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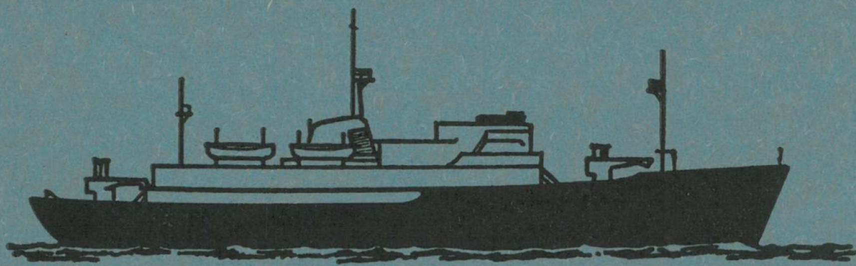

R.R.S. DISCOVERY

CRUISE 49

31st AUGUST — 2nd OCTOBER 1972

AIR-SEA INTERACTION OBSERVATIONS

"JASIN 1972"

N.I.O. CRUISE REPORT No. 57

1973

N. I. O. CRUISE REPORTS

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Air-Sea Interaction Observations

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NIO Cruise Report No.57

(1973)

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INTRODUCTION

During September 1972 three ships (Weather Adviser, Researcher and Discovery) and one aircraft worked in a triangular area 100 km across near Ocean Weather Station "J" in the observational phase of the JASIN 1972 experiment.

The aims of that experiment and details of its design have been widely circulated already and will not be repeated here. This report is concerned only with the observations made by the Discovery; it is primarily a station list, with enough notes about the equipment and observations to show what was done and what data are likely to emerge. It is too early to attempt any presentation of the results, especially as the weather was unusually mild and air-sea interaction was not particularly vigorous, so that no very dramatic meteorological situations or changes in the upper layer of the ocean were seen.

Discovery's main tasks were, first, to set five of the seven moorings planned (all except D1 and D2 in Fig.1), then to do various experiments near the "A" mooring. The three corner moorings, A, B1 and B2, were to have surface buoys carrying meteorological recorders and pressure sensing and telemetering equipment. The experiments near "A" mooring were to include intensive studies of the atmospheric boundary layer using LOCATE radiosondes, detailed measurements of the heat and salt distribution in the upper part of the ocean, current shear in the seasonal thermocline and trials of various methods of measuring near-surface currents. Finally, it was planned that Discovery should recover all seven instrumented moorings.

In the event, most of these tasks were accomplished, though some plans had to be changed as will be seen in the narrative and station list below.

NARRATIVE OF CRUISE

(a) Outward passage and setting moorings, 31st Aug. - 7th Sept.

Discovery sailed as planned at 1100/31 Aug. but had to wait outside Barry docks until 2230 that evening for a Radio Officer to join. Setting off westwards then, good progress was made in favourable weather. One of the three instrumented surface buoys (B2) was assembled and wires for one of the two subsurface moorings (C2) were wound on to the trawl winch in preparation for laying moorings in the first phase of the experiment. Hourly surface meteorological observations started at 0900/2 Sept. Trial dips were made with the CTD and STD (Stn 8075). During Discovery cruise 46 in May, two subsurface moorings (117 and 118) had been set and we had intended to recover them on the way out but the timing was not convenient. Instead, mooring 117 was checked acoustically early on 3rd September and later that morning work started in the JASIN area with laying mooring C2. An attempt at laying the surface buoy B2 that afternoon was frustrated when the buoy capsized on launching. Repairs were made overnight and a CTD section was occupied in the southern part of the JASIN area, and mooring B2 was laid during the afternoon of 4th Sept. Equipment was got ready overnight for the next two moorings, five more CTD stations were occupied and moorings C1 and B1 were laid during 5th Sept. Meanwhile Researcher laid mooring D2, having laid D1 the previous day.

After more CTD stations overnight, mooring B2 was visited and further repairs made to the telemetering pressure sensor. It proved quite practicable for people to board the toroidal buoy from the rubber boat and work on it in force 5 wind and 5 ft. waves. The third corner mooring "A" was then laid 100 km N of B2 in the afternoon of 6th Sept. Again, CTD stations were worked overnight, and, after a practice launch for adjustment of buoyancy, the shear spar (carrying 5 VACMs closely spaced through the bottom of the mixed layer) was attached to the surface toroid "A". That completed the initial layout of moorings.

(b) Intensive radiosondes and oceanographic observations, 7th Sept. - 10th Sept.

A two-hourly series of radiosonde flights was started at 1315/7 Sept., and hourly CTD dips to 200 m at a position $2\frac{1}{2}$ miles SW of buoy "A" were started at 1530. These series continued until 1300/10 Sept., one CTD dip being omitted when, on inspecting the "A" mooring, the marker buoy had to be untangled from the line tethering the shear spar to the toroid. During that three-day period, the mixed layer depth varied irregularly between 6 and 33 m and much of the variation evidently occurred at periods shorter than the one-hour sampling time. A series of dips at approximately 3 min. intervals through the mixed layer (Stn 8109) revealed depth changes with periods of about 20 to 40 min. Winds decreased during the three days from force 4 to force 2 and the mixed layer began to restratify.

(c) Observations and mooring work, 10th Sept. - 18th Sept.

Being free to move about after the intensive observations on one station, CTD dips were made to 200 m in a pattern around the "A" mooring, to reveal the regional diatribution of near-surface properties. During that survey, overnight 10th-11th Sept., the marker buoy of mooring C2 was not seen as expected on the radar, and Weather Adviser reported further northward movement of the B2 buoy. (They had reported it to have moved 5 miles N by the morning of 9th Sept.) Its position was fixed by Discovery on the morning of 11th Sept. 17 miles north of its original position and apparently re-anchored in shallower water. Mooring C2 was then recovered. Its dan buoy had pulled under and collapsed, fortunately without tangling with any of the current meters. Both these mishaps must have been due to a strengthening of the current, which had previously been about $\frac{1}{2}$ knot northward according to a drogue tracked relative to "A" mooring. As a precaution, the dan buoy was removed from C1 mooring in case it also might get pulled under.

Overnight, more CTD dips to 1500 m were made to define the topography of the main thermocline around the north-eastern moorings, and C2 was re-laid without a surface dan buoy early on 12th Sept.

Discovery and Researcher then co-operated in laying and tracking three parachute drogues in the region between C1 and C2 moorings. A pattern of deep CTD dips was occupied at the same time with a short interruption for a rendezvous when Researcher needed help with repairs to their STD. The parachute drogues were recovered in the afternoon of 13th Sept. and Discovery returned to within radar range of "A" mooring. A drogue was set at 12 m (the same depth as the Aanderaa current meter on the "A" mooring) and multiple CTD dips (Stn 8136) were made whilst tracking the drogue relative to "A". Another intensive radiosonde series was started, but was given up after six flights in very light winds. By 2200/14 the drogue was near the limit of the radar range on "A" and was recovered. Meanwhile, buoy D1 had gone adrift and a possible sighting of it had been reported from a position 100 miles NW. With no immediate prospect of suitable weather for resuming intensive radiosonde work, Researcher left station near B1 to go and look for the missing D1 and Discovery left "A" for 15 hours in order to recover mooring 117. CTD and drogue work was then resumed near "A" and continued until the morning of 17th. Another intensive series of sondes was flown 16th-17th Sept.

The north-east part of the area was re-surveyed with deep CTD dips until 0500/18, when a rendezvous was kept with the other two ships and Researcher transferred some equipment to Discovery before leaving the area.

(d) Mooring work and revision of Discovery's programme, 18th - 19th Sept.

After Researcher's departure, an unsuccessful attempt was made at recovering mooring 118. Returning then to mooring "A", it was found to have continued moving north-eastward, as had been apparent since the 16th. By now it was 5 miles from its laid position and might soon move into deeper water. Moreover, with the surface current of the order of 30 cm/sec. and the patchy distribution of mixed layer depth and properties found near "A", it was not an ideal site for continuing observations of mixed layer development. In the western part of the triangle, Researcher had found much weaker currents. With D1 buoy having disappeared and still missing, it seemed risky to leave B2 and D2 unattended. For all these reasons it seemed sensible to recover the "A" mooring and for Discovery to transfer the detailed observations in the mixed layer to the neighbourhood of B1. Accordingly the shear spar was recovered in the afternoon of 18th and, after an overnight deep CTD survey, the rest of the "A" mooring was recovered on the morning of 19th. During the recovery, the wind increased and some shallow CTD dips were made (Stn 8155) to look for development of a new mixed layer.

(e) Work near B1 mooring, 19th - 27th Sept.

On passage towards B1, mooring C1 was interrogated and Discovery arrived near B1 at 2344/19. A drogue (10 m depth) was launched and shallow CTD dips were made whilst tracking it overnight.

A different version of the VACM spar, with VACMs at 5 m and 10m depths in cages built into the spar itself and two more VACMs suspended below it, was attached to the B1 toroid in the morning of 20th. After an unsuccessful search for D2 mooring that afternoon, shallow CTD dips near B1 were resumed overnight. Next day, D2 was located and a spar carrying 3 electromagnetic current sensors ("e.m. spar") was attached to B1 and the VACM cage spar during the afternoon of 21st. A series of CTD dips alternating with wave recording using the pitch-roll buoy was then started. The wind had increased to 25 - 30 kts. The pitch-roll buoy was badly damaged when its line caught in the bow propeller (a.m. 22nd). CTD dips continued but were given up for 3 hours that afternoon because of heavy rolling. It proved possible then to work the CTD whilst lying-to, the wind being almost at right angles to the swell. Normal hove-to operation was resumed at 0400/23rd.

By then it was apparent that B1 mooring had begun to drag its sinker. With only 5 days remaining that could be spent in the area, and the possibility of bad weather, it seemed advisable to start recovering moorings while conditions were suitable. Mooring D2 was recovered (a.m. 23rd), the e.m. spar was detached from B1 and the VACM cage spar, and the subsurface mooring C1 was recovered that afternoon. Returning then to B1, shallow CTD dips were resumed and observations were made to determine the dependence of shipboard atmospheric pressure readings on the relative wind. Meanwhile an unexpected radar echo had been identified as the missing buoy D1, and that mooring was recovered (a.m. 24th). A series of 13 hourly radiosonde flights was started at 0715. Returning to B1, CTD dips were resumed near it. A spherical buoy with 3 VACMs suspended below it was tethered to the VACM cage spar, in an attempt to study the effect of vertical motion of the surface float on current meter performance. The e.m. spar was attached again, at the same time and wave records alternating with CTD dips were resumed using the repaired pitch-roll buoy. That continued from 24th (p.m.) until 26th (p.m.) when the e.m. spar and the spherical buoy with 3 VACMs were recovered. Eight more radiosondes were flown during the day. Overnight more CTD dips were done and more comparisons between shipborne pressure sensors in various relative winds. The VACM cage spar and B1 mooring were recovered on 27th (a.m.).

