R.R.S. DISCOVERY

CRUISE 66

31 August - 29 September 1974

GATE Phase III

C-Scale Experiment

Cruise Report No. 20
(1975)

Institute of Oceanographic Sciences,
Wormley, Godalming, Surrey.

CONTENTS

1. Dates

31 August	Sailed from Dakar for C-Scale area
2 September	Arrived C-Scale area
16 September	Left C-Scale area
21 September	Arrived Santa Cruz, Tenerife
22 September	Sailed from Santa Cruz
29 September	Arrived Barry

2. Scientific Personnel

Name	Affiliation	
R.I. Tait	L.U.D.O.	(Principal Scientist)
J.D. Woods	S.U.D.O.	(Left in Santa Cruz)
J.H. Simpson	U.C.N.W.	" " " "
M.J. Harris	I.O.S.	
J.W. Cherriman	I.O.S.	(Transferred to Hecla 12.9.74)
G.K. Morrison	I.O.S.	
J. Murphy	L.U.D.O.	
Mrs P. Edwards	I.O.S.	
Mrs R. Sherwood	I.O.S.	
P. Hartland	I.O.S.	
M. Larby	I.O.S.	
P. Minnett	S.U.D.O.	
J. Stratford	U.C.N.W.	
E.R. Johnson	S.U.D.O.	
A.P. Fielding	L.U.D.O.	
C. Paul	P.M.E.L.	
D. Boon	U.C.N.W.	(Left in Santa Cruz)
Mrs B. Noyce	S.U.D.O.	
Mrs D. Heathershaw	U.C.N.W.	
P. Kent	I.C.	
M.V. Angel	I.O.S.	(Joined in Santa Cruz)
M.J.R. Fasham	I.O.S.	" " " "
H.T. Bull	I.C.	(Transferred from Hecla; left in Santa Cruz)

L.U.D.O.	Liverpool University, Department of Oceanography
S.U.D.O.	Southampton University, Department of Oceanography
U.C.N.W.	University College of North Wales (Bangor)
I.O.S.	Institute of Oceanographic Sciences (Wormley)
P.M.E.L.	Pacific Marine Environmental Laboratory (Washington University)
I.C.	Imperial College (London)

3. Introduction and Summary of Cruise Intentions

Discovery 66 was a combined University/I.O.S. cruise for participation in GATE Phase III (the C-Scale Experiment).

The main objectives of GATE (the GARP* Atlantic Tropical Experiment) were summarised in GATE Report No. 3 as follows:

(1) To provide a means of estimating the effects of smaller tropical weather systems on the large synoptic-scale circulations.

(2) To facilitate the development of numerical modelling, and prediction methods.

The Oceanographic sub-programme for Phase III of GATE was aimed at an investigation of the temperature, salinity and current systems which interact locally with the atmosphere on the time scales covered by the experiment. (See GATE Report No. 8 "The Oceanographic Sub-programme"). This programme, devised by SCOR WG/43, was designed to take advantage of the spacing of the C-Scale ships for time series measurements of the temperature, salinity and current profiles, supplemented by profiles from moorings between the ships to improve the spatial resolution. Fig. 1 shows the location of the C-Scale area while details of the disposition of ships and moorings relevant to this report are given in Fig. 2. Discovery was responsible for the deployment of moorings E_1 and E_3 (see also report for Cruise 65).

Discovery's role in the C-Scale Experiment was to operate as a roving ship with the primary objective of describing the spatial variability in the upper layers, using a Batfish fitted with a Neil Brown C.T.D. system. These measurements were considered a crucial requirement for the interpretation of Eulerian time series from fixed ships and moorings. By making Batfish tows at subgrid scale it was hoped to resolve the extent to which variability in the Eulerian time series was due either to temporal changes, due to local atmospheric forcing, or to horizontal advection. To this end two types of measurement were planned:

(1) Eulerian in which the ship followed the same ground track, navigating relative to fixed moorings, and
(2) Lagrangian in which the ship's track was related to the water mass under observation.

In the latter, the navigation was by computer integration of the water flow relative to the ship as measured by the electromagnetic log and displayed on the IBM 1800 VDU. These experiments which were the responsibility of the Southampton University group were planned and directed by J.D. Woods.

Measurements of current shear using PROTAS were the responsibility of the University College of North Wales (J.H. Simpson). To provide additional data on the shear structure to 300 m, two 13 hour time series were planned and it was intended that supplementary measurements should be made on an opportunity basis throughout the cruise including an intercomparison test with a similar type of instrument deployed by Quadra.

*Global Atmospheric Research Programme

The interests of Liverpool University (R.I. Tait) in the diurnal heating cycle in the mixed layer were to be covered by the analysis of STD/CTD profiles from fixed ships, particularly Hecla, and the deployment of an instrumented buoy, attached to the E_1 mooring, for measurements of the temperature profile in the immediate surface layer. Unfortunately the buoy was lost by the Airways in transit to Dakar and this part of the programme had to be abandoned.

The meteorological observations on board were supplemented by an all-sky camera and a met. balloon programme as part of a GATE project conducted by Imperial College (P. Kent). The balloons were to be used for wind profile measurements, using a photographic technique, on an 'opportunity' basis to avoid interference with the other programmes, thus reducing the demand on an already tight schedule.

Personnel from I.O.S. Wormley provided essential expertise and technical back-up to support the above programmes. Discovery was responsible for 2 current meter moorings laid during Cruise 65. One of these, E_3, belonged to P.M.E.L. who were represented on board by C. Paul.

4. Narrative

Discovery sailed from Dakar at 1300 on 31 August. Once clear of the harbour the PES fish and surface T/S profiler were launched. A PES watch was subsequently maintained throughout the cruise except when on station.

An initial course of 207° was set with a view to the possible interception and recovery of the drifting toroid from mooring E_2 whose last sighting (R.V. Dallas on 29 August) was 09°15'N 21°17'W giving an estimated drift velocity of 0.9 kts, 078° (see Report, R.R.S. Discovery Cruise 65). As this course required a deviation from the direct approach to the C-Scale area, ship's speed was increased to 11.9 kts on 3 engines. Preparation of equipment and briefing of scientific personnel proceeded throughout the day.

The following afternoon (1 September) a trial launch of Batfish was made. Although some data was obtained, the operation was intended as an equipment trial and as a training exercise to familiarise those concerned with the launch and recovery procedures as well as the computer routines for data storage and on line plotting. During the Batfish operation an intensified lookout was maintained as the ship approached the estimated position of the E_2 toroid. The Batfish was recovered at 2100 in order to investigate a possible radar contact but nothing was found. The search was finally called off at midnight when all hopes of finding the buoy were abandoned.

Discovery arrived on station at E_1 (see Fig. 2) at 1330 on 2 September. An examination of the mooring by Z-boat indicated that all was well. The I.O.S. spar buoy, supporting 6 VACMs was then launched and tethered to E_2; a dhan buoy was in turn tethered to the spar. A trial PROTAS and CTD cast to 250 m then followed without incident. All the above

work at E_3, including two met. balloon flights during the afternoon, comprised Sta.8624.

