Indexed #R. MRS P EDWARDS. 86

I.O.S.

RRS DISCOVERY

CRUISE 159

15 MAY – 25 JUNE 1986

BIOGEOCHEMICAL FLUX STUDIES IN THE N.E. ATLANTIC – GME 26°N TRANSECT AND TAG HYDROTHERMAL FIELD

CRUISE REPORT NO. 193

1987

INSTITUTE OF OCEANOGRAPHIC SCIENCES DEACON LABORATORY

NATURAL ENVIRONMENT RESEARCH COUNCIL

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Biogeochemical flux studies in the N.E. Atlantic - GME 26°N transect and TAG hydrothermal field

Principal Scientist

W.R. Simpson

1987

DOCUMENT DATA SHEET

AUTHOR	SIMPSON, W.R. *et al*	*PUBLICATION DATE* 1987
TITLE	RRS *Discovery* Cruise 159, 15 May - 25 June 1986. Biogeochemical flux studies in the N.E. Atlantic - GME, 26°N transect and TAG hydrothermal field.	
REFERENCE	Institute of Oceanographic Sciences, Deacon Laboratory, Cruise Report, No. 193, 59pp.	

ABSTRACT

The report describes "Discovery" Cruise 159 conducted in June 1986 in the N.E. Atlantic.

The objectives were:

a) reoccupy a station over the Madeira Abyssal Plain

b) recover and redeploy trap and transmissometer moorings

c) mark a transect for flux studies along 26°N

d) investigate the TAG hydrothermal plumes.

Extensive particulate and dissolved phase chemical sampling, biological and microbiological sampling and studies of particle properties, particle concentration and mass fluxes were carried out.

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KEYWORDS	*MICROBIOLOGY* *WATER COLUMN* *ATLANTIC OCEAN (NE)* *MADEIRA ABYSSAL PLAIN* *TAG HYDROTHERMAL FIELD*	*CONTRACT* *PROJECT* CO 33 *PRICE* £13.00
BIOGEOCHEMICAL CYCLE *BIOGEOCHEMICAL FLUXES* *CHEMICAL OCEANOGRAPHY* *MARINE BIOLOGY*		

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SCIENTIFIC PERSONNEL - Leg 1

S.M. Boswell	Cambridge	Earth Sciences
A.R. Credland	IOS	Biology
G. Eglinton	Bristol	Organic Geochemistry
T.J.P. Gwilliam	IOS	Applied Physics
H.R. Harvey	Bristol	Organic Geochemistry
N.J. Hooker	IOS	Applied Physics
A.E. Isley	Rhode Island	Oceanography
D.A. Jones	RVS	Computing
H.R. Jones	IOS	Geochemistry
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P.J. Mason	RVS	Computing
J.G. Poynter	Bristol	Organic Geochemistry
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H.E. Sutherland	IOS	Geochemistry
R.F. Wallace	IOS	Engineering
D. White	IOS	Applied Physics
L.H. Wright	IOS	Engineering

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C.R. German	Cambridge	Earth Sciences
T.J.G. Gwilliam	IOS	Applied Physics
P.J. Herring	IOS	Biology
N.J. Hooker	IOS	Applied Physics
A.G. Howard	Southampton	Chemistry
D.J. Hydes	IOS	Geochemistry
A.E. Isley	Rhode Island	Oceanography
D.A. Jones	RVS	Computing
R.W. Jordan	Surrey	Microbiology
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W.R. Simpson	IOS	Principal Scientist
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R.F. Wallace	IOS	Engineering
D. White	IOS	Applied Physics
L.H. Wright	IOS	Engineering

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M.A. Harding	Master
P.J. MacDermott	Chief Officer
A.R. Louch	Second Officer
A.K. Maltby	Third Officer
P.E. Jago	Chief Engineer
N.A. Wilson-Deroze	Second Engineer
R.J. Perriman	Third Engineer
B.J. Entwistle	Third Engineer
P.E. Edgell	Electrical Engineer
C.T. Robinson	Radio Officer
R.O. Symonds	Personnel Manager (RVS)
F.S. Williams	Chief Petty Officer (Deck)
P. Biggs	Petty Officer (Deck)

SHIP'S PERSONNEL - Leg 2

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W.D. Coverdale	Chief Officer
A.R. Louch	Second Officer
A.K. Maltby	Third Officer
P.E. Jago	Chief Engineer
N.A. Wilson-Deroze	Second Engineer
C.J. Phillips	Third Engineer
B.J. Entwistle	Third Engineer
W.E. Groody	Electrical Engineer
C.T. Robinson	Radio Officer
F.S. Williams	Chief Petty Officer (Deck)
P. Biggs	Petty Officer (Deck)

ITINERARY

Leg 1	Falmouth to Tenerife	15 May to 27 May 1986
Leg 2	Tenerife to Tenerife	29 May to 25 June 1986

OBJECTIVES

1. To return to Great Meteor East (GME) on the Madeira Abyssal Plain to carry out follow-up studies of biogeochemical fluxes over the proposed radioactive waste disposal site.
2. To recover, service and redeploy sediment trap and transmissometer moorings at GME and make comparisons of pumped particle data with trap samples (mass fluxes, metals and organics).
3. To complete a transect of stations along 26°N taking particle and water samples for chemical analysis to estimate fluxes.
4. To locate and sample plumes produced by hydrothermal venting from the TAG field on the mid-Atlantic ridge. The programme was to include studies on water and particle chemistry, microbiology and general biology (nekton).

NARRATIVE

Discovery set sail from Falmouth on May 15th for the twelve-day leg to the Canary Islands. The only bad weather during the cruise was encountered in Biscay on the second day out. A short shakedown station to test equipment was run at 38°N 18°W in readiness for commissioned work over the Madeira Abyssal Plain. The work at GME involved the re-occupation of a station in the vicinity of the proposed radioactive disposal site as part of the Department of Environment investigations.

In the early afternoon of May 21st, the search commenced for the transmissometer tide-gauge mooring and sediment trap mooring laid from Darwin (Cruise 9A) on 21 November 1985; both were successfully recovered within five hours. Although there were some problems with the closing mechanisms on the traps, the samples were unaffected. The data collected by the transmissometer appeared to be good but full evaluation was to be carried out at a later date at

IOS. The plan for the remainder of the station work at GME was to alternate deep water particle sampler (FIDO) work with the CTD rosette. Filter samples (> 1000 litre) were to be taken using GFC filters for subsequent organic analysis by the Bristol Organic Geochemistry Group and also Nuclepore filters for major and trace element analysis by neutron activation analysis at Rhode Island. Manganese dioxide cartridges were fitted to FIDO for the scavenging of zirconium and hafnium (Cambridge) from the water. Water collected by the rosette was subsampled for trace metal (Southampton), nutrient (IOS), bacteria (UCG) and coccolithophorid (Surrey) analysis.

Three CTD rosette casts and five FIDO casts were run on the midships winch without mishap until, in the early hours of May 24th, the main hydraulic pump seized on the winch system. Luckily FIDO was suspended only 1 m above the deck at the time and not at full depth. By the middle of the following afternoon FIDO was back on the deck and checks on the hydraulic pump proved it necessary to fly a replacement from the UK for the second leg. Work was thus halted on the mid-ships winch and attention was turned to the aft winch. Permission was obtained from IOS to take a box core for the Bristol group, this also providing an opportunity to test the new release system fitted to the corer in readiness for Cruise 160. A full core was recovered. Before leaving GME the transmissometer mooring was relayed using a new Seatech instrument and the trap mooring was also redeployed.

At the most, two FIDO casts were missed due to the breakdown; the only other disappointment in an otherwise successful and enjoyable leg of the cruise was problems with the new Plessey computing system. The ship berthed at Santa Cruz late morning of May 27th.

The port call in Tenerife involved the changeover of half the scientific personnel and ships' officers. After a brief stay, we embarked on Leg 2 at 1100 on May 29th, leaving port shortly after the QE II and alongside the Norwegian tall ship Christian Radich bound for Bermuda. The square-rigger was crewed by young students on a ten-month voyage.

On this leg, work was carried out over the TAG hydrothermal field in the median valley of the mid-Atlantic Ridge (MAR) at 26°N, 45°W. Stations were worked along 26°10'N on the outward and return passage to and from TAG. Surface water samples were collected at regular intervals for ^{210}Pb analysis (MIT).

The new hydraulic pump was installed in port and we were able to recommence FIDO and CTD casts on Station 11288 at 26°11'N, 23°20'W (May 30th). The FIDO

samples on this station were taken for subsequent Pu and Am analysis by the IAEA at Monaco, filling in the sampling missed at GME. The biologists who joined in Tenerife trawled the RMT 1 + 8 nets to 230 m and from 650 to 415 m and, on passage to Station 11290, from 485 to 800 m. Filters were also taken on this and other stations for particle mobility studies (UEA).

On Station 11290, some problems were encountered with equipment. There were power supply problems to both filter and particle cell pumps on FIDO and the net monitor failed. However, the MIT pump (nicknamed FIFI) was tried successfully for the first time, it being clamped on the wire 50 m above the CTD-rosette. After a second FIFI cast, FIDO was run to 1000 m after correction of the power supply problems. Four filter samples were taken.

The nets were trawled to 1300 m (Station 11291) on the way to the TAG area on the ridge. Contact was made with Atlantis II that was finishing work with Alvin on the vent field. Peter Rona, Principal Scientist on Atlantis II, told us of very strong venting activity and they kindly laid a transponder on the hydrothermal mound to aid our navigation to the vents. However, we were unable to activate the transponder because we could not transmit on the frequency required.

A preliminary N/S bathymetric survey was run along the median valley. The plan was to lay three transponders to form an approximate equilateral triangle with the base running N/S down the valley axis with the vents to the left of centre of this base and the third at the top of the triangle, west of the vent field. The first transponder to the north of TAG failed to work, the second to the south operated successfully but was later found to be partially hidden behind a small, formerly uncharted, hummock (see Bathymetry, Figure 6) and the third to the west was laid close to the valley axis. Thus we were left with two working transponders, one of which was partially obscured. The precise position of the transponders was determined by satellite fixes over the duration of our stay over the median valley.

The first cast with FIDO located the plume, there being a strong particle signal obtained in the transmissometer read-out with maximum attenuation at 3340 m. Samples were taken in the plume. FIFI was placed 100 m above FIDO on this cast. The CTD-rosette was run after returning to the adjudged correct position. During this passage the neuston net was fished.

Holding position over the vent was found to be problematic on this and all subsequent stations. The wind (15-20 kts) came steadily from the E/SE with strong surface currents. The ship's drift during casts is exemplified by the

ship tracks plots in Figures 7 and 8. Thus the combination of wind/current and insufficient transponder coverage made the positioning of the instrument difficult but, over the two weeks period of our stay in the vicinity, we learned from experience. For instance, navigation was aided by recognition of topographic features and we learned where to position the ship at the start of a cast for the prevailing conditions so as to pass close to the vents with the instruments.