(f) Remainder of mooring work and passage to Barry, 27th Sept. - 2nd Oct.

Mooring B2 was recovered by 2230/27 and a pattern of deep (1500 m) CTD dips was then occupied, near C2's position. Mooring C2 was released on 28th (a.m.) but only partly recovered (2 current meters out of 7), the remainder being lost when a shackle caught on the winch traverse and the wire broke. The wind having increased to 28 knots, further CTD dips were made in the hope of detecting some deepening of the mixed layer. The wind soon dropped again, however, and *Discovery* left the area at 1404/28. Hourly met. observations were continued until midnight. A deep CTD station (2003 m, Stn 8192) was occupied overnight 29th-30th in Porcupine Seabight, the 100 fm line was crossed and echo-sounding stopped at 1330/30th and *Discovery* entered Barry Docks at 0030/2nd Oct.

LIST OF SCIENTIFIC PARTICIPANT

Mr. F. Bilimoria	NIO	Computing
Mr. N.L. Brown	WHOI	CTD equipment
Mr. J.W. Cherriman	NIO	Current meters; moorings
Dr. C.H. Clayson	NIO	E.M. Spar; wave buoy
Mr. M.J. Cooper	NIO	Radiosondes
Mr. P. Éden	U. of Miami	Pressure measurement and telemetry
Mrs. P. Edwards	NIO	Meteorology
Mr. B. Hart	NIO	Spars and drogues
Mr. D. Latham	U. of Miami	Pressure measurement
Mrs. G. Lawrence	U. of S'ton	Computing
Mr. D.A. Mansfield	Imp. Coll.	Meteorology
Mr. W. McLeod	WHOI	CTD equipment
Mr. G.K. Morrison	NIO	STD: multisampler; CTD observations
Dr. R.E. Payne	WHOI	Met. recording equipment
Mr. G.R.J. Phillips	NIO	Acoustic equipment; moorings
Dr. R.T. Pollard	U. of S'ton	CTD and pressure observations
Mr. W. Slade	NIO	Computing
Mr. N.D. Smith	NIO	E.M. Spar; wave buoy; met. recorders
Dr. J.C. Swallow	NIO	Moorings, etc. (Principal Scientist)
Mr. P.K. Taylor	U. of S'ton	Radiosondes
Mr. A.L. Watson	NIO	Surface buoys; met. observations

NOTES ON EQUIPMENT AND OBSERVATIONS

1. Radiosonde measurements

A LO-CATE radiosonde tracking system was used to investigate the lowest 2000 m of the atmosphere. Profiles of temperature, humidity and wind velocity were obtained, the radiosonde being tracked by means of retransmitted Loran-C signals.

A double balloon system was used to take the radiosonde to a predetermined pressure level where one balloon was released. The radiosonde descended slowly on the remaining balloon allowing detailed measurements to be taken. During a few flights the descent balloon burst and accurate ascent values only were obtained.

The radiosondes used were of a new type (VIZ model 1220-100) and some data was lost due to transmitter failure or through oscillation of the Loran-C receiver system. The latter fault was overcome by stringent pre-flight testing. The radiosonde temperature and humidity sensors were very carefully calibrated before being used.

The following series of flights were obtained -

(a) A three-day series of two-hourly flights from 1315Z/7 to 1315Z/10 (41 flights).

(b) Hourly- or two-hourly flights between 1115Z/14 to 1740Z/14 (6 flights).

(c) Hourly flights from 1115Z/16 to 2115Z/16 followed by two-hourly flights until 1715Z/17 (21 flights).

(d) Hourly flights from 0715Z/24 to 1915Z/24 (13 flights).

(e) Hourly or two-hourly flights between 0900Z/26 and 1715Z/26 (8 flights).

In addition a number of single balloon ascents were performed at 1315Z and 2315Z for use in the estimation of infra-red radiation fluxes.

Between the main series of ascents the phase stability of the Loran-C signals received at the ship was continuously recorded. The results will be used to estimate the accuracy of the radiosonde wind profiles obtained.

P.K. Taylor

2. Surface meteorological observations

Visual observations of meteorological variables were made hourly from 0900 on 2nd Sept. to 2300 on 29th Sept. according to pre-arranged schedule in order that readings be synchronised to within a few minutes on all three participant ships; specially printed observation forms based on, but different from, the Met. Office Ocean Weather Ship forms, were used. Observed variables were - wind (apparent) averaged over two minutes, ship's heading and speed, dry and wet bulb temperature (aspirated), sea and hull temperatures, atmospheric pressure, clouds, sea swell, visibility, present weather and remarks when appropriate. Special cloud observations were made by Dr. Mansfield of Imperial College.

Computer data logging of meteorological variables continued throughout the cruise except for short periods when the computer was fully loaded with on-line logging; these variables were dry and wet bulb temperatures from port and starboard screens on the upper bridge deck (not aspirated), incoming radiation from a solarimeter, wind speed and direction, hull temperature and relative humidity. These were sampled every second and two-minute mean values computed and stored on disk; every fifth two-minute value was printed out on a typewriter in the plotting office. Integrated values of incoming radiation and heat flux are available. New electronics had been installed just before this cruise for the potential divider stage for data logging and careful comparisons between this and the visual observations indicated that the logging is reliable. Air temperatures and solarimeter values were recorded by analogue trace on a Leeds and Northrup recorder throughout the cruise and computer plottings were also made. Interference from radio transmissions is most evident on both plots and seriously contaminates the data.

Atmospheric pressure was measured from three precision aneroid barometers specially installed in the gravimeter room and connected to a static pressure head on the fore-mast about 17 metres above water level; readings were to 0.05 mb but scatter in readings for any one PAB at any time could be as much as ±0.45 mb in a twenty foot swell. Checks on the ship's draught were kept during the cruise to enable accurate allowance for height of the PABs above water level. Allowing for height difference, the three PABs agreed with that on the bridge, but inter-comparisons with the Miami instruments indicated a difference of about one mb and this has not yet been accounted for. Two special series of PAB readings at different ship's head and speed were taken.

Sea "surface" temperature was measured by several sensors at differing depths. Comparison of all the sensors shows that the readings taken with the Crawford Bucket agreed within its reading accuracy (±0.1°C) with the one metre CTD probe reading except on 8th and 9th Sept. when the air was 3° to 4°C cooler than the sea surface and the ship was stopped almost all the time; at this time the Bucket readings were about 0.5°C lower than those of the CTD.

Inter-ship comparisons of instrument readings were made on five occasions, twice between Discovery and Weather Adviser and three times between Discovery and Researcher; the ships were usually less than one mile apart during these periods and VHF contact ensured synchronisation of times of readings. Series of PAB and aspirated psychrometer readings were made, together with wind and ship's heading and sometimes sea temperature readings by various sensors were included. These inter-ship comparisons should enable any instrumental differences to be allowed for. All thermometers used were checked against an NIO sub-standard at intervals.

Shipborne wave recorder traces were taken at three-hourly intervals throughout the cruise (subject to the ship being stopped at or near that time)and these were accompanied by either computer logging and analysis of wave records or by special wave buoy measurement. About 180 records of 20 minutes duration were taken.

P. Edwards

3. Special cloud observations

Additional observations of convective clouds were made in an attempt to identify organisation on scales of 1 to 10 km and 10 to 100 km. During 18 days when convective clouds were present all-sky photographs were taken every 5 minutes on 16 mm colour ciné film. To back this up visual reports were made whenever the meteorological observers saw evidence of cloud bands or ensembles. Organisation into bands was never positively identified but on several occasions a decrease in the spacing of clouds in part of the sky indicated the possibility of an ensemble and in these cases the azimuth of the edges and, where possible, the elevation of the centre were noted. It is hoped that these observations from the three ships can enable the passage of an ensemble to be correlated with changes in the wind and temperature fields. Further observations of organisation can be made from satellite photographs received at Imperial College and visual observations from the Hastings aircraft.

D.A. Mansfield

4. CTD, XBT and STD

The CTD system brought by Mr. N. Brown of the Woods Hole Oceanographic Institution was used to collect over 150 hours of data during the cruise. Out of 256 dips, 42 were to 1500 m and the remainder shallow dips to 200 m or less. Most of the 1500 m dips were in the vicinity of moorings 122 (C2), 124 (C1) and 126 (A) arranged in sections to investigate the strong north to north-eastward current found in the area. Substantial displacements of the main thermocline were found, causing geostrophic currents as large as 10 cm/sec at 900 m relative to 1500 m, in a band 20 to 30 miles across.

Several factors hindered the investigation of the development of the mixed layer and seasonal thermocline during the first half of the cruise. With light winds and ovecast conditions, little air-sea exchange took place. Large horizontal temperature gradients and the strong current at "A" caused advection to dominate temperature changes at a point. The sampling scheme of one dip per hour was found to be inadequate.

On 10th Sept. 3.5 hours of continuous yo-yo dips between 5 and 60 m revealed internal waves with typical periodicity 20 minutes to 45 minutes and crest-to-trough amplitudes of up to 10 metres. Thereafter, all dips were yo-yo lasting half to one hour per dip, to remove aliasing caused by internal waves from the longer period trends,

After moving to B1 (M 125) on 19th Sept. where Researcher had reported negligible currents and small horizontal temperature variations, yo-yo dips were made every one or two hours until 27th Sept. with no gap larger than ten hours between dips. The mixed layer developed to 40 to 45 m during this period under the action of winds up to 30 kts and cooling. CTD work was interspersed with e.m spar and wave buoy work and series were collected at a fixed position, following a drogue, towing the CTD at slow speed and drifting with the ship lying-to. Only once was CTD work suspended

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due to bad weather, when XBTs were dropped half-hourly for three and a half hours. XBTs were also used when steaming between stations but only 29 were used in all.