A mishap during the Batfish launch at 1935 necessitated the use of the Z-boat to release the faired cable which had snagged the fish. This rather tricky operation was hampered by heavy rain and a moderate sea. As neither cable nor fish appeared to have been damaged, launching continued and the equipment was run until 2300 primarily as a final check on the plotting routines.

On recovery of Batfish, the ship steamed N to rendezvous with F.S. Planet who had requested Discovery's help in fixing her station position. We remained in the vicinity of Planet until 0300 (3 September), allowing sufficient time for 3 satellite fixes, and then returned to the central area for a final check on moorings E_1 and E_3. Discovery then steamed to a position W of Prof Vize (see Fig. 3) for the start of the 1st Lagrangian survey.

Batfish was streamed at 1300 for the start of Batmap 1 which consisted of a series of E-W traverses at 2 miles spacing covering a 12 mile square. Ship's speed was 8 kts. All the equipment worked well and the survey was completed by 2225. This was immediately followed by a series of Batfish tows, at fixed depths in the mixed layer and thermocline, around a 4 mile square central to Batmap 1. Some difficulty was experienced with a blocked conductivity cell which was cleared on this as on subsequent occasions by stopping the ship and allowing the fish to sink deep. A similar problem was encountered at the beginning of Batmap 2 whose start was also delayed by a fault on the IBM 1800. Otherwise Map 2 proceeded according to plan and was completed by 1300 on 4 September.

Station 8624 which followed consisted of two PROTAS and CTD casts to 300 m in a central position relative to Batmap 2. Two balloon launches were also made on this station. We then steamed to rendezvous with Meteor. Two scientists and the chief officer boarded Discovery for a brief visit which resulted in a useful discussion and exchange of information. The Batfish was serviced during this period.

Batmap 3 started at 2217 with rather poor dynamic performance from the fish, but as the control was adequate the survey continued and the fault eventually cleared itself during the night. An improvement in the hydraulic control of the fish was also gained by reducing the tow length from 200 to 150 m. Map 3 was followed by another series of constant level tows at the central position. As the fish was working satisfactorily we went straight on into Batmap 4 at 1420. At 2300 Discovery was joined by Iselin who deployed her acoustic profiling equipment (for internal wave observations) while maintaining station $\frac{1}{2}$ mile abeam of Discovery. Iselin withdrew at 0310 6 September after an unsuccessful attempt to use her S/T Hydroglider (an equivalent instrument to Batfish + CTD). Discovery then proceeded with Batmap 5 which was finished by 1445. As Batfish was working well over this period it was left in the water at 5 m during another test run with PROTAS (Sta. 8626) at 1530.

Batfish was streamed again while Discovery steamed to rendezvous with Hecla who had requested additional magnetic tapes for their STD recording system. Films were also exchanged. The ship then proceeded to E_1 for the start of Batmap 6 which was planned as a joint exercise with Iselin. The survey started at 2042 with Iselin stationed 1000 yds on the starboard beam. The experiment went smoothly except that some track deviation had to be made during the night to allow passage to a super tanker and also to avoid another vessel which appeared to be drifting to the east of Hecla. Map 7 started directly on completion of Map 6 at 0700 7 September with Iselin again in support. About half way through, the survey was interrupted for Sta. 8627: a final PROTAS/CTD test. Map 7 was resumed at 1600. At 1830 Iselin assumed a new station $\frac{1}{2}$ mile ahead of Discovery, and maintained this position for the remainder of the survey. The completion of Map 7 at 2300 marked the end for Discovery of the 1st Lagrangian experiment. Quadra continued the survey with Map 8.

A 13 hour PROTAS time series, Sta. 8628, was started the following morning, 8 September, at 0700 near E_1. Simultaneous PROTAS and CTD casts to a depth of 300 m were made every hour on the hour at a lowering speed of 0.4 m/sec. The CTDs took about 20 minutes while PROTAS was usually recovered within the half hour which allowed sufficient time for changing tapes or batteries as required. The work continued without incident throughout the day until the 12th launch when PROTAS suffered some superficial damage on recovery. The final (13th) cast was therefore abandoned. A total of 6 met. balloon flights were made during the day on this station.

Discovery then steamed to E_3 for a visual check on the mooring. Then from 2000 until midnight, Batfish was towed at various cycling rates on a reciprocal course up and down the direction of the surface current. The aim of this exercise was to investigate the thermal lag effect which had been observed in the CTD pressure sensor. The ship then proceeded to D_2 for a 3-day Eulerian experiment which began at 0128 on 9 September.

The Eulerian survey consisted of repeated Batfish/CTD circuits, each taking about $3\frac{3}{4}$ hours, around moorings E_1, E_3, D_2. Apart from a short delay due to engine trouble during the second circuit, the operation proceeded uneventfully until 1800 the following day (10 September) when on the 11th circuit a deterioration in the Batfish performance became apparent. By 1900 control had been lost and the fish was recovered. Attempts at a short term repair were unsuccessful and by midnight it was clear that a full overhaul of the Batfish hydraulics would be necessary. The Eulerian experiment was therefore terminated at this stage.

Mooring E_1 was recovered the next day, 11 September. Work started at 0900 under ideal weather conditions; the spar buoy was secured and its string of VACMs lifted on board with little difficulty. As it was not possible to fire the acoustic release

on E_1 (see report Cruise 65) a line was passed to the toroid which was then towed for $\frac{3}{4}$ hr at 2 kts into the current to slacken the mooring before the toroid was lifted on board. The hauling of the rest of the mooring which followed without incident was completed by 1400. Several met. balloon flights were made during the recovery period.

Discovery then steamed to E_3 for Sta. 8629 consisting of 3 PROTAS/CTD casts. This was followed by a trial of the now refurbished Batfish, which was towed around a box circuit centred on E_3, until 2400. The fish performed well. A series of CTD casts to 1000 m, Sta. 8630, was then made. This station was completed by 0730 12 September with the ship in position for the recovery of E_3.

The procedure for E_3 differed from E_2 in that, immediately above the acoustic release, E_3 had a number of glass floats with sufficient buoyancy to bring the lower end of the mooring to the surface. Accordingly the release was first interrogated and then fired at 0845. The floats were sighted on the surface at 0930. Attempts to use the Z-boat to secure the toroid at this stage were abandoned because of failure of the outboard motor. It was therefore grappled, a lifting line attached, and hauled on board. The upper series of instruments (VACMs, temperature, pressure and tension recorders) were quickly recovered, but the hauling of the nylon warp proceeded slowly owing to numerous unexplained knots in the line, all of which had to be untangled as they came on board. The work was further hampered by a particularly severe rain squall. In spite of these problems, recovery was completed by 1410.

Discovery then steamed to rendezvous with Hecla for exchange of personnel: J. Cherriman transferred to Hecla, in order to direct the recovery of an I.O.S. mooring on the return passage, while H.T. Bull transferred to Discovery. We then steamed to F_1 for Sta. 8631: an overnight series of CTD casts to 1000 m. The opportunity was taken during this station to tension and relay by hand the CTD wire on the electric winch. The last, 5th, CTD cast was completed by 0630 on 13 September.