On Station 11294, FIFI was placed above FIDO. The CTD cast was run west of TAG and, unfortunately, touched bottom. The sensors were, however, in good working order for Station 11298. The RMT 8 + 1 was fished on 11295 between 1550 and 2015 m but, on the subsequent trawl, the net failed to open. Samples were taken in the plume by FIDO and FIFI (Station 11298) and two trawls run successively, the second of which failed because of immediate net closure.

The rosette cast on Station 13001 was worked SE of the vent; the vents were sampled by FIFI but FIDO developed a valve control fault. The subsequent CTD was close to the vents. In the early hours of Friday, June 13th with FIDO and FIFI at 3140 m, the main pump for the midships winch seized again (Station 11304). The situation was quite serious since the ship was effectively "anchored" in the median valley with the ridge crests up to 2000 m on either side. The ship steamed slowly astern in a N/S then S/N direction while a solution to the problem was found. It was decided to connect the hydraulics of the forward crane to the winch and use the crane motor to recover the gear. It worked, and by 1600 FIDO was back on deck, much to everyone's relief. However, this was not the end of the problems. The aft crane starter motor broke down and, coupled to difficulties with the net monitor, the nets had to be fished open using a combination of capstan and aft davit for launch and recovery (Station 11305).

In the meantime, it became obvious that the midships winch could not be used again on the cruise. We still had FIFI operational and we required some means of measuring particle concentration to identify plumes. Necessity being the mother of invention, a stand-alone filtration unit was rapidly designed consisting of remote on-off control of the filter motor, flow meter, power pack, filter stack and transmissometer that relayed data in real-time. The obvious choice of name after FIDO and FIFI was DODO.

All subsequent work was carried out on the electric winch (6.4 mm cable), the transmissometer was combined with the CTD rosette (Station 11306#1) and the CTD was used as the wire weight for FIFI casts (#2). On Series 3 of 11306 (CTD

and transmissometer) north of TAG, a strong particle plume suggested the presence of a second vent field.

Before leaving TAG to take up a station west of the ridge, the nets were trawled open to 2000 m and a CTD-transmissometer-FIFI cast run to 3333 m.

The station west of the ridge was worked at 26°01'N, 46°36'W at the end of a minor transform fault; the idea was to compare this water column with that of TAG and to investigate the possibility of material transport along the fault from the valley. Water samples were taken throughout the water column and two FIFI samples obtained at 2000 m.

By the end of Station 11310 the net monitors were repaired. However, while it was necessary to use the davit for launching and recovery there was insufficient height for the full monitor-RMT 8 + 1 arrangement, therefore the RMT1 net was removed. The RMT8 caught many interesting specimens. Also the DODO filtration unit was ready and, on return to the TAG area, a cast with the instrument showed the possible existence of a third vent field at 26°09.40'N, 44°50.21'W (Station 11311). This cast, and two further casts on Station 11312, were run to 3400-3500 m and alternated with rosette sampling. The aft crane was repaired which allowed the first and last long deep trawl along the median valley over TAG. The nets were opened at 2930 m and closed at 3460 m. From this trawl, estimated to be 200 m above the vents, was obtained a specimen of R. chacei found previously in samples collected on the vents by the submersible Alvin.

Station 11314 was worked east of the ridge (26°35'N, 42°02'W°) (four hydrocasts and three filter samples) after which the heading was set for Tenerife. A stop was made for DODO casts on the re-occupation of Station 11290 to fill in gaps in the filter sampling. A short near-surface trawl was made at 26°46'N, 26°40'W (Station 11316).

The ship produced one more eventful afternoon when the cam sleeves on the third engine seized during run-up. We docked in Santa Cruz at 1500 on June 15th.

The cruise was not without incident but, despite mishaps, was scientifically successful and was both productive and enjoyable for everyone involved. It was a particular pleasure to have a large proportion of willing and enthusiastic Ph.D. students on board.

All the scientific party are deeply indebted to the officers and crew of Discovery for all their efforts, especially for skilled navigation over TAG and the help freely given when Murphy's Law came into operation. Particular thanks

are due to the ship's engineers and electrical officers and the IOS Applied Physics and Engineering Groups for working exceedingly long hours, often in very cramped and uncomfortable conditions, to repair winches, cranes and engines.

APPLIED PHYSICS - LEG 1

(a) FIDO

The normal complement of sensors were included on FIDO, i.e. particle cell, pressure sensor, temperature sensor and two flow sensors. Four filters were used on all deployments.

Station 11287#1	750 metres - cast time 5.5 hours
Station 11287#3	2300 metres - cast time 5.75 hours
Station 11287#5	5365 metres - cast time 8.5 hours
Station 11287#6	5523 metres - cast time 6.5 hours
Station 11287#8	Problems with cable at 2240 metres. Returned to the surface, rectified problem but unable to redeploy due to overheating of hydraulic pump. In preparing for this cast, a connector 'O' ring had failed on the main electronics tube. On inspection of the end-cap, a small groove was found which required the whole face to be machined.

The total amount of water pumped through all four filters was 31,537 litres. The new interface between the FIDO demodulator and the Digidata was put into commission and all FIDO data for Cruise 159 was recorded on the Digidata system as well as on the audio-magnetic tape.

(b) CTD

The spare deep CTD which incorporated conductivity, temperature and pressure sensors with the twelve-bottle rosette sampler was used.

Station 11287#2	Day 141
Station 11287#4	Day 141
Station 11287#7	Day 143

(c) Mooring 402 - Long-term Transmissometer Mooring

This mooring was laid on Cruise 9a/85 from RRS Charles Darwin, Day 322. It was recovered on this cruise on Day 141 for data tape replacement, battery pack renewal and transmissometer change. The mooring was redeployed on Day 145.

Time in water	09-11-30 GMT
Water depth	5370 metres
Position	31°-33.6°N, 24°-43.4°W

The transmissometer which was recovered from this mooring was then incorporated into the FIDO system for the remainder of the cruise.

(d) Sediment Trap Mooring

This was recovered on Day 141 from GME. Samples were obtained from all four traps on the string. There were some problems with trap closure but these were resolved before relaying the mooring on Day 145. Time on bottom, 1255 GMT.

T.J.G. Gwilliam D. White

APPLIED PHYSICS - LEG 2

(a) FIFI

A prototype pump for in-situ filtration of suspended particulate material (dubbed FIFI) was given its first thorough sea trials on this cruise. The pump is a battery-powered, self-contained unit designed to be attached to a hydrowire at any point along its length, and to "weathervane" in ambient relative current so that the sampling port is always "upstream" of metal contamination from the wire and instrument. An HP-41CX computer and CMT-200 interface control the pre-set pumping interval and record flow rate versus time data. Performance was very good; in fifteen deployments, a single broken filter and two minor pressure-case leaks were the only problems.

R.M. Sherrell

(b) Transponder Moorings

Three transponders were laid in the TAG area for navigational requirements. Unfortunately, the first mooring failed to operate although wire-tested previously. In practice, the two transponder system worked well despite the topography of the TAG area which, at times, limited reception to one transponder only.

Mooring Position

Position	Details
	Failed after deployment
26°08.2'N	TR1 - depth 3400 m - Laid 7 June 1986
44°48.4'W	
26°08.48'N	TR2 - depth 3680 m - Laid 8 June 1986

(c) FIDO

As in the first leg, the normal complement of sensors was included (particle cell, pressure sensor, temperature sensor and two flow sensors). Four filters were included on all deployments. Problems occurred on this leg with three failures of the filter pump motor. Inspection of two of the faulty motors revealed burnt out armature windings. By reducing the drive voltage, the filter pump remained operational, although this resulted in a reduction in total volume pumped. The filter flow transducer was damaged by sea water which resulted in the flow calibration being invalidated. Accurate volumes were taken from the Kent flow meters. At Station 11290#1 FIDO was deployed to a depth of 5335 metres (5 metres off bottom), water entered the particle cell via the window. Inspection of the glass revealed stress fractures around the edge. The window was replaced.

A total of sixteen battery packs was manufactured for this cruise giving FIDO a fast turn-round capability. No problems arose which reflected the care taken in their manufacture and maintenance. Unfortunately, during the cruise the midships winch hydraulic system failed which curtailed any further work with it. However, eleven deployments of FIDO were achieved with a total volume of water pumped of 7639 litres. The CTD and rosette work continued on the electric winch system, the latter working well.

A filter pumping unit, together with the transmissometer, was constructed from the FIDO equipment which included start/stop facilities from deck.

Although this meant a reduction in the amount of filtration, it did result in the majority of the work being completed. All FIDO data was recorded on audio-magnetic tape and Digidata. However, problems with the shipboard computer system did not allow full use of the plotting routines and the logging of data was also suspect.

Station 11288#1	750 metres - cast time 2 hours 40 minutes
Station 11288#3	5043 metres - cast time 9 hours 15 minutes
Station 11290#1	5496 metres - cast time 8 hours 30 minutes
Station 11290#6	1000 metres - cast time 4 hours 46 minutes
Station 11293#1	3624 metres - cast time 4 hours
Station 11294#1	3700 metres - cast time 5 hours 30 minutes
Station 11296#2	3600 metres - cast time 5 hours 30 minutes
Station 11298#1	3370 metres - cast time 5 hours 15 minutes
Station 11299#2	3370 metres - cast time 5 hours
Station 11301#2	3273 metres - cast time 3 hours
Station 11304#1	3657 metres - cast time 18 hours 45 minutes

The mini-pumping system (DODO) was deployed five times at various depths using the electric winch. Total volume pumped was 2649 litres.

Station 11311#1	Volume pumped - 202 litres
Station 11312#1	Volume pumped - 556 litres
Station 11313#1	Volume pumped - 726 litres
Station 11314#2	Volume pumped - 653 litres
Station 11314#4	Volume pumped - 512 litres

(d) CTD and Rosette

Station 11288#6	Day 152
Station 11290#2	Day 153
Station 11290#4	Day 154
Station 11292#1	Day 158
Station 11293#2	Day 160
Station 11296#6	Day 161
Station 11301#1	Day 163

Station 11303#1	Day 163
Station 11306#1	Day 165
Station 11308#1	Day 166
Station 11310#1	Day 167
Station 11314#3	Day 170
Station 11314#5	Day 170

All CTD data was recorded on Digidata but not necessarily on the shipboard computer system.

T.J.G. Gwilliam D. White

BIOLOGICAL SAMPLING

The aims of the biological programme were (1) to investigate the possible effects of the vent conditions in the TAG area on the deep pelagic fauna and (2) to collect material for biochemical and physiological investigation.

Fifteen tows were made with the RMT8 trawl, either alone or in combination with the RMT1. The release gear flooded on the first trawl (11288#3) and had to be replaced. Persistent problems were experienced with both net monitors ("white" and "black" leads) and, in consequence, only three of the first nine tows were wholly successful. The unreliability of the monitors precluded any attempt to fish near the vents during the main working period in the TAG area. It was finally necessary to fish the combination net (RMT1 + 8) in the open condition until the monitor problems could be resolved. This decision coincided with the failure of the crane and required new methods to be devised for deploying and recovering the nets using the Schat davit alone, with its much smaller potential lift (14 ft). The RMT1 + 8 combination was deployed by removing the cross, tying the nets in the open configuration and lifting the weight bar off the deck by means of a single line to one end which ran through a fixed block on the end of the Schat davit and was hauled on the capstan. A lazy line from the weight bar to the top bar allowed recovery to proceed similarly (Stations 11305, 11307 and 11309). Even when a monitor was repaired, it could not be used with both nets together because of the limited lift available. It was used successfully with the RMT8 alone (11310#6) after re-rigging the net so that the weight bar could be lifted on the two side wires by a divided line running through the block to the capstan.

