NATIONAL INSTITUTE OF OCEANOGRAPHY

WORMLEY, GODALMING, SURREY

R.R.S. DISCOVERY

CRUISE 53

April - June 1973

PHYSICAL OCEANOGRAPHY IN THE WESTERN NORTH ATLANTIC OCEAN

(contribution to MODE-1)

N.I.O. CRUISE REPORT No. 58

1973

Index

Introduction

The purpose of 'Discovery' Cruise 53 was to contribute to the first Mid-Ocean Dynamics Experiment, MODE-1. This project is part of the Environmental Forecasting Program of the International Decade of Ocean Exploration. Its purpose is to study the role of medium-scale geostrophic eddies in the general circulation of the oceans.

The observational phase of MODE-1 consisted of a large number of loosely coordinated experiments involving a total of six ships and two aircraft working within a circular area of 300 km radius centred on 28°N, 69°40'W, during the four months mid-March to mid-July 1973. Three main experiments formed a framework within which the others fitted. They were (1) an array of 16 current meter moorings set out by the WHOI buoy group, and supplemented by more moorings from the University of Rhode Island, and NIO, (2) a flock of about 20 Sofar floats tracked from shore-based hydrophones (a joint WHOI-Yale University project) and (3) a grid of hydrographic stations, reoccupied several times during the whole experiment, to which all the ships contributed to a greater or less extent.

'Discovery's' part in MODE-1, besides contributing to the mooring array and the density survey, was to operate the Minimode float tracking system. Thirty-six recoverable transponding floats were available, intended for use at any depth from 500 to 4000 m. The tracking system was designed to give ranges simultaneously on up to 18 floats, whilst making hydrographic observations with the STD or CTD. The plan was to track floats, set initially 5 to 20 km apart, in an area to the west of the centre, on the abyssal plain, during April, and in the eastern region of rough topography during May. Apart from losing three current meters when a mooring wire broke, which reduced the number of NIO moorings from five to four, the 'Discovery' programme was carried out more or less as intended. The four moorings set were recovered successfully. A total of 134 CTD lowerings was made to 3000 m, and 9 to shallower depths. These were supplemented by water bottle casts from 3000 m to near bottom at 25 stations. A total of 52 float trajectories was collected, with a total duration of 714 days. Eleven of the floats were not recovered, but all of them transponded as expected when within range.

Narrative

Leg 1

Discovery sailed from St George, Bermuda at 0900 local time (1300 Z) on April 1st. On the passage out to the first current meter mooring position, N4, the new 6000 m length of armoured electric cable was wound on to the electric hydrographic winch in the forward hold, and two stations were occupied (using the midships steam winch) at 380 km and 280 km from the centre of the MODE area. These stations were to 3000 m depth, using the CTD sea unit with the Rosette multisampler. A brief bathymetric survey was made around the nominal N4 mooring position on arriving there in the evening of April 2nd, and the mooring was set early next morning. Continuing to the N2 mooring position, the new length of armoured electric cable was tensioned first, then a start was made at setting N2. When that was almost completed, a length of Brunton's 6 mm wire broke at a swaged end, with the loss of 3 current meters and an acoustic release and command pinger. New wires were wound on the winch and tensioned and a substitute for N2 was set a few miles north of the lost mooring, in the evening of April 3rd. Early next morning, a test lowering was made with the acoustic interrogator array for the Minimode floats combined with the CTD and multisampler. Test lowerings with an acoustic release and float circuits followed, and bathymetric surveys of the sites for moorings N1 and N3. The latter mooring was set in the afternoon of April 4th, and the final mooring N1 was set next morning. Although these moorings were in the "rough" area the region around each of the sites had only a small slope, and no difficulty was experienced in setting the moorings in the intended depths of water.

Moving then to the position for starting float tracking, about 20 km south of No 3 mooring on the abyssal plain, three floats were launched in the evening of April 5th. They were loaded for 500, 1500 and 3000 m depths. They were tracked using the towed interrogator fish, and the array lowered with the CTD, for nearly two days, when more floats were launched. The two deep ones had moved slightly west of north at about 2 cm/sec, so the new deep floats were started 20 km 080° from the existing ones. These were loaded for 1500, 3000 and 4000 m depths, and a 4000 m float was added to the first group. The 500 m float had moved northeast at 10 cm/sec, and in the evening of April 7th its recovery was attempted, so that it could be restarted upstream of the working area. The release circuit switched but the float showed no signs of coming up: this failure of the first release to be tried in a working situation made it seem necessary to recover another float next day (though it did not need to be moved) just to check the release system. Accordingly, the first 1500 m float was recovered and re-launched in the morning of April 8th. More deep floats (1500, 3000 and 4000 m) were started 10 km and 15 km west of the original launch position overnight April 8th-9th. By then we had an array of 12 deep floats spaced 5, 10, and 20 km apart across the direction of flow revealed by the first group. The nine closely spaced western ones continued in much the same way, but the eastern group moved approximately at right angles, slightly south of west. CTD stations continued, simultaneously with the float tracking. A deep cast of water bottles was done on the new armoured cable, but the electric winch overloaded, burnt out its circuit breaker and had to be wired into a spare. It still overloaded intermittently, and on later stations its load was reduced by using the drum of 4 mm hydrographic wire. Four 500 m floats were set out during the evening of April 9th spaced 5, 10 and 20 km apart in a line running NW-SE, about 30 km SW of the middle of the working area. The three closely spaced ones at the NW end of the line moved northeast as expected, but again the one spaced 20 km away behaved differently; in this case the float moved slowly westwards and eventually curved into the northeastward flow. Some of the floats responded to an interfering signal with a 16 sec repetition rate, which turned out to be from a beacon on an inverted echo-sounder near the central mooring. This caused a much heavier drain on the float batteries than normal use would, and on April [illegible] after the interfering echo-sounder had been recovered by 'Researcher' one of the most severely affected floats was recovered and replaced by another. Overnight on April 11th-12th, further trials were made and various measurements taken of the performance of the electric winch under load. Float tracking and CTD stations continued, until a.m. 13th when an excursion was made to the northwest, to occupy three stations in the NW corner of the MODE density grid. All the floats were soon found when tracking was resumed on the 14th. Another 500 m float was started, north of the west-going one, on 15th April, and two of the northeast-going 500 m floats were recovered that evening. Only one was meant to be recovered, but their release frequencies were so close that both fired simultaneously. Another excursion to the northwest, to occupy 3 more density grid points, was made on 16th-17th April. By 18th April the west-going 500 m float had turned northeast, and another was started at 500 m to check whether the weak westward flow was still present (it was). Since the greatest differences between float velocities were seen between 500 m and 1500 m depths, another float was loaded for 800 m and launched on April 19th. It moved northeastwards, in the same direction but at about half the speed of neighbouring 500 m floats. Float tracking and CTD stations continued, with another shorter excursion to the north on 20th April. Returning to the floats, by April 21st three of the 500 m ones were getting out of range; one of them was recovered then and the other two were picked up next day. There had been changes in velocity of the deep floats, which seemed to occur progressively across the area from east to west. An extra 4000 m float was put in, west of the others, to help confirm that impression. The easternmost 4000 m float, originally moving westwards, had turned towards south and speeded up. By 23rd April it had moved too far out of the area and had to be recovered. On the 24th, one of the two remaining 500 m floats speeded up to 30 cm/sec. It was recovered at the surface early next morning - its release weight had come loose without being fired. Five more floats were recovered on the 25th - the two southernmost ones and the central group of 1500 m floats. On the 26th April, four of the seven remaining deep floats (3000 and 4000 m) were recovered; the other three would not release. Final fixes were obtained on them early next morning, the two remaining floats (500 m and 800 m depths) were recovered, and course was set for Bermuda. Two more CTD stations were occupied on the way in, and the new 6000 m length of armoured electric cable was transferred from the new winch to the midships steam winch. The port EM log was damaged by some unknown floating object on passage - an unfortunate loss since it had been working very well and yielding useful surface currents when combined with satellite fixes. The starboard log was working but its calibration was less certain. 'Discovery' arrived back at St George at 1000 local time on 29th April.

Some general comments on the whole of this part of the cruise may be appropriate here. (1) Working with the combined instrument package on the midships winch was much easier than had been imagined - the combination of CTD sea unit, Rosette multisampler, interrogator array plus preamplifier and tone-operated switch was quite convenient to handle. (2) Loran-C agreed closely with satellite fixes and appeared to be very stable, so that by the end of the first leg it was being accepted as the best available navigation aid and the satellite fixes were used mainly for checking that the Loran-C was in the right lane. (3) The high standard of catering that has been much appreciated on board 'Discovery' in the past few months was well maintained, and with the work going reasonably well the atmosphere was generally pleasant, despite earlier doubts about a relatively long cruise away from U.K. ports.

Whilst 'Discovery' was in at Bermuda at the end of April, various activities were filmed on board by a group making a film about the whole MODE-1 experiment. There was a severe shortage of water in Bermuda and we had to move round to Hamilton on 2nd May, to take on water more quickly.