The second 13 hour PROTAS series, Sta. 8632, started in the same position (F_1) at 0700. Some problems were encountered during the day because of heavy rain, and a temporary breakdown of the after crane which necessitated a transfer of operations to the forward crane. Two CTD casts were also missed because of a cable fault. However, all 13 PROTAS launches were completed on time.

Earlier that morning Hecla reported that Planet's F_2 mooring was adrift and heading westward with the current towards our position at F_1. As Discovery was the only available roving ship we accepted responsibility for the recovery of F_2, but rather than cancel the PROTAS series already started we decided to monitor F_2's position with a view to recovery the next day. The mooring which was drifting at only about $\frac{1}{4}$ of the surface current speed, was held on radar throughout the PROTAS series. During

the night of 13-14 September, two consecutive Lagrangian Batfish surveys on a somewhat smaller scale (5 x 6 miles) were made. These were successfully completed by 0944 on 14 September and the ship then proceeded toward F_2 for the salvage operation.

Attempts at acoustic interrogation were unsuccessful. This was not surprising as it was by then realized that, in spite of all precautions, the AMF release frequencies of F_2 and E_3 were the same. As the two moorings were only about 6 miles apart, there is little doubt that F_2 was released by Discovery at the same time as E_3. The toroid was grappled and lifted inboard followed by 6 Bergen current meters. Hauling of the mooring line continued until 1315 when the glass float assembly was sighted off the port bow, and operations were halted while the ship manoeuvred to a safe relative position. The recovery of the F_2 mooring complete with all underwater units was finished by 1400.

Discovery then steamed back to F_1 where Batfish was launched for the start of the final Lagrangian series. The first map consisted of a pattern of N-S traverses creeping W against the current while Iselin made supporting observations with her acoustic equipment along a N-S line 1 mile E of F_1. On completion the second map followed immediately along E-W lines with Iselin again in support 1 mile N of D_1. Map 3 started at 0850 15 September and continued the 1 mile spacing but with the leg length increased to cover twice the area of the previous survey. This time both Iselin and Quadra were in support, the latter deploying her Batfish to N.E. of E_4 during legs 1-6, and making a series of CTD casts during legs 7-12. Batmap 3 was finished by 0630 on 16 September.

As a grand finale to the Lagrangian series, Discovery was joined on the survey by both Iselin and Quadra for the whole of Map 4. Discovery and Quadra, both with Batfish/CTDs steamed on parallel E-W courses 1 mile abreast at 9 kts while Iselin, being restricted in speed when operating her Hydroglider/CTD, filled in with shorter legs in between. The experiment proceeded without incident throughout the day until termination at 2000. Quadra returned to her station and with the transfer of some equipment to Iselin, Discovery's work on GATE was concluded. The ship set course for Santa Cruz.

Discovery arrived at Santa Cruz at 1200 on 21 September. The time on passage from the GATE area was mainly spent on clearing the plotting backlog of Batfish and PROTAS data and the preliminary evaluation of some of the results. At Santa Cruz J.D. Woods, J. Simpson, H.T. Bull and D. Boon disembarked for return to the U.K. by air. M. Angel and M. Fasham joined the ship for biological work in the Biscay area.

Discovery sailed from Santa Cruz for Barry at 0830 on 22 September. Throughout the whole of the homeward passage the IBM 1800 was fully utilized for plotting and data analysis. All the backlog of Batfish, PROTAS and CTD data were covered during this period. On 23 September, a small course deviation was made to investigate a suspect 55 fm sounding near the Salvagen Islands (Ref: IHB Doubtful Hydrographic Data 1973: 110/24/01). The reported sounding proved to be false. Later

that day, while one engine was stopped for repairs, the opportunity was taken to stream a pinger on 170 m of wire for an acoustic location experiment relating to the towing of Batfish.

At 2000 on 25 September we arrived on station 8633 for the biological work: 6 net hauls covering a total range of 300-600 m and one oblique haul of 0-1000 m were completed by 1713 on 26 September. The station finished with a 1000 m CTD cast. The rest of the return passage was uneventful: we managed to miss most of the bad weather and arrived in Barry at 0700 on Sunday 29 September. Most of the scientific party disembarked that day.

A summary of the main observations made is given in the GATE Weekly Operational Status Summary appended to this report. The scientific team on board was divided into 3 watches throughout the active period in the C-Scale area. Each watch was generally responsible for the work of the moment regardless of its nature but extra expertise was recruited as the occasion demanded. Care was taken throughout to ensure that the meteorological observations, which were reported on a regular schedule to GOCC Dakar, were made to the GATE requirements.

The proposed programme was an ambitious one which relied heavily on the operation of new equipment, notably Batfish and the Neil Brown CTD. The satisfactory performance on Cruise 66 of the Batfish/CTD system as a whole was largely due to the efforts of M. Carson and R. Wild, in overcoming the problems encountered in the Fish hydraulics during Cruise 65, and to the expertise of G.K. Morrison. Much of the planned programme was in fact achieved. A large amount of good data was collected which will make a substantial contribution towards the overall aims of GATE. The success of the cruise was due to the combined efforts of all the scientific groups on board and to the co-operation of the Master and Officers of R.R.S. Discovery to whom I extend my thanks.

R.I. Tait

5. Project Reports

A. Batfish Experiments

A full account of the Lagrangian and Eulerian surveys together with a preliminary appraisal of the results has been published by J.D. Woods as a separate University of Southampton Department of Oceanography report:

"Batfish Experiments on R.R.S. Discovery during Phase III of GATE. Part I: Measurements and Analysis at Sea." September, 1974.

B. Technical Report on Batfish and C.T.D.s

The CTD system and data logging arrangements for this cruise are the same as those described in the report on Discovery Cruise 64.

During Cruise 64 the Batfish/CTD was used for making sections N-S across the equator looking for the equatorial undercurrent core water. On Cruise 66 the Batfish was utilised to map areas rather than make simple sections. These maps have been both Lagrangian - relative to water mass, and Eulerian - relative to fixed buoys.

Most of the surveys covered the top 60 metres with the fish undulating with a period of ~ 2 mins, equivalent to 500 metres/cycle at an operating speed of 9 kts.

Batfish handling

Although statistically the behaviour of the Batfish has been satisfactory it is still not safe for the controls to be left unattended while the vehicle is in the water. There was only one occasion when total loss of control was experienced, necessitating the premature termination of an experiment and a complete stripdown of the hydraulic system and servo valve. On several occasions, however, the bias offset control required quite drastic adjustment to maintain the required profile pattern. It seems likely that these bias shifts are caused by partial blockages in the servo valve, which always seem to be temporary.

Several times during the cruise the fish was observed towing off up to 30° to starboard as it approached the surface and returning directly astern or slightly to port upon diving. This behaviour was attributed to jammed fairing sections and a bent rudder: certainly servicing and greasing the fairing near the fish reduced this alarming feature. It was not fully understood how the rudder became bent, and when it happened for the second time it was decided to reduce the towing speed back to 9 kts whilst working close to the surface in case the damage was occurring upon breaking surface.

Unfortunately the pressure transducer in the CTD is temperature sensitive (~ .010% of FSD/°C). With a 3000 d-Bar gauge and about a 10 minute temperature time constant in the pressure case when working in a 10-15°C thermocline, the pressures were a little difficult to interpret to better than ±3 decibars absolute - requiring operators to either be very conservative and risk missing near surface data or to be cavalier and risk breaking surface. When towing on less than 200 metres of cable our towing speed on two engines was never limited by cable tension. At 10 knots it was only peaking at about 0.4 tonnes.