Frequent calibrations of the CTD against reversing thermometers and water bottle samples were done at depths of 10, 200 and 1500 m. The modified Cox salinometer was used on board and duplicates of all samples were kept for verification and intercalibration with Researcher's samples at the NIO. The temperature calibration was very stable and (bottle - CTD) differences were a function of which thermometers were used. There was, however, a general offset of about 0.00 to 0.01 °C at 10 m (15°) increasing to 0.01 to 0.02° at 200 m (10°) and to 0.05° at 1500 m (4°).

CTD salinities were computed from uncorrected spot readings of temperature, pressure and conductivity, using Brown's formula. Salinity (bottle - STD) differences showed a trend with depth, the mean offset being 0.0001‰ at 10 m - 0.001‰ at 200 m and -0.007‰ at 1500 m. These differences are much smaller than the temperature offsets suggest, implying either that the thermometer standard is in error, or that the CTD conductivity calibration is in error by an amount which cancels the temperature error. The CTD will be recalibrated at the end of the cruise to resolve the matter.

The CTD unit is designed to interface directly with a computer but, as this was not possible, the data were stored on audio-tape for later analysis. Accordingly, only plots of temperature and conductivity were immediately available but these were adequate for immediate analysis and the operation of the deck unit and display was very straightforward. Radio transmissions occasionally affected the display units but did not appear to have contaminated the recorded data when the audio-tapes were played back.

Only two STD dips were made from Discovery and the data were later overwritten in error. STD casts carried out by Researcher were recorded on audio-magnetic tape and transferred to Discovery when Researcher left the area on 17th Sept. Due to the failure of the hydraulic winch on Researcher there were only 40 hours of recorded data. These tapes were played into the IBM 1800 computer through the NIO deck unit and plots of temperature, salinity and density *versus* pressure were obtained whilst all the raw data were stored on magnetic disk in the computer.

As the played-back data are more noisy than the direct STD signal, it will be conditioned from the disk data files at the NIO before the final corrections are applied and the final computations are carried out.

R.T. Pollard
G.K. Morrison

5. Moorings, spars and drogues

Three surface (A, B1, B2) and two subsurface moorings (C1, C2) were laid and recovered by Discovery and the two surface moorings (D1, D2) laid by Researcher were recovered by Discovery. The sequence of events relating to the mooring work has been outlined in the narrative above and details of positions, times, instruments and depths are given later in the station list and table of moorings. Some notes on the construction of the moorings are given here.

The buoys D1 and D2 laid by Researcher were lent by the Hydrographic Department, MOD. They were the same ones as were used by Hecla in JASIN 1970, but carried different instruments this time. The three other surface buoys A, B1 and B2 were more heavily instrumented. A taller framework, made of aluminium instead of stainless steel, was used, with the same type of 8 ft diam. toroid for buoyancy. They were moored on a mixture of 8 mm diam. wire and 16 mm diam. polypropylene line ($3\frac{1}{2}$ tons breaking load), anchored by 1400 lb of scrap chain. This arrangement was chosen with the aim of keeping the load on the aluminium framework below 1 ton, and having a mooring drag its sinker rather than pull under in a strong current. All the surface moorings did in fact drag their sinkers. B2, initially in 4241 m depth, moved 14 miles northwards in 2 days, soon after it was laid, then remained anchored. Buoy "A" stayed anchored for 8 days then moved NE at about 2 miles per day. B1 stayed put for 16 days, then moved 18 miles northward in 5 days, soon after the VACM spar and other satellites were attached to it.

Moorings C1 and C2 were subsurface moorings of the usual NIO type, with a 4 ft diam. spherical float anchored on a mixture of 8 mm and 6 mm wire and 800 lb of scrap chain. The shallowest current meter was intended to be at 40 m depth, and initially both moorings had a surface dan buoy connected by 100 m of polypropylene line to the subsurface float. These were removed after the one on mooring C2 pulled under, when that mooring had to be recovered and re-laid.

The "shear spar" attached to buoy A had an immersed length of 9 m and the thin top section protruded 1.5 m above the surface. It had enough buoyancy to carry 5 vector-averaging current meters. These were linked by solid rods 2 m long, to minimise relative rotation. The whole array of closely spaced current meters was suspended on 8 mm wire below the spar so as to span the boundary between the surface mixed layer and the top of the seasonal thermocline. The spar was intended to reduce the effect of surface waves on the depth and performance of the VACMs. The bottom 6 m of the spar was surrounded by a framework which could be covered with canvas to entrain about a ton of water, which would increase the natural period of the spar. With the 30-35 cm/sec. surface currents encountered, however, the horizontal drag and lift was too much with the canvas on and it had to be removed.

The "cage spar" tethered to B1 buoy used similar buoyancy units but included two cages containing VACMs, built into the spar to float at depths of 5 m and 10 m. The total immersed length of the spar was 13.5 m. There was enough buoyancy to carry two more VACMs, suspended on 8 mm wire below the spar.

The drogues used at 10 m and 12 m depths consisted of a vertical array of 3 canvas crosses, each 1.8 m square, closely spaced and suspended at the nominal depth below a surface float (a dan buoy body) carrying a small flag and a flashing light. These were used for labelling a part of the mixed layer whilst repeated CTD dips were being made. The depths of 10 m and 12 m were chosen for comparison with currents observed by neighbouring moored current meters. For deeper drogues, 8.5 m diam. parachutes were used, attached to dan buoys carrying radar reflectors.

J.C. Swallow

6. Atmospheric pressure measurements

The University of Miami participation in JASIN 1972 consisted of an attempt to observe pressure at three buoys by means of telemetry and on shipboard (Discovery) by direct recording.

The telemetering pressure systems consisted of -

(a) A static intake head (modified Beckman wind direction sensing head).

(b) Pressure transducer (Mk 5 Baratron with special modifications).

(c) Analogue-digital converter (12 bit) with accompanying formatting electronics.

(d) Transmitter.

(e) Command receiver and electronics.

Shipboard equipment included -

(a) Receiver.

(b) Decommutator and storage.

(c) Digital magnetic tape recorder.

(d) Command electronics and transmitter.

The Mk 5 pressure transducers as used for this experiment have a span of 60 mb with an offset zero at 1005 miles. Resolution is governed by the value of the least significant bit of the A-D converter; in this case ±14.4 μb. The Kollsman instrument has a far larger span and has a resolution (claimed by the company) of ±10 μb. If there are no errors due to noise, the recording apparatus introduces no errors.

Wave motions are filtered by an acoustic first-order filter with an approximate time constant of 10 minutes.

Shipboard data was taken with a Kollsman transducer, read by counter and the result printed on paper tape.

Stations are interrogated in turn at the beginning of 5-minute intervals. After the shipboard antenna has swung around to the direction of the desired station, the command transmitter activates the pressure-sensing package. Upon activation, the analogue voltage produced by the pressure transducer is digitized and transmitted, received and recorded. Provision was made for checking the received signal for errors and re-interrogating if errors were found.

Although all systems had been in operation when installed on the buoys on shipboard, mishaps during deployment caused serious malfunctions.

B2, the first toroid deployed, went in upside-down. The resulting overpressure, even though filtered, apparently stretched the diaphragm of the pressure transducer. Realising that we could substitute shipboard measurements at one corner of the proposed triangle, we installed another transducer after the buoy was in the water. In process of changing the battery connector was momentarily reversed, causing failure of the telemetry transmitter which was subsequently changed. B2 then operated satisfactorily for the duration of the experiment.

During offloading of B1, the crane hook smashed the pressure intake of that system. As we had only four intakes, one damaged in shipment due to careless assembly, it was decided to align the intake with the wind vane on the buoy. This proved unsatisfactory, variations of 300 μ bars appearing in the data. This intake was repaired by the crew on Researcher but large variations persisted. We have not yet determined the cause of these variations.

At position "A", we took data on shipboard with the Kollsman instrument; its intake being mounted on the Monkey Island.

Recapping: B2 operative; good data through experiment; B1 doubtful due to large excursions; shipboard data good.

Raymond Pollard of Southampton used the Kollsman instrument as a comparison standard between the Met. Office barometers on the ship's bridge and those mounted in the gravimeter room. Both rapid sampling and 100 second average readings were taken. He also compared readings taken using the Met. Office intakes on the Monkey Island and the foremast and the Miami intake on the Monkey Island. These comparisons were made over a range of wind speeds and ship headings. Preliminary analysis indicates that the Monkey Island intakes cause readings to be lower than the mast intake. No cause has been found for this behaviour.

One very important result of the experiment is the demonstration of the reliability of the telemetry at distances up to 85 miles with indications that longer paths are feasible in practice.

Since the data has not been reduced, no conclusions can be drawn as to the scientific aspects of this study. Some engineering changes, however, must be considered. Of primary importance is the redesign of the pressure intakes, including increased ruggedness and installation of a check valve. In addition, definitely polarised power plugs or an external power switch must be installed.

P. Eden
D. Latham

7. WHOI buoy meteorological package

Among the instruments mounted on the "A" buoy was a meteorological sensing and recording package developed at the Woods Hole Oceanographic Institution (WHOI) for the JASIN experiment. The core of the package is a vector-averaging current meter which, in this application, computes and records both vector-averaged and scalar-averaged wind velocities for each recording interval (1 7/8 minutes). Other meteorological sensors include -

(a) Air-temperature-thermistor in a radiation shield.

(b) Sea temperature-thermistor mounted under the buoy.

(c) Relative humidity - a pair of matched strain guages bonded to a cellulose crystal.

(d) Solar radiation - an Eppley 6-90 type paraanometer.

(e) Barometric pressure - Rosemount capacitor type.

The output of each meteorological sensor is converted to an analogue voltage which drives a voltage-to-frequency converter. The pulses from this converter are totalled by a counter. At the end of each recording interval, the total counts from each counter are recorded yielding the mean of each meteorological quantity for the recording interval.

On 6th September the "A" buoy was moored with the WHOI meteorological package mounted on it and on 19th September the buoy was retrieved. For the remainder of the period when Discovery was in the JASIN area, another 11 days, the meteorological package was mounted on the bridge deck and air temperature and relative humidity were recorded. The values from this period will be compared to the standard meteorological observations to obtain an indication of the performance of the sensors.

