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NORTH SEA PROGRAMME

Challenger cruise 58/89

7 - 21 August, 1989

Process Study (Frontal mixing)

Cruise Report

A.E. Hill

School of Ocean Sciences,
Marine Science Laboratories,
Menai Bridge, Gwynedd,
LL59 5EY

(Principal Scientist)

Introduction

The purpose of this study was to obtain detailed observations in relation to circulation and mixing at the Flamborough Head front in the North Sea. The prime objectives of the cruise programme were satisfactorily achieved although it was not possible to carry out our planned rhodamine dye releases.

Narrative of the cruise

The cruise track is shown in Fig.1.

The cruise began when Challenger left Great Yarmouth on the afternoon of Monday, 7th August. An initial CTD survey was conducted with a view to broadly locating the Flamborough front. The first CTD casts were made at locations close to the current meter moorings FA, FB and FC laid by POL Bidston during cruise 56. These moorings were inspected at night and all surface spar buoys were present. The CTD survey consisted of 29 stations, the last of which was cast 2544 of the North Sea Project and was made at 0606 on Wednesday, 9th August.

The remainder of daylight hours on Wednesday was spent in the deployment of 9 Decca/Argos drifting buoys. These were laid in the diamond configuration shown in Fig.2. Buoys 3, 6, 7 were nominally on the stratified side of the front, buoys 1, 5 and 8 in the frontal zone and buoys 2, 9, 10 on the mixed side. It was known at the time of deployment that buoy 3 was not providing Argos position updates. It was considered, however, that the final positions of the other buoys would provide sufficient clue of the final buoy 3 location to allow it to be deployed.

At 2033 on Wednesday 9th SEASOAR was deployed for the first time to obtain a detailed picture of the front that had been located in the vicinity of Outer Silver Pit from the Coarse CTD Survey. The front was oriented in an approximately east-west direction at latitude 53°55'N. SEASOAR was towed eastward to near 2°00E in a series of zig-zag crossings of the front. It was then towed westward again in an even finer scale front survey with a front crossing at about every 4 n miles along the front. This first SEASOAR Survey was conducted continuously until 1738 on Friday, 11th August. On Friday we learned that a spar buoy had been picked up by a fisherman and that it was likely to be from one of the POL moorings. We therefore inspected the Flamborough moorings FA, B and C on Friday evening and were able to determine that the missing spar was from FC.

SEASOAR was briefly brought on board for inspection before being redeployed for the first of three 12½ hour SEASOAR/ADCP Surveys of a short 10 mile section across the front. The aim of these sections was to obtain coincident pictures of the density and velocity field in the vicinity of the front with sufficient time resolution to permit the estimation of residual flows by the extraction of tidal constituents by least squares analyses. The SEASOAR/ADCP legs took a slightly different form from that previously employed in consisting of a "figure of 8" form. This configuration permits along frontal variations in structure to be examined and thus will help to split local and advective sources of temporal variation in the front. On the first SEASOAR/ADCP Survey successive downstream sections were separated by 1 nautical mile.

Upon completion of the frontal transects SEASOAR was towed to the north-western flanks of the Dogger Bank and towed south again in a series of broad zig-zags which extended into the strongly stratified waters (6-7°C in 10m) north of the northern extention of the Flamborough front. On Tuesday 15th a site on the north western Dogger Bank close to the moorings DA and DB was selected for the second SEASOAR/ADCP 12½hr survey. When this was completed on the morning of Wednesday, 16th August, whereupon SEASOAR was taken on board and the recovery of the POL moorings at DA and DB was started. The 'U' shaped mooring at DA was successfully recovered. The acoustic release on a second single point thermistor chain mooring at DA failed to respond. Suspiciously a fishing marker float was situated at the exact position at which the mooring was laid. The standing instruction not to interfere with fishing gear prevented us from dragging at this site. Both the 'U' shaped and acoustic release moorings at DA were, however, recovered successfully.

SEASOAR was redeployed at the end of the mooring recovery and was towed southward in a further set of zig-zag crossings of the front between Flamborough Head and Dogger Bank. The night and early morning of Wednesday 16th/Thursday 17th was occupied by a coastal survey using SEASOAR close to Flamborough Head itself. On Thursday 17th, the POL moorings FA, FB and FC were all recovered. Despite the missing spar buoy at FC the surface marker of the subsurface float was visible and the mooring was recovered using the Gifford grapnel.