CTD packages

In the thermocline one expects to find small animals, and so when towing a small conductivity cell occasional cell fouling becomes predictable. Sometimes as often as once per day the conductivity reading would jump low and refuse to return until the ship was effectively stopped and the Batfish allowed to stall to get a reverse water flow through the sensors.

A more serious problem was the temperature coefficient of the pressure transducer. If the temperature range in the thermocline and the limited profiling range to be used had been

appreciated before the cruise it would have been possible to avoid this problem, either by temperature compensating electronically or by fitting a limited range pressure transducer. Predictably the new CTD (CTD#14) has double the temperature sensitivity with its 6000 decibar sensor. Apart from this, no trouble was experienced with either CTD.

Some station time was lost due to leaking electrical splices on the vertical profiling wire and one of the conductors in the 7 core Batfish towing cable went open circuit necessitating the use of one of the four redundant cores.

Statistics

During Cruise 66 there were a total of 385 hours spent in the C-Scale area. 20 Batfish tows occupied 225 of these hours with good data being collected for 91% of the towing time - the other 9% falls prey to setting up undulation patterns rather than catastrophic failures. One experiment was terminated prematurely due to total loss of control of the vehicle.

The longest tow lasted 53 hours at speeds of up to 10½ kts.

Vertical profiling

The new CTD (#14) commissioned on this cruise was used in conjunction with PROTAS for 30 dips to between 200 and 350 decibars, and a further 10 stations to 1000 decibars. Of these 40 dips, 3 were aborted due to poor electrical splices. No CTD instrument failures were experienced.

G.K. Morrison

C. PROTAS

An improved version of the original PROTAS system was used to make observations down to 300 m in the C-Scale area. In addition to measuring two components of shear, the revised system has a full CTD capability so that simultaneous observations of both velocity and density gradients are now possible. The data is recorded on a version of the Clayson data logger at a sampling interval of 0.5 secs which gives a vertical resolution of 15-20 cms at the normal fall speed.

An initial test of the system was made on 2 September to check that all channels were functioning correctly and optimally scaled for the GATE area. This test revealed an offset in the conductivity system which did not accord with the laboratory calibration. After further tests on 4 and 6 September the cause of this offset was diagnosed and the correct scaling obtained.

A 13 hour time series of observations at hourly intervals was commenced at dawn on 8 September, and continued throughout the day with CTD supporting dips on all runs. Unfortunately the final launch of this series had to be cancelled because of damage to PROTAS during the recovery operation, when the strayline was caught in the bow propeller. However, the damage proved

repairable and after two days intensive work, during which a new velocity sensor was fitted, the system was again in working order.

Two further series of observations were then taken at the mooring E_3 (3 profiles) on 11 September, and at F_1 (13 profiles) on 13 September, both with CTD support. These were completed without incident except that the aft crane failed during the series at F_1, necessitating the use of the forward crane for launch and recovery.

Preliminary analysis of the data using the shipboard computer has shown that most of it is of good quality, although one of the shear channels malfunctioned on the later drops. High levels of shear (up to 0.1 sec^{-1}) are observed in the mixed layer and at the top of the thermocline while below this, the shear values diminish rapidly (as does the Brunt-Väisälä frequency) to relatively low levels at 300 m.

It had been hoped to make additional observations in association with the Lagrangian mapping experiments but this was not possible because of the exigencies of the Batfish programme. A planned intercomparison of PROTAS with the Canadian Octoprobe had also to be cancelled because of shortage of time.

J.H. Simpson

D. Meteorological Experiments - Imperial College

Two of the aims of the I.C.'s participation in GATE were (i) to study the circulation and consequent organisation of cumulus convection on the scale 10 km to 100 km, and (ii) to study the tropical boundary layer structure. To help achieve these objectives all-sky camera records and sub-cloud layer wind data derived from photographic records of balloon ascents were obtained on board Discovery.

The all-sky photographs were taken throughout the Phase III period during daylight at one shot per minute with the exception of 8.9.74, due to the motor jamming and 15.9.74 due to the focus being set wrongly. From 16.9.74 one shot was taken every three minutes as the previous setting no longer worked. The camera was sited on the deck immediately above the radio office as this gave the best all-round view of the sky.

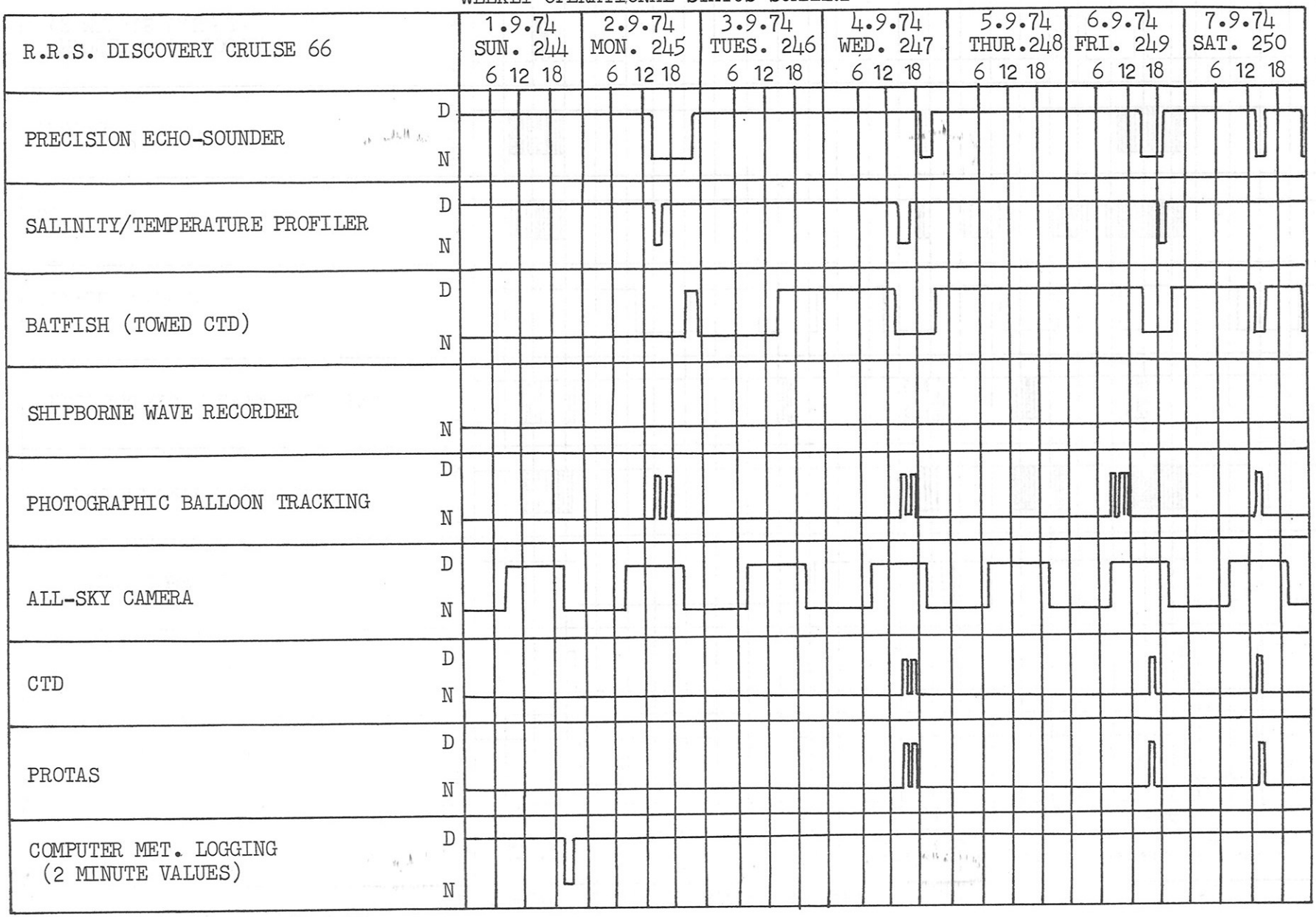
The photo-tracking balloon system consisted of an upper balloon filled with helium and a lower balloon on a 20 m tail filled with air. The ascent rate was approximately 180 m min^{-1}. The balloons were released from the aft end of the boat deck. They could only be released when the ship was stationary or steaming at a slow speed due to the difficulty in launching when the wind relative to the ship was greater than 15 knots. A further limitation was that the elevation of the balloons relative to the observer should be less than 45°, thus in most flights the ship headed to wind. This also prevented the balloons from flying over the ship, which would make the flight