The subsequent repair of the crane provided a last chance to attempt a deep trawl over the TAG area with the complete net system. The net was fished for a two-hour period to a maximum depth of 3460 m (11313#1), using the calculated horizontal range of the net from the ship and the dead reckoning ship positions to "aim" the net at the vent area. The catches were very small but that of the RMT8 included four specimens of an unusual shrimp (perhaps an alpheid) that had not been encountered previously.

It is clear from the experience of this tow that it will remain very difficult in any future programme to achieve accurately-located, near-bottom tows in the area without additional navigational aids, allowing precise real-time positioning of the net itself relative to the bottom topography. When fully deployed (7274 m.w.o.) the net was at a horizontal range of approximately 6.5 km from the ship with no information about its lateral position relative to the ship's path. The bottom transponders could not be utilised as the net monitor pulses produced multiple triggering. This uncertainty about the position of the net, combined with the near-bottom currents and the small target area of the vents, renders such tows both hazardous and uncertain as to whether they achieve their objective.

Net catches in general were of low biomass, typical of other central gyre regions (e.g. GME). Unusual organisms included a giant leptocephalus larva, a stomiatoid fish with an unusually elongate barbel, and two specimens of the squid Selenoteuthis. Observations were made on the luminescence of several species of copepod and some material was collected for trace metal analysis.

R.A. Aldred P.A. Domanski P.J. Herring

COMPUTING - Leg 1

Logging of navigational data into the shipboard computing system commenced on May 18th (138: 11.06 Z). Breakdown of the CTD Level A was repaired and connected into the computing system on May 17th.

During the cruise two faults occurred, one being a memory board in the Level C computer failing; this was soon rectified by replacing it with a spare board. The other problem encountered was the electrostatic top on the flatbed plotter became detached around the edges and could only be repaired effectively be removing the static top completely and fixing it down with double-sided tape.

Difficulty was experienced in the logging of FIDO data due to the quantity

of data that it produced. Other than the above problems occurring, the shipboard computing system was reliable and the logging of navigational and CTD data was never interrupted.

P. Mason

COMPUTING - Leg 2

The cruise was plagued with hardware and software problems.

(a) Hardware

At the start of Leg 2, while checking the serial numbers of the rest of the boards in the computer, the ribbon cable to the second winchester (the data disk) was pinched. The cable was not severed and the computer was restarted.

Later on in the leg, a memory board failed again. There was no other spare on board but, when the two memory boards in the Level C were swapped, the fault disappeared.

The Cambridge ring failed. There was no apparent cause but it could not be restarted. The Level As were plugged directly in to the Level B so that logging could continue, and the data was transferred to the Level C via magnetic tape.

During Station 11294#2, the CTD Level A failed. After consultation with Barry, the problem was traced to a B1044 i/o board. This was replaced and logging continued.

After a general power failure the Cambridge ring partially recovered. For the rest of the cruise, the data was transferred from Level B to Level C via the ring thus speeding up operations.

The Level B halted three times during this leg for no obvious reason. No other peripherals were affected at the same time.

(b) Software

During the first leg, it was discovered that the Cambridge ring or Level B was not accepting data fast enough from the FIDO Level A. After numerous experiments, it was decided to pass the data directly from the Level A to the Level C via a serial link. Ths worked better, but it was not very satisfactory because sections of 'good' data were interspersed with sections containing data gaps of 4-6 seconds. Attempts were made to discover what caused this, but no

real progress was made. However, if the computer was working hard, the gaps seemed to become more numerous. This meant that no software development or editing could be done during a FIDO station. This hampered the debugging of another major program in the FIDO processing suite to the extent that it was never completed. The processing of the FIDO data will be finalised at RVS.

As a safety precaution, ASCII tapes were made of the raw FIDO data.

For each CTD station, the pressure temperature and salinity data were listed at bottle sample times for calibration purposes.

Modifications to existing software include:

1. Altering ctdplot s.th. It plots one variable at a time, cutting out the pen changes which normally occur every eighth of an inch of plot.
2. Altering grid s.th. It will draw one-second tick marks - necessary when the work area is only a few minutes of latitude and longitude wide.
3. Altering trackplot s.th. It will annotate only the start and end of a line when using a small plotting scale.
4. Increasing the buffer sizes of subroutines which send to and receive data from the Cambridge ring.

D. Jones

ENGINEERING

Several engineering problems were encountered on this cruise. The forward ring-main pump failed on one station. Fortunately, the wire was all inboard. There was complete loss of pressure on the pump, due to a leak from high to low pressure. Also, the head of the split pin was found in the drain line. It was decided to remove the pump. This was done in about one-and-a-half days with the help of the chief engineer and ship's electrician and IOS technicians. The new pump was fitted and tested successfully.

After sailing from Tenerife, the pump ran for about sixty hours then failed due to an internal fault. There were 3500 m of wire out with FIDO and FIFI on the wire. There was not time to fully investigate the fault on the pump so it was decided to connect the forward crane hydraulics to the midships winch for recovery. The wire was hauled back at 0.5 m/sec and FIDO and FIFI were brought back with comparative ease. The pump was investigated and found to be very noisy and to have a high drain-flow thus needing replacement in Tenerife.

The aft crane starter motor failed at the beginning of a net station.

This was removed and after several days of work was found to have a burnt-out coil. This was rewound and fitted to the crane with success. The electric winch was used for several stations and worked well. Likewise, there were no problems with the traction winch.

Manufacturing facilities were utilised throughout the cruise by both IOS and University personnel.

R.F. Wallace L.H. Wright A.R. Staszkiewicz

HYDROGRAPHIC SAMPLING

Water samples were obtained using a rosette of twelve GOFLO bottles. Sub-samples were obtained for the following analyses, some of which were carried out on board, whilst others are to be processed on return to the UK:

1. Salinity
2. Nutrients (nitrate, phosphate and silicate)
3. Dissolved oxygen
4. Bacteria
5. Metalloids
6. Trace metals
7. Iodine-iodate
8. Aluminium
9. Zirconium and Hafnium
10. Coccolithophorids

Several faults in the GOFLO bottles became evident prior to and during the cruise:

1. Pressure release valve not functioning. Tap incomplete.
3. Leaky ball valves.
6. Extensive fracturing of main body. Pressure release valve not functioning reliably.
7. Pressure release valve not functioning reliably. Tap incomplete.
8. Part of tap missing.
9. Sticky ball valves.

All except two were repaired.

A.G Howard

(a) CTD measurements

All rosette casts, up until the terminal failure of the midships winch, were accompanied by CTD measurements of the water-column structure. Whilst this was generally highly successful and permitted accurate selection of the water sampling positions, several aspects of shipboard utilisation of the system became evident; in particular, problems with the new Plessey computer system.

(b) Aluminium determinations

During Discovery Cruise 149 (May 1984) a single station was occupied over the Mid-Atlantic Ridge (MAR) at 43°N. Below 2500 m depth the water at that station was in an enclosed valley. In the valley, elevated concentrations of aluminium were observed. These corresponded to elevated concentrations of manganese which were probably of hydrothermal origin.

The stations occupied during Cruise 159 have enabled us to study the possible input of dissolved aluminium to ocean waters resulting from reactions between seawater and hot rock at the MAR, at a site of known hydrothermal venting.

A total of 242 samples was processed for the determination of dissolved aluminium, from stations on and off the Ridge. At the TAG site, aluminium concentrations are enhanced at depths below 3000 m by some 15 and 30 per cent with respect to off-ridge crest stations to the west and east respectively.

(c) Nutrient determinations

Dissolved silicon, phosphate and nitrate were determined on some 250 samples by continuous-flow analysis using the IOS ChemLab analyser system. During the cruise a data collection and reduction system based on an Acorn-BBC micro-computer was set up.

D.J. Hydes

(d) Oxygen

Water samples from the CTD-rosette casts were analysed for D.O. using the Winkler Method. The minimum was generally noted at 900 m. Surface waters tended to be depleted relative to deeper waters and more variability was noted in samples shallower than 900 m.

S. Boswell

(e) Metalloids

Recent studies of the Mid-Atlantic Ridge (MAR), centred around the area of the Kane and Atlantis fracture zones, have indicated the presence of active hydrothermal activity which is implicated in significant anomalies in the chemistry of the overlying water column. While such regions have been studied in the fast-spreading centres of the Pacific, little is known of the chemical implications of hydrothermal activity in the slow-spreading MAR. The influence of hydrothermal inputs into the water column can be twofold. Firstly, they represent a direct input of matter into the water column as both dissolved and particulate components. This can result in locally elevated levels of elements such as manganese, lithium, rubidium, silicon and barium. In addition to this role, they can be responsible for the scavenging of trace elements from the water column (Edmond et al., 1979). At present little is known of the rates of scavenging and release of material by vent plumes and the chemical changes involved during the early stages of hydrothermal release.

The metalloid elements offer particular advantages for the study of chemical activity in the region of hydrothermal vents. In most oceanic waters they are typically present at concentrations lying between 10 and 1000 ng/litre. Thermodynamics predict that they should be present in their higher oxidation states. This is generally supported by experimental observations but, in the presence of extensive biological activity or in regions subject to abnormal geochemical conditions, significant deviations can occur. Taking the specific example of arsenic, techniques are available for the measurement of the reduced and oxidised oxyanions (presumed to be arsenite and arsenate) and various methylated arsenic species. Samples have therefore been collected from the TAG region of the MAR for the study of processes influencing the distribution and chemical form of vent-derived material. Whilst it is premature to anticipate the results of analyses to be carried out on the collected samples, analysis of the samples on return to the UK is expected to elucidate the magnitude of metalloid release into the water column, its rate of oxidation and any biological methylation. In addition, as particulate material in the TAG plumes is believed to contain up to 15.8% iron (Trefry et al., 1985), it is to be anticipated that the hydrothermal plume may be a highly efficient arsenic scavenger, resulting in significant depletion of the element from the water column in the vicinity of the vents.

A.G. Howard

(f) Pb and Pb-210 in Eastern North Atlantic surface water

Surface water samples were collected throughout the cruise using the "pole sampling" technique. This method avoids metal contamination from the vessel hull by sampling in bottles on the end of a non-metallic pole while the ship is steaming at 2 knots. Sampling interval was about every degree of longitude, but was twice as dense in the Beta Triangle region. Samples will be analysed by E. Boyle (MIT) for Pb and by M. Bacon (WHOI) for Pb-210 as part of an investigation of the concentration and spatial variability of Pb in the surface ocean. The expected ban in use of Pb additives in Europe in fuels will lead to decreased atmospheric Pb input to this study area over the next decade. Measurements from this cruise will make possible the quantification of the response rate of the surface ocean to this decreased input. The overall objective is to understand the cycling dynamics for the removal of this fairly reactive trace metal to the deep ocean.

