum amount of tidal information to be extracted from a given set of data.

In addition, the daily mean values of current components were extracted using Doodson's X_0 stencil, which filters out all oscillations of frequency 1 c.p.d. and higher.

Tidal Results

The harmonic constants for the major tidal constituents are given in Table 1. Units are cm/sec and in G.M.T.

Tidal streams in this area are known to be weak, and this is confirmed by the analysis. It is not surprising, therefore, that considerable scatter exists between the streams at different depths and at different stations. Semidiurnal streams predominate, but average only 20-30 cm/sec.

Figure 1a illustrates the M_2-tidal ellipses at each station and each depth. The ratio of the minor/major axes averages 0·4, and in all cases the direction of the major axis lies NE/SW. All streams rotate cum sole or clockwise. Similar conclusions are indicated from the S_2-tidal ellipse of Figure 1b.

At stations A and B velocities decrease with depth, as would be expected in the presence of bottom friction. But at station C the increase takes place from surface to bottom.

Station B also exhibits an anomaly in that the ellipses are appreciably larger, and their major axes lie nearer to N/S, than those for stations A and

C. In this connection the relatively high north-going, non-tidal current at B, of 7·8 cm/sec. at near surface (see Table 1) should be noted. It seems possible that the analysis has not completely succeeded in preventing contamination of the tidal constants by this strong non-tidal current.

The vector shown for each ellipse in Figures 1a and 1b denotes the tidal stream at an arbitrary, common time origin. In all cases the streams display a tendency to reach their maximum near the bottom earlier than at higher levels. This is another consequence of the existence of bottom friction. The average indication from the M_2 and S_2 results is of 0·9 hours phase shift between near bottom and mid-depth, and a similar amount between mid-depth and near surface.

To summarize, the tidal stream analyses indicate a reasonable degree of coherence in the results, and in general respects are compatible with tidal theory. Some anomalies exist, however, which suggest that any one (or all) of the following possibilities cannot be ignored :-

(a) partially unreliable data, (e.g. intermittent velocity or direction errors)

(b) the existence of internal waves of tidal period

(c) the contamination of semidiurnal streams, as deduced from analysis, by inertial currents (period 14·5 hours) and other non-tidal phenomena.

Non-tidal Results

The hodographs compiled from daily mean (non-tidal) drifts are shown for all stations and depths in Figures 2a to 2c. The drifts are shown in units of cm/sec.

A preliminary scrutiny of these diagrams reveals

(i) little coherence between near surface movement at any pair of stations

(ii) little coherence, at any station, between near surface movement and movement at greater depths

(iii) strong coherence between movements at mid depth and near bottom at each of stations A and C.

The most striking feature is the comparitively strong north-going drift at station B in the surface layers. During the period 19-25 August this amounted to a mean daily flow of 9 cm/sec., compared with a south-going flow of half this amount at C and a meandering, smaller flow at A. These values suggest a N/S shear between B and C, with station A somewhere in the vicinity of the associated frontal line.

Since these stations are each within 70 km. of their neighbours, it seems unlikely that such varying patterns can be due to only one agency. One possibility is that the surface movements at the three stations are the resultants of wind drift superimposed upon a stronger, more stationary current.

For example, during 21st August strong southerly winds prevailed over the area. This does not seem to have affected the north-going surface drift at B, but temporarily arrested the south-going drift at C and reversed the south-west going drift at A. At both B and C this effect was transmitted to the lower layers, as witnessed by the rotary effects at C and the north-west going tongues at A during the relevant time.

Again, during 25th August even stronger winds from the north west quadrant were experienced. This slowed down the northward drift in the upper layers at B, induced a south to south east drift in the upper layers at A and C, and caused marked interruption of the flow pattern in the lower layers at all three stations.

The lack of coherence between movement in the upper layers and those at greater depths is no doubt a consequence of the thermocline observed at about 20-30 m. depth. At stations A and C the hodographs show the general picture to be one of a current below the thermocline flowing in a direction 90° to the left of that above the thermocline.

Conclusions

1. The total motion shown by the current meter data indicates a high degree of variability in the area.
2. This variability is a maximum in the upper layers, and decreases with depth.
3. The periodic movement (tidal streams) is well defined, though small, and displays the influence of bottom friction.
4. The non-periodic motion appears to consist of a reasonably stationary current, with transient modifications due to wind drift. The flow at mid depth and near bottom is inclined 90° to the left of the near surface flow; this may be related to the existence of a strong thermocline.
5. To gain a clearer insight into water movements of the complexity

found during the Rheno 65 experiment, it will be necessary to monitor such movements for appreciably longer periods than one month. Attention will also need to be given to identifying the horizontal scale of movement for different frequencies and different causes by having a dense network of vectors both horizontally and vertically.