Leg 2

'Discovery' sailed from Hamilton, Bermuda at 0700 local time (1100 Z) on 3rd May. As before, two CTD stations were worked on passage to the MODE area. Mooring N4 was checked in the afternoon of 4th May, and four floats were started that evening. They were loaded for 500, 1500, 3000 and 4000 m depths, and were placed within the triangle formed by moorings 8, N1 and N2, near a known ridge approximately 1 km high in water typically 5.3 km deep. The usual combination of float tracking and CTD stations continued, with breaks to check moorings N1 and N2, until p.m. 6th May when more floats were launched. The three deep floats had moved slightly east of north, so the new deep ones were placed on a line bearing 120°-300° from the original group, with a 20 km spacing on the eastern side and spacings of 10 km and 5 km to the west. One new 500 m float was launched, 25 km E of the starting position of the first one, which had gone southwards at approx. 10 cm/sec. It was started there so as to run close by mooring N2. Altogether, 10 floats were launched on 6th May. One of the 'Airmode' aircraft dropped some replacement parts for the Hewlett-Packard computer used with the CTD, during that day. After checking mooring N3 and fixing all floats on 7th May, 'Discovery' broke off to revisit the area worked in during April, to see whether any of the floats that were not recovered could still be detected. After a quick passage westwards overnight, one of them (the only one that had not switched) was located during 8th May, only 11 km away from its last fix 11 days earlier. Returning to the eastern area, two more 500 m floats were launched on 9th May, aimed to run past No 8 mooring. Float tracking and CTD stations continued, density grid points being occupied whenever possible, though most of the stations were placed as needed for the float fixing. During 10th May the R.V. 'Hunt' arrived and transferred mail, laundry and some spare cards for the tape recorder. By then, the 3 western groups of deep floats had curved westwards and were moving almost in line, so two more floats were launched at 3000 m and 4000 m depths, 20 km northeast of the original starting position, to give a better spread across the deep flow. The first 500 m float was now too far away to the south; it was recovered on 11th May, reloaded for 1500 m and launched near the two new deep floats on the 12th. That float, and the 3000 m one, moved slowly westward across the nearby ridge. The 4000 m float moved more quickly southwest, parallel to the ridge, then did a loop of about 3 km radius near the southern end of the ridge. The three western pairs of floats at 3000 m and 4000 m gradually turned southwards and slowly converged.

The echo-sounder was kept going whenever the ship was moving, and more seamounts were being revealed in this rough area. To the east of the ridge near which most of the floats had been started, there was another ridge with a gap in it. This was surveyed in some detail overnight 13th-14th May while the float interrogation and recording equipment was being repaired after a nearly catastrophic fault had occurred. By the evening of the 14th, float tracking was resumed, and next day R.V. 'Chain' arrived and began making velocity profiles and more CTD observations near the western ridge where most of the floats were.

The easternmost 4000 m float, and the 500 m float started near N2 mooring, had moved to the far south of the area by the 15th. Both their releases were switched then, but only the 4000 m float came up. It was relaunched, together with another float loaded for 3000 m, in the gap in the eastern range of abyssal hills. On the morning of the 16th, passing close by the 'Chain', a package was floated across to them containing our latest float tracks and bathymetric information. The two 500 m floats that had been started near No 8 mooring were then recovered, having moved far to the southwest. After another deep hydrographic station the two floats just recovered were relaunched, loaded for 500 m and 4500 m, near the northern end of the western ridge on 17th May. The two deep floats in the gap in the eastern ridge were moving quickly southeastwards, the 3000 m float moving faster than the 4000 m one. Another 500 m float was started near them early on the 19th. Later that day, one of the western deep floats (now converged into a small slowly moving group) was recovered, and one of the two 1500 m floats that had gone off to the northwest. One of them was loaded for 4500 m and started close to the middle of the western side of the western ridge, and the other, intended for 1500 m depth, was launched in the eastern gap, overnight 19th-20th May. Tracking the floats continued to be done partly by ranges obtained on CTD stations and partly using the fish interrogator on passage, the time being divided about equally between stations and passage. By the 21st May two of the eastern floats, at 500 m and 3000 m, had gone so far east that their recovery was attempted, but neither of them would come up. They continued to be tracked until the end of the cruise. Two more floats were then started, upstream (i.e. northwest) of the starting point of the eastern floats, also loaded for 500 m and 3000 m. By now, the limit of 18 floats (one in each signal channel) had been passed, and 22 floats were being tracked. The extra ones were arranged to occupy the same signal channels as those floats whose release circuits had switched but which had not come up. Their transponder circuits put out shorter pulses which could be distinguished from those from unswitched circuits. Recovery of the moored current meters started with N3 on 22nd May, then N4, N1 and N2, one on each following day, interspersed with the float tracking and CTD work. Two floats were recovered on the 26th, and 8 out of 9 attempted on the 27th. That left 11 floats, five of which were not recoverable. Most of the daylight hours on 28th May were spent in dragging for the lost mooring, without success. Four of the remaining floats were recovered on the 29th. 'Discovery' left the MODE area that evening and arrived at Ireland Island for fuel in the morning of 31st May, returning to St George that afternoon.

That completed 'Discovery's' contribution to the MODE observations. For the whole two months, the totals were 143 CTD stations (25 with deep water bottle casts), 4 moorings with a total of 16 current meter records of about 7 weeks duration each, and 52 float trajectories with an average duration of about 2 weeks each, plus fairly detailed bathymetric coverage of our two working areas.

Leg 3

In order to gain time for fitting the 'Gloria' equipment at Southampton, 'Discovery' sailed a day earlier than originally planned, in the evening of 2nd June as soon as the magnetometer (flown out from U.K.) was delivered on board. The return passage was uneventful, apart from occasional faults on the magnetometer and 2 days of less accurate navigation than usual when the satellite receiver was out of action. For the most part, work was concentrated on preliminary reduction of the MODE data, the only observations made on passage being echo-sounding, magnetic field and the usual meteorological variables. Cruise 53 ended on arrival at Southampton in the forenoon of 14th June.

Acknowledgements

The work described in this report was a combined effort by many people. Only those directly involved know how much was done in the NIO workshop and down at Barry before the cruise, and how much was contributed during the cruise by all departments of the ship's company. In particular, the efforts of Mr A.E. Fisher in seeing to the scientific needs during the preceding refit, and of the Master, Captain G.L. Howe, and Chief Engineer, Mr C. Storrier, during the cruise, are greatly appreciated.

Scientific Staff

T.R. Barber	Legs 1, 2, 3
J.R. Berry	1, 2
J.W. Cherriman	1, 2
J. Crease	1, 2
Sir George Deacon	2
W.J. Gould	1, 2, 3
B.S. McCartney	1, 2, 3
N.W. Millard	1, 2, 3
J.A. Moorey	1
G.K. Morrison	1, 2, 3
G.R.J. Phillips	1, 2, 3
S.C. Riser (M.I.T.)	1
T. Sankey	1, 2, 3
J. Sherwood	3
Mrs R. Sherwood	1, 2, 3
W.K. Strudwick	1, 2
J.C. Swallow (Pr. Sci.)	1, 2, 3
R.F. Wallace	1, 2

Notes on Equipment and Observations

Current meter moorings

Five moorings were planned to be set from Discovery in the southeast quadrant of the MODE array area. The moorings were designed to have subsurface buoyancy at the 200 m level and to use wire above 2000 m and polypropylene line below. Each mooring had Aanderaa current meters at 500, 1500, 3000 and 4000 m. The two lower levels required the use of instruments with the new deep pressure cases.

The first mooring (NIO 135, MODE N4) was set uneventfully on April 3rd (Table 2). The following day during the laying of NIO 136 (N2) part of the mooring was lost. The upper swaged fitting on the 1000 m, 6 mm wire length below the 500 m current meter was found to be defective when the termination was outboard of the A frame. It appeared that only the outer layers of wire were gripped by the termination and the inner ones were free. When being wound back onto the winch drum this termination failed with the loss of the mooring below this point (3 current meters, command pinger and acoustic release). Later that day, April 3rd, mooring 137 was set at the N2 position. Moorings 138 and 139 (N3 and N1) were set on April 4th and 5th without incident. The moorings were left unattended until the beginning of the second leg of the MODE cruise (May 4th and 5th). Each of the moorings was then found to be in position.

The recovery of the NIO moorings was started on May 22nd and completed on the 25th. All were recovered without serious difficulty. On three of the moorings the linkage made up from shackles and sling rings between the buoy and the upper wire length had become seriously tangled but this is thought to have occurred during recovery when the buoyancy sphere reached the surface. In addition the lower ends of the lowermost 6 mm wire length showed evidence that the wires were not very well torque balanced, the bottom 10 m or so being badly twisted on recovery. Presumably this also occurred during the tension release when the explosive bolt fired.

The only physical damage to the current meters was a missing rotor from the 500 m instrument on mooring 139 (N1). All the current meters were recording when recovered and the deep pressure cases had worked satisfactorily.

An unsuccessful attempt was made to drag for the missing part of mooring 136 on May 28th . Unfortunately only the acoustic release pinger could be turned on and the transponder on the trawl wire failed to lock onto this signal.