The accompanying table provides a summary of the samples.

R.M. Sherrell

(g) Zirconium and Hafnium

Two types of sampling were used for Zr/Hf, water and cartridges. The water samples (11 x 2.5 litres) were taken using the CTD and Rosette across a plume, which had been located using transmissometer data. These samples were filtered using 0.4 μm Nuclepore filters. These are for IDMS work.

The cartridge samples are MnO_2 coated polypropylene filters which were put downflow of FIDO filter stacks through which the water passed. The MnO_2 scavenged dissolved trace metals from the water. The large volumes sampled will, it is hoped, give sufficient sample size for Hf isotope ratio measurements.

S.M. Boswell

MICROBIOLOGICAL STUDIES

(a) Bacteria

Bacteria are thought to play a significant role in chemical transformations and the particulate/dissolved exchange of material in the oceans. There is, however, a lack of quantitative data concerning microbial biomass and activity and also the association of bacteria with particulate material, especially with respect to deep oceanic waters.

Throughout this cruise, samples were taken and preserved for subsequent study with the aim of determining the size spectrum and abundance of bacteria in the water column and their degree of association with particulate material. It was also hoped to obtain a relative measure of their productivity by the frequency of dividing cells technique.

Water samples (2 x 50 ml) were collected as part of the regime of samples taken from rosette casts. Casts which were sampled are listed below. Samples were immediately preserved by the addition of 2.5 ml of particle-free formalin (40% w/v) giving a final concentration of 2% w/v.

Subsequent analysis will involve epifluorescence microscopy, photomicrography and subsequent analysis of the photographs by means of an image analyser.

Stations and casts sampled

11288#2, 11288#6, 11293#2, 11294#2, 11296#1, 11301#1, 11310#1, 11310#5, 11312#2, 11314#1, 11314#3, 11314#5.

J.W. Patching

(b) Marine coccolithophorids (Prymnesiophyceae) and other micro-organisms

Further coccolithophorid community structures of the NE Atlantic will be compiled from the filter samples, as well as the general phytoplankton community assemblages. From the culture tubes, uni-algal cultures (especially of coccolithophorids) will be attempted so that life-cycle studies can be conducted and internal morphology investigated.

Water samples were obtained from the 2.5 litre water bottles during shallow CTD casts between 0-200 m. Using nitrogen gas at about 10 psi, one litre of water was passed through a Nuclepore filter until approximately 40 ml of water

remained above the filter (0.4 μm porosity, 47 mm diameter). About 10 ml of this "soup" was then transferred to sterile culture tubes, each containing 5 ml of Erd-Schreiber medium, and then placed in an illuminated incubator (16 h/8 h light/dark periodicity) set at 20°C. The filters were washed with distilled water, air-dried and stored in Petrislides for later analysis by Scanning Electron Microscopy.

On a few of the deep CTD casts, "soups" were collected and placed in sterile test-tubes and about 0.2 ml of concentrated glutaraldehyde (25%) added to make a 1% solution. The tubes were stored in the fridge at 4°C and will be analysed later by Professor Manton of Leeds University for benthic amoebo-flagellates similar to those found on Cruise 156.

During the RMT net trawls the neuston net was deployed for thirty minutes. Five-millilitre water samples were taken from each catch and added to 5 ml of Erd-Schreiber medium in sterile culture tubes. These were then placed in the illuminated incubator as before (to be analysed as above).

R.W. Jordan

PARTICLE SAMPLING

(a) Inorganic Geochemistry

On Discovery Cruise 159, large volume pumping-filtration systems (FIDO, FIFI and DODO) allowed collection of mg-size samples of suspended particulate matter throughout the water column at several Eastern North Atlantic and Mid-Atlantic Ridge stations. These samples will be analysed at the Graduate School of Oceanography, University of Rhode Island, by instrumental neutron activation (INAA) and scanning electron microscopy-X-ray diffraction/electron microprobe (SEM-XRD/EMP) techniques and by atomic adsorption spectrometry at MIT. Such analyses should provide information on the concentration of a number of elements (specifically, particulate Al, V, Ba, Ca, Si, Fe, Mn, Mg, As, Cu, Cr, Zn, Ti) and a suite of rare earth elements (REEs), as well as the mineralogical composition and degree of weathering of detrital (specifically, clay) materials. This data base will be used to examine the following:

1. The flux of materials through the water column from surface waters, particularly those associated with biogenically-derived particles.
2. The flux of materials through the water column from the sea floor

associated with deep-sea resuspension. Surface sediment was collected at one station and will also be analysed by INAA, SEM-XRD/EMP. This will enable surface sediment geochemistry and mineralogy to be compared with that of particles comprising the nepheloid layer. Vertical sampling in the nepheloid layer at this station was completed at + 1, + 10, + 100 and + 1000 metres above bottom, which may allow us to learn more about the modification of particles during resuspension and the relative contributions of vertical and horizontal input of particles to the nepheloid layer here.

3. The character and flux of particles derived from hydrothermal vents along the Mid-Atlantic Ridge in the TAG area. By completing such large volume filtration work, we have at our disposal samples of plume particulates several orders of magnitude larger than previously recovered. This should enhance the statistical validity of geochemical and mineralogical analyses, and provide an excellent opportunity to examine the mineralogical character of particles associated with hydrothermal emissions and the geochemical modification of those particles during their advection. This, in turn, coupled with analyses of dissolved elements completed by other members of the Discovery 159 party, may allow qualitative evaluation of adsorption-desorption and weathering processes associated with plume particulates. Comparisons can be made directly with "typical" and water and deep samples collected off the ridge.

Nuclepore polycarbonate filters (1 μ pore size, 273 mm diameter) were used with the FIDO and DODO systems. On Leg 1, Nuclepore polycarbonate pre-filters (30 μ pore size, 179 mm diameter) were used in conjunction with the others to provide size-fractionated samples. Filters were loaded into the top-hat filter holders using plastic forceps and rinsed with distilled, de-ionised water (DDI). Filter holders were closed with stainless steel bolts and mounted on to the filtration systems. Filter holders were covered with clean plastic bags until equipment was lowered over the side. On recovery, filters were washed under vacuum using DDI (on Leg 2, DDI of pH approximately 8.3). Filters were then folded and placed in clean plastic bags to dry. Filters were stored in the plastic bags for transport.

These filters will be analysed for the elements listed above following short (minutes) and long (hours) irradiations. A list of filters to be analysed in this fashion and their sampling location is provided in this report.

SEM-XRD/EMP work will be completed using samples obtained from water

2300 m from surface
750 m from surface
250 m from surface
25 m from surface

At GME all GF/C filters were supported by a nylon mesh to prevent tearing. On all filters collected at GME only a small number of intact particles were visible owing to the low particle density in the water column. Filters were frozen for later lipid analysis at the University of Bristol. The number of lipid classes analysed will be dependent upon concentration.

Certain biolipids are now recognised as organic marker compounds ("biomarkers" or "biological markers") for the organisms which biosynthesise them. These compounds can survive long distance aeolian transport (e.g. n-C_{29}-C_{33} alkanes from terrestrial plants) and passage through the water column from the photic zone to the bottom sediments (e.g. dinosterol from dinoflagellates). Work at Bristol and Kiel Universities has shown that an unusual group of compounds, the very long-chain unsaturated C_{37}-C_{39} ketones biosynthesied by coccolithophorids, can provide a record of palaeo-water temperature for the photic zone.

Besides the filter samples, we obtained two box cores and aliquots of the trap contents at GME. All of these samples will be extracted and the extracts fractionated, prior to analysis by GC and GSMS.

Our aims will be, first, to measure the unsaturation parameter for the ketones, where present, as part of the endeavour to obtain sea truth data to validate molecular stratigraphic techniques and, second, to survey a wide range of lipids of potential significance as biomarkers, notably hydrocarbons, sterols, fatty acids and especially microbially-derived lipids such as the isoprenoid ethers. These molecular abundance data will then be examiend for correlations related to the food web modification and mineralisation processes involved in the descent of the organic matter to the sea floor.

G. Eglinton H.R. Harvey J.G Poynter

(d) Electrophoretic mobilities of suspended particles

Suspended particulates were collected on 1 μm Nuclepore filters by the in-situ filtration devices FIDO, FIFI, DODO. Sub-samples of these filters were

filtered from 2.5 litre General Oceanics GOFLO bottles. (For further details, see R. Jordan's report).

After cooling, filters will be re-analysed for REEs in the UK. Other samples will be re-analysed using ICPMS techniques for many of the same elements listed above. Furthermore, SEM-XRD work will be completed on a series of small-volume filtration samples at IOS. Such work will provide external validation of all data gained in this study and may serve as an opportunity for intercalibration of independent techniques of analysis.

A. Isley R.M. Sherrell W.R. Simpson

(b) Sampling for Zr and Hf

For rare earth elements, a suite of five samples of suspended particulate material from hydrothermal plumes in the TAG area of the Mid-Atlantic Rift Valley were taken. The samples were collected using FIDO and subsequently DODO; details of the samples are given below. The samples taken are to be analysed to investigate the behaviour of the REE in association with Fe and Mn, under potentially varying redox conditions.

C.R. German

(c) Organic Geochemistry

A total of ten samples was collected by filtration of water through pre-cleaned GF/C filters for lipid analysis. During the shakedown two samples were collected from the particle maximum (45 m). Although one filter was torn which reduced the sample collection volume, the remaining filter was intact and had a distinctive green appearance and "algal" odour.

At GME a total of eight FIDO samples was collected from the depths shown below:

5 m above bottom
10 m above bottom
100 m above bottom
1000 m above bottom

re-immersed in unfiltered sea water collected by CTD-rosette at the filtration depth, and the particles resuspended by low power sonication. The mean electrophoretic mobility of each particle sample was determined within twenty-four hours of resuspension using a Rank Mark II micro-electrophoresis apparatus. Particles were also resuspended and oxidised by ultraviolet irradiation for twenty-four hours (1 kw Hg) and the mobilities determined. These experiments were repeated, resuspending both natural and oxidisesd particles in 0.01 M NaCl.

This determination of particle mobilities represents an investigation of particle surfaces from the open and deep ocean, particularly the influence of adsorbed natural organic material. Ultra-violet irradiation is intended to oxidise, and hence remove, organic matter. 0.01 M NaCl serves as a simple "inert" electrolyte, i.e. no Ca/Mg ions which, along with adsorbed organic matter, are important in controlling the mobility of suspended particles in fresh estuarine and coastal surface waters.

P.P. Newton

(f) Sediment traps

On recovery of the sediment traps, the samples bottles were removed and deep frozen for transport to IOS. Only one of the retractors worked correctly and the other three valves were turned manually. However, this did not appear to have any marked effect on sampling efficiency. The traps were redeployed in the order 2, 3, 4, 1 with a honeycombed baffle mounted in the top trap (1). To each sample cup was added 10 ml of HPLC grade chlororoform and 250 ml of filtered sea water. The traps were to be recovered on Cruise 160.