The night of Thursday/Friday 18th was occupied with a second SEASOAR/ADCP

Survey of the front at Outer Silver Pit, this time at spring tide (the previous survey there had been at neaps). On Friday 18th, when the survey was complete, the search for drifting Decca/Argos buoys commenced. Five buoys (2, 5, 1, 9 and 8) were recovered that day, although buoy 8 had lost its drogue. The UHF/VHF location and direction finding systems worked extremely well during these recoveries. On Friday evening, we began a "blind" search for buoy 10 for which there had been no Argos fixes. The buoy was located very quickly but it was too dark to safely recover it. Challenger, therefore, held position close to the buoy and it was recovered at first light. The remaining buoys (6, 7 and 3) were all recovered during the course of Saturday. Fortunately buoy 3 provided an Argos update on Saturday morning, greatly easing its recovery.

SEASOAR was redeployed after the buoy recoveries and a third SEASOAR/ADCP survey was conducted at Silver Pit on Saturday 19th/Sunday 20th August. This time the along front spacing of transects in the "figure of 8" was increased to two miles. Upon completion of the Survey, SEASOAR was towed to the southern flanks of the Dogger Bank, the least surveyed part of our study region. SEASOAR was recovered for the last time at 1344 on Sunday 20th. The CTD was removed from SEASOAR and placed in the CTD frame whereupon 3 CTD casts were made with it at 3 different locations for calibration purposes. With this the scientific programme was completed and Challenger sailed to Great Yarmouth where she arrived on the morning of Monday, 21 August.

In all about 190 hours of SEASOAR data were obtained (equivalent to 8 days continuous towing). With an average cycle time of 3 minutes, this is equivalent to nearly 4,000 CTD casts.

Rhodamine-B dye was not released during this cruise as intended because the weather conditions were rather unfavourable for much of the cruise. Experience from Challenger cruise 36/88 showed that in conditions of force 6 or above it becomes very difficult to perform an adequate dye patch survey from the ship. Towards the end of the cruise the weather improved considerably but priority was then given to mooring and buoy recoveries in daylight hours.

Equipment

Equipment performed well throughout the cruise. Significant improvements are, however, required to the way in which SEASOAR is operated. At present the SEASOAR is controlled semi-automatically with the scientific watchkeeper manually adjusting from time to time the amplitude of the SEASOAR cycle. The operator must continually be aware of bottom depth and correct for changes. During cruise 58 we modified software on the BBC monitoring system to allow the operator to input a nominal present bottom depth; the program then sounded an alarm when SEASOAR was within 15m of the sea bed. When using SEASOAR for very long periods, as was done on this cruise, the potential for human error increases as concentration tends to wain. It is imperative that the actual bottom depth (say from the Simrad) is incorporated into the SEASOAR control and the necessary alarm given when the SEASOAR is too close to the bottom. Ideally there should be automatic control to bring SEASOAR up when it approaches too close to the sea bed. We have reason to suspect that the SEASOAR vehicle did come in contact with the sea floor on a couple of occasions during cruise 58. If the control system is not improved to take account of its operation in shallow water SEASOAR will almost certainly be lost. During poor weather the Simrad echo sounder performed badly and we had to rely upon the ADCP for reliable bottom depth measurements. This point may be relevant in determining the source of the depth input to the future SEASOAR control system.

During the course of cruise 58 the ADCP on Challenger was calibrated to determine the misalignment angle using Decca navigation and bottom tracking on 30 minute straight steaming courses. The misalignment is about 1.2° clockwise of the forward direction.

The Argos/Decca drifting buoys performed satisfactorily. The new large $30m^2$ window blind drogues have much reduced windage effects. Buoys released south of and in the front tracked eastwards whilst those north of the front (in stratified water) moved to the west. Buoy 8 lost its drogue and it moved rapidly northwards (under the influence of the wind) after doing so. Buoy 10 did not give Argos updates but we were aware of this before deployment. It is probably a problem with the Buoy 10 Argos PTT.