R. Payne

8. EM spar and wavebuoy

The EM spar was set for the first run with two-component EM current meters at 2, 5 and 10 metre depths. The outputs of these sensors were sampled twice per second for 11-minute periods every 3 hours. Other sensors sampled were a vertical accelerometer, roll and pitch sensors and a digital compass. Nine records were obtained on quarter-inch magnetic tape: these were replayed into the wavebuoy/computer interface and the data were sorted and stored on computer disk files. The data retrieval was 100% and the only apparent defect was a zero shift in the vertical accelerometer output.

Wave buoy observations were made at the times at which the spar was recording. The NIO pitch-roll buoy was used, tethered to the ship by 150 metres of buoyant cable. Twenty-three minute records were taken with a sampling rate of 3 scans/second. The records were marred by the loss of the capacitance compass; this necessitated visual observations of wavebuoy orientation. During the fifth launch, the buoy overturned and became trapped in the bow thruster tunnel bars. After a while it was freed but when recovered it was found that the tripod frame had been sheared off and that the lid had been knocked off resulting in flooding of the electronics assembly. Fortunately, prompt immersion in fresh water prevented damage to the electronics and temporary repairs to the buoy were possible. In addition, a Bergen current meter compass was mounted in gimbals and connected to the buoy electronics so as to allow sampling once every ten scans. Faster sampling was not possible because of the limited mechanical response of the compass. This system was used successfully through the second EM spar run, when 15 wave records were made. All wave records were recorded on line on the computer, although quarter-inch back-up tapes were recorded simultaneously.

For the second EM spar run, the 2-metre EM current meter x and y components were replaced by the outputs of horizontal accelerometers mounted in the x and y axes of the gyro. After recovery it was found that the 10 metre EM y component had only operated intermittently and that half of one 11-minute record had been spoiled by a temporary malfunction of a power supply regulator. This defect coincided with a period of unusually fast rotation of the spar and has yet to be explained. The data retrieved was 97% on this occasion.

No problems were experienced in handling the long spar: in fact its length became an advantage when handling over the side because of the steadying effect of the bottom end in the water. Some minor mechanical defects showed up and will be remedied before further use is made of the spar.

C.H. Clayson
N.D. Smith

LIST OF TABLES AND FIGURES

Notes

1. All positions are based on satellite fixes.

2. Symbols used in figures are Z : CTD or STD station, Δ : mooring, Y : XBT, D : drogue.

3. Abbreviations:

   CTD : conductivity-temperature-depth probe (N. Brown, WHOI)

   STD : salinity-temperature-depth probe (Bisset-Berman)

   XBT : expendable bathythermograph

   VACM : vector averaging current meter

   PRB : pitch-roll buoy

TABLE 1

Discovery Cruise 49 - Station List

No.	Date	Time Start	Time End	N Lat.	W Long.	Observations
8075A	2	1408	1457	52°06.0'	14°59.2'	CTD1(200m), XBT1, STD1(200m)
8076A	3	0810	1127	52°55.0'	18°43.2'	Mooring 122 (C2)
8077		1834	2119	52°22.6'	18°46.0'	STD2 (1500m)
8078		2238	2305	52°21.3'	19°01.9'	CTD2 (200m)
8079	4	0042	0109	52°17.9'	19°23.1'	CTD3 (200m)
8080		0237	0358	52°18.9'	19°44.6'	CTD4 (1500m)
8081		1254	1550	52°24.9'	18°39.5'	Mooring 123 (B2)
8082	5	0016	0129	52°32.2'	18°40.8'	CTD5 (1500m)
8083		0233	0303	52°40.4'	18°40.8'	CTD6 (200m)
8084		0416	0448	52°52.6'	18°40.8'	CTD7 (200m)
8085		0550	0652	53°03.4'	18°39.3'	CTD 8 (1500m)
8086		0847	0914	53°02.4'	19°11.0'	CTD9 (200m)
		0915	1140	53°02.4'	19°11.2'	Mooring 124 (C1)
8087		1253		52°56.5'	19°28.3'	XBT2
8088		1354		52°51.3'	19°44.0'	XBT3
8089		1538	1722	52°46.1'	20°02.5'	Mooring 125 (B1)
8090		1939	2100	52°44.1'	19°53.7'	CTD10 (1500m)
8091	6	2257	0008	52°29.1'	20°09.5'	CTD11 (1500m)
8092		0128	0157	52°30.2'	19°47.7'	CTD12 (200m)
8093		0322	0439	52°31.8'	19°26.4'	CTD13 (200m)
8094		0752		52°28.9'	19°04.6'	XBT4
8095		1002		52°25.1'	18°39.1'	XBT5
8096		1005		52°33.7'	18°41.3'	XBT6
8097		1220		52°49.1'	18°42.1'	XBT7

No.	Date	Time Start	Time End	N Lat.	W Long.	Observations
8098		1345		53°04.2'	18°42.9'	XBT8
8099		1431	1716	53°11.8'	18°43.0'	Mooring 126 (A)
8100	6	1927	2029	53°06.8'	19°07.9'	CTD14 (1500m)
8101		2156	2305	53°03.3'	19°31.1'	CTD15 (1500m)
8102	7	0050		52°59.6'	19°13.4'	XBT9
8103		0146	0255	52°54.9'	18°59.8'	CTD16 (1530m)
8104		0354	0418	52°50.3'	18°44.4'	CTD17 (200m)
8105		0520	0618	52°47.7'	18°31.0'	CTD18 (1501m)
8106		0650		52°51.9'	18°33.0'	XBT10
8107		1228	1346	53°11.8'	18°43.4'	Shear spar attached to "A" buoy
8108		1530	1550	(Within $\frac{1}{2}$ mile radius of 53 10.0'N, 18 46.4'W)		CTD19 (200m)
		1630	1650			CTD20 (200m)
		1730	1751			CTD21 (200m)
		1844	1907			CTD22 (200m)
		1944	2006			CTD23 (200m)
		2047	2106			CTD24 (200m)
		2144	2202			CTD25 (200m)
		2243	2305			CTD26 (200m)
		2344				CTD27 (200m)
	8		0003			
		0042	0105			CTD28 (200m)
		0144	0202			CTD29 (200m)
		0243	0303			CTD30 (200m)
		0345	0403			CTD31 (200m)
		0445	0503			CTD32 (200m)
		0543	0600			CTD33 (200m)
		0644	0701			CTD34 (200m)
		0744	0811			CTD35 (200m)
		0845	0910			CTD36 (200m)
		0945	1008			CTD37 (200m)
		1042	1100			CTD38 (200m)
		1140	1200			CTD39 (200m)
		1244	1306			CTD40 (200m)
		1346	1406			CTD41 (200m)
		1444	1503			CTD42 (200m)
		1545	1608			CTD43 (200m)
		1644	1707			CTD44 (200m)
		1744	1804			CTD45 (200m)
		1844	1905			CTD46 (200m)
		1943	2006			CTD47 (200m)
		2044	2103			CTD48 (200m)
		2144	2202			CTD49 (200m)
		2244	2307			CTD50 (200m)
		2344				CTD51 (200m)
	9		0003			

No.	Date	Time Start	Time End	N Lat.	W Long.	Observations
8108	9	0043	0100	Within $\frac{1}{2}$ mile radius of 53 10.0'N, 18 46.4'W		CTD52 (200m)
		0144	0202			CTD53 (200m)
		0244	0303			CTD54 (200m)
		0343	0402			CTD55 (200m)
		0443	0500			CTD56 (200m)
		0545	0603			CTD57 (200m)
		0643	0701			CTD58 (200m)
		0743	0802			CTD59 (200m)
		0846	0904			CTD60 (200m)
		0944	1006			CTD61 (200m)
		1045	1105			CTD62 (200m)
		1145	1206			CTD63 (200m)
		1244	1305			CTD64 (200m)
		1347	1406			CTD65 (200m)
		1445	1508			CTD66 (200m)
		1544	1605			CTD67 (200m)
		1644	1703			CTD68 (200m)
		1845	1904			CTD69 (200m)
		1943	2005			CTD70 (200m)
		2045	2104			CTD71 (200m)
		2144	2206			CTD72 (200m)
		2244	2304			CTD73 (200m)
		2343				CTD74 (200m)
	10		0003			
		0043	0103			CTD75 (200m)
		0143	0202			CTD76 (200m)
		0243	0302			CTD77 (200m)
		0343	0403			CTD78 (200m)
		0443	0504			CTD79 (200m)
		0544	0607			CTD80 (200m)
		0644	0702			CTD81 (200m)
		0743	0803			CTD82 (200m)
		0844	0904			CTD83 (200m)
		0943	1005			CTD84 (200m)
		1043	1105			CTD85 (200m)
		1143	1202			CTD86 (200m)
		1243	1304			CTD87 (200m)
8109		1402		53°11.0'	18°42.3'	12 m drogue launched
		1408	1608	53°11.0'	18°42.4'	CTD88 (5-50m, 36 dips)
		1624	1803	53°11.4'	18°41.9'	CTD89 (10-60m, 31 dips)
			1820	53°11.9'	18°44.7'	12 m drogue recovered
8110		1924	1948	53°12.1'	18°27.4'	CTD90 (200m)
8111		2046		53°10.5'	18°27.1'	XBT11
8112		2210	2232	53°06.3'	18°46.2'	CTD91 (200m)
8113		2356		53°01.6'	19°05.3'	CTD92 (200m)
	11		0016			
8114		0131	0155	52°55.5'	18°53.1'	CTD93 (200m)
8115		0319	0344	52°47.7'	18°37.5'	CTD94 (200m)