H.R. Jones

SKY CAMERA

The Geography Department of the University of Liverpool provided a fish-eye lens camera for recording cloud cover which, coupled with meteorological data,

will allow for 'ground truth' comparisons with satellite data. The film was changed every 24 hours at 1330 GMT, after taking one frame every 45 minutes.

S.M. Boswell A.G. Howard

REPORT ON BIRD SIGHTINGS

A series of daily observations for sea birds were made, normally of ten-minute counts, using the "standard" technique of observing birds in an arc of 180 degrees from beam-to-beam to straight ahead. Any birds seen with the naked eye were identified using 8 x 40 binoculars. When the ship was stopped for long periods a more general 360 degree watch was kept.

Sea Birds

The voyage proved very disappointing from a sea bird watching point of view with low numbers of relatively few different species seen. The first leg between Falmouth and Tenerife gave low numbers of Manx Shearwater/P. Puffinus in the northern area and Corys Shearwater/Calonectris diamedea in the south with two sightings of Bulwers Petrel/Bulweria bulwesii nearer Tenerife. Small numbers of Fulmar/Fulmarus glacialis and Kittewake/Larus tridactyla were seen in the first few days after leaving Falmouth. Two Skuas, one Great Skua/Catharacta skua and a dark phase Arctic Skua/Stereorarius skua were observed around the same time. On the second leg, eleven days passed without a single bird being seen except for a solitary Bulwers Petrel. In the extreme west, however, three sightings were made of Tropic Birds. A single bird was seen on June 15th, believed to have been a White-tailed Tropic Bird/Phaeton lepturus and a second reported the day after. On June 19th, a single Red-billed Tropic Bird/P. aethereus was sighted. One all-dark Shearwater, possibly a Sooty Shearwater/P. griseus, was seen at the westernmost side of the working area - 45°W. Two of three Skuas sighted were identified as McCormics Skua/Catharacta mccormicii. A single Sabines Gull/Lalrus sabini and small numbers of Corys Shearwater/C. diamedea were seen soon after leaving Tenerife.

Land Birds

Small numbers of migrant passerines were observed, mainly on the first leg when southerly and south-easterly winds predominated. Species found on board

included House Martin/Delichon urbanica and Swallow/Hirudo rustica. Up to four of the former were seen resting on board at any one time, a favourite place being the PSO's cabin. A single female Blackcap/Sylvia attricapilla and a single Turtle Dove/Strep. turtur were seen on board at the same time. One Swallow was seen as far as 720 miles WNW of the Cape Verde Islands. A solitary Lanner Falcon/Falco biarmicus was seen on the day the ship sailed from Tenerife.

A. Louch

STATION LOG

1986 Time Zone: GMT R.R.S. Discovery

Day	Time	Series	Lat (N)	SAT. Long (W)	Gear	Cast	P.E.S.	O/B-I/B	Remarks
135	1900				**LEG 1. CRUISE 159**				Sailed from Falmouth (15th May 1986). On passage to Great Meteor East. Day 137 only bad weather of cruise.
139			**SHAKEDOWN STATIONS**						
	1343	1	38.46.1	17.44.2	CTD/R	200			Bottle firing and CTD test .
	1957	2	38.16.5	18.13.7	FIDO	400		Outboard	Three test dips. Samples
	2025		38.16.6	18.13.7				Inboard	taken at position given (Nuc & G.F.C.) Strong 50 m particle max.
141	1524	Mooring			TRANSMISS	5m a.b.			Commenced search for mooring.
	1555		31.33.6	24.43.4	-OMETER		5440	Released	
	1800	Recovery			MOORING			Inboard	Data good.
	1830	Mooring			SEDIMENT	5m a.b.		Released	Retractors or Trap 2 and 3
			31.32.9	24.40.2	TRAP	10m a.b.	5447		did not fire. 4 fired did not
	2055	Recovery			MOORING	90m a.b.		Inboard	close. 1 OK. However, samples
						1000m a.b.			appeared to be good.

Day	Time	Series	SAT. Lat (N)	Long (W)	Gear	Cast	P.E.S.	O/B-I/B	Remarks
			STATION 11287 GREAT METEOR EAST						
	2210	1	31.33.1	24.35.1	FIDO	750		Outboard	22.20 cell on, 2232 at depth.
142	0326		31.33.9	24.36.6				Inboard	G.F.C. filters (x3), Nuc, 3Mn Scavengers. All Good. Weak particle max. 118 m.
	0420	2			CTDR	750		Outboard	0440 at depth.
	0542							Inboard	
	0742	3	31.32.4	24.35.2	FIDO	2300		Outboard	0821 at depth. 1 G.F.C., 3 Nuc + 2Mn Scavengers. A Nuc at 2300 ruptured.
	1327		31.32.1	24.34.5				Inboard	
	1516	4	31.32.9	24.35.1	CTDR	18m a.b.	5365	Outboard	1717 at depth.
	1904		31.33.2	24.35.1				Inboard	
	2050	5	31.32.9	24.35.2	FIDO	5m a.b.	5365	Outboard	All Nuc. 2100 cell on 2234 at depth. All good.
143	0440		31.34.1	24.35.7				Inboard	
	0805	6	31.33.1	24.35.4	FIDO	5-10m a.b.	5365	Outboard	All Nuc. Pressure transducer on filter flow sensor flooded 0808 cell on, 0944 at depth.
	1520		31.34.5	24.34.7				Inboard	
	1555	7	31.33.0	24.35.1	CTDR	4000		Outboard	Midwater sampling. 1602 cast began. 1704 at depth.
	1834		31.33.0	24.35.1				Inboard	

Day	Time	Series	SAT. Lat. (N)	Long (W)	Gear	Cast	P.E.S.	O/B-I/B	Remarks
	2146 0330	8	31.32.9	24.35.4	FIDO	1m above platform		Outboard Inboard	FIDO fault at 2300. Main pump on winch seized. Aborted. Halt of midships operations.
145	0355 0800	9	31.32.6 31.35.0	24.36.3 24.37.0	BOX CORE		5440		Test of new release. Very successful. Full core.
			STATION END						
	0912 1015	Mooring Deployed	31.33.59	24.43.31	TRANSMISS -OMETER Mooring			Outboard Down	New transmissometer used.
	1203 1308	Mooring Deployed	31.32.9	24.41.4	Sediment Trap Mooring	8m a.b. 99m a.b. 1000m a.b. 1021m a.b.		Outboard Down	Trap 1 plus baffle. Order No. 2, 3, 4, 1.
	1309		**WORK COMPLETED**						Course 112°
146	0916								PES retrieved.
147			**END OF LEG 1**						Berthed, Santa Cruz,

Day	Time	Series	SAT. Lat. (N)	Long (W)	Gear	Cast	P.E.S.	O/B-I/B	Remarks
149	1100		**LEG 2 CRUISE 159**						Sailed from Tenerife (29th May 1986) On passage to 26°12'N 23°20'W Transect station.
			STATION 11288						
150	2110	1	26.11.8	23.19.9	FIDO	750		Outboard	Nuc filters (2 only).
	2138					and		At depth	Problem with filter motor.
	2345		26.11.5	23.19.6		140		Inboard	Samples for IAEA, Monaco.
151	0115	2	26.10.9	23.20.0	CTDR	750		Outboard	CTD dipped to wash and check
	0146							At depth	timing before cast.
	0220							Inboard	
	0807	3			RMT 1+8	230		Outboard	On first trawl net failed to
	0824		26.24.7	23.18.1		To		Open	open.
	0848					240		Closed	
	0910		26.14.2	23.19.7				Inboard	
	1138	4	26.12.0	23.20.8	FIDO	4m a.b.	4975	Outboard	4 Nuc. 100m a.b. filter
	1320		26.12.1	23.20.9				At depth	ripped. 1, 10 and 1000m for
	2100		26.14.5	23.20.9				Inboard	IAEA, Monaco.
	2120	5			RMT 1+8	650		Outboard	
	2146		(26.17.3	23.18.8)		To		Opened	
	2346		26.20.5	23.16.2.		415		Closed	
152	0008							Inboard	

Day	Time	Series	SAT. Lat (N)	Long (W)	Gear	Cast	P.E.S.	O/B-I/B	Remarks
	0156	6	(26.11.7	23.19.8)	CTDR	10m a.b.	4975	Outboard	Intermittent signal
	0325		26.11.2	23.19.2				At depth	throughout cast.
	0502		26.11.3	23.19.5				Inboard	
	0505		**STATION END**						270° toward 26°10'N 30°W.
			STATION 11289						
	2148	1	(26.10.3	26.47.0)	RMT 1+8	800		Outboard	
	2226		26.10.7	26°46.0		To		Open	
	2400		26.14.8	26.43.6		485		Closed	
153	0024							Inboard	
			STATION 11290						
	1708	1	26.10.1	30.00.1	FIDO	10m a.b.	5335	Outboard	Cast aborted due to voltage
	1840		26.10.0	30.00.2				At depth	failure on particle cell and
	2122		(26.09.9	30.00.2)				Inboard	filter voltage down. One
									filter at 10m above bottom.
	2300	2	26.10.2	30.00.4	CTDR/	1000		Outboard	Cable fault fixed. MIT pump
154	0007		26.10.5	30.00.4	FIFI			At depth	at 50m above rosette.
	0152		26.10.5	30.00.2				Inboard	1 hr. pumping.
	0218	3	26.11.1	29.59.9	RMT 1+8	1800		Outboard	Monitor failure net did not
	0645				(NEUSTON)				open.
	1000		(26.23.5	29.45.8)				Inboard	Neuston outboard 0310.
	1234	4	26.10.2	30.00.0	CTDR	15m a.b.	5360	Outboard	
	1403		26.10.2	29.59.6				At depth	
	1549		(26.10.2	29.59.6)				Inboard	

Day	Time	Series	SAT. Lat (N)	Long (W)	Gear	Cast	P.E.S.	O/B-I/B	Remarks
	1606	5			W.B. FIFI				Test dip of water bottle 7 - u/s. FIFI O.K.
	1650 1708 2136 2140	6	(26.10.7 26.10.3 **STATION END**	29.59.3) 29.58.4	FIDO	1000		Outboard At depth Inboard	Good filters. All Nuc. Heading to TAG.
			STATION 11291						
156	1508 1525 1800 1855	1	 26.10.2 (26.14.2	 38.28.5 38.29.9)	RMT 1+8	 180 1300		Outboard Open Closed Inboard	
			TAG						
			STATION 11292						Unable to receive signal from NOAA transponder.
158	0201 0308 0428		(26.09.4 (26.09.6 26.10.6	44.49.3) 44.49.1) 44.50.1	CTDR	20m a.b.	3715	Outboard At depth Inboard	3 fixes. Hf/Zr samples. Transponders deployed. From first, no response.
			STATION 11293						All sampling carried out during drift.
	2130	1	(26.07.50	44.48.96)	FIDO	3340	3670	Outboard	In plume at 3340dp (3544m w.o.) No floor indication.