Buoy 3, on the other hand, updated only once with a new Argos position and gave old data (from cruise 57) when the Argos system was interrogated. This requires further investigation but is possibly a problem with the Argos computer system in Toulouse. The Decca data logged by the buoys was fairly corrupted with failed fixes although we were aware that our study site was not located in a good Decca region. Despsite the losses, there appears to be an adequate data return from the buoys and we experienced nothing like the data losses encountered on cruise 57/89.

Preliminary Results

The Flamborough Head front was established during the course of this study. There were two parts to the front as can be seen in the SEASOAR section shown in Fig.3. North of Flamborough Head strong stratification 6°C/10m was established. This region is separated from an area of weaker stratification near 1°E by an intense bottom front although there is also a weak surface front. In the region of Outer Silver Pit (Fig.4) stratification is re-established and a second front separates this water from vertically homogeneous water in the shallow region to the south.

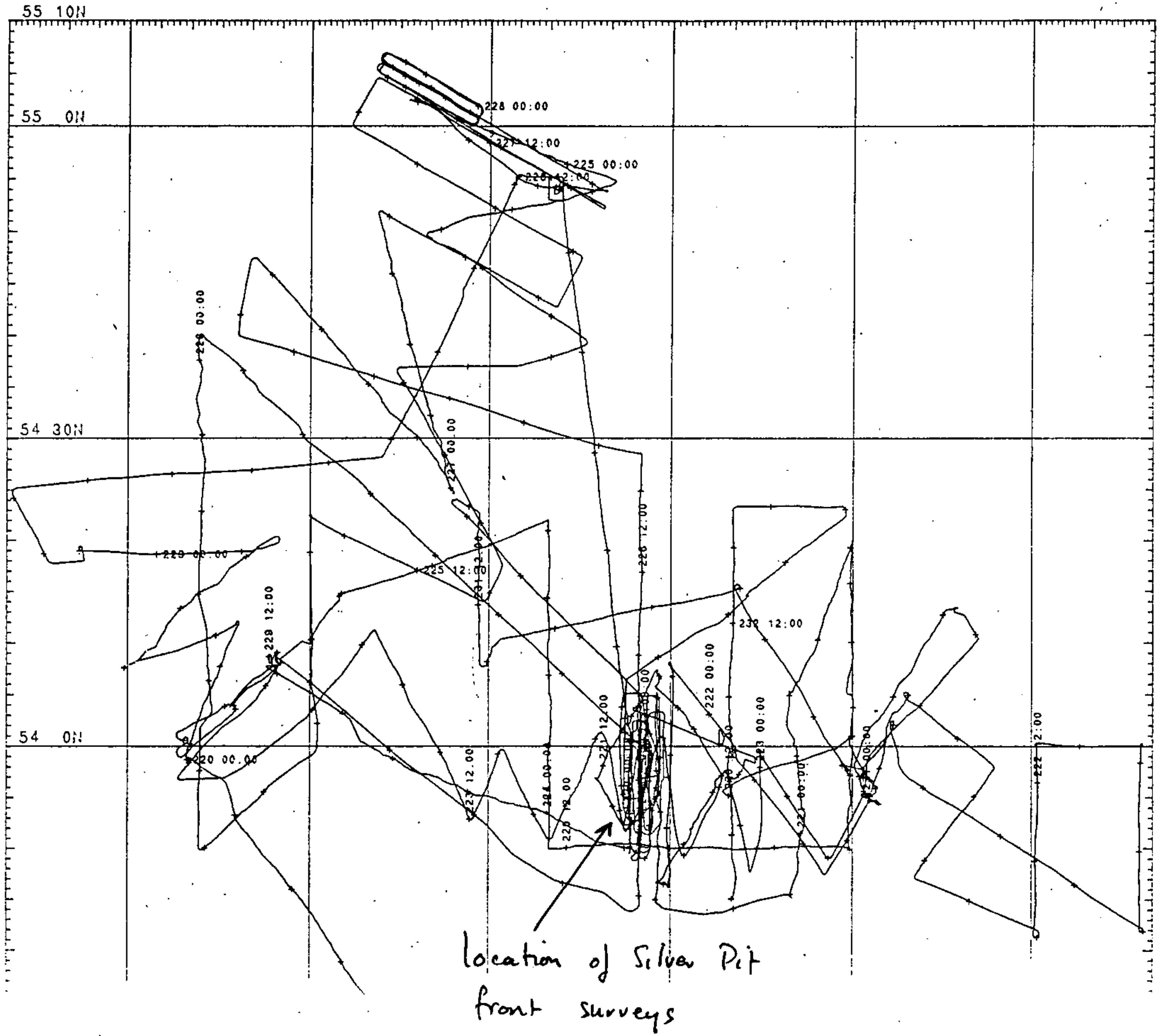
The Silver Pit front was sampled more intensively on a number of subsequent occasions. Fig.5a shows a SEASOAR temperature section across the front and Fig.5b shows contours of north south velocity component in CMS^{-1} along the same section. From the series of such sections over 12½ periods at different times we will attempt to extract the tidal residual velocity from the data and thereby relate the density and residual velocity fields.