No.	Date	Time Start	Time End	N Lat.	W Long.	Observations
8116		0458	0520	52°42.4'	18°49.3'	CTD95 (200m)
8117		1151		52°58.9'	18°57.8'	XBT12
8118		1222		53°01.1'	19°06.3'	XBT13
8119		1247		53°01.6'	19°13.1'	XBT14
8120		1552		53°10.7'	18°43.3'	12 m drogue launched
		1600	1715	53°10.6'	18°43.7'	CTD96 (1500m)
			1924	53°11.6'	18°45.2'	12 m drogue recovered
8121		2029	2143	53°05.5'	18°51.6'	CTD97 (1500m)
8122		2235	2345	52°59.7'	18°59.5'	CTD98 (1500m)
8123	12	0031	0143	52°53.8'	19°03.0'	CTD99 (1500m)
8124		0231	0343	52°48.7'	19°07.6'	CTD100 (1500m)
8125		0553	0917	52°55.4'	18°37.6'	Mooring 129 (C2 relaid)
8126		0949		52°58.9'	18°38.3'	XBT15
8127		1134	1253	53°10.9'	18°42.6'	CTD101 (1500m)
8128		1338	1444	53°04.7'	18°43.0'	CTD102 (1500m)
8129		1539		52°57.7'	18°42.8'	20 m drogue launched
		1546	1704	52°58.0'	18°42.5'	CTD103 (1500m)
	(13		1424	53°12.5'	18°32.6'	20 m drogue recovered)
8130	12	1757	1913	52°55.9'	18°51.4'	CTD104 (1500m)
8131		2010	2124	52°51.4'	19°02.3'	CTD105 (1500m)
8132		2215	2327	52°48.2'	19°13.4'	CTD106 (1500m)
8133	13	0203	0311	52°59.8'	18°34.2'	CTD107 (1500m)
8134		0419	0527	53°05.8'	18°46.2'	CTD108 (1500m)
8135		0615	0719	53°10.3'	18°55.3'	CTD109 (1500m)
8136		1800		53°07.1'	18°43.2'	12 m drogue launched
		1801	1858			CTD110 (100m, 6 dips)
		1940	2028			CTD111 (90m 5 dips)
		2100	2158			CTD112 (90m, 6 dips)
		2230	2328			CTD113 (90m, 6 dips)
	14	0000	0058			CTD114 (90m, 6 dips)
		0130	0229			CTD115 (90m, 6 dips)
		0300	0359			CTD116 (90m, 6 dips)
		0430	0529			CTD117 (90m, 6 dips)
		0600	0659			CTD118 (90m, 6 dips)
		0730	0828			CTD119 (90m, 6 dips)
		0900	0958			CTD120 (90m, 6 dips)

No.	Date	Time Start	Time End	N Lat.	W Long.	Observations
8136	14	1030	1128			CTD121 (90m, 6 dips)
(Cont'd)		1159	1300			CTD122 (90m, 6 dips)
		1330	1429			CTD123 (90m, 6 dips)
		1500	1600			CTD124 (90m, 6 dips)
		1630	1728			CTD125 (90m, 6 dips)
		1800	1859			CTD126 (90m, 6 dips)
		1930	2029			CTD127 (90m, 6 dips)
		2100	2159			CTD128 (90m, 6 dips)
			2208	53°14.6'	18°39.7'	12 m drogue recovered
8137	15	1452		53°07.9'	18°45.3'	12 m drogue launched
		1513		53°08.4'	18°44.5'	CTD129 (10-40m, 14 dips,
			1604	53°07.5'	18°45.3'	towing CTD at 1½ kts)
		1631		53°08.5'	18°45.2'	CTD130 (10-40m, 10 dips,
			1710	53°08.1'	18°42.8'	towing CTD at 1½ kts)
		1800	1858			CTD131 (90m, 6 dips)
		1930	2030			CTD132 (90m, 6 dips)
		2100	2159			CTD133 (90m, 6 dips)
		2230	2330			CTD134 (90m, 6 dips)
	16	0000	0059			CTD135 (90m, 6 dips)
		0130	0229			CTD136 (90m, 6 dips)
		0300	0400			CTD137 (90m, 6 dips)
		0430	0529			CTD138 (90m, 6 dips)
		0600	0659			CTD139 (90m, 6 dips)
		0730	0828			CTD140 (90m, 6 dips)
		0900	0958			CTD141 (90m, 6 dips)
		1030	1128			CTD142 (90m, 6 dips)
		1200	1240			CTD143 (90m, 6 dips)
			1326	53°16.9'	18°35.3'	12 m drogue recovered
8138		1447		53°08.4'	18°44.1'	12 m drogue launched
		1500	1600			CTD144 (90m, 6 dips)
		1630	1729			CTD145 (90m, 6 dips)
		1800	1859			CTD146 (90m, 6 dips)
		1930	2029			CTD147 (90m, 6 dips)
		2100	2159			CTD148 (90m, 6 dips)
		2230	2329			CTD149 (90m, 6 dips)
	17	0000	0058			CTD150 (90m, 6 dips)
		0130	0228			CTD151 (90m, 6 dips)
		0300	0358			CTD152 (90m, 6 dips)
		0430	0528			CTD153 (90m, 6 dips)
		0600	0658			CTD154 (90m, 6 dips)
			0720	53°15.8'	18°32.2'	12 m drogue recovered
8139		0906	1021	53°13.6'	18°38.4'	CTD155 (1500m)
8140		1127	1240	53°11.2'	18°44.7'	CTD156 (1500m)
8141	[illegible]	1345	1455	53°18.4'	18°44.4'	CTD157 (1500m)
8142		1544	1700	53°18.4'	18°32.0'	CTD158 (1500m)
8143		1925	2036	53°24.1'	18°58.7'	CTD159 (1500m)
8144		2116	2229	53°20.5'	18°52.7'	CTD160 (1500m)

No.	Date	Time Start	Time End	N Lat.	W Long.	Observations
8145	18	0014	0127	53°11.0'	18°31.0'	CTD161 (1500m)
8146		0204	0313	53°08.1'	18°26.3'	CTD162 (1500m)
8147		0349	0500	53°04.0'	18°21.0'	CTD163 (1500m)
8148		1815	1926	53°27.7'	18°17.2'	CTD164 (1500m)
8149		2009	2127	53°24.5'	18°23.3'	CTD165 (1500m)
8150		2357		53°09.0'	18°49.1'	CTD166 (1500m)
	19		0106			
8151		0213	0321	53°12.0'	19°04.1'	CTD167 (1500m)
8152		0419	0523	53°06.0'	18°55.1'	CTD168 (1500m)
8153		0624	0726	53°01.3'	18°45.2'	CTD169 (1500m)
8154		1109	1121	53°16.7'	18°35.8'	CTD170 (200m)
8155		1316	1334	53°16.5'	18°35.5'	CTD171 (30m, 6 dips)
		1412	1427	53°16.7'	18°34.9'	CTD172 (30m, 6 dips)
8156		1731		53°04.0'	19°11.2'	XBT16
8157		2041		52°57.8'	19°30.5'	XBT17
8158		2205		52°51.8'	19°48.1'	XBT18
8159		2344		52°45.5'	20°05.8'	10 m drogue launched
		2358				CTD173 (90m, 4 dips;
	20		0103			80m, 2 dips)
		0130	0229			CTD174 (80m, 6 dips)
		0300	0358			CTD175 (80m, 6 dips)
		0400	0421			CTD176 (10-40m, 9 dips)
		0440	0459			CTD177 (15-40m, 9 dips)
		0522	0552			CTD178 (35m, 11 dips)
		0620	0652			CTD179 (36m, 12 dips)
		0720	0753			CTD180 (35m, 13 dips)
		0820	0853			CTD181 (35m, 13 dips)
			0905	52°44.6'	20°06.7'	10 m drogue recovered
8160		1124	1200	52°45.7'	20°02.4'	VACM cage spar attached to B1
8161		1303	1335	52°45.7'	20°02.6'	CTD182 (35m, 13 dips)
8162		1850	1923	52°45.3'	20°02.4'	CTD183 (35m, 12 dips)
		1949	2023			CTD184 (35m, 40m, 11 dips)
		2050	2123			CTD185 (40m, 12 dips)
		2150	2223			CTD186 (40m, 5 dips; 35m, 7 dips)
		2250	2323			CTD187 (35m, 11 dips)
		2350				CTD188 (35m, 11 dips)
	21		0021			
		0050	0122			CTD189 (35m, 10 dips)
		0150	0223			CTD190 (35m, 9 dips; 40m)
		0250	0322			CTD191 (40m,3 dips; 35m,8 dips)

No.	Date	Time Start	Time End	N Lat.	W Long.	Observations
8162 (cont'd)	21	0351	0420	52°45.3'	20°02.4'	CTD192 (40m;35m,7 dips,5-35m 2 dips)
		0451	0522			CTD193 (5-35m,6 dips;8-40m,6 dips)
		0551	0619			CTD194 (5-50m, 9 dips)
		0652	0721			CTD195 (5-50m, 9 dips)
		0749	0824			CTD196 (5-50m, 11 dips)
		0851	0926			CTD197 (5-50m, 11 dips)
		0951	1026			CTD198 (5-50m, 11 dips)
		1049	1123	52°45.4	20°03.1'	CTD199 (5-50m, 11 dips)
8163		1314	1425	52°46.3'	20°03.2'	EM spar attached to B1 & VACM spar)
8164		1439	1514	52°46.6'	20°03.1'	CTD200 (5-50m, 12 dips)
8165		1600	1640	52°46.9'	20°02.7'	PRB1
		1705	1737			CTD201 (5-50m, 10 dips)
		1804	1837			CTD202 (5-50m, 11 dips)
		1906	1941			PRB2
		2005	2035			CTD203 (5-50m, 9 dips)
		2105	2136			CTD204 (5-50m, 10 dips)
		2204	2240			PRB3
		2304	2336			CTD205 (5-50m, 9 dips)
	22	0004	0039			CTD206 (5-50m, 10 dips)
		0100	0123			PRB4
		0203	0238			CTD207 (5-50m, 10 dips)
		0303	0337			CTD208 (5-50m, 10 dips)
		0502	0539			CTD209 (5-50m, 10 dips)
		0605	0637			CTD210 (5-50m, 9 dips)
		0702	0740			CTD211 (5-50m, 10 dips)
		0805	0836			CTD212 (5-50m, 9 dips)
		0900	0935			CTD213 (30-45m11 dips;10-50m,7 dips)
		0950	1020			CTD214 (10-50m, 10 dips)
		1050	1122			CTD215 (10-50m, 11 dips)
		1154	1221			CTD216 (10-50m, 9 dips)
		1253	1321			CTD217 (10-50m, 11 dips)
		1350	1420			CTD218 (10-50m, 13 dips)
		1450	1522			CTD219 (10-50m, 10 dips)
		1536		52°49.7'	19°58.7'	XBT19
		1545				XBT20
		1615				XBT21 (no record obtained)
		1645				XBT22
		1715				XBT23
		1745				XBT24
		1815		52°50.3'	19°59.6'	XBT25
8166		1850		52°51.1'	19°59.7'	CTD220 (10-50m 35 dips,
			2047	52°54.3'	19°59.4'	lying to)
8167		2132		52°52.0'	19°59.4'	CTD221 (10-50m, 38 dips,
			2325	52°53.6'	20°01.7'	lying to)
8168	23	0001		52°52.0'	19°59.8'	CTD222 (10-50m, 37 dips,
			0200	52°55.0'	19°59.0'	lying to)
8169		0403	0437	52°52.7'	20°00.2'	CTD223 (10-50m, 10 dips)
8170		0605	0631	52°52.9'	19°59.5'	CTD224 (10-50m, 9 dips)