Indeed, a very real need now exists for such an experiment to be conducted, supported by instruments for measuring elevation movements, and designed from the hydrodynamical point of view.

RHENO 65 TIDAL STREAM ANALYSES

TABLE 1

Harmonic constants are H cm/sec, g° (Zone 0)

STATION A

	11-N		36-N		50-N		11-E		36-E		50-E	
Z_0	-0·16	-	+1·41	-	+0·92	-	+0·18	-	+1·57	-	+1·68	-
O_1	1·78	239	2·47	281	2·03	263	1·57	161	0·48	170	0·30	198
K_1	1·69	123	0·53	143	0·55	74	0·16	169	1·17	26	1·32	11
M_2	10·67	173	8·83	187	5·13	154	14·77	223	14·95	237	12·61	207
S_2	4·83	241	3·28	225	2·17	216	5·42	289	4·31	273	3·82	263
MS_4	0·69	157	0·61	203	0·37	134	0·19	328	0·60	303	0·13	137

STATION B

	11-N		52-N		11-E		52-E	
Z_0	+7·85	-	+1·45	-	-1·51	-	+0·12	-
O_1	2·68	194	1·90	235	0·40	88	0·46	214
K_1	2·30	120	0·99	54	0·50	357	0·77	326
M_2	21·00	191	11·72	186	13·80	241	6·48	217
S_2	7·09	244	5·54	236	4·17	303	2·77	283
MS_4	0·80	276	0·70	240	1·66	18	0·67	329

STATION C

	10-N		50-N		10-E		50-E	
Z_0	-1·81	-	+2·03	-	-0·58	-	+1·17	-
O_1	1·01	142	0·75	34	1·07	176	1·01	78
K_1	1·35	207	2·58	232	1·30	233	1·24	294
M_2	7·16	173	10·91	143	6·46	223	10·84	205
S_2	4·08	238	5·54	211	3·91	303	4·88	274
MS_4	0·29	329	0·52	264	0·35	48	0·23	69