useless. In all, forty three successful flights were obtained with flight times of 4 to 10 minutes. The elevation, azimuth and height of the balloons for each pair of photographs can be evaluated at the College and hence a wind profile obtained.

It was intended to do most of the flights in and around organised cumulus. However, such conditions were rare and most of the flights were therefore made in the vicinity of rain cloud cumulus. The wind profiles obtained from their flights will be used in conjunction with the all-sky records and surface meteorological observations to attempt to evaluate the circulation about the cumulus, particularly rain cloud cumulus.

P.M. Kent

WEEKLY OPERATIONAL STATUS SUMMARY



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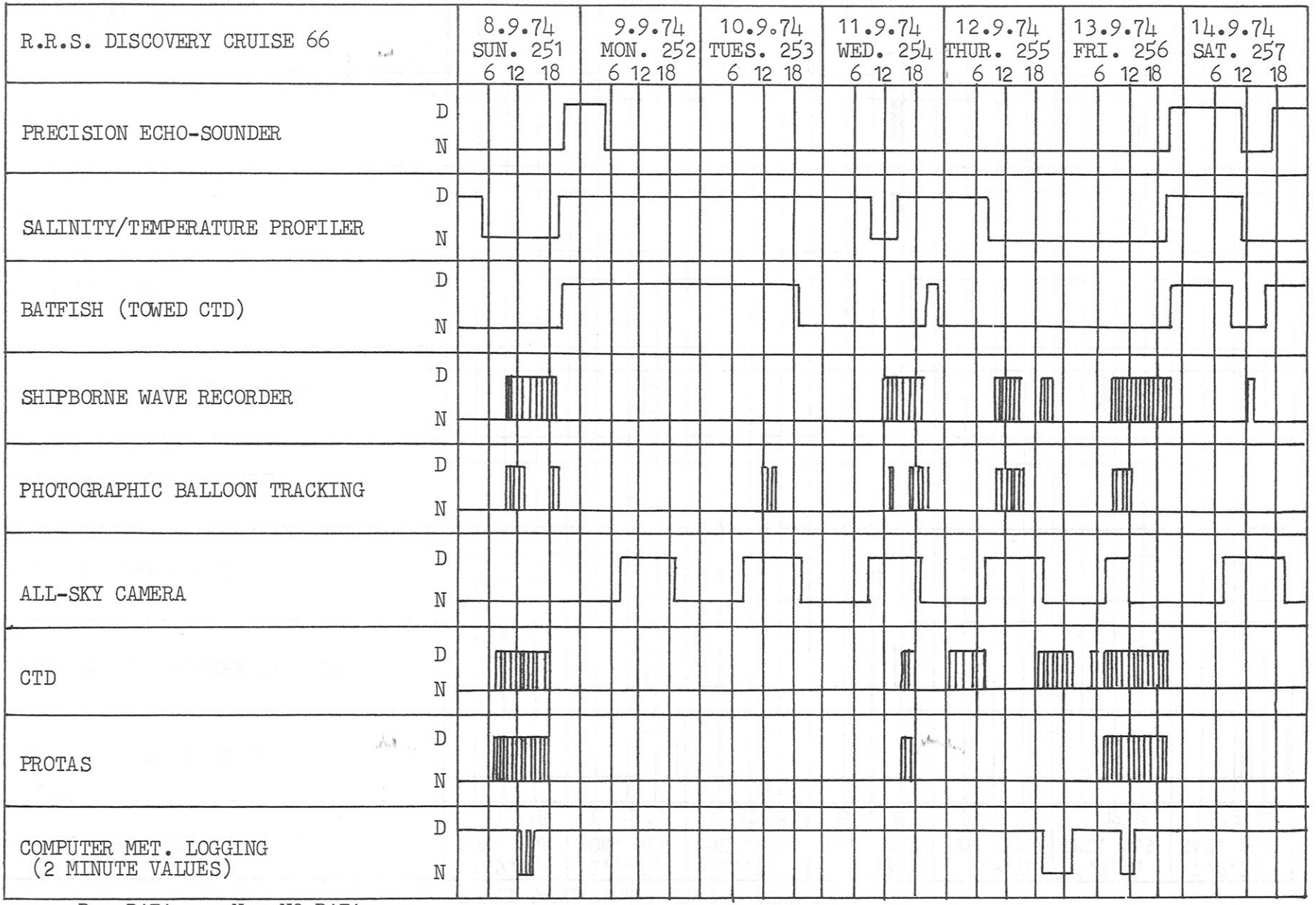
WEEKLY OPERATIONAL STATUS SUMMARY