The mooring details are given in Table 2 . From the depths of the pinger signals before and after release it appeared that the synthetic line in the mooring had stretched during the experiment by typically 40-50 m. The instrument depths in the table are mean values for the period of the experiment.

The MODE cruise was the first on which the NIO Aanderaa current meter tape reader had been used. The reader is interfaced to the IBM 1800 computer and stores the decoded data and error diagnostics on disk. A suite of programs for error analysis and data display is also available.

When the first current meter tapes from mooring N3 were removed from the instruments and checked using a magnetic tape viewer it appeared that none of the four had recorded any data. Since all the instruments were working properly and could be made to record data on another tape it was presumed that the tapes which had been used were defective. Of the total of 16 tapes recovered 6 were recorded normally and the remaining 10 showed no data when studied with the tape viewer.

In fact signals had been recorded on the bad tapes but the level was a factor of 200 below normal. The six good tapes were decoded easily and all contained good data. After considerable modification to the decoder it was possible to read the defective tapes although the bad signal to noise ratio on the tapes and from radiative pick-up from ship machinery produced more error signals than were found on the normal tapes.

To date only one record has been found to have bad data (500 m mooring 139, N1), here there is an encoder fault for the last $\frac{1}{4}$ of the recording period. This is also the instrument which lost its rotor but the record shows that this occurred at the time of mooring recovery.

W.J. Gould.

CTD & Multisampler

System description

For the air-sea interaction cruise in September 1972 a new Conductivity, Temperature and Depth (C.T.D.) profiling instrument, designed and built by Neil Brown at Woods Hole Oceanographic Institution, was used on board 'Discovery' for the first time. This instrument proved to be so stable and reliable on this September cruise that it was arranged to borrow it for the profiling during the MODE-1 cruise. In order to facilitate the storage of data in a computer compatible form a Hewlett Packard 2100A computer which was not available in September was used on this cruise. The whole C.T.D. system replicated that used by Fofonoff and Millard at Woods Hole and system software for acquisition and processing of the CTD data developed on the Woods Hole system was made available to the Institute.

The C.T.D. instrument is designed for microstructure work, it also differs from the S.T.D. in that it telemeters conductivity for computation into salinity in a programmable digital computer rather than computing 'salinity' in an <u>in situ</u>, hard-wired, analogue system and telemetering this 'salinity' without taking account of variables such as the response times of sensors and the lowering rate of the instrument, which are both input into the new system. The conductivity sensor is a four electrode cell with a length scale less than one centimetre, the temperature sensor is a platinum resistance thermometer with a time constant of the order of 300 milliseconds and the pressure sensor is a strain gauge bridge. Signals from the three transducers are digitized by three transformer ratiometers in the sea unit. Data are telemetered in frequency shift key mode as six eight bit words (two per channel) in standard serial teletype format. This provides a dynamic range of:-

0 - 6553.6 decibars
0 - 32.768 degrees centigrade
0 - 65.536 mmhos/cm

where the resolution, i.e. one least significant digit, is equivalent to:-

0.1 decibars
0.0005 degrees
0.001 mmho/cm

The frequency shift key system represents a binary '1' as two cycles of $6^2/3$ kHz and a binary '0' as one cycle of $3^1/3$ kHz, giving a bit rate of $3^1/3$ kHz which corresponds to more than 30 samples of conductivity temperature and depth per second.

As the telemetered data are coded into the audio band it is straightforward to record them raw on an entertainment tape recorder. This provides inexpensive data logging and a back up system should any of the deck equipment fail during a station. This facility proved to be extremely useful on occasions when the computer was inoperable, allowing the data to be replayed into the computer during passage time after the computer had been repaired.

During MODE-1 it was necessary to combine density stations with float interrogations. In order to circumvent the necessity for doing two casts to 3000 metres on each of these stations, the CTD, multisampler and interrogator array were combined in a frame. The single conductor cable was switched by means of a tone operated two pole change-over switch so that float interrogations could be carried out by interrupting the CTD cast - normally these interrogations were arranged to coincide with intervals when thermometers were soaking prior to being reversed.

Operation

During the two months of 'Discovery's' participation in the MODE-1 experiment 143 C.T.D. casts were completed, all but 9 to 3000 metres. No faults were experienced on the CTD sea unit and only one minor fault occurred on the deck unit, this affected only the engineering unit display on the deck unit.

Most of the time lost on station was attributable to leaking underwater connectors many of which were utilized to combine the CTD with the multisampler, tone operated switch and float interrogating array. Some difficulties were also experienced with the multisampler deck unit where a lead had broken away from a large capacitor for which no replacement was available.

Calibrations

During September 1972 a discrepancy was noticed, at low temperatures, between the CTD temperature and the NIO reversing thermometers. Observations confirming this discrepancy are noted in a later section (Thermometry). From observing the digital display in nearly isothermal conditions it is possible to say that the short term drift or noise level on the CTD temperature channel is equivalent to less than 0.001°C. The absolute calibration of the temperature sensor will be repeated when the instrument arrives back at Woods Hole.

The pressure transducer was calibrated against the bottom separations of a free running pinger attached to the instrument during a lowering over the abyssal plain. On the down cast agreement to ±1 decibar was recorded to the full depth of 3000 metres. There was however some hysteresis and on hauling the pressure transducer appeared to lag by about 10 db.

Two sources of error were anticipated in the conductivity measurement one time dependent and the other temperature dependent. The time dependent correction was considered by plotting the computed salinity at the 2.8°C isotherm on every station against station number. A time dependent correction was devised to correct this salinity to that predicted by the deep T-S relation. The temperature dependent correction was obtained by comparing computed salinities with water bottle values over the whole temperature range.

The smoothed time dependent correction varied by ±.0005 ppt per station. With only very few notable exceptions the plot of computed salinity at the 2.800°C isotherm versus station number was continuous from station to station. A jump of 0.05 ppt occurred after it had been necessary to remove fouling from the conductivity sensor. Other smaller jumps occurred when the cell was syringed with salt water and when the external electrodes were straightened. The temperature dependent correction remained fairly constant throughout the cruise, having a value of approx. 0.0006 ppt per degree centigrade.

G.K. Morrison.

Thermometry

1. Work done

143 CTD casts with rosette multisampler,
134 of these were to 3000 m with full use of sampler,
i.e. 12 salinity samples, 6 thermometer frames,
25 deep WB casts.

2. Comparisons with CTD

Graphs plotted for each thermometer used on rosette of difference between CTD and corrected thermometer readings as function of temperature.

Main features: NIO thermometers between 0.040°C and 0.080°C high relative to CTD at 2.7°C decreasing irregularly to between 0.000°C and 0.040°C above 20°C.

Exceptions: Therm. no. 18218 from earlier Lowestoft calibration than others +.010°C high between 4° and 8°C.

Therm. no. 21109 recalibrated at NPL. About .025°C high at low temperatures.

WHOI thermometers: (6 protecteds were received in exchange for some of ours).

These were between +.020°C and +.040°C high at all temperatures.

It is believed the high differences at low temperatures were due to an inadequate calibration procedure used at Lowestoft. The temperature of the experimental tank rose sufficiently fast for the difference in time constants of the sample and standard thermometers to give these errors.

3. Comparisons with WHOI thermometers

Sheets of comparison figures are available.

As can be deduced from the last paragraph agreement was good within the scatter of the two batches above 20°C but at low temperatures there was an appreciable difference. Data supplied by WHOI for the difference between their exchanged thermometers and their CTD suggested that the Chain CTD was between .015 and .030°C higher than our CTD after applying a laboratory measured calibration (without it, the Chain CTD read a further 0.010°C higher). This was based on two -2 to 6°C thermometers but the number of readings available was small.

4. Deep cast pairings

The thermometers used on the deep cast were frequently rotated. The pairings were analysed and using thermometers also used on the rosette at low temperatures, a set of corrections one for each thermometer was derived to give temperatures compatible with the CTD. These corrections have been applied to all deep cast temperatures. The T-S relation obtained is a tighter line if the corrections are used. They are basically only for temperature close to 2.7°C.

5. Unprotected thermometers

These agreed well with the CTD (±0.5%) though they showed some tendency to read low at high pressures. This error was a little more than would be expected from the known protected temperature errors. The WHOI unprotecteds read low relative to the NIO ones by not more than 1% at depths less than 1500 m.

6. Malfunctions

5 protected and 3 unprotected thermometers malfunctioned (excluding temporary stickiness).

The only breakages on Discovery were 3 unprotected thermometer shells. One was successfully araldited, spares were available for the other two.

T. Sankey.

Floats

The float circuits and transducers had all been tested during Cruise 52 and minor repairs and adjustments made. The improvements mentioned as being needed in the report on Cruise 46 had been incorporated into the tracking system. After one test lowering had shown that the combined instrument package (CTD, multisampler, interrogator array, preamplifier and tone-operated switch) on the 6000 m armoured cable overloaded the new electric winch, the package was operated from the midships steam winch. Its new 2:1 reduction gearbox proved very satisfactory, the winch pulling readily from 3000 m.