Figure 1a

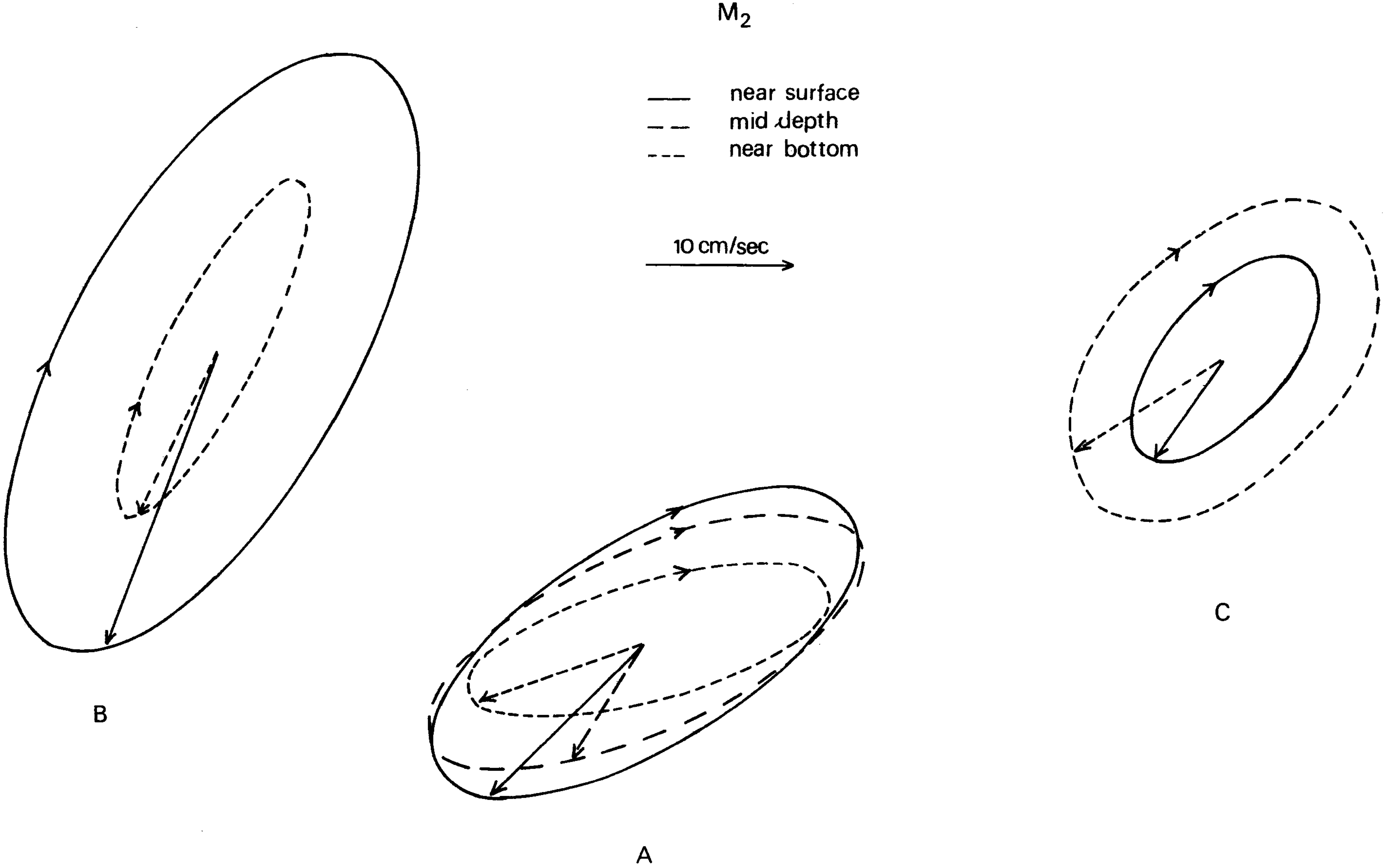


Figure 1b

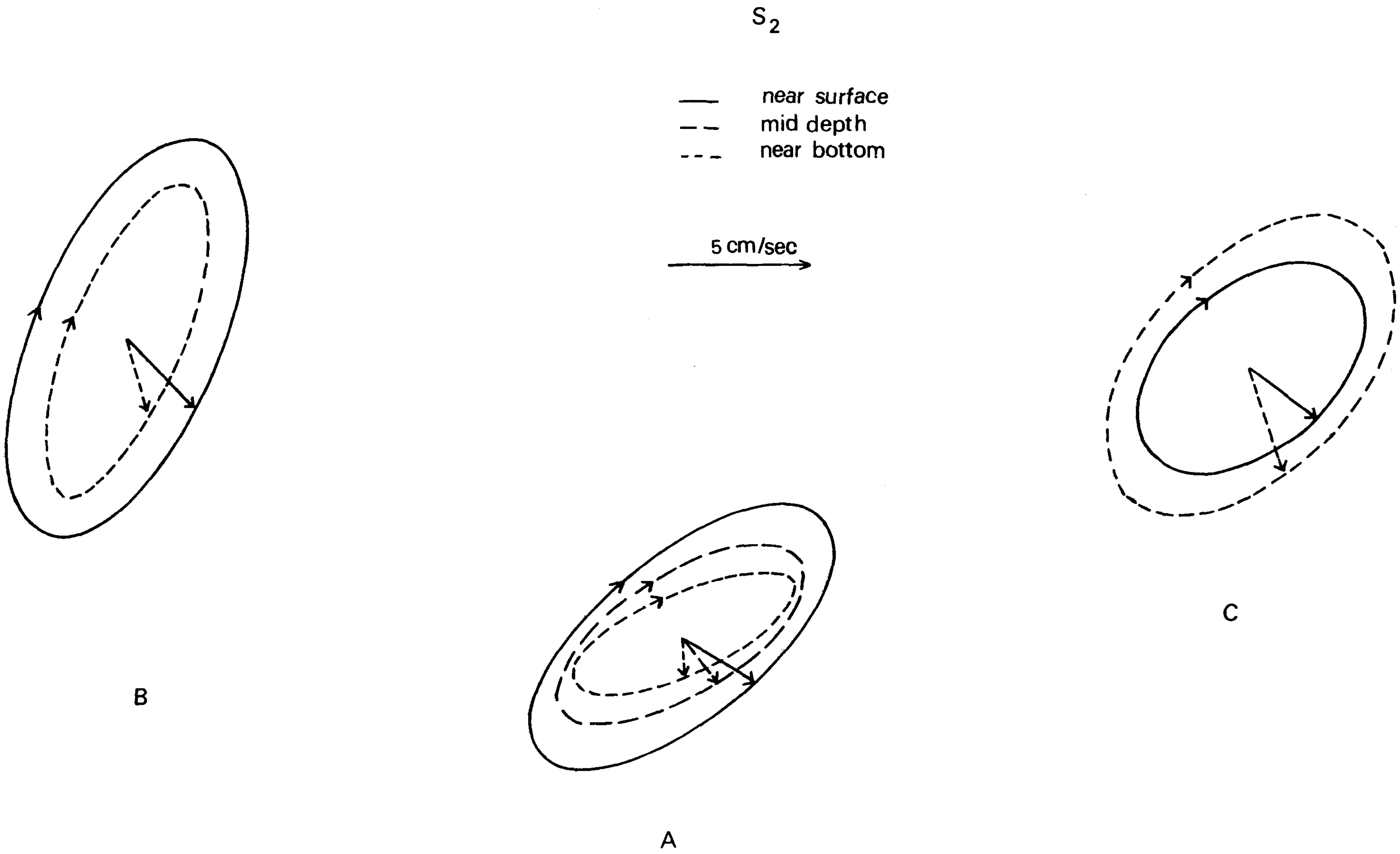


Figure 2a

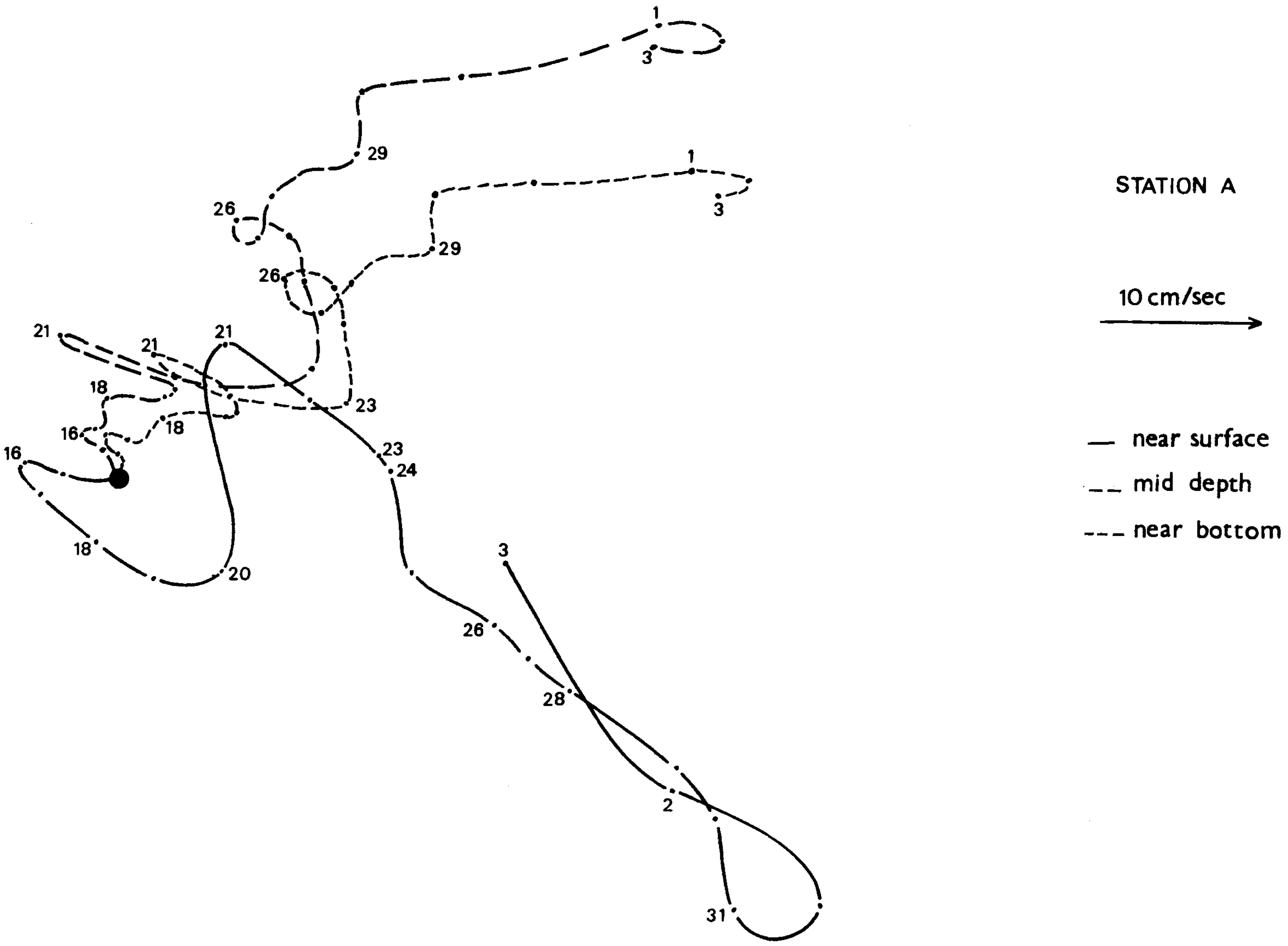

STATION A
10 cm/sec
near surface
mid depth
near bottom
1
3
29
26
1
3
29
26
21
21
21
18
16
18
16
18
20
23
23
24
26
28
3
2
31