No.	Date	Time Start	Time End	N Lat.	W Long.	Observations
8171	23	1217	1300	52°54.3'	19°57.3'	CTD225 (10-50m, 13 dips)
8172		2337		52°56.5'	19°57.4'	CTD226 (5-50m, 19 dips)
	24		0045			
8173		0123	0207	52°54.6'	19°58.5'	CTD227 (5-50m, 13 dips)
8174		0315	0546	52°57.0'	20°01.0'	Effect of relative wind on pressure
8175		0657	0727)	53°00.8'	20°05.2'	CTD228 (5-50m, 9 dips)
		0800	0832)			CTD229 (5-50m, 10 dips)
8176		1232	1327)	52°58.5'	19°56.9'	CTD230 (5-50m,2 dips; 5-80m,8 dips)
		1400	1505)			CTD231 (5-90m, 11 dips)
8177		1645	1758	52°58.9'	19°58.6'	VACM sphere and EM spar attached to B1 and VACM spar
		1934	2010	52°58.8'	19°59.0'	CTD232 (5-90m, 5 dips)
		2049	2150			CTD233 (5-85m, 10 dips)
		2235	2305			PRB5
		2348				CTD234 (5-85m, 11 dips)
	25		0054			
		0133	0210			PRB6
		0252	0353			CTD235 (5-85m, 11 dips)
		0434	0512			PRB7
		0551	0649			CTD236 (5-85m, 10 dips)
		0732	0810			PRB8
		0850	0952			CTD237 (5-85m, 10 dips)
		1030	1106			PRB9
		1148	1252			CTD238 (5-85m, 10 dips)
		1330	1405			PRB10
		1605	1629			CTD239 (5-85m 5 dips)
		1631	1708			PRB11
		1751	1853			CTD240 (5-85m, 10 dips)
		1933	2006			PRB12
		2050	2155			CTD241 (5-85m, 10 dips)
		2233	2306	53°04.0'	19°59.7'	PRB13
8178		2348		53°03.2'	19°59.2'	CTD242 (5-85m, 9 dips)
	26		0052			
		0130	0202			PRB14
		0250	0356			CTD243 (5-85m, 11 dips)
		0430	0505			PRB15
		0548	0657			CTD244 (5-85m, 10 dips)
		0729	0801			PRB16
		0850	0957			CTD245 (5-85m, 9 dips)
		0925		53°03.2'	19°59.6'	12 m drogue launched
		1032	1107			PRB17
		1148	1250			CTD 246 (5-85m, 9 dips
		1333	1406			PRB18
		1449	1555			CTD247 (5-85m, 9 dips)
		1630	1705			PRB19
		1752		53°05.2'	19°57.9'	12m drogue recovered
8179		2022	2110	52°58.1'	20°10.2'	CTD248 (85m, 6 dips)

No.	Date	Time Start	Time End	N Lat.	W Long.	Observations
8180		2218	2307	53°06.7'	20°19.1'	CTD249 (85m, 7 dips)
8181		2316		53°07.2'	20°20.0'	Effect of relative wind on pressure measurements
	27		0132			
8182		0257	0352	53°18.4'	20°06.8'	CTD250 (5-85m, 9 dips)
8183		0503	0544	53°17.7'	19°52.8'	CTD251 (5-85m, 8 dips)
8184		0708	0800	53°08.8'	19°42.4'	CTD252 (5-85m, 10 dips)
8185		1420		52°56.0'	19°31.6'	XBT26
8186		1502		52°52.7'	19°21.6'	XBT27
8187		1610		52°47.2'	19°04.0'	XBT28
8188		1711		52°43.3'	18°47.9'	XBT29
8189		2346		52°52.0'	18°24.2'	CTD253 (1500 m)
	28		0050			
8190		0307	0441	52°51.2'	18°50.6'	CTD254 (1500 m)
8191		0844	1013	53°04.2'	18°39.5'	CTD255 (1500 m)
		1026	1334	53°05.4'	18°42.1'	CTD256 (5-75m, 36 dips)
8192	29	2203		50°16.9'	13°00.5'	CTD257 (2003m), multi-sampler
	30		0049			
		0253	0430	50°16.2'	13°00.6'	CTD258 (2011m), multi-sampler

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TABLE 2

List of radiosonde flights

s = single balloon flight. d = double balloon flight.

Launch No.	Time(GMT)/ Date	Type	Maximum Height mb	Ascent rate ms^{-1}	Descent rate ms^{-1}	Comments
D 1	1432/2	d	750	5.0	2.5	Practice flight
D 2	1218/5	d	-	-	-	Practice flight, signals lost
D 3	1317/5	d	766	5.2	3.1	Practice flight
D 4	1312/7	d	780	4.8	4.4	
D 5	1511/7	d	700	5.9	3.0	
D 6	1708/7	d	713	6.7	3.0	
D 7	1908/7	d	714	6.1	2.6	No Loran signals from sonde
D 8	2115/7	d	-	-	-	<u>Researcher</u> sonde tracked
D 9	2218/7	d	821	3.4	-	Descent balloon burst in flight
D 10	2308/7	d	792	5.4	2.3	
D 11	0108/8	d	764	3.2	2.8	
D 12	0315/8	d	747	4.5	1.9	Poor Loran signals from sonde
D 13	0520/8	d	717	5.2	2.2	
D 14	0715/8	d	737	5.0	2.2	
D 15	0911/8	d	859	5.4	2.7	
D 16	1100/8	d	760	5.7	2.6	
D 17	1312/8	d	835	5.8	3.4	
D 18	1506/8	d	700	5.4	1.7	
D 19	1710/8	d	-	-	-	Sonde transmitter failure
D 20	1817/8	d	810	3.2	-	Descent balloon burst during launch
D 21	1915/8	d	675	4.9	2.6	Loran receiver oscillated
D 22	2115/8	d	976	-	-	Early release
D 23	2145/8	d	730	5.5	2.6	Poor Loran signals from sonde
D 24	2315/8	d	725	6.0	1.2	
D 25	0113/8	d	807	5.8	2.1	
D 26	0309/9	d	716	5.5	1.8	
D 27	0510/9	d	715	5.5	2.7	
D 28	0706/9	d	765	5.4	1.7	
D 29	0912/9	d	692	6.9	2.5	
D 30	1107/9	d	740	5.1	2.5	
D 31	1327/9	d	708	5.3	2.0	
D 32	1515/9	d	735	5.1	2.2	
D 33	1714/9	d	674	5.4	2.0	
D 34	1923/9	d	630	5.4	1.6	
D 35	2109/9	d	733	4.6	2.5	
D 36	2324/9	d	720	5.4	0.7	
D 37	0120/10	d	718	5.2	2.8	
D 38	0309/10	d	762	4.2	-	Descent balloon burst in flight
D 39	0507/10	d	727	5.1	1.8	
D 40	0705/10	d	722	4.6	-	Continued upwards after release
D 41	0914/10	d	-	-	-	Transmitter failure
D 42	1006/10	d	709	5.4	2.3	
D 43	1107/10	d	676	5.2	3.3	Loran receiver oscillated
D 44	1309/10	d	699	5.0	2.7	
D 45	1447/11	s	98	6.2	-	Radiosonde test flight
D 46	1915/11	s	65	5.5	-	Radiosonde test flight, receiver oscillated

Launch No.	Time(GMT)/ Date	Type	Maximum Height mb	Ascent rate ms^{-1}	Descent rate ms^{-1}	Comments
D 47	1116/14	d	716	4.9	3.2	
D 48	1303/14	d	780	5.0	2.2	
D 49	1408/14	d	709	4.5	2.5	
D 50	1506/14	d	755	4.4	3.3	
D 51	1615/14	d	-	-	-	Transmitter failure
D 52	1740/14	d	769	4.9	1.8	
D 53	2308/14	s	-	-	-	Humidity and Loran signals only
D 54	2355/14	s	48	6.2	-	
D 55	0507/15	s	40	5.3	-	
D 56	1105/15	s	335	5.3	-	Terminated by transmitter failure
D 57	1509/15	s	555	5.9	-	Terminated by transmitter failure
D 58	1708/15	s	168	6.2	-	
D 59	1905/15	d	669	5.5	2.5	
D 60	1112/16	d	720	4.8	2.1	
D 61	1210/16	d	813	4.6	3.3	
D 62	1312/16	d	724	4.7	1.9	
D 63	1408/16	d	765	4.7	4.2	No Loran signals from sonde
D 64	1509/16	d	714	5.2	-	Descent balloon burst
D 65	1610/16	d	734	4.8	1.3	
D 66	1710/16	d	712	5.0	3.2	
D 67	1812/16	d	715	4.9	2.3	
D 68	1910/16	d	738	4.5	4.3	
D 69	2015/16	d	-	-	-	Sonde transmitter aerial broke off
D 70	2104/16	d	658	4.3	-	Descent balloon burst
D 71	2307/16	d	731	5.1	1.9	
D 72	0107/17	d	702	4.9	2.1	
D 73	0317/17	d	680	5.2	2.9	
D 74	0529/17	d	664	5.4	1.5	
D 75	0711/17	d	673	5.3	-	Descent balloon burst
D 76	0925/17	d	823	4.6	1.2	
D 77	1100/17	d	743	5.2	1.1	
D 78	1305/17	d	725	5.3	1.5	
D 79	1512/17	d	719	5.5	1.6	
D 80	1706/17	d	710	5.3	1.3	
D 81	2301/17	s	312	6.8	-	Temperature only above 312 mb
D 82	1256/18	s	214	5.7	-	
D 83	2315/18	s	110	5.8	-	
PA4 263 D 84	1351/19	s	96	6.5	-	
D 85	2309/19	s	362	5.9	-	
264 D 86	1312/20	s	232	5.6	-	
D 87	2315/20	s	57	6.2	-	
265 D 88	1340/21	s	81	5.3	-	
D 89	2315/21	s	44	6.1	-	
D 90	1328/23	s	175	5.7	-	
D 91	2309/23	s	124	6.0	-	Loran receiver oscillated
D 92	0734/24	d	693	6.4	2.0	
D 93	0823/24	d	715	5.2	3.2	
D 94	0908/24	d	727	5.6	1.9	
D 95	1006/24	d	705	5.2	-	Descent balloon burst
D 96	1105/24	d	745	5.6	-	Continued upwards after release
D 97	1204/24	d	904	6.6	1.4	Early release
D 98	1308/24	d	725	5.6	1.1	
D 99	1415/24	d	759	5.7	1.3	
D100	1515/24	d	748	2.3	-	Descent balloon burst