Day	Time	Series	SAT. Lat (N) Long (W)	Gear	Cast	P.E.S.	O/B-I/B	Remarks
	2320			FIFI	3240		Depth	100m above FIDO, 1 3/4 hrs pumping.
160	0034		26.07.89 44.49.98				Filter off.	4 fixes during cast.
	0136		(26.08.20 44.50.31)				Inboard	Neuston net 0026 to 0206.
	0238	2	(26.07.00 44.48.38)	CTDR	20m a.b.	3680	Outboard	3 fixes during cast.
	0501		26.07.72 44.49.26				At depth	
	0630		(26.07.78 44.99.75)				Inboard	
			STATION 11294					
	1048	1		FIDO	3350	3700	Outboard	Initial fault on FIDO.
	1206			FIFI		To	At depth	4 fixes. Station 2-3nm west
	1217		26.08.42 44.52.82			3300	Filters on	of Tag. One filter ripped.
	1431		26.09.11 44.52.05				Filters off	
	1520						Inboard	
	1900	2		CTDR	25m a.b.	3975	Inboard	West of Tag. Hit bottom-mud in sensor.
	2010		26.07.70 44.51.19				At depth	2 fixes.
	2150		(26.07.69 44.51.51)				Outboard	
			STATION 11295					
	2348	1		RMT 1+8	1550		Outboard	Neuston Net 0152 to 0300.
161	0206		(26.08.64 44.48.53)		To		Open	2 fixes.
	0419		(26.14.12 44.45.01)		2015		Closed	
	0554						Inboard	

Day	Time	Series	SAT. Lat (N) Long(W)	Gear	Cast	P.E.S.	O/B-I/B	Remarks
			STATION 11296					
	0901	1	26.07.64 44.48.60	CTDR	25m a.b.	3650	Outboard	Bad conductivity data.
	1005		26.07.81 44.49.12				At depth	2 fixes.
	1116						In board	
	1152	2	(26.07.82 44.48.32)	FIDO	3340	3680	Outboard	One of the two Nuc. ripped. GFC O.K.
	1315		26.08.06 44.48.76	FIFI	3290		At depth	2 fixes.
	1317						Filters on	
	1620		26.09.01 44.49.44				Filters off	
	1718		(26.09.09 44.50.87)				Inboard	
			STATION 11297					
	1948	1	26.10.78 44.51.04	Net	500			Did not open.
	2054							
			STATION 11298					
	2244		26.07.39 44.49.11					Check on conductivity cell. O.K.
162	00.02		26.07.03 44.47.22				Outboard	Passed too far north
	0518	1	(26.06.78 44.48.33)	FIDO	20m a.b.	3350	Outboard	therefore restarted at 0518.
	0728		26.07.16 44.48.57	FIFI	70m a.b.		Filter on	Two out of three filters
	0818		26.07.00 44.49.37				Filter off	ripped. One good and in the plume.
	1005		26.07.49 44.49.35				Inboard	

Day	Time	Series	SAT. Lat (N) Long (W)	Gear	Cast	P.E.S.	O/B-I/B	Remarks
			STATION 11299					
	1036	1	(26.07.5 44.49.1)	RMT1+8	500		Outboard	NEUSTON net 1145. Water in
	1105				To		Open	Marsh Marine plug.
	1312		26.08.22 44.43.24		916		Closed	
	1350		(26.08.37 44.42.29)				Inboard	
			STATION 11300					
	1538	1	26.08.87 44.45.23	RMT1+8	1500		Outboard	Failed. Opened then immediate closure.
	1854						Inboard	
			STATION 11301					
	2045	1	26.06.61 44.48.73	CTDR	20m a.b.	3650?	Outboard	3 fixes.
	2300						At depth	
163	0017		26.07.88 44.29.28				Inboard	
			STATION 11302					
	0154	1	26.07.41 44.47.98	FIDO	3315-	3650	Outboard	Excellent physical data. No
	0538		26.08.00 44.48.02	FIFI	3470		At depth	value control indication.
	0644		(26.08.23 44.49.29)				Inboard	FIFI sampled in plume. In log as 13001 #2. 4 fixes.
			STATION 11303					
	1529	1		CTDR	10m a.b.	3740?		Digidata clock 7 hrs in
	1633		26.07.94 44.49.88					advance i.e. 23.00.00.
	1746		26.08.42 44.49.88					2 fixes.

Day	Time	Series	SAT. Lat (N) Long (W)	Gear	Cast	P.E.S.	O/B-I/B	Remarks
			STATION 11304					
	2230	1	(26.07.79 44.48.40)	FIDO	3340	3670	Outboard	Particle cell down. First cast attempt aborted.
	2342		26.08.23 44.49.47	FIFI	3290		At depth	
			26.07.85 44.50.28				Filters on	3 good filters and 1Mn scavenger.
164							Filters off	2 fixes during filtration.
	0230				3153		Breakdown	Main pump on midships winch broke down. Gear recovered using forward crane to haul Position in median valley maintained by steaming astern N to S, S to N. NEUSTON Net 2235 to 2325.
	1530		26.03.91 44.52.86				Inboard	
			STATION 11305					
165	1430	1	(26.05.95 44.56.09)	RMT 1+8	0-2000		Outboard	Aft crane starter motor u/s and net monitors. Nets launched on capstan/davit, and fished open. 4 fixes.
	1830		(26.07.60 44.47.76)	(Open)	wire out		Inboard	
			STATION 11306					
	1928	1	(26.08.25 44.49.43)	CTDR+T	500		Outboard	Casts subsequently run on 6.4mm cable (electric winch). CTD + Oxygen and transmissometer used.
	1940						At depth	
	2031		26.08.2 44.49.4				Inboard	

Day	Time	Series	SAT. Lat (N) Long (W)	Gear	Cast	P.E.S.	O/B-I/B	Remarks
	2202	2	(26.09.13 44.48.31)	FIFI			Outboard	CTD used as weight.
	2321						Filter on	3 fixes during cast.
	2352						Filter off	
166	0111		(26.07.34 44.49.48)				Inboard	
	0319	3	26.09.33 44.48.59	CTDR+T	20m a.b.	3680	Outboard	Proximity of new vent?
	0536						At depth	
	0713		(26.09.72 44.51.23)				In board	
			STATION 11307					
	0735	1	(26.10.00 44.51.34)	RMT 1+8	0-2000			No monitor. 3 fixes.
	1242		(26.10.84 45.03.07)	Open	wire out			
			STATION 11308					
	1501	1	(26.10.03 44.49.58)	CTDR+T	3333		Outboard	Over-loaded wire, drawing
	1630			FIFI			Filter on	85 amps from winch.
	1800		26.08.89 44.50.63				Filter off	4 fixes.
	2020		(26.08.65 44.50.70)				In board	Proceeding west to station at ridge.
			STATION 11309 - WEST OF RIDGE					
167	0210	1	(25.57.71 45.54.40)	RMT1+8	1500		Outboard	
	0500		(25.55.48 46.05.82)	Open	wire out		Inboard	

Day	Time	Series	SAT. Lat (N) Long (W)	Gear	Cast	P.E.S.	O/B-I/B	Remarks
			STATION 11310					
	1124	1	26.01.09 46.30.60	CTDR	1000		Outboard	
	1147						At depth	
	1230						Inboard	
	1308	2		FIFI	2000		Outboard	Pump alone
	1618						Inboard	
	1706	3	26.01.07 46.34.38	R	3596		Outboard	Rosette alone. Wire out depths.
	2026						Inboard	
	2112	4	26.00.71 46.36.16	FIFI	2000		Outboard	
	2325		26.00.73 46.37.11				Inboard	
	2342	5	(26.00.72 46.37.57)	R	3600		Outboard	Wire out depths.
168	0216						Inboard	
	0240	6		RMT8	800		Outboard	Monitor fixed. RMT1 removed
	0340		(26.01.47 46.35.63)				Open	to allow davit lift.
	0500		(26.02.06 46.31.51)				Closed	
	0533						Inboard	Proceeding to TAG

Day	Time	Series	SAT. Lat (N)	Long (W)	Gear	Cast	P.E.S.	O/B-I/B	Remarks
			TAG						
			STATION 11311						
	1600	1	26.09.57	44.49.54	DODO+T	3400		Outboard	Made up filter unit + transmissometer.
	1713		26.09.41	44.50.21				Filter on	Possible location of third
	1813		26.09.71	44.50.81				Filter off	vent.
	2030		(26.10.63	44.52.42				Inboard	4 fixes.
	2114	2	(26.10.93	44.52.83)	R	220		Outboard	Rerun after bottle firing
	2133							Inboard	fault.
			STATION 11312						
	2234	1	26.07.38	44.49.22	DODO+T	3500	3640	Outboard	Back to TAG.
169	0108		(26.07.51	44.49.33)		wire out		Filter on	50m pinnacle noted on seabed.
	0206		(26.07.64	44.49.54)				Filter off	3 fixes.
	0348		26.08.34	44.49.98				Inboard	
	0429	2	26.07.84	44.48.32	R	3400-		Outboard	3 fixes.
	0722		(26.08.02	44.49.96)		1000		Inboard	
	0834	3	26.07.07	44.49.13	DODO+T	3550	3600	Outboard	Steaming at 1kt to hold station.
	0951		26.08.03	44.49.22		wire out		Filter on	3 fixes.
	1052							Filter off	
	1215		(26.08.00	44.48.80)				Inboard	

Day	Time	Series	SAT. Lat (N)	Long (W)	Gear	Cast	P.E.S.	O/B-I/B	Remarks
			STATION 11313						
	1340	1	(26.00.37)		44.50.79)	RMT 1+8		Outboard	Crane fixed. Not fully operational.
	1648					2930		Open	Fished across Tag at 200m off bottom.
	1848					3460		Closed	
	2106		(26.16.85	44.51.40)				Inboard	Proceeding to 26°35'N 42°W.
			STATION 11314 - EAST OF RIDGE						
170	1106	1			CTDR	3605		Outboard	
	1201		26.35.07	41.59.95				At depth	
	1328							Inboard	
	1340	2			DODO+	2000		Outboard	Loop of warp wound around
			26.35.67	42.01.07	FIFI			Filter on	FIFI
								Filter off	
	1706							Inboard	
	1727	3			CTDR	500		Outboard	
	1737		26.36.07	42.02.49				At depth	
	1808							Inboard	
	1834	4			R+	3300		Outboard	
	2118		26.36.35	42.03.03	FIFI			Inboard	
	2226	5	(26.37.0	42.05.8)	CTDR	2000		Outboard	
	2300							At depth	
	2352							Inboard	

Day	Time	Series	SAT. Lat (N) Long (W)	Gear	Cast	P.E.S.	O/B-I/B	Remarks
			STATION 11315					
173	1213	1	26.10.49 30.00.85	DODO	3400		Outboard	Reoccupation of Station 11290
	1345						Filter on	
	1445						Filter off	
	1516						Inboard	
	1617	2	26.10.52 30.00.61	DODO	2300		Outboard	
	1656						Filter on	
	1756						Filter off	
	1836						Inboard	
			STATION 11316					
174	1050	1	(26.45.7 26.41.8)	RMT1+8	400		Outboard	
					-200		Open	
							Closed	
	1242		(26.46.5 26.38.9)				Inboard	
			WORK COMPLETED					Course 078°
176	1500		**END OF LEG 2**					Berthed, Santa Cruz, Tenerife