Figure 2b

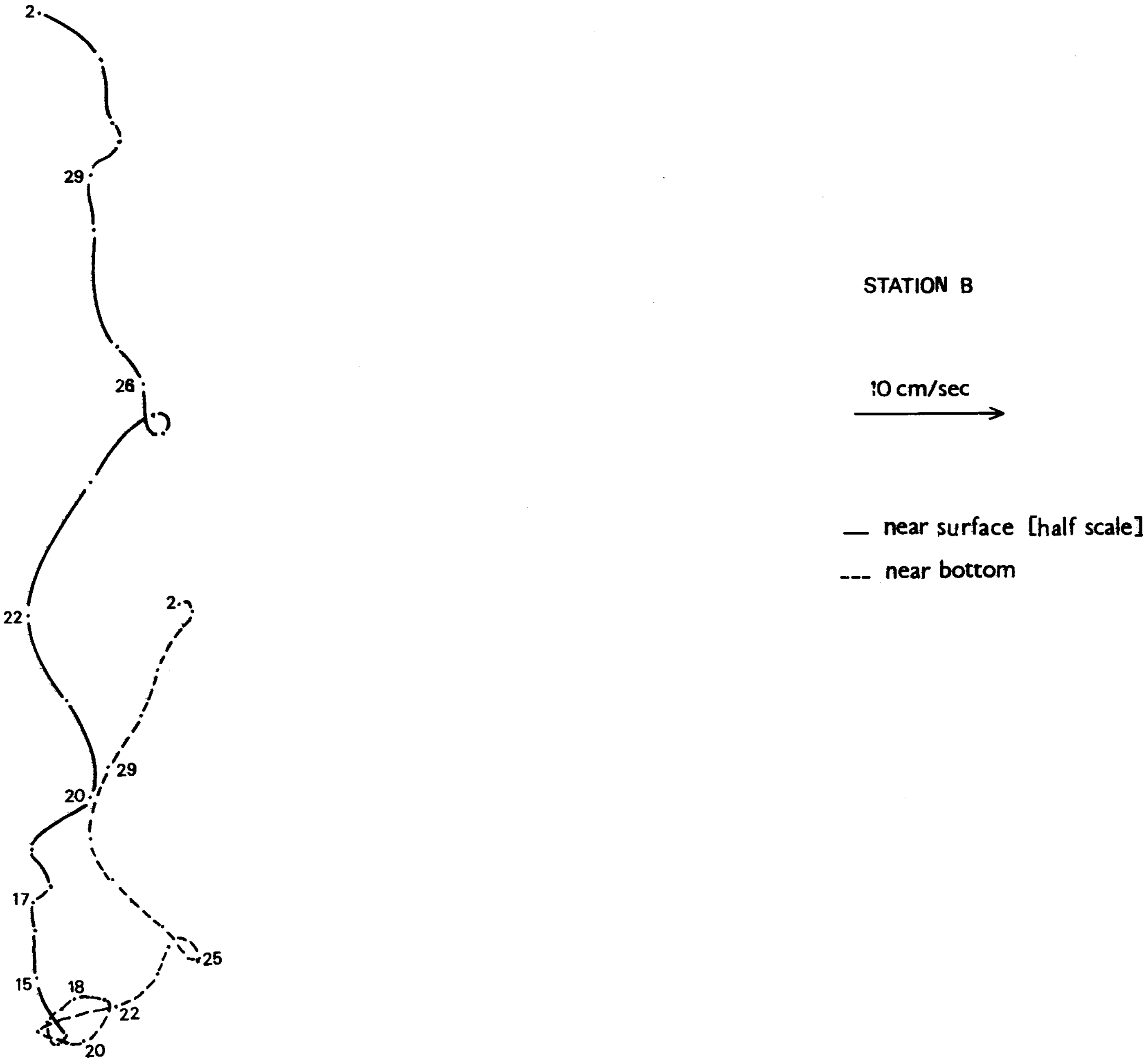
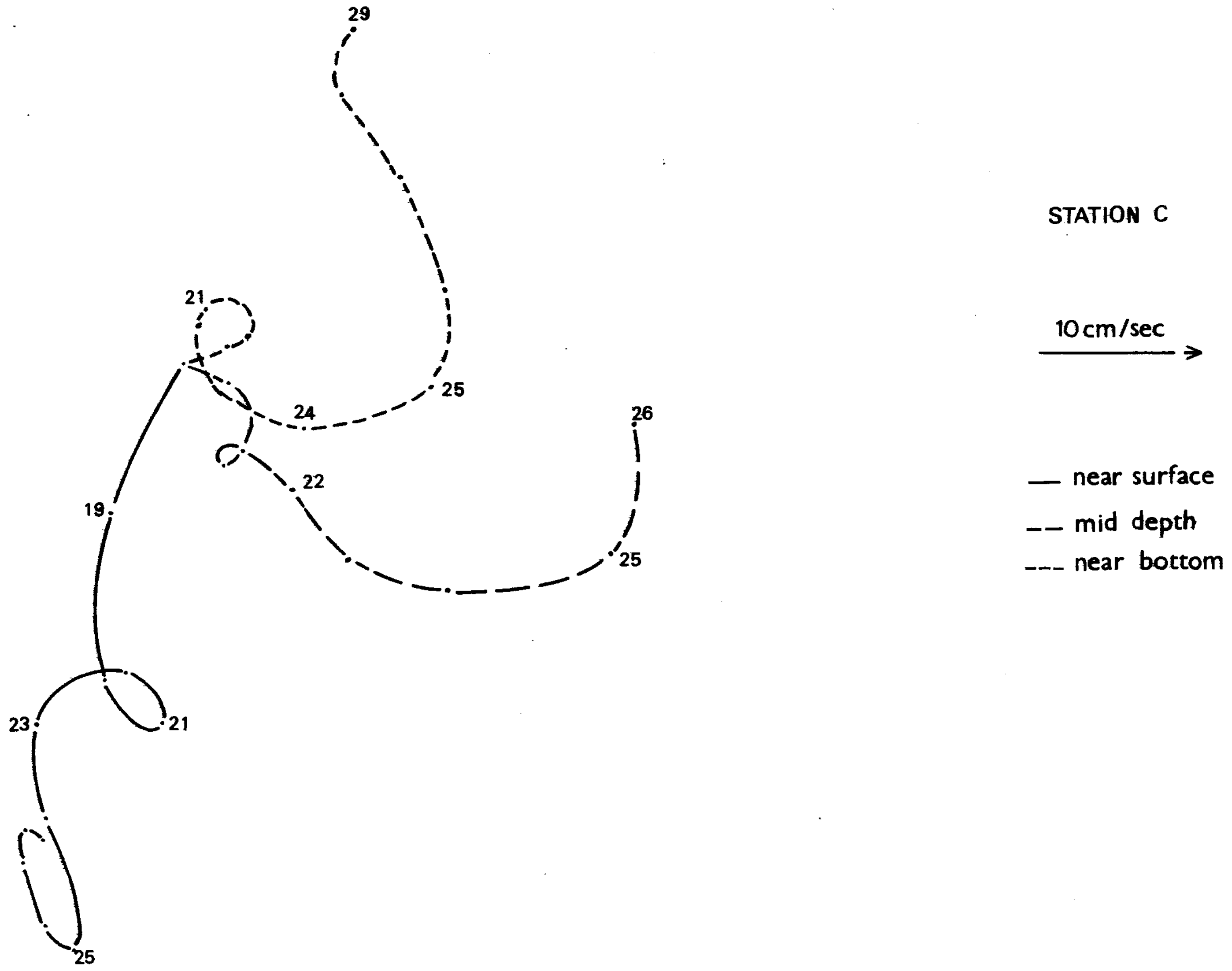

STATION B
10 cm/sec
near surface [half scale]
near bottom
2
29
26
22
20
17
15
2
29
25
18
22
20

Figure 2c


29
21
25
24
26
22
19
25
23
21
25
STATION C
10 cm/sec
near surface
mid depth
near bottom