First indications are that drifting buoys seeded on either side of the Silver Pit front moved in opposite directions indicating large scale velocity shear across the front. On the stratified side of the front drifters tracked westwards, whilst south of the front they tended eastwards.

Acknowledgements

I would like to extend my thanks to Captain P. Maw, the officers and crew of RRS Charles Darwin for the help during the course of this cruise. I also wish to thank R. Lloyd, R. Pearce and D. Teare of RVS, D. Leighton of POL Bidston as well as the groups from Cambridge University and UCNW who participated in the cruise.

fig 1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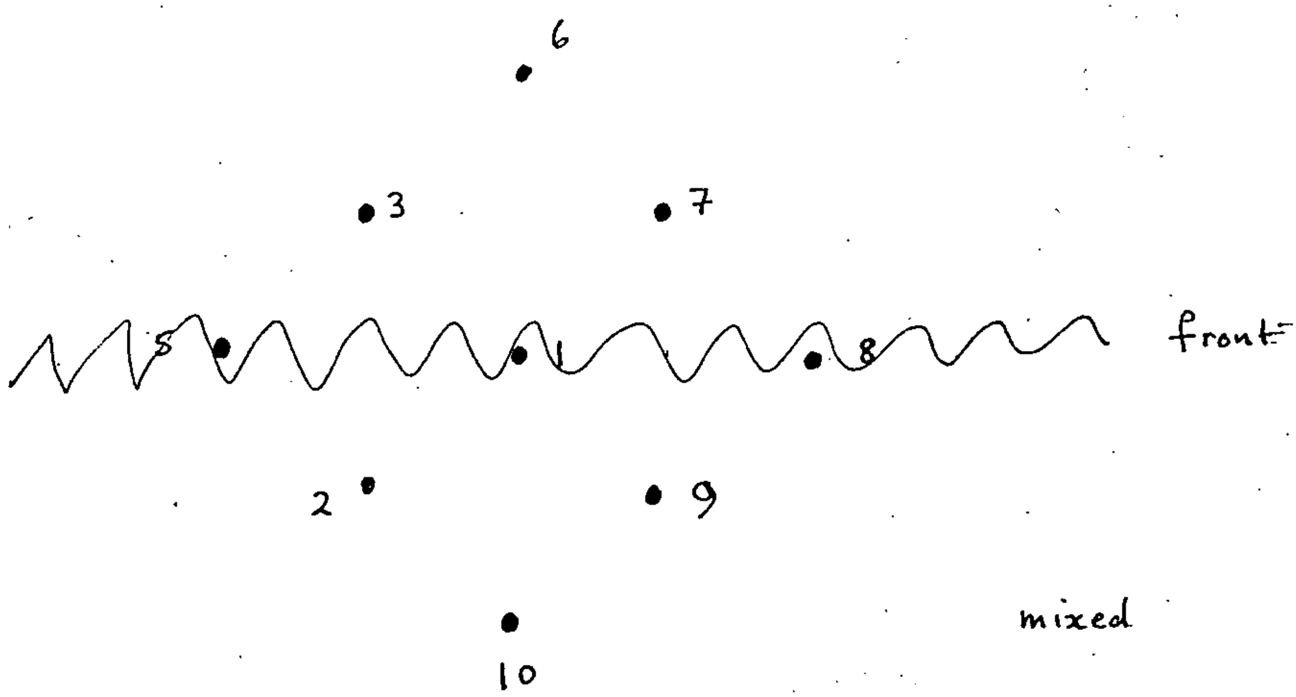
location of Silver Pit front surveys