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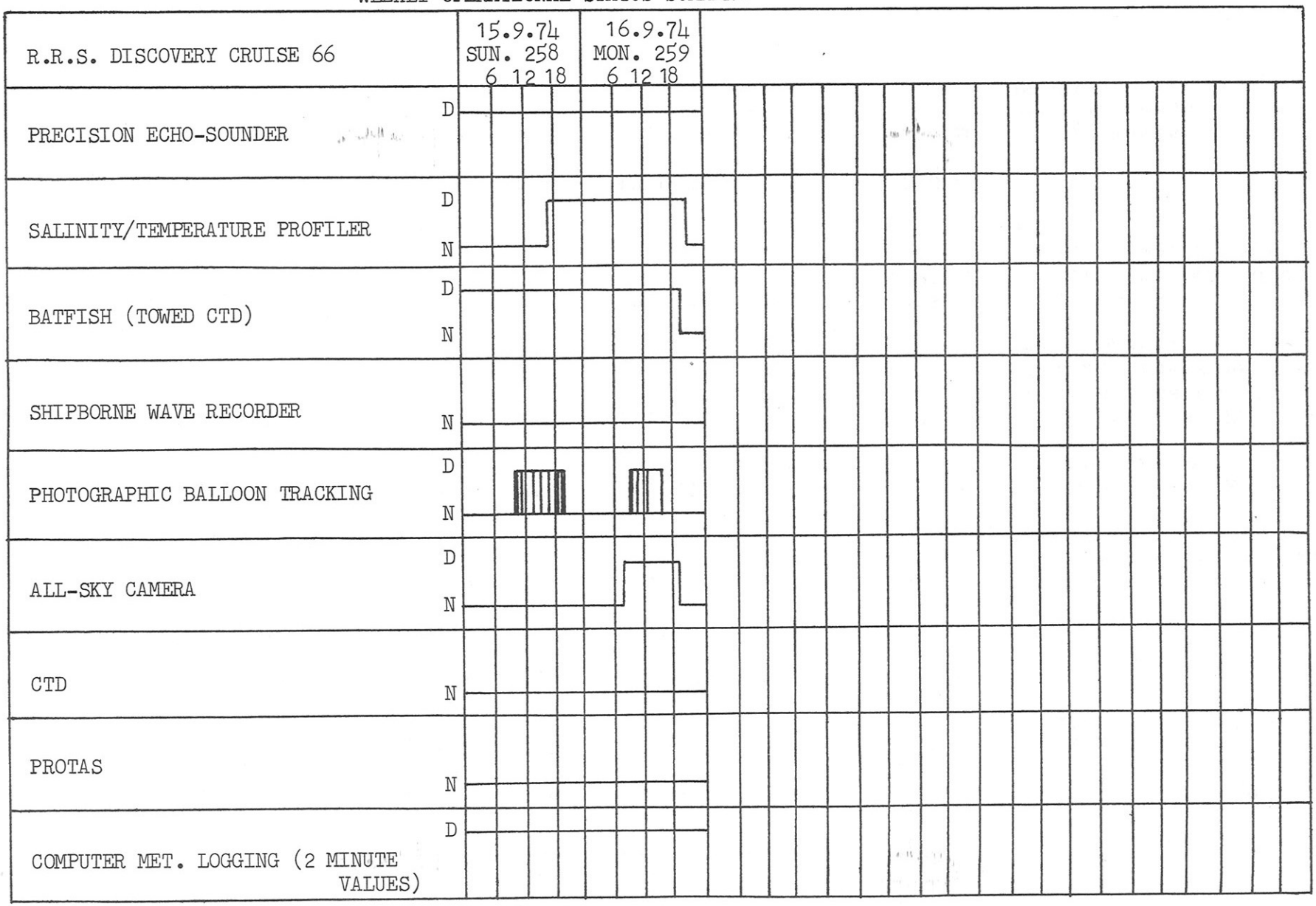
WEEKLY OPERATIONAL STATUS SUMMARY



D = DATA N = NO DATA

R.R.S. Discovery Cruise 66 C.T.D. Station List

Station No.	Lat.	Long.	Day	Date	Time	Depth	Remarks
8625	08°40.38'N	23°35.58'W	247	4.9.74	1440	350 m	CTD cast in conjunction with PROTAS
8626	08°45.73'N	23°10.48'W	249	6.9.74	1530	350 m	" " " " "
8627	08°49.70'N	22°37.82'W	250	7.9.74	1340	350 m	" " " " "
8628	08°40.04'N	22°55.09'W	251	8.9.74	0700) -1800)	350 m	12 CTD casts at E_1 on the hour in conjunction with PROTAS
8629	08°41.15'N	23° 7.53'W	254	11.9.74	1509) -1700)	350 m	3 CTD casts at E_3 in conjunction with PROTAS
8630	08°41.34'N	23° 5.90'W	255	12.9.74	0027 0158 0419 0545	1000 m) " " "	4 CTD casts at E_3. Bottle calibrations at 10 m and 1000 m. Lowering speed ~0.5 m/sec.
8631	08°48.72'N	22°51.53'W	255	12.9.74	1806 2005 2213 2359	978 m) 1000 m) " "	5 CTD casts at F_1. Calibrations at max. depth and 10 m. Lowering speed ~0.5 m/sec.
			256	13.9.74	0457	770 m	
8632	08°49.68'N	22°51.11'W	256	13.9.74	0700) -1900)	350 m	13 CTD casts at F_1 on the hour in conjunction with PROTAS.

R.R.S. Discovery Cruise 66 Station 8633

Stn.	Date 1974	Position Lat.	Position Long.	Gear	Depth (m)	Fishing Time GMT	Remarks
8633	25/9	43°41.0'N	12°47.5'W	RMT 1	300- 405	2103-2303	Repeat series 9
# 1		43°44.7'N	12°43.7'W	RMT 8		Night	Flow dist. 7.31 km
8633	25/9	43°46.4'N	12°42.2'W	RMT 1	405- 500	2358-0158	Repeat series 9
# 2		43°50.7'N	12°39.1'W	RMT 8		Night	Flow dist. 7.69 km
8633	26/9	43°53.8'N	12°36.8'W	RMT 1	495- 600	0310-0510	Repeat series 9
# 3		43°57.8'N	12°34.2'W	RMT 8		Night	Flow dist. 6.99 km
8633	26/9	43°59.7'N	12°33.7'W	RMT 1	0-1000	0555-0734	Repeat series 9
# 4		44° 4.4'N	12°32.6'W	RMT 8		Dawn	Flow dist. 5.69 km
8633	26/9	44° 8.1'N	12°30.5'W	RMT 1	400- 500	0901-1101	Repeat series 9
# 5		44°13.0'N	12°27.8'W	RMT 8		Day	Flow dist. 7.42 km
8633	26/9	44°15.0'N	12°27.1'W	RMT 1	300- 400	1154-1354	Repeat series 9
# 6		44°20.1'N	12°24.8'W	RMT 8		Day	Flow dist. 7.58 km
8633	26/9	44°22.6'N	12°23.7'W	RMT 1	500- 600	1450-1650	Repeat series 9
# 7		44°26.9'N	12°21.2'W	RMT 8		Day	Flow dist. 7.58 km
8633	26/9	44°27.7'N	12°20.7'W	CTD	0-1000	1723-1845	WB at 10 and 1000 m
# 8		44°27.3'N	12°20.4'W	WB 1		Dusk	

DISCOVERY CRUISE 66

S.B.W.R. RECORDS

		ANALOGUE			COMPUTER ANALYSES			
Day No.	Date Sept. 1974	Roll No.	Record No.	Time	Time	SIG. HT M	SIG. PERIOD Sec.	SPECTRAL WIDTH
251	8	-	1	0955-1016				
			2	1055-1120				
			3	1155-1220				
			4	1255-1320				
			5	1355-1420				
			6	1455-1520				
			7	1555-1621	1636	1.6	6.6	0.57
			8	1655-1720				
			9	1755-1821	1826	1.5	7.6	0.63
			10	1855-Abandoned (ship moving)				
254	11	2	11	1157-1222				
			12	1255-1322				
			13	1401-1410 (ship then moving)				
			14	1555-1655				
			15	1655-1721	1702	0.9	6.0	0.51
			16	1757-1824	1746	1.0	5.6	0.52
			17	1855-1925	1856	1.0	5.9	0.46
255	12	3	18	0955-1020				
			19	1051-1123				
			20	1157-1222				
			21	1254-1320				
			22	1352-1428 (ship moving at 1415 on)				
			23	1857-1926				
			24	1955-2021				
256	13	4	25	0859-0925				
			26	0958-1028				
			27	1056-1122				
			28	1156-1205 (paper not moving)				
			29	1303-1323				
			30	1359-1421				
			31	1455-1520				
			32	1555-1625				
			33	1655-1729				
			34	1754-1855				
			35	1855-1924				
			36	1955-2020				
257	14	5	37	1152-1221				
			38	1255-1320				