Launch No.	Time (GMT)/ Date	Type	Maximum Height mb	Ascent rate ms^{-1}	Descent rate ms^{-1}	Comments
D101	1605/24	d	751	5.0	1.8	
D102	1703/24	d	767	6.1	-	Descent balloon burst
D103	1806/24	d	770	5.1	-	Descent balloon burst
D104	1905/24	d	730	4.8	1.3	
D105	1308/25	s	83	6.6	-	
D106	2321/25	s	80	6.8	-	
D107	0903/26	d	706	5.9	1.7	
D108	0945/26	d	810	4.9	0.9	Detailed humidity and wind traces only
D109	1109/26	d	700	5.9	1.7	
D110	1309/26	d	711	5.9	3.8	
D111	1408/26	d	735	5.8	1.5	
D112	1510/26	d	826	4.8	1.6	Early release
D113	1616/26	d	713	5.6	2.0	
D114	1713/26	d	760	5.1	-	Descent balloon burst
D115	2253/26	s	55	5.9	-	
D116	1320/27	s	75	6.4	-	
D117	2345/27	s	-	-	-	Baroswitch not set
D118	0035/28	s	-	-	-	Oscillated, poor met. data
D119	1312/28	s	109	6.0	-	

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TABLE 3

Moorings

117 Subsurface. Set 1114Z/18.5.72 Lat. 52°59.0'N, Long. 17°45.0'W.
Recovered 0453Z/15.9.72 same position
Water depth 4060 m. Float depth 146 m.

Instrument	Serial No.	Depth (m)	Remarks
Aanderaa CM	154	158	Rotor damaged
" "	219	466	
Braincon "	111	1995	Some corrosion
Aanderaa CM (deep)	420/73	3010	

118 Not recovered. Subsurface float probably collapsed.

122 (C2) Subsurface. Set 1123Z/3.9.72 Lat. 52°55.0'N, Long. 18°43.2'W.
Recovered 0852Z/11.9.72 same position.
Water depth 3030 m. Float depth 35 m.

Instrument	Serial No.	Depth (m)	Remarks
Aanderaa CM	282/75	38	Re-used on mooring 129
" "	465	49	" " " "
" "	278	99	Flooded
" "	279	202	Tape not removed, lost on mooring 129
" "	281	511	-ditto-
" "	304	1019	-ditto-
" "	464	2028	-ditto-

123 (B2) Surface. Set 1550Z/4.9.72 Lat. 52°24.9'N, Long. 18°39.5'W.
Recovered 1800Z/27.9.72 Lat. 52°40.8'N, Long. 18°35.9'W.
Water depth 4241 m.

Instrument	Serial No.	Depth (m)	Remarks
MO Met. package	-	-	On surface buoy
Aanderaa met. package	89	-	(OSU) "
Pressure sensor and telemetry	-	-	(U. of Miami) "
Pyranometer	-	-	(WHOI) "
Aanderaa CM	467	10	Rotor No.311 used
Plessey therm. chain	243		(Hydrog.Dept., MOD)
Thermistor No.	6	47	
"	2	57	
"	5	62	
"	4	72	
"	1	77	
"	3	82	

124 (C1) Subsurface. Set 1140Z/5. 9.72 Lat. 53°02.4'N, Long. 19°11.2'W.
Recovered 1826Z/23.9.72 same position
Water depth 2582 m. Float depth 36 m.

Instrument	Serial No.	Depth (m)	Remarks
Aanderaa CM	155	39	
" "	75/282	50	
" "	466	102	
" "	156	217	
" "	280	525	
" "	301	1034	
" "	305	2075	

125 (B1) Surface. Set 1722Z/5. 9.72 Lat. 52°45.9'N, Long. 20°02.6'W,
(until p.m. 21.9.72)
Recovered 1000Z/27.9.72 Lat. 53°04.2'N, Long. 19°59.3'W.
Initial water depth 2500 m.

Instrument	Serial No.	Depth (m)	Remarks
Aanderaa met. package (incl. humidity sensor)	57	-	(OSU) on surface buoy
Pyranometer	-		(WHOI) -ditto-
Pressure sensor and telemetry	-		(U. of Miami) -ditto-
Aanderaa CM	468	10	Lost its rotor
Aanderaa therm. chain	76	30-80	
Aanderaa therm. logger	81	81	

Extra items tethered to mooring 125:

(a) VACM cage spar. Attached 1154Z/20.9.72. Removed 0930Z/27.9.72. Length of line from B1 to spar = 132 m, from spar to dan buoy = 46 m.

Instrument	Serial No.	Depth (m)
VACM	158	5
"	155	10
"	130	25
"	132	30

(b) EM spar. Attached to VACM cage spar 1422Z/21.9.72. Removed 1339Z/23.9.72. Length of line from VACM cage spar to EM spar = 47 m, from EM spar to dan buoy = 52 m. Sensors (2-compt. EM current meters) on EM spar at 2, 5 and 10 m depths.

(c) VACM sphere mooring. Attached to VACM cage spar 1710Z/24.9.72. Removed 1850Z/26.9.72. Length of line from VACM cage spar to VACM sphere mooring = 64 m.

Instrument	Serial No.	Depth (m)
VACM	157	5
"	156	35
"	159	40

(d) EM spar. Attached to VACM sphere mooring 1742Z/24.9.72. Removed 1824Z/26.9.72. Length of line from VACM sphere to EM spar = 81 m, from EM spar to dan buoy = 52 m. Sensors (2-compt. EM current meters) at 5 and 10 m depths.

126 (A) Surface. Set 1716Z/6. 9.72 Lat. 53°11.8 N, Long. 18°43.0'W.
Recovered 1110Z/19.9.72 Lat. 53°16.6 N, Long. 18°35.9'W.
Water depth 2470 m.

Instrument	Serial No.	Depth (m)	Remarks
WHOI met. package	-	-	On surface buoy
Pyranometer	-	-	(WHOI) " "
Aanderaa met. package	90	-	(OSU) " "
VACM	157	10	
Aanderaa CM	469	12	Suspension rod bent
VACM	158	33	

Extra item tethered to mooring 126:

Shear spar. Attached 1346Z/7.9.72. Removed 1611Z/18.9.72. Length of line from A to spar = 132 m, from spar to dan buoy = 46 m.

Instrument	Serial No.	Depth (m)
VACM	159	28
"	156	32
"	130	36
"	155	40
"	132	44

127 (D1) Surface. Set 1713Z/4. 9.72 by Researcher, Lat. 52°53.8'N, Long. 19°47.6'W.
Recovered 0924Z/24.9.72. Lat. 53°00.8'N, Long. 20°05.4'W.
Water depth 2650 m.

Instrument	Serial No.	Depth (m)	Remarks
Aanderaa met.package	60	-	(OSU) on surface buoy
Aanderaa CM	308	10	Suspension rod bent
Aanderaa therm. logger	82	29	(OSU)
Aanderaa therm. chain	77	30-80	-ditto-

128 (D2) Surface. Set 1453Z/5. 9.72 by Researcher, Lat. 52°41!6 N, Long. 19°45.2'W.
Recovered 0921Z/23.9.72. Lat. 52°41.6 N, Long. 19°52.3 W.
Water depth 2522 m.

Instrument	Serial No.	Depth (m)	Remarks
Aanderaa met.package	88	-	(OSU) on surface buoy
Aanderaa CM	312	10	
Aanderaa therm. logger	83	29	(OSU)
Aanderaa therm. chain	78	30-80	-ditto-

129 (C2, mooring 122 reset). Subsurface. Set 0917Z/12.9.72
Lat. 52° 55.4 'N, Long. 18° 37.6 'W.
Released 0650Z/28.9.72 same position.
Water depth 3043 m. Float depth 27 m. Wire broke during recovery, lowest 5 current meters lost.

Instrument	Serial No.	Depth (m)	Remarks
Aanderaa CM	282/75	30	
" "	465	41	
" "	311	84	Lost
" "	279	187	"
" "	281	497	"
" "	304	1005	"
" "	464	2014	"