The 36 float tubes were stowed in a special rack in the aft rough lab., which had been enlarged during the previous refit. It was very convenient having that laboratory available for float assembling. Floats could be put together and tested by 2 people at the rate of 1 in 15 mins. They were launched over the stern, lowered horizontally into the water by hand in two bights of line. Tracking was done mainly by ranging from the interrogator lowered with the CTD, but an appreciable proportion of fixes (more than 30%) were obtained on passage using the towed fish interrogator. It was not difficult to cope with 18 or more floats in the water at the same time, at the spped they were moving in this experiment (usually less than 10 cm/sec). The small amount of adjacent channel interference was not serious. Only one instrumental failure (when a power supply went high in voltage, destroying a total of 18 integrated circuits) caused any delay in fixing, and then only for half a day. Float signals were almost always clearly visible if an allowable propagation path existed. The batteries gave rather more than the expected life. Although in the early stages interference from the inverted echo-sounders was serious, little or no trouble was experienced working near the Sanford free-fall current profiler. Navigation was better than expected; the Loran-C was so stable and accurate that it came to be relied on as the basic navigation aid - quite the reverse of the "white elephant" comment in the report of Cruise 51.

Separate plotting sheets ($\frac{1}{2}$" = 1 ml scale) were maintained, in each leg of the cruise, for the ship's positions at each interrogation and for each of the main levels at which floats were being tracked (i.e. 500, 1500, 3000 and 4000 m). The latter sheets were overlays that could be placed in turn over the navigation sheet and ranges marked off with a compass. It was not difficult to read off all the travel times recorded at one interrogation, convert them to ranges and plot them, before starting the next interrogation. Typically two were done on each CTD station, at 500 m and 3000 m, with an interval of about an hour between them.

Although it cannot be proved, it seems likely that the losses of floats in which the release circuit had switched were due to faulty pyro releases. It is still possible that some of them may have been damaged by the sound emitted by the transducer, as was suspected in the May 1972 trials when the releases were initially fitted much closer to the transducers. We need a re-usable mechanical release to replace the consumable and doubtful pyro releases.

Once the floats had dropped their weights, recovery was straightforward. There was no difficulty in homing on a surfaced float to within a cable or less, by which time it had usually been seen. The average time between sighting a float and getting it inboard was 11 mins. More details of float operations are given in Table 3 and in the Narrative section above.

J.C. Swallow.

Computing

A persistent system error at the beginning of the cruise eventually caused a complete breakdown after a few days. A new leg was initialized to overcome this problem and as a result leg 1 of the actual cruise is stored in the computer files as legs 1 and 2, and 2 and 3 are stored as 3 and 4. When the data storage system is developed later this year these inconsistencies will be removed.

It was decided that Loran-C positions should be used when float tracking in preference to satellite positions. This caused several amendments to be made to the hyperbolic sampling routines to enhance their versatility.

During float tracking Loran-C fixes were printed out every two minutes. One of the special switches in the computer room was used to stop and start the print-out. Also, two minute fixes were stored in a circular file on disk, which held two hours data. It will be possible to calculate and print out current velocities every half hour by using the difference of the Loran-C positions and the dead-reckoned positions.

It was soon realised that lane jumps on the receiver were causing erroneous positions to be calculated, some of which were not immediately noticeable.

A system was therefore set up whereby six lane jumps would cause the alarm on the panic box in the plot to buzz and the sampling stopped. The sampling could be restarted by the bridge who were supplied with a reset button.

The live track plot facility developed on cruise 52 was used for a short while during the float tracking and hard-copy track plots were available on a daily basis.

John Berry's Current Meter Decoder was used for the first time on leg 2. The software for the decoder needed some initial changes and apart from a few errors discovered in use it worked well. Various improvements were suggested and several of them were carried out.

The visual display unit was used to plot data and a program to list data to the alphanumeric terminal was attempted but abandoned due to lack of high-level software.

The decoder itself had to be adjusted for some of the tapes which were otherwise unreadable.

The air-conditioners in the computer room once again proved troublesome and without the combined efforts of the Chief Engineer, Chief Electrician and John Berry the units would have completely failed.

The anemometer became faulty during the first leg and was replaced, but unfortunately the replacement also proved to be faulty. The wind data for this cruise is, therefore, mainly erroneous.

The hardware functioned satisfactorily although there were several minor faults which were quickly located and corrected. The VDU's were used to great advantage both on-line and off-line.

The operating system, despite intermittent errors, worked very well and the computer was always available when needed.

W.K. Strudwick.

Meteorological Observations

The following notes are intended as a guide to use of the meteorological data logged by computer in 'Discovery' during the period 1 April to 14 June 1973 (day nos. 91-165).

Variable/Instrument	Quality/Reliability of Data
Dry and Wet Bulb Temps.	Dry bulbs OK. Wet bulb wicks occasionally dried out so data unreliable.
Electronic Barometer	OK after day 97 (not switched on until then). Correction of +0.8 MB to be applied throughout.

Wind	OK up to and including day 108 (status 2, caution). Faulty on and after day 109 - data to be given status 1 from day 109 to day 165. (The reserve anemometer, no. 200, was fitted on or about day 114 but was incorrectly fitted, being loose, thus invalidating all subsequent wind data).
Hull Temp.	OK; mean difference from M.O. sea temp. (R.A.S.T.U.S.) = -0.25°C AP.
Solarimeter	OK.

General Note: All meteorological channels were subject to radio frequency interference which has resulted in the inclusion of random noise spikes in the data.

P. Edwards.

Table 1. Station List

Notes

1. Times are all GMT and are bottom of cast times for the CTD and messenger times for W/B's.

2. Mode No. refers to the sequential Discovery CTD station number in the Mode Experiment.

3. Grid point refers to the Mode density grid (Fig. 2). Stations within 3' of grid points have been designated as such for easy reference.

4. Positions are either by Loran-C or Satellite. The systematic difference between the two systems is $< 0.1'$.

5. Depths are in corrected metres using Matthews Area 14 Tables.

6. An asterisk against position indicates more than a mile drift on station.

7. Work.

CTD-3000 - Neil Brown CTD to 3000 metres and Rosette.
I - Interrogation of floats.
M(N4)-135 - Mooring, Mode number N4, NIO number 135 set.
WB - Water bottle station from 3000 metres to bottom.

STATION LIST-LEG 1

DAY	TIME	STATION NO.	MODE NO.	GRID PT	POSITION N	POSITION W	DEPTH	WORK
APRIL								
2	0821	8282	1		29 58.1	66 28.1	5107	CTD-3000
2	1655	8283	2		29 10.8	67 08.2	5159	CTD-3000
3	0526	8284			28 14.2	67 52.0	5256	M(N4)-135
3	1740	8285			27 47.0	68 17.8	5275	M(N2)LOST-136
4	0000				27 49.5	68 17.4	5318	M(N2)RESET-137
4	0709	8286	3		27 28.7	68 32.4	5360	CTD-3000
4	2225	8287			27 21.7	68 29.9	5370	M(N3)-138
5	0714	8288	4	G9	27 41.9	68 43.1	5290	CTD-3000
5	1141				27 41.8	68 44.0	5261	M(N1)-139
5	1545	8289	5		27 47.0	69 7.3	5276	CTD-3000
6	0115	8290	6	F5	28 0.7	70 2.5	5453	CTD-3000,I
6	0458	8290			28 1.4	70 1.9	5453	WB
6	1316	8291	7		28 12.8	69 52.5*	5451	CTD-3000,I
6	1802	8292	8		27 57.3	69 54.9*	5453	CTD-3000,I
6	2209	8293	9		27 53.9	70 5.1	5453	CTD-3000,I
7	0304	8294	10	F4	27 59.9	70 19.7*	5457	CTD-3000,I
7	0530	8294			28 0.4	70 19.7	5457	WB
7	1058	8295	11		28 8.6	70 2.5	5455	CTD-3000,I
7	1504	8296	12		28 3.1	69 52.1	5457	CTD-3000,I
7	1908	8297	13		28 1.9	70 3.5	5457	CTD-3000,I
8	0031	8298	14		28 9.2	69 56.7*	5457	CTD-3030,I
8	0447	8299	15		27 57.4	69 57.2*	5457	CTD-3000,I
8	1358	8300	16		28 2.4	70 3.6	5457	CTD-3000,I
8	1935	8302	17	F4	27 59.8	70 20.0	5453	WB
9	0123	8302			28 0.5	70 20.8	5453	CTD-3000,I
9	0659	8304	18		28 6.0	70 4.5*	5455	CTD-3000,I
9	1023	8305	19		28 8.0	69 54.7	5455	CTD-3000,I
9	1512	8306	20		28 11.6	70 9.6	5453	CTD-3000,I
9	1903	8307	21		28 3.9	70 18.3	5457	CTD-3000,I
10	0147	8308	22		27 45.7	70 11.1	5463	CTD-3000,I
10	1106	8309	23		28 14.1	70 4.0	5453	CTD-3000,I
10	1644	8310	24		28 9.3	69 50.1	5457	CTD-3000,I
10	1911	8310			28 9.3	69 49.1	5453	WB
11	0525	8311	25		27 59.1	70 25.1*	5455	CTD-3000,I
11	1332	8312	26	E6	28 19.4	69 38.6	5453	CTD-3000,I
11	1924	8313	27		28 1.5	69 56.8	5457	CTD-3000,I
11	2327	8314	28	F5	28 0.1	70 1.0*	5457	CTD-3000,I
12	0523	8314			28 0.6	70 0.2	5457	WB
12	1525	8315	29	G4	27 41.7	70 18.4	5459	CTD-3000,I
12	2102	8316	30		28 3.1	70 10.3	5457	CTD-1500,I
13	0143	8317	31	F5	28 19.0	69 59.3	5453	CTD-3000,I
13	0711	8318	32	E4	28 18.0	70 19.7	5451	CTD-3000,I
13	1618	8319	33	B3	29 22,1	70 10.8	5438	CTD-3000,I
13	2115	8320	34	A1	29 46.1	70 10.3	5436	CTD-3000,I
14	0216	8320			29 45.3	70 9.5	5436	WB