DISCOVERY CRUISE 66

RAINFALL DATA

Date	Time Read	Amount	Comments
1.9.74	2000	0.0 mm	
2.9.74	0900	"	
"	1300	0.3 "	Between 1200 and 1250
"	1900	29.0 "	" 1700 and 1900
3.9.74	0050	1.7 "	
"	0900	0.0 "	
"	2000	0.0 "	Short sharp showers during day
4.9.74	0830	1.7 "	
"	2000	0.0 "	Light showers during day
5.9.74	0800	6.3 "	Between 0600 and 0700
"	1700	2.1 "	1.2 mm by 1013
6.9.74	0800	0.8 "	
"	2100	0.0 "	
7.9.74	0830	2.7 "	
"	2000	0.0 "	
8.9.74	0800	3.5 "	
"	2000	0.0 "	
9.9.74	0800	0.0 "	
"	1940	0.8 "	1400 rain
10.9.74	0800	0.0 "	
"	2000	0.0 "	
11.9.74	0800	0.0 "	
"	2000	0.0 "	
12.9.74	0800	0.8 "	
"	1945	6.7 "	Between 1325 and 1400
13.9.74	0800	0.0 "	
"	1610	17.7 "	4.4 mm in storm 0905 rain most
"	1900	33.7+"	of day from 1230
14.9.74	0800	0.2 "	
"	1645	9.2 "	1420 to 1645
15.9.74	0900	4.9 "	
"	2000	0.0 "	
16.9.74	0800	5.5 "	
"	1530	5.5 "	Heavy 1320
"	2000	0.0."	
17.9.74	0800	0.8 "	

TOTAL RAINFALL IN 17 DAYS 151.9 mm.

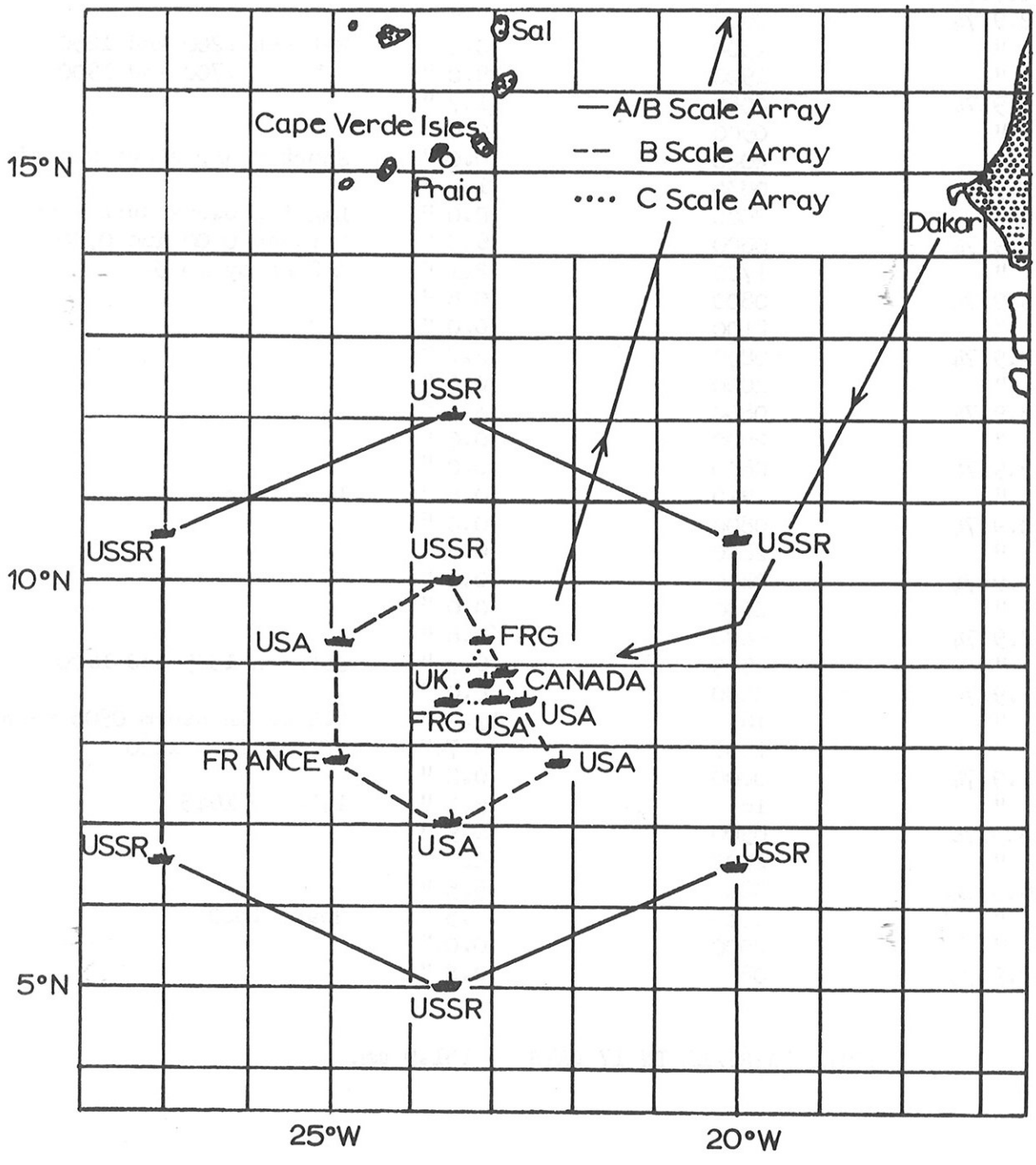
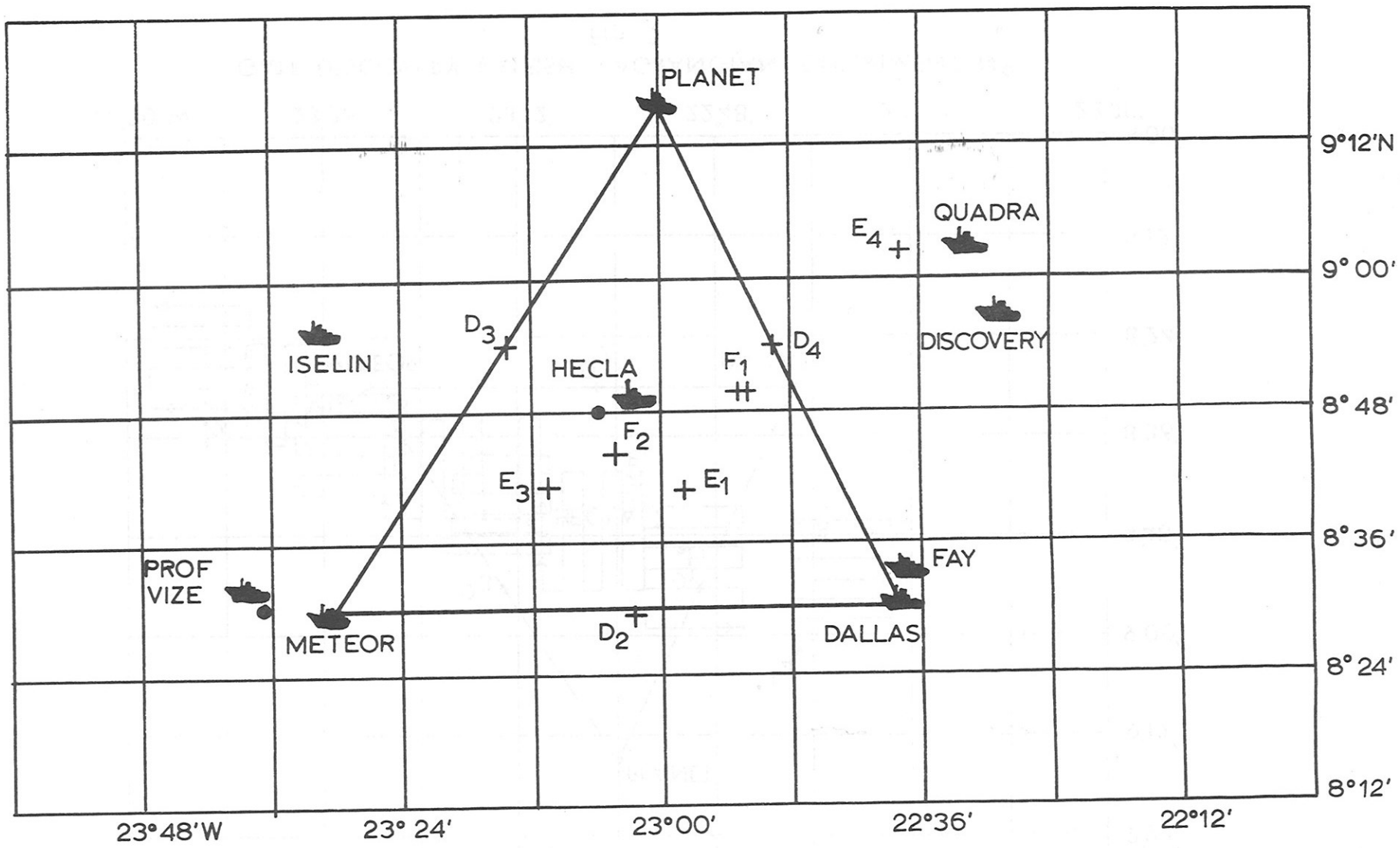