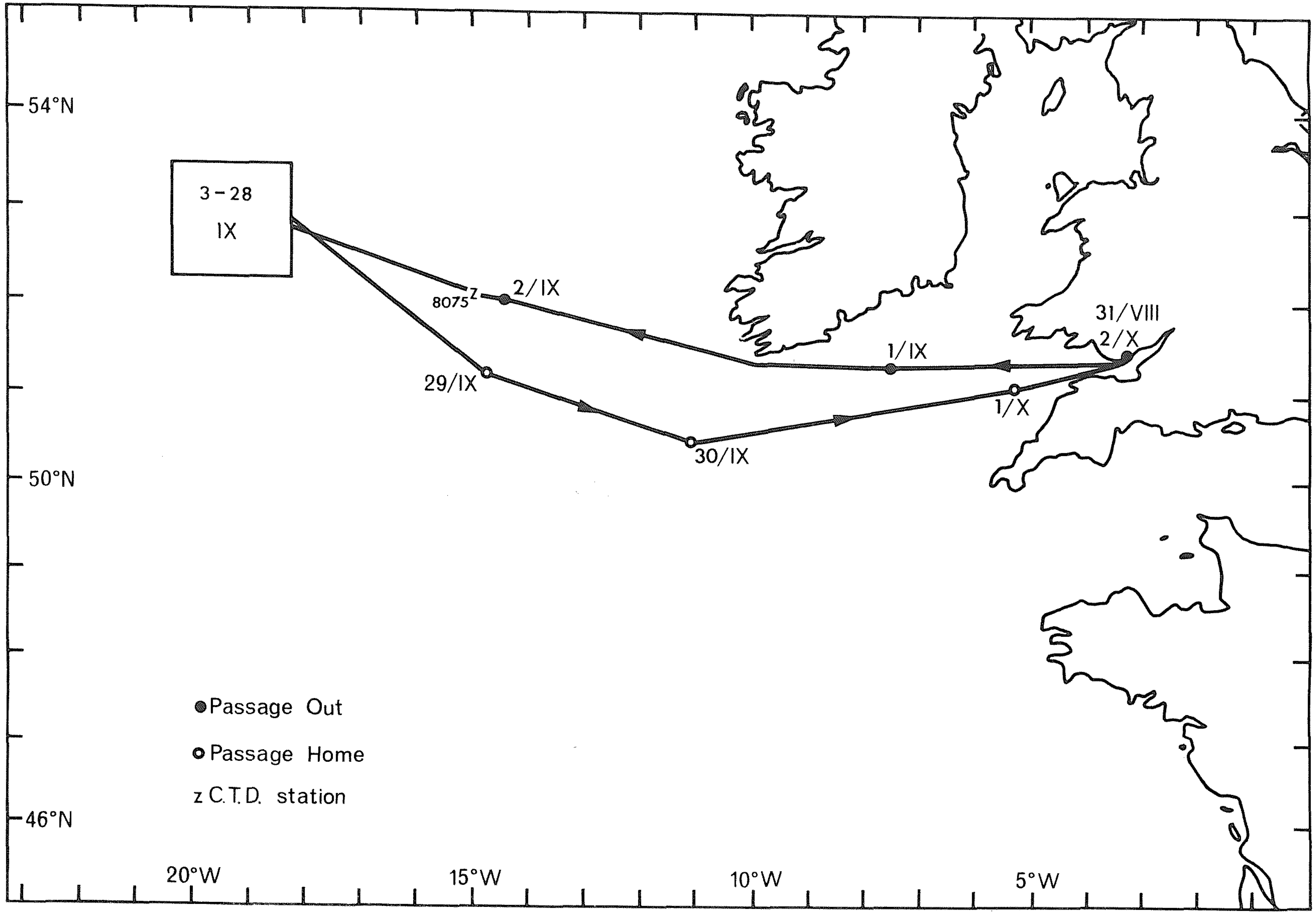

Fig.1 DISCOVERY CRUISE 49 Noon Positions

Fig. 2a Discovery Cruise 49 Stations 3–28·IX·72

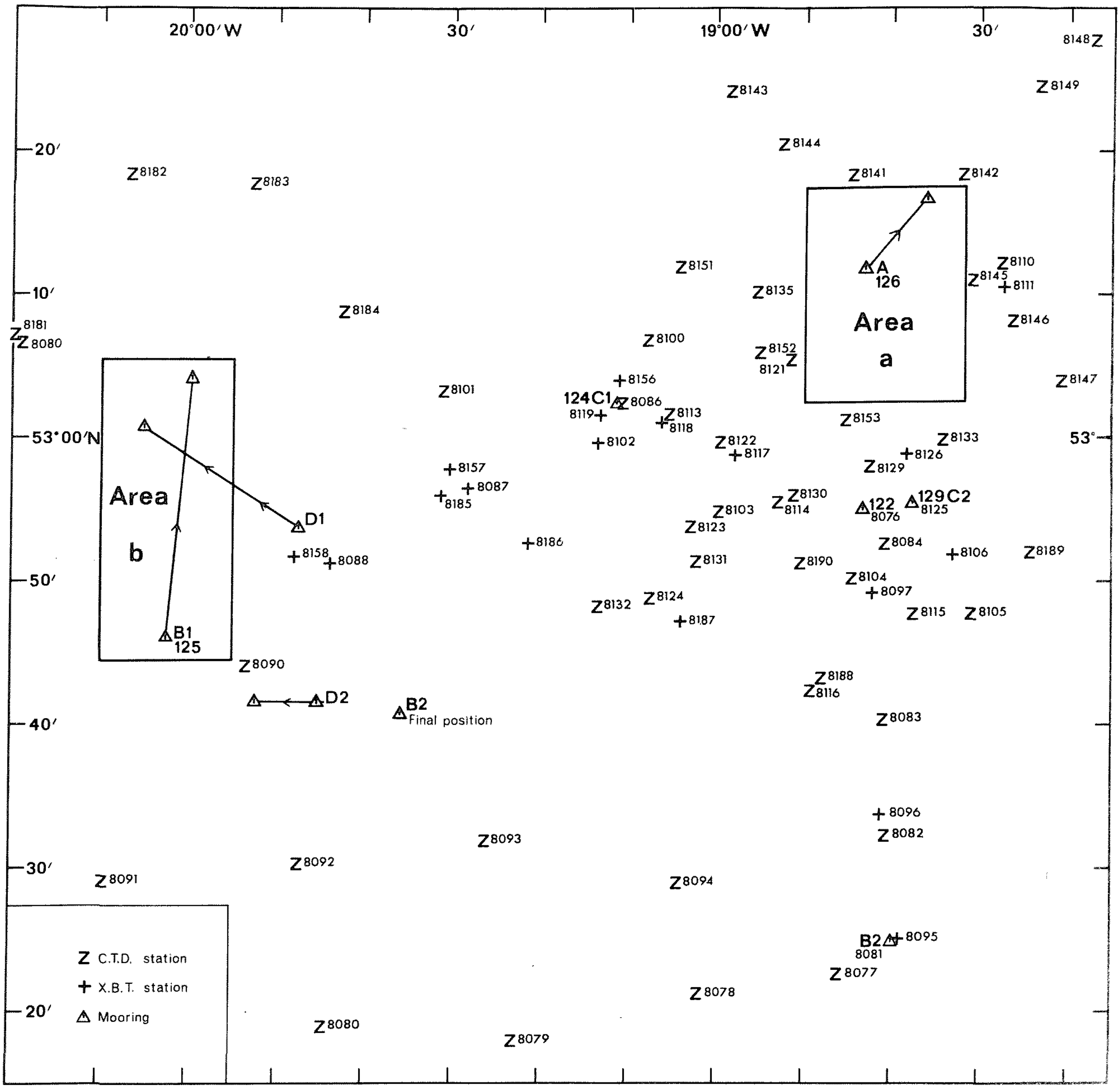

Fig. 2b Stations 3–28·9·72, Area a

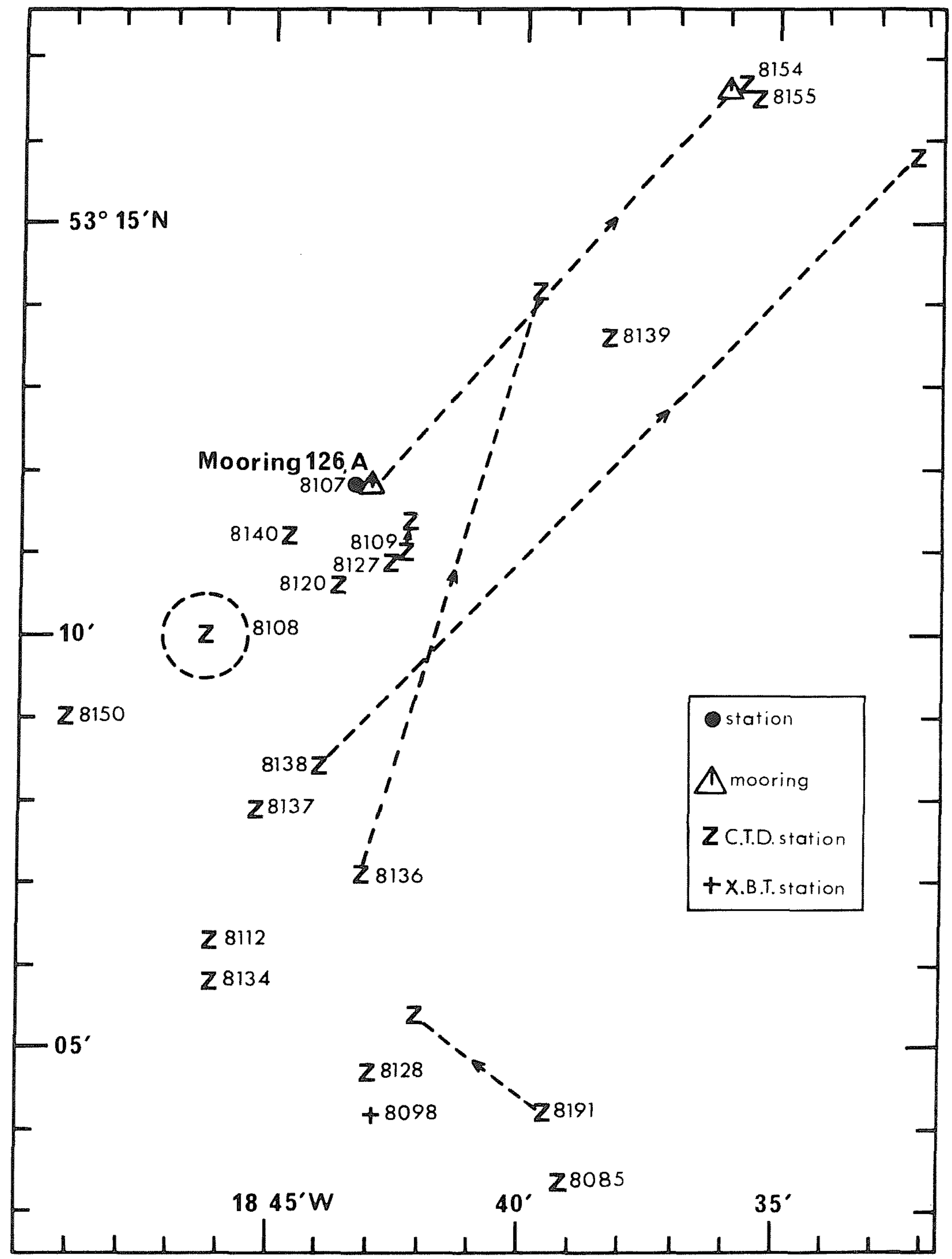

Fig. 2c Stations 3-28·9·72, Area b