R.R.S. DISCOVERY 53

STATION LIST-LEG 1

DAY	TIME	STATION NO.	MODE NO.	GRID PT	POSITION N	POSITION W	DEPTH	WORK
APRIL								
14	1112	8321	35	C2	28 56.1	70 41.8	5442	CTD-3000,I
15	0325	8322	36	F5	28 0.6	70 0.5	5455	CTD-3000,[
15	0801	8323	37	G5	27 42.5	70 1.5	5461	CTD-3000,I
15	1105	8323			27 43.0	70 2.2	5461	WB
15	1615	8324	38		27 53.9	70 27.2	5457	CTD-1000,I
15	1723	8325	39		27 51.1	70 26.2	5457	CTD-1000,[
15	1828	8326	40		27 49.0	70 24.6	5457	CTD-1000,I
16	0330	8327	41		28 3.3	69 55.2	5457	CTD-3000,[
16	1522	8328	42		28 29.9	70 54.6	5430	CTD-1015
16	2020	8329	43	C1	28 54.8	71 11.8	5418	CTD-3000
17	0209	8330	44	B1	29 23.6	71 1.3	5430	CTD-3000
17	0450	8330			29 23.9	71 2.2	5430	WB
17	1043	8331	45	B2	29 21.8	70 41.8	5438	CTD-3000
17	2337	8332	46		28 5.4	69 57.1	5457	CTD-2911,[
18	0553	8333	47		28 7.8	70 11.1*	5455	CTD-3000,I
18	1515	8334	48		27 42.1	70 13.0	5465	CTD-3000,[
18	1955	8335	49		27 55.8	70 12.1*	5459	CTD-3000,I
19	0009	8336	50		28 6.5	70 21.5	5453	CTD-3000,[
19	0512	8337	51	E4	28 19.7	70 21.2*	5449	CTD-3000,I
19	1054	8338	52	E5	28 19.3	70 0.8*	5449	CTD-3000,[
20	0246	8339	53	D1	28 40.5	70 24.5*	5448	CTD-3000,I
20	0558	8339			28 42.3	70 24.8	5448	WB
20	1145	8340	54	C3	28 51.9	70 3.7	5446	CTD-3000,I
20	1737	8341	55	C4	28 54.4	69 39.7	5430	CTD-3000,[
20	2032	8341			28 54.7	69 39.4	5426	WB
21	0654	8342	56	F5	28 0.9	70 1.6*	5457	CTD-3000,[
21	1340	8343	57	F4	28 3.8	70 20.1*	5455	CTD-3000,I
21	1837	8344	58	E5	28 18.0	70 1.1	5449	CTD-500,I
22	0113	8345	59	D2	28 37.1	70 1.3	5449	CTD-3000,I
22	0635	8346	60		28 25.9	70 23.9	5449	CTD-3000,[
22	1022	8347	61		28 12.7	70 19.0	5453	CTD-1500,I
22	1331	8348	62		28 13.7	70 8.1	5453	CTD-1500,[
23	0450	8349	63		28 21.2	70 24.7*	5453	CTD-3000,I
23	1910	8350	64		27 48.1	70 4.6*	5461	CTD-3000,[
24	0239	8351	65		28 12.1	70 4.6	5457	CTD-3000,I
24	0746	8352	66		28 26.7	70 8.8*	5453	CTD-3000,[
24	1315	8353	67		28 7.9	70 20.7	5453	CTD-3000,I
24	1909	8354			28 0.4	70 41.7	5447	WB
24	2228	8354	68	F3	28 1.6	70 40.8	5449	CTD-3000,[
25	2352	8355	69		28 16.8	70 14.8*	5453	CTD-3000;[
26	0447	8356	70		28 29.0	70 18.7*	5449	CTD-3000,I
26	1127	8357	71		28 16.5	70 28.8*	5449	CTD-3000.[
27	0549	8358	72		28 13.1	70 15.1	5457	CTD-3000,I
28	0659	8359	73		29 56.7	67 50.9	5153	CTD-3000

28	1446	8360	74	30 29.6	67 00.6	5128	CTD-3000

STA TION LIST-LEG 2

DAY	TIME	STATION NO.	MODE NO.	GRID PT	POSITION N	W	DEPTH	WORK
MAY								
4	0421	8361	75		29 59.1	66 29.5*	5105	CTD-3000
4	1229	8362	76		29 11.3	67 8.7*	5143	CTD-3000
5	0149	8363	77		27 52.4	68 32.9*	5318	CTD-3000
5	0804	8364	78	G9	27 38.5	68 42.2	5285	CTD-3000,[
5	1113	8364			27 38.2	68 42.0	5091	WB
5	1630	8365	79		27 47.1	68 20.4*	5300	CTD-3000,[
5	2226	8366	80	F9	27 58.8	68 37.1*	5217	CTD-3000,I
6	0126	8366			27 57.1	68 35.4	5325	WB
6	0800	8367	81	F10	27 59.9	68 7.0	5273	CTD-3000,I
6	1015	8367			27 59.9	68 7.0	5295	WB
6	2342	8368	82	F9	27 58.6	68 41.3*	5331	CTD-3000,I
7	0657	8369	83	G8	27 41.2	68 59.5*	5325	CTD-3000,[
7	1342	8370	84		27 28.0	68 30.3	5328	CTD-3000,I
7	2127	8371	85		27 49.1	68 30.0	5265	CTD-3000,[
8	0227	8372	86		28 3.2	68 26.0	5364	CTD-3000,I
8	1515	8373	87	E4	28 19.0	70 20.0*	5457	CTD-3000,[
8	1726	8374			28 23.8	70 25.6	5459	I
8	1844	8375			28 24.6	70 18.0	5461	I
9	0346	8376	88	F8	27 59.3	68 58.9	5246	CTD-3000,I
9	0845	8377	89		28 3.1	68 34.8*	5151	CTD-3000,[
9	1317	8378	90		27 45.5	68 38.2	5287	CTD-3000,I
10	0134	8379	91	F9	28 20.6	68 41.9	5263	CTD-3000,[
10	0607	8379			28 20.4	68 43.5	5256	WB
10	1218	8380	92		27 51.1	68 39.2*	5291	CTD-3000,[
10	1711	8381	93		28 2.2	68 25.0*	5298	CTD-3000,I
10	2323	8382	94	E8	28 17.4	68 58.7	5349	CTD-3000,[
11	0408	8383	95		28 5.4	68 40.1	5215	CTD-3000,I
11	0847	8384	96		27 56.1	68 30.2	5256	CTD-3000,[
11	1308	8385	97		27 40.8	68 25.4	5335	CTD-3000,I
11	2036	8386	98	G10	27 33.4	68 7.7	5306	CTD-3000,[
11	2310	8386			27 33.2	68 8.2	5325	WB
12	0724	8387	99		27 56.0	68 8.0*	4873	CTD-3000,[
12	1321	8388	100		27 59.0	68 25.1	5271	CTD-3000,I
12	1743	8389	101	F9	27 59.6	68 38.0	5356	CTD-3000,[
12	2311	8390	102	F8	27 58.8	68 58.8*	5240	CTD-3000,I
13	0829	8391	103	E10	28 27.0	68 7.9	5209	CTD-3000,[
13	1105	8391			28 27.4	68 8.4	5217	WB
13	1812	8392	104	F11	28 0.4	67 36.1	5252	CTD-3000,[
13	2029	8392			28 0.9	67 36.1	5258	WB
14	1041	8393	105		27 48.1	68 12.1*	5265	CTD-3000,[
15	0208	8394	106		27 49.9	68 33.0	5325	CTD-3000,I
15	0745	8395	107		27 59.7	68 48.6	5205	CTD-3000,[