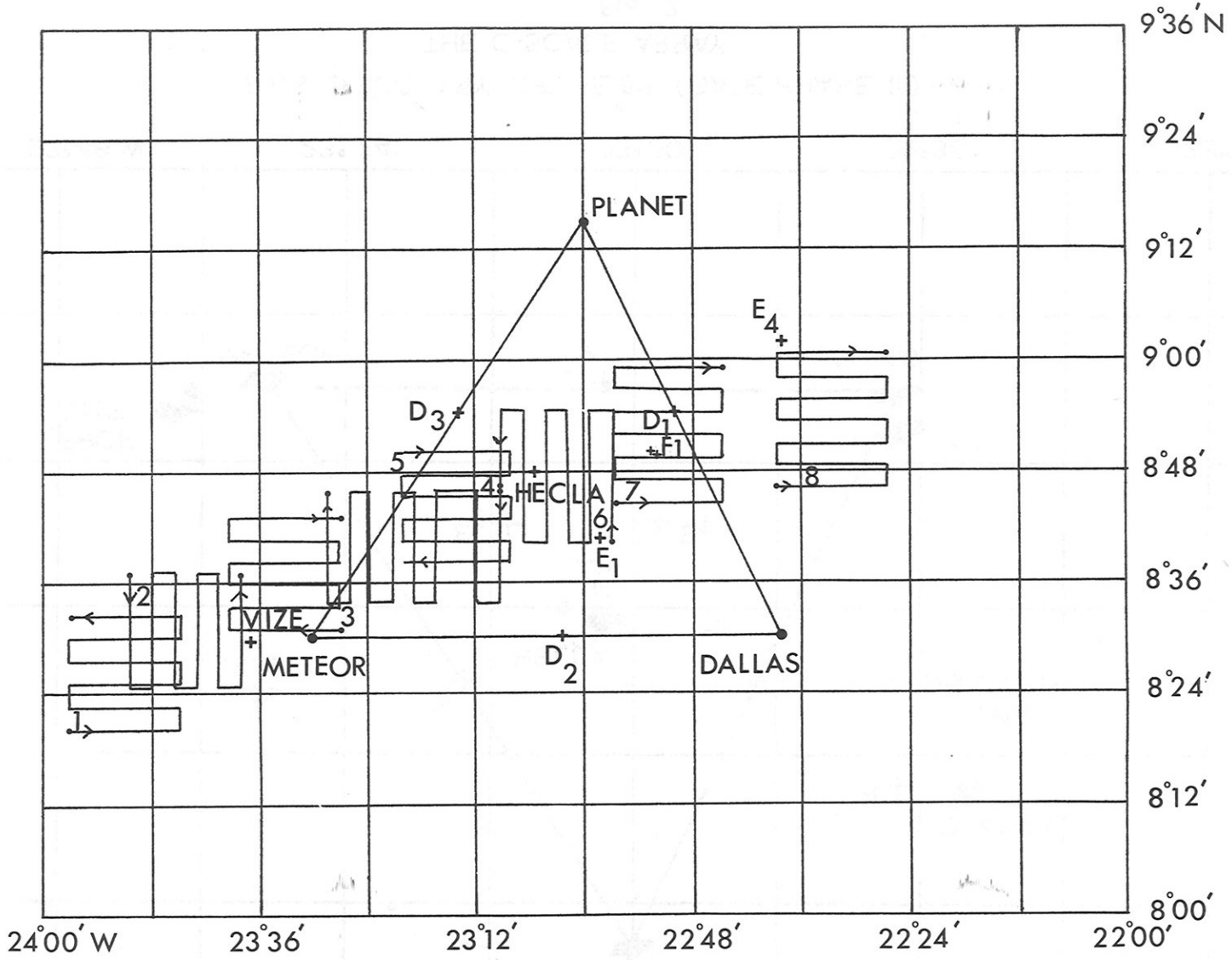
Fig 1 LOCATION OF B&C ARRAYS SHOWING SHIP'S TRACK TO & FROM THE AREA



RRS DISCOVERY CRUISE 66 (GATE PHASE III)

THE C-SCALE ARRAY

Fig. 2



GATE DISCOVERY BATFISH LAGRANGIAN EXPERIMENT N°1

Fig. 3