Deployment Positions (in order of deployment)

Buoy	lat	long
1	53° 57.0′N	01° 28′E
2.	53° 51.8′N	01° 22.8′E
5.	53° 57.0′N	01° 17′.8 E
3.	54° 02.2′N	01° 22.8′E
6.	54° 07.4′N	01° 28.0′E
7.	54° 02.2′N	01° 33.2′E
8.	53° 57.0′N	01° 38.4′E
9.	53° 51.8′N	01° 33.2′E
10.	53° 46.6′N	01° 28.0′E.

fig 2

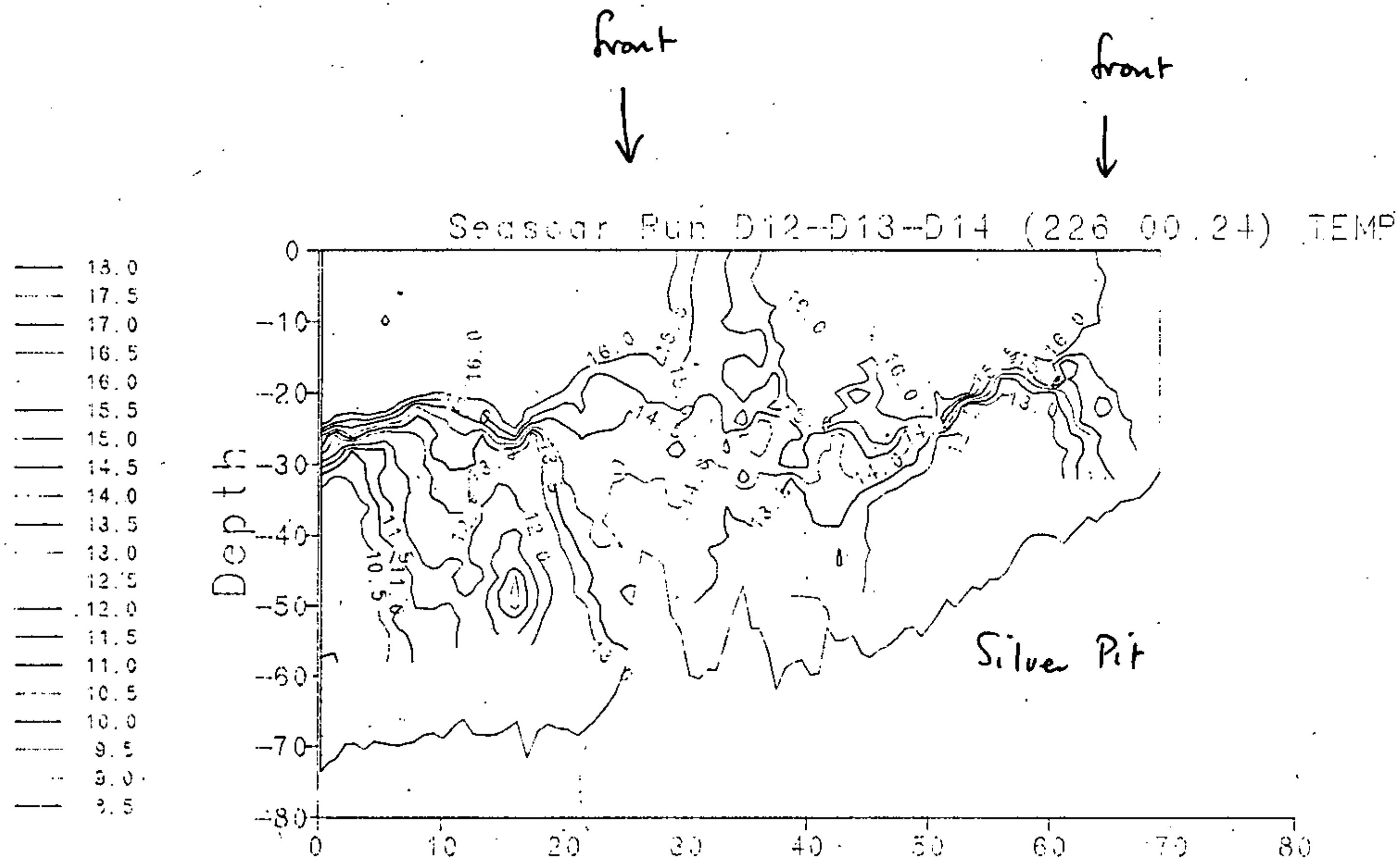

front
front
Seascar Run D12–D13–D14 (226 00.24) TEMP
Depth
Silver Pit
18.0
17.5
17.0
16.5
16.0
15.5
15.0
14.5
14.0
13.5
13.0
12.5
12.0
11.5
11.0
10.5
10.0
9.5
9.0
0
-10
-20
-30
-40
-50
-60
-70
-80
0
10
20
30
40
50
60
70
80