STATION LIST-LEG 2

DAY	TIME	STATION NO.	MODE NO.	GRID PT	POSITION N		POSITION W		DEPTH	WORK
MAY										
15	1254	8396	108		28	5.8	68	30.9*	4821	CTD-3000,I
16	0022	8397	109		28	0.0	68	9.7*	5180	CTD-3000,I
16	0617	8398	110		27	52.8	68	20.5	5300	CTD-3000,I
16	1013	8399	111		28	5.8	68	19.6	5310	CTD-3000,I
16	2214	8400	112	H5	27	20.5	68	55.2	5318	CTD-3000,I
17	0429	8400			27	20.4	68	54.7	5322	WB
17	1135	8401	113		27	50.3	69	0.2	5351	CTD-3000,I
17	1855	8402	114		28	7.8	68	34.9	5196	CTD-3000,I
18	0326	8403	115		27	40.3	68	9.9	5343	CTD-3000,I
18	1225	8404	116		27	43.0	68	35.6	5236	CTD-3000,I
18	1454	8404			27	43.2	68	35.9	5229	WB
18	2118	8405	117		28	0.2	68	19.9	5339	CTD-3000,I
18	2340	8405			28	0.8	68	20.2	5345	WB
19	0654	8406	118		28	10.2	67	59.8*	4786	CTD-3000,I
19	0916	8406			28	10.4	67	59.8	4792	WB
20	0307	8407	119		28	2.4	68	30.8	4688	CTD-3000,I
20	0952	8408	120		27	59.5	68	10.7	5194	CTD-3000,I
20	1531	8409	121		27	44.6	68	4.5*	5272	CTD-3000,I
20	2143	8410	122		27	45.2	68	31.2	5271	CTD-3000,I
21	0154	8411	123		27	44.7	68	45.7*	5300	CTD-3000,I
21	0737	8412	124		28	6.2	68	37.2	5184	CTD-3000,I
21	2156	8413	125		28	7.3	68	19.9	5289	CTD-3000,I
22	0531	8414	126	G9	27	39.0	68	42.2	5298	CTD-3000,I
22	0739	8414			27	39.3	68	42.0	5294	WB
22	2019	8415	127	G8	27	40.7	68	59.3*	5306	CTD-3000,I
23	0208	8416	128	F8	27	59.2	68	58.7*	5300	CTD-3000,I
23	0742	8417	129		27	59.9	68	34.6*	4933	CTD-3000,I
24	0547	8418	130		27	50.1	68	50.2	5240	CTD-3000,I
24	1152	8419	131	E8	28	18.0	68	59.1*	5368	CTD-3000,I
25	0836	8420	132	F10	28	0.2	68	6.4	5322	CTD-3000,I
25	1125	8420			28	0.2	68	5.6	5318	WB
25	2154	8421	133		27	50.1	67	49.1*	5143	CTD-3000,I
26	0251	8422	134		28	10.3	67	49.8	5263	CTD-3000,I
26	0948	8423	135		27	53.1	68	21.2	5252	CTD-3000,I
26	1403	8424	136		27	47.6	68	32.6	5269	CTD-3000,I
27	0125	8425	137		28	11.3	68	41.8*	5345	CTD-3000,I
27	0619	8426	138		28	3.5	68	58.4	5267	CTD-3000,I
28	0001	8427	139		28	2.1	68	44.3	5265	CTD-3000,I
28	0425	8428	140		27	54.8	68	30.2*	5252	CTD-2600,I
28	0941	8429	141		27	47.6	68	16.5	5279	CTD-3000,I
29	0245	8430	142		27	45.9	68	15.2	5209	CTD-500,I
29	0628	8431	143		27	58.2	68	31.0	5318	CTD-3000,I

Table 2. List of Moorings

NIO/MODE number		Position N	Position W	Date/Time Set	Date/Time Recovered	Water depth (m)	Instrument depths (m)
135	N4	28°14.2'	67°52.0'	0526Z 3-IV	1350Z 23-V	5256	468, 1496, 3045, 4109
137	N2	27°47.5'	68°17.4'	0000Z 4-IV	1519Z 25-V	5318	459, 1478, 3063, 4155
138	N3	27°21.7'	68°29.9'	2232Z 4-IV	1202Z 22-V	5370	491, 1508, 3071, 4133
139	N1	27°41.9'	68°44.0'	1548Z 5-IV	1933Z 24-V	5261	456, 1492, 3050, 4159

Table 3. List of Floats Tracked

Consecutive Trajectory No.	Float No.	Nominal Depth (m)	Launch Date	Launch Time	Recovery Date	Recovery Time	Remarks
242	11	1500	5 Apr	2318	8 Apr	1010	Recovered early to check release system.
243	15	3000	5	2320			Attempted recovery 26 Apr. Circuit would not switch. Last fix 8 May.
244	2	500	5	2321			Release switched 2109/7 Apr. but float did not surface. Last fix 11 Apr.
245	7	4000	7	1413	23	1730	
246	10	1500	7	1415	25	1603	
247	17	3000	7	1417	11	1749	Recovered early to check battery (run down by IES).
248	8	4000	7	1751			Release switched 1346/26 but float did not surface. Last fix 27 Apr.
249	11	1500	8	1206	25	1834	Continuation of 242.
250	9	4000	8	1600			Release switched 2004/26 but float did not surface. Last fix 27 Apr.
251	13	1500	8	1602	25	1913	
252	16	3000	8	1604	26	1322	
253	12	1500	9	0423	25	1839	
254	14	4000	9	0425	26	2025	
255	18	3000	9	0426	26	1304	

Consecutive Trajectory No.	Float No.	Nominal Depth (m)	Launch Date	Launch Time	Recovery Date	Recovery Time	Remarks
256	3	500	9	2145	15	2136	
257	4	500	9	2213	15	2136	Release fired unintentionally when recovering Float 3.
258	5	500	9	2257	21	2053	
259	6	500	10	0004	27	1230	
260	19	3000	11	1808	25	1516	
261	17	500	15	1555	22	1530	
262	4	500	16	0155	22	1856	
263	3	500	18	1254	25	1100	Release weight dropped off without being triggered. Last reliable fix 24 Apr.
264	2B	800	19	1616	27	1030	
265	17	4000	23	0316	26	2049	
266	19	4000	4 May	2359	27 May	1240	
267	7	3000	5	0006	27	0926	
268	4	1500	5	0011	27	2014	
269	10	500	5	0013	11	1603	
270	11	500	6	1325			Release switched 1813/15 but float did not surface. Last fix 27 May.
271	18	4000	6	1356	15	1736	

Consecutive Trajectory No.	Float No.	Nominal Depth (m)	Launch Date	Launch Time	Recovery Date	Recovery Time	Remarks
272	9	3000	6	1357	27	1545	
273	2	1500	6	1358	26	1228	
274	17	4000	6	2125	27	1121	
275	14	3000	6	2126	19	1806	
276	5	1500	6	2128			Release switched 1353/24 but float did not surface. Last fix 24 May.
277	12	4000	6	2204			Attempted recovery 27 May. Circuit would not switch. Last fix 28 May.
278	15	3000	6	2206	27	1123	
279	13	1500	6	2207	19	2143	
280	16	500	9	2243	16	1559	
281	3	500	9	2330	16	1734	
282	8	4000	10	1714	27	1713	
283	6	3000	10	1720	26	2106	
284	10	1500	12	1041	27	1633	
285	18	4000	15	2203	29	1548	
286	11B	3000	15	2208			Release switched 1412/21 but float did not surface. Last fix 29 May.
287	3	4500	17	1631			Attempted recovery 29 May. Circuit would not switch. Last fix 29 May.

Consecutive Trajectory No.	Float No.	Nominal Depth (m)	Launch Date	Launch Time	Recovery Date	Recovery Time	Remarks
288	16	500	17	1633	26	1754	
289	12B	500	19	0343			Release switched 1450/21 but float did not surface. Last fix 29 May.
290	14	4500	20	0100			Attempted recovery 29 May. Circuit would not switch. Last fix 29 May.
291	13	1500	20	0742	29	1334	
292	16	3000	21	1942	29	1548	
293	5B	500	21	1943	29	1005	

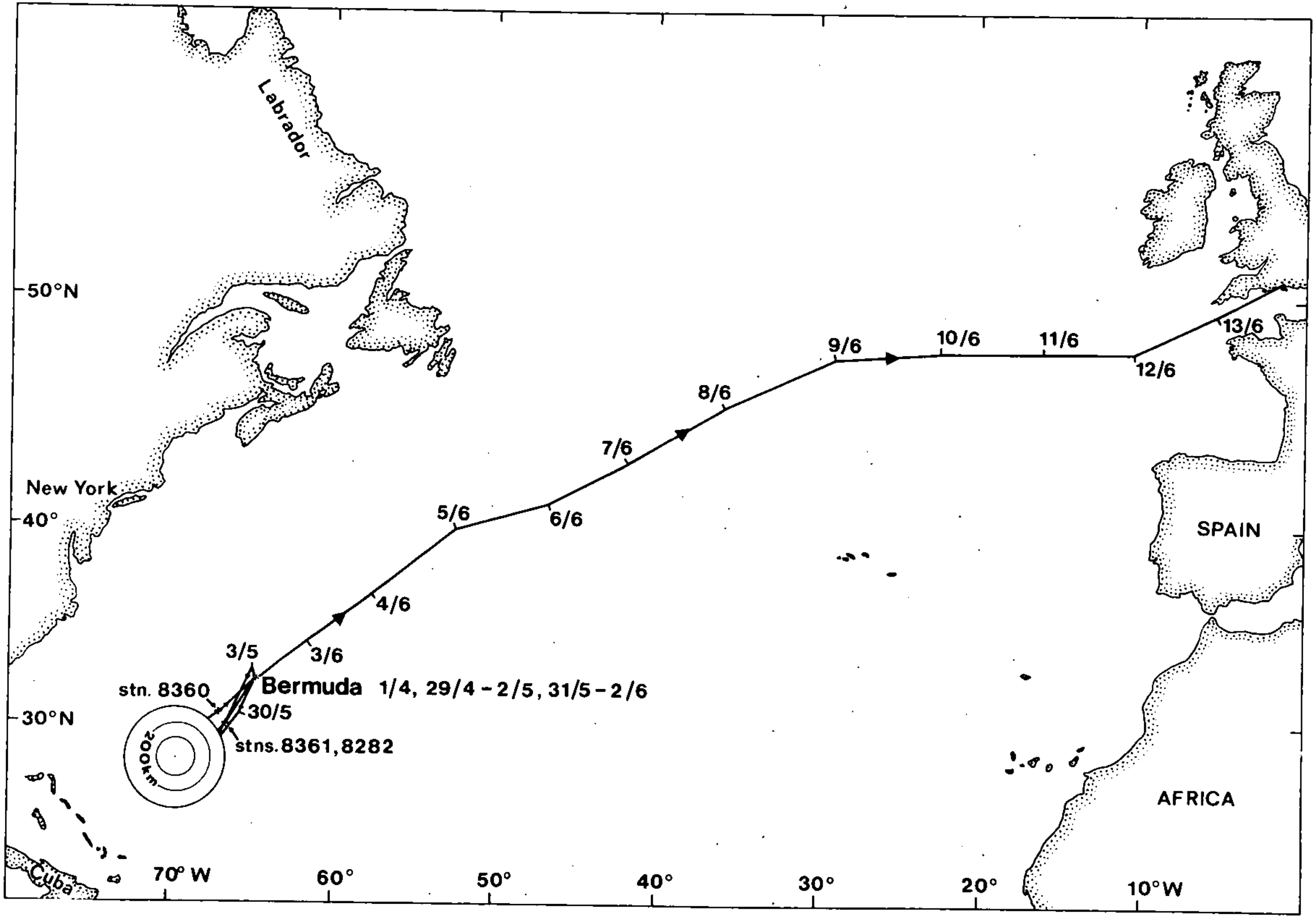
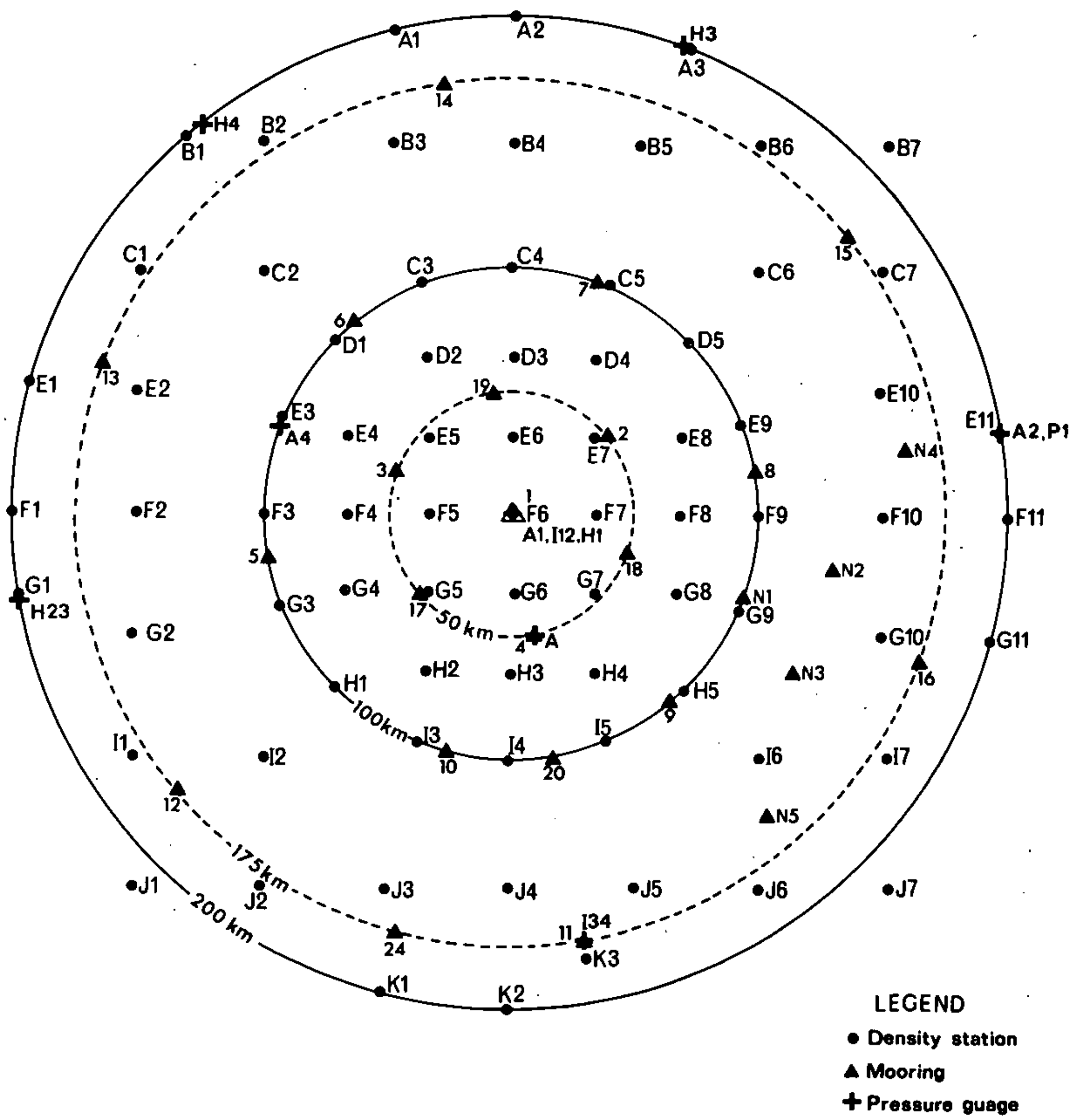


Fig. 1 Discovery Cruise 53 Noon positions

Fig.2 Density Grid and Fixed Instruments in the MODE area



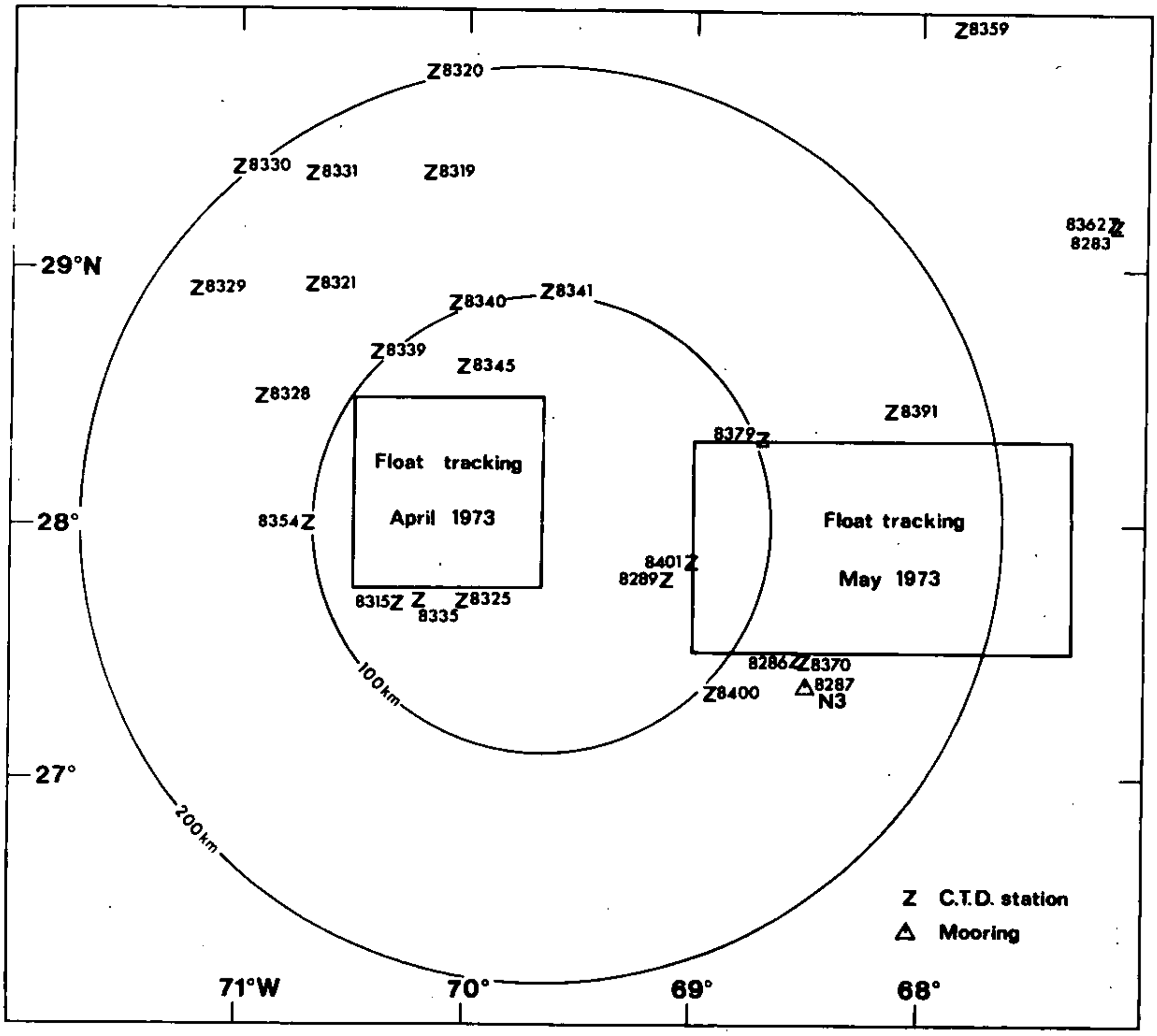


Fig. 3 Areas of float tracking and Discovery stations

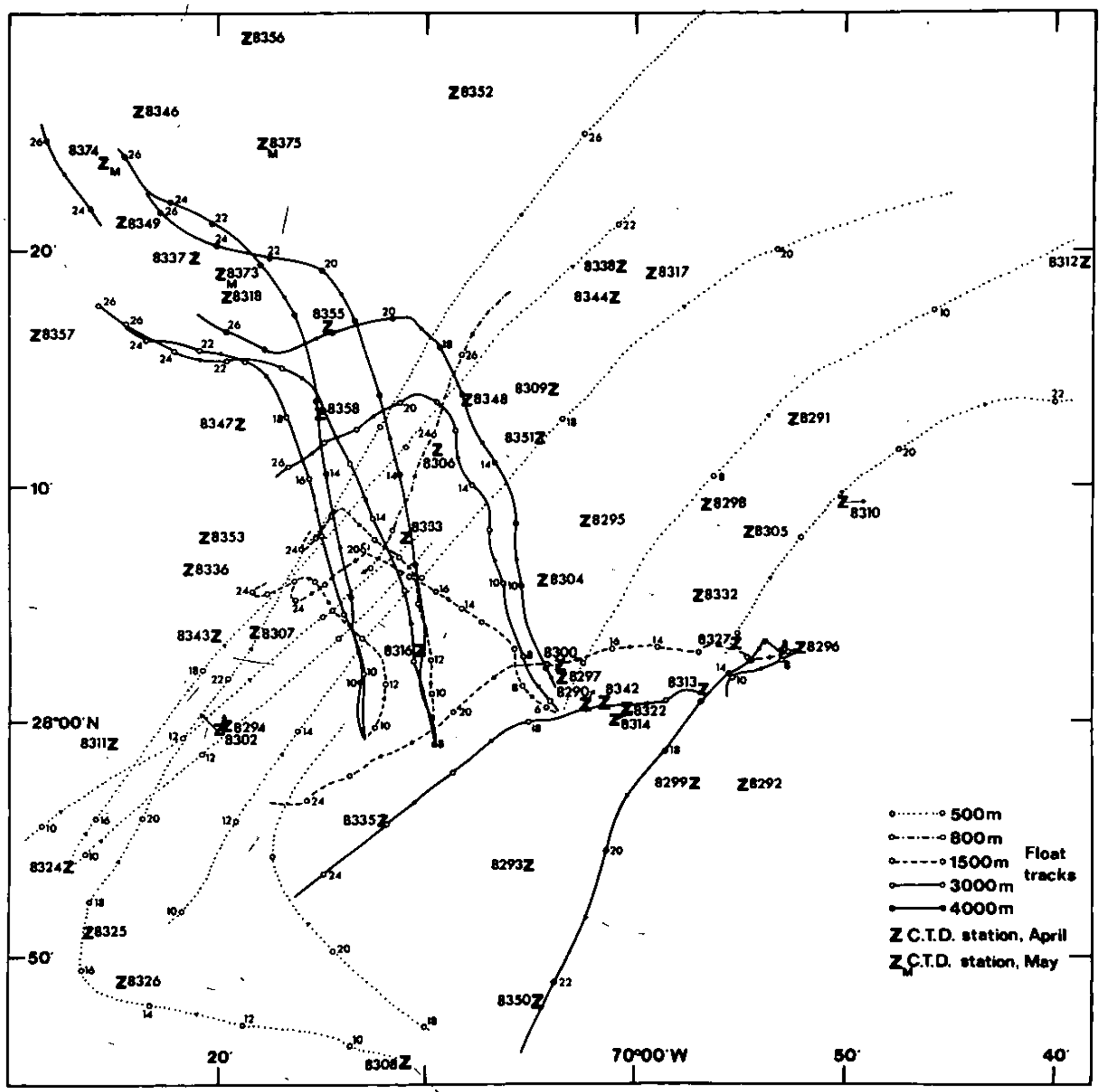


Fig.4 Float tracks during April 1973 and Discovery stations

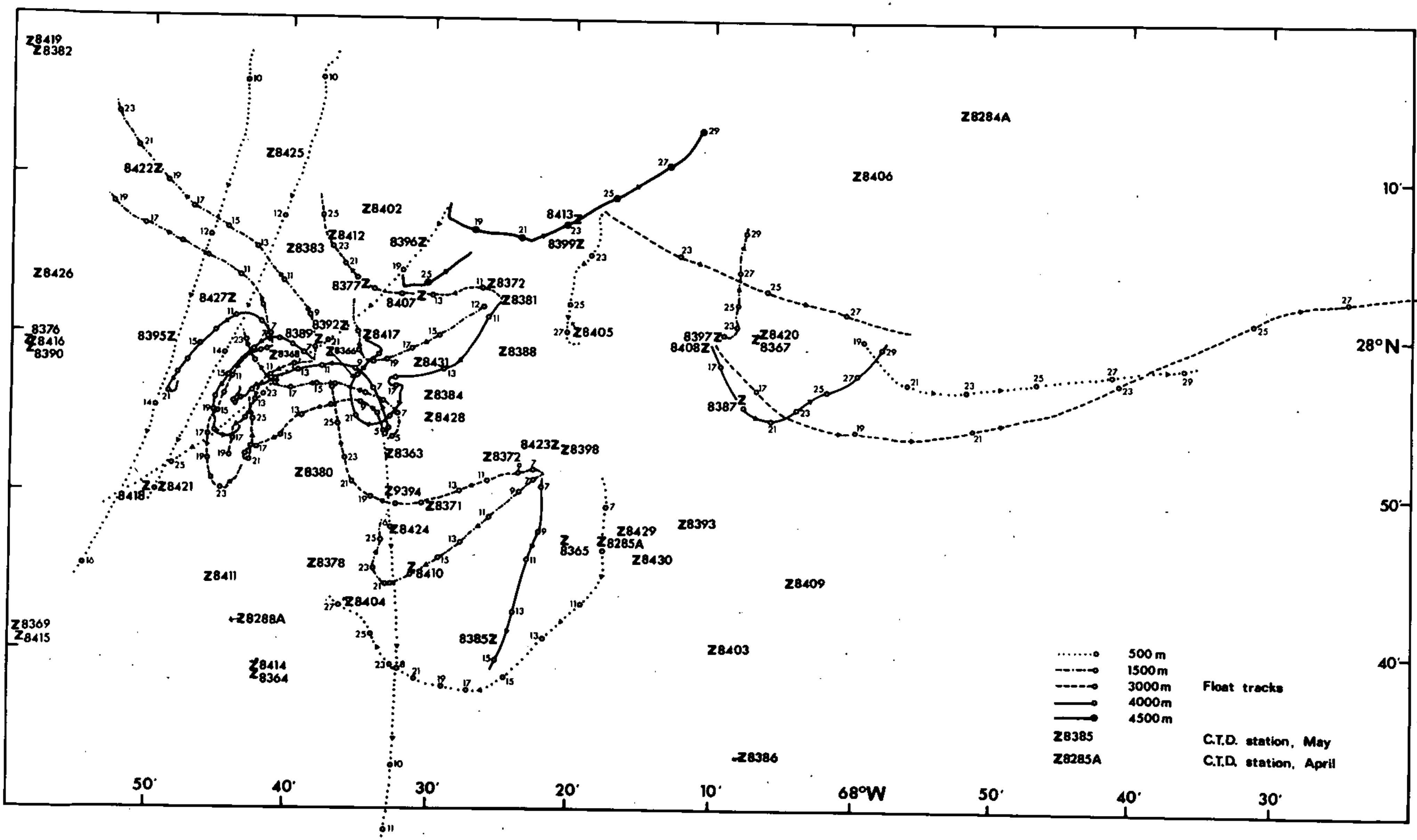


Fig. 5 Float tracks during May 1973 and Discovery stations