TABLE 2 - SAMPLE LOG - (a) Surface Sea Water "Pole" Sampling

SAMPLE NUMBER	DATE	TIME	LATITUDE N	LONGITUDE W	250 ml	1000 ml
1	30.5.86	21.20	26°11.8'	23°19.9'	1	-
2	1.6.86	12.00	26°08.7'	24°48.5'	2	-
3	1.6.86	18.30	26°10.8'	26°10.8'	2	-
4	2.6.86	01.50	26°14.7'	26°54.5'	2	-
5	2.6.86	08.50	26°09.5'	28°19.8'	2	-
6	2.6.86	15.15	26°09.8'	29°41.7'	2	-
7	4.6.86	00.20	26°10.7'	30°27.4'	2	-
8	4.6.86	04.30	26°10.9'	31°16.3'	2	1
9	4.6.86	07.20	26°09.7'	31°52.0'	2	1
10	4.6.86	10.40	26°09.1'	32°33.7'	2	-
11	4.6.86	14.10	26°08.2'	33°19.4'	2	-
12	4.6.86	16.50	26°08.1'	33°52.8'	2	-
13	4.6.86	20.20	26°08.3'	34°37.9'	2	1
14	4.6.86	22.50	26°08.5'	34°59.8'	2	-
15	5.6.86	01.45	26°08.5'	35°37.0'	2	-
16	5.6.86	04.20	26°08.5'	36°05.9'	-	-
17	5.6.86	16.00	26°11.3'	38°27.8'	2	1
18	5.6.86	18.40	26°15.1'	38°25.4'	2	-
19	6.6.86	01.20	26°15.8'	39°50.3'	2	-
20	6.6.86	07.30	26°12.8'	41°09.9'	2	-
21	6.6.86	13.25	26°11.2'	42°26.7'	2	-
22	6.6.86	19.40	26°09.5'	43°50.7'	2	-
23	7.6.86	01.10	26°07.3'	44°50.5'	2	1
24	16.6.86	10.20	26°00.7'	46°29.1'	2	-
25	16.6.86	14.10	26°01.2'	46°32.3'	3	-
26	16.6.86	10.50	26°16.0'	45°30.1'	2	-
27	18.6.86	20.40	26°16.0'	44°51.2'	2	-
28	19.6.86	23.50	26°37.3'	42°06.4'	2	-
29	20.6.86	21.25	26°09.7'	37°44.6'	2	-
30	20.6.86	21.30	26°09.7'	37°44.6'	2	-
31	21.6.86	00.10	26°09.6'	37°14.4'	2	-
32	21.6.86	00.15	26°09.6'	37°14.4'	2	-
33	21.6.86	02.55	26°09.8'	36°44.4'	2	-
34	21.6.86	06.10	26°10.0'	36°06.9'	2	-
35	21.6.86	06.15	26°10.0'	36°06.9'	2	-
36	21.6.86	08.50	26°10.2'	35°36.8'	2	-

TABLE 2 - SAMPLE LOG - (b) Water Samples

11287	11288	11290	11292	11294	11301	11306	11308	11310	11311	11314
5	5	10	1500	20	3100	10	982	5	20	5
10	10	35	2500	60	3160	20	2372	100	40	25
20	20	50	3100	100	3220	45	2630	200	60	50
40	40	100	3175	160	3280	70	2884	300	80	75
80	90	135	3250	3000	3340	80	2910	500	100	100
100	120	-	3325	-	-	90	-	500	-	125
120	140	150	3325	3300	3400	120	3211	600	120	149
140	180	200	3400	3350	3460	180	3266	700	140	175
160	400	300	3475	3450	3520	300	3249	800	160	200
200	600	500	3550	3650	3580	400	3279	900	180	300
500	750	750	3625	3853	3640	500	3319	1000	200	400
750		1000	3715	4053	3696		3333		220	500
	750					2500		2300		
4467	1000	50				3150		2430		500
4667	1100	500				3300		2560		650
5067	1200	1000				3380		2690		800
5267	1500	2500				-		2820		950
5367	-	-				3420		2950		1100
5367	2200	2500				3460		3080		1250
5367	2200	3500				3500		3200		1400
5392	3000	4500				3540		3340		1550
5417	4000	5300	———	———	———	3600		3470	———	1700
5429	4500	5448				3778		3596		1850
5439	5042	5448	11293	11296	11303				11312	2000
5448			———	———	———			1000	———	
								1200		
95			2500	2900	3000			1400	1000	
195			3200	3100	3200			1600	1400	
902			3300	3200	3250			1800	1600	
1004			3400	3250	3300			1800	2000	
1105			3450	3300	3350			2000	2000	
1307			-	-	-			2200	-	
1510			3500	3350	3400			2400	2400	
1814			3550	3400	3450			2700	2800	
2017			3600	3450	3495			3000	3100	
2321			3650	3500	3595			3600	3300	
3290			3700	3549	3706				3300	
4055			3744	3625	3756				3400	

TABLE 2 - SAMPLE LOG - (c) Filter samples

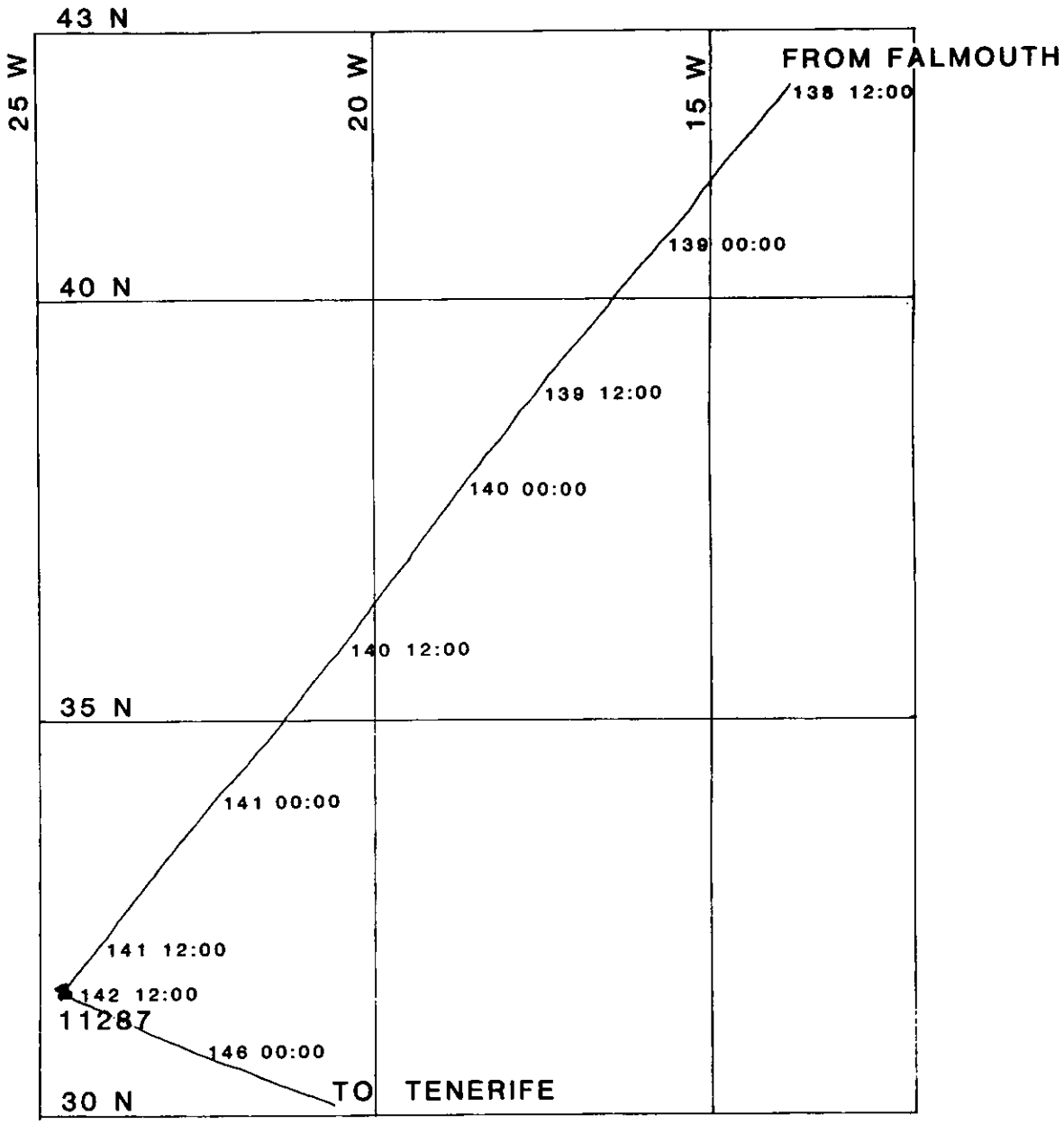
STATION	DEPTH	VOL.	TYPE	LAB.
11287	118	753	N	U
	118	818	G & M	B & C
	250	1706	G & M	B & C
	750	1741	G & M	B & C
	750	1708	G	B
	2300	1252	N	U
	2300	1284	N	E
	2300	1225	N	U
	4365	1324	G & M	B & C
	5265	1123	G & M	B & C
	5350	1237	G & M	B & C
	5360	1263	G & M	B & C
	4523	1292	N	U
	5364	1198	N	U
	5441	1335	N	U
	5449	1270	N	U
11288	BLANK	-	N	U
	BLANK	-	N	U
	140	272	N	I
	750	1253	N	E & I
	+ 1000	1161	N	I
	+ 100	1637	(N)	-
	+ 15	1565	N	I
	+ 4	1719	N	I
11290	1000	361	N	M
	+ 10	1400	N	U & E
	BLANK	-	N	M
	20	370	N	U & E
	50	827	N	U & E
	150	965	N	U & E
	1000	1230	N	U & E
11293	BLANK	-	N	U
	3390	83	N	U
	3290	240	N	M
11294	3290	428	N	M
	3346	1450	N	C
	3346	1115	N	E

TABLE 2 - SAMPLE LOG - (c) Filter samples

STATION	DEPTH	VOL.	TYPE	LAB.
11296	3315	188	N	M
	3367	999	N	U
	3367	1268	G	B
	3367	965	N	C
11298	2610	488	N	M
	2610	165	N	U
	2610	113	N	E
	2610	35	N	C
	3375	432	N	M
11301	3355	270	N	M
11304	3340	223	N	M
	3390	400	N	U
	3390	342	N	E
	3390	632	N	C
11306	3000	172	N	E
11308	3300	287	N	MEU
11310	1815	419	N	M
	2000	233	N	M & E
11311	3350	202	N	C
11312	3370	556	N	E
	3350	726	N	C
11314	2000	413	N	M
	2020	?	N	E
	3300	230	N	M
	3320	?	N	U

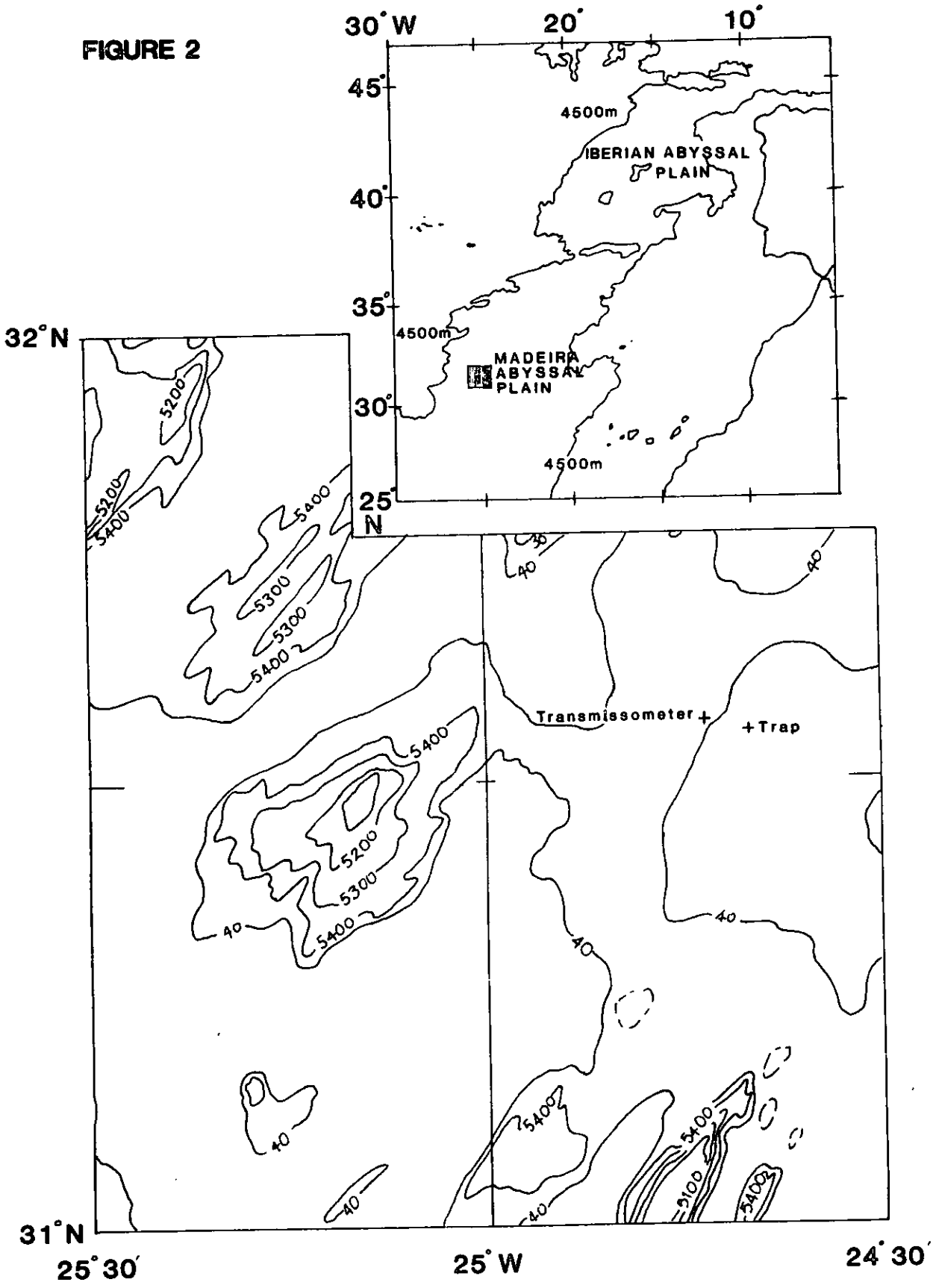
Key: N = Nuclepore, G = GFC
M = Mn scavenger B = Bristol
C = Cambridge E = East Anglia
I = IAEA (Monaco) M = MIT

FIGURE 1



CRUISE 159 LEG 1 GREAT METEOR EAST

FIGURE 2


30° W
20°
10°
45°
40°
35°
30°
25° N
4500m
IBERIAN ABYSSAL PLAIN
4500m
MADEIRA ABYSSAL PLAIN
4500m
32° N
31° N
25° 30'
25° W
24° 30'
Transmissometer
Trap
5200
5300
5400
40

MOORING 402 TO RECOVER AND LAY

31° 33.6' N
24° 43.4' W

DEPLOYED (5440m)
20.11.85
RECOVERED
21.5.86
REDEPLOYED
25.5.86

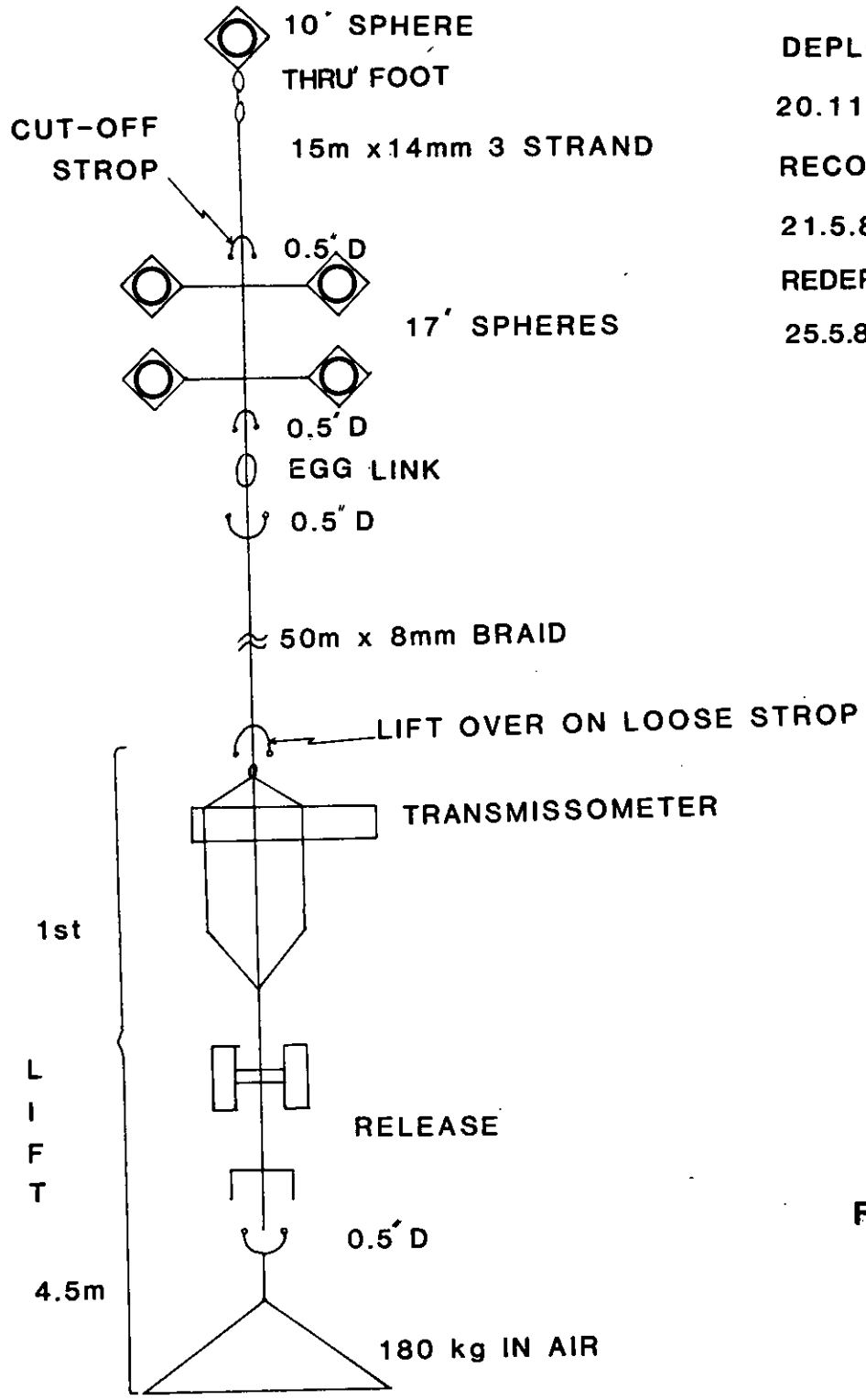
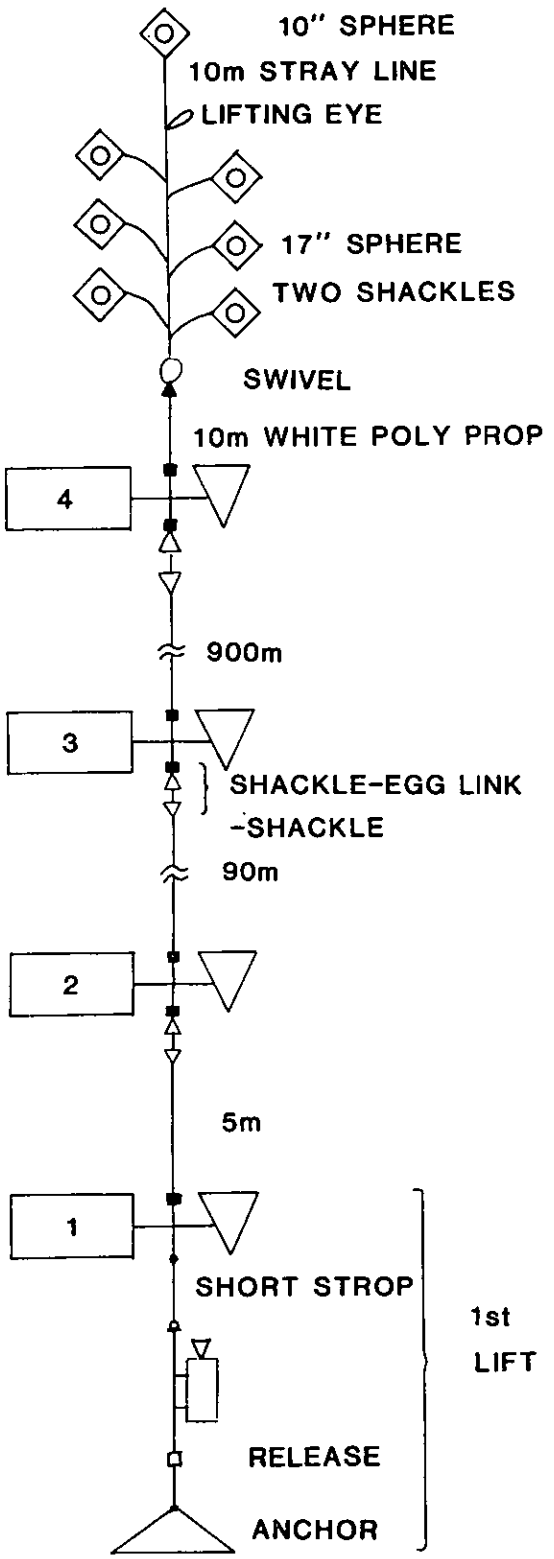


FIGURE 3

STATION 11287

TRAP MOORING RECOVERED

TRAP MOORING LAYED



31°32.9'N
24 41.4'W
(5447m)

50m and HONEYCOMB BAFFLE

20m

900m

90m

7m

FIGURE 4

CRUISE 159.

LEG 2