fig 3

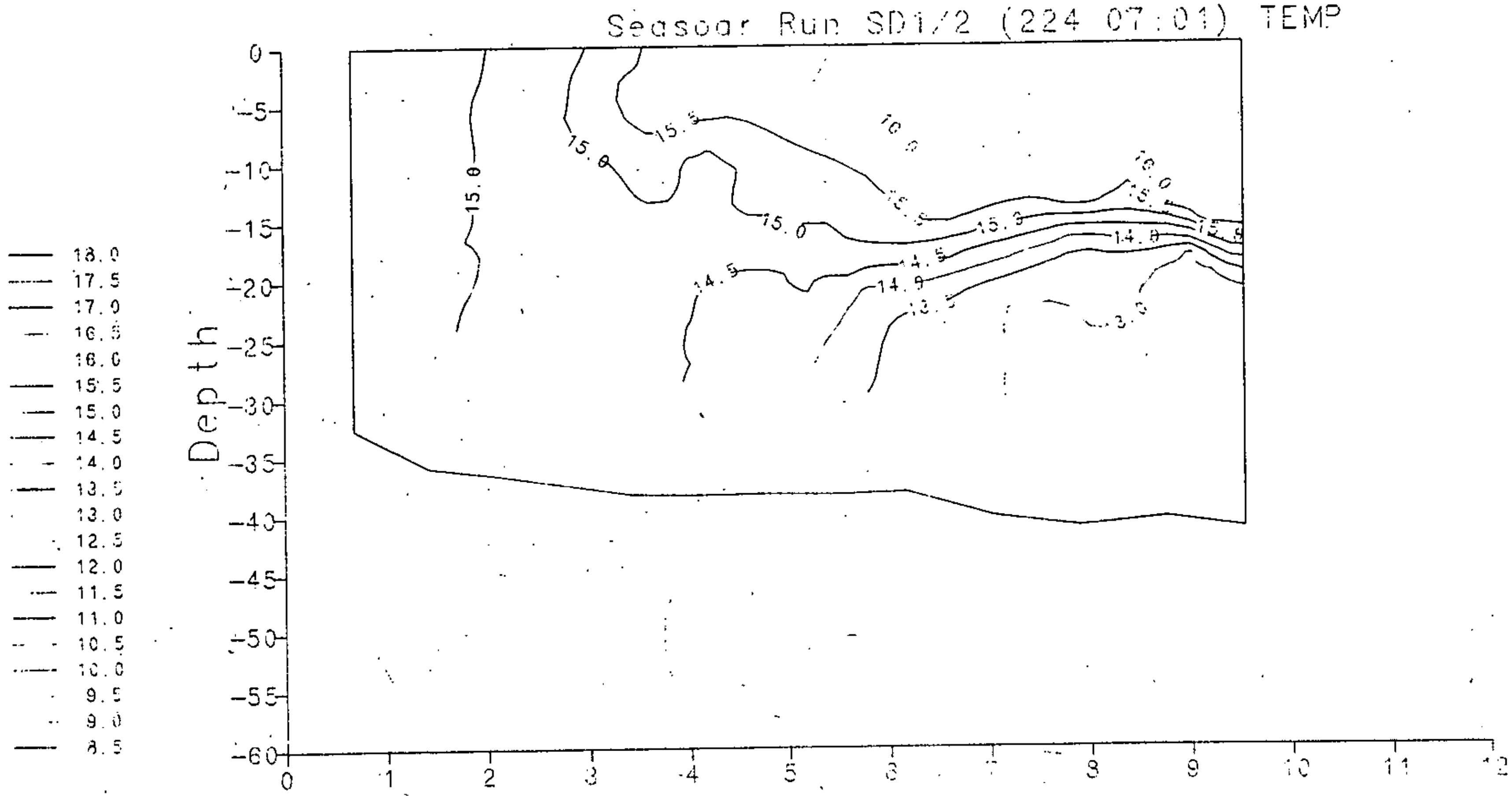
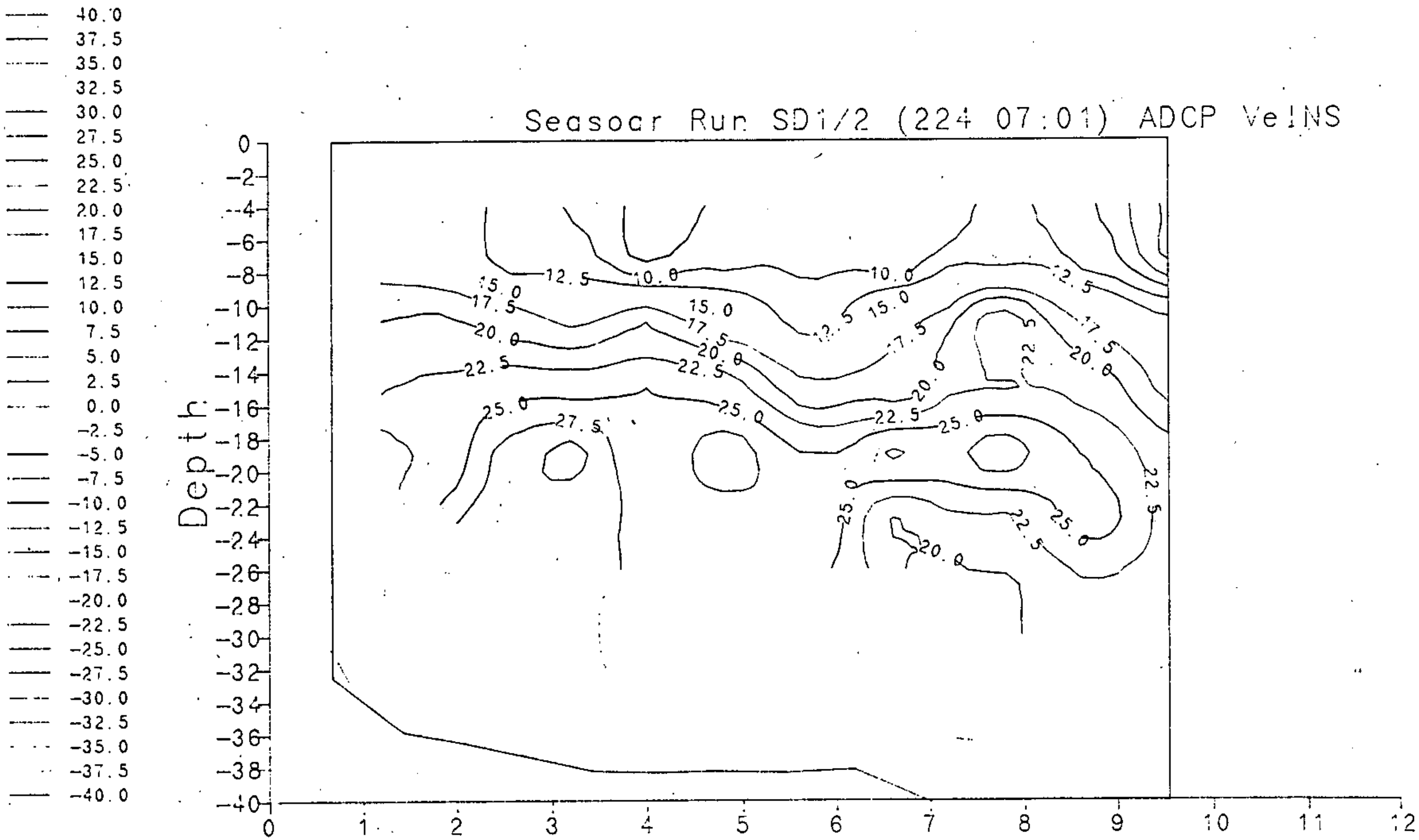


Fig 4a

Seasoar temperature section at Silver Pit front

Fig 4b



ADCP velocity field at silver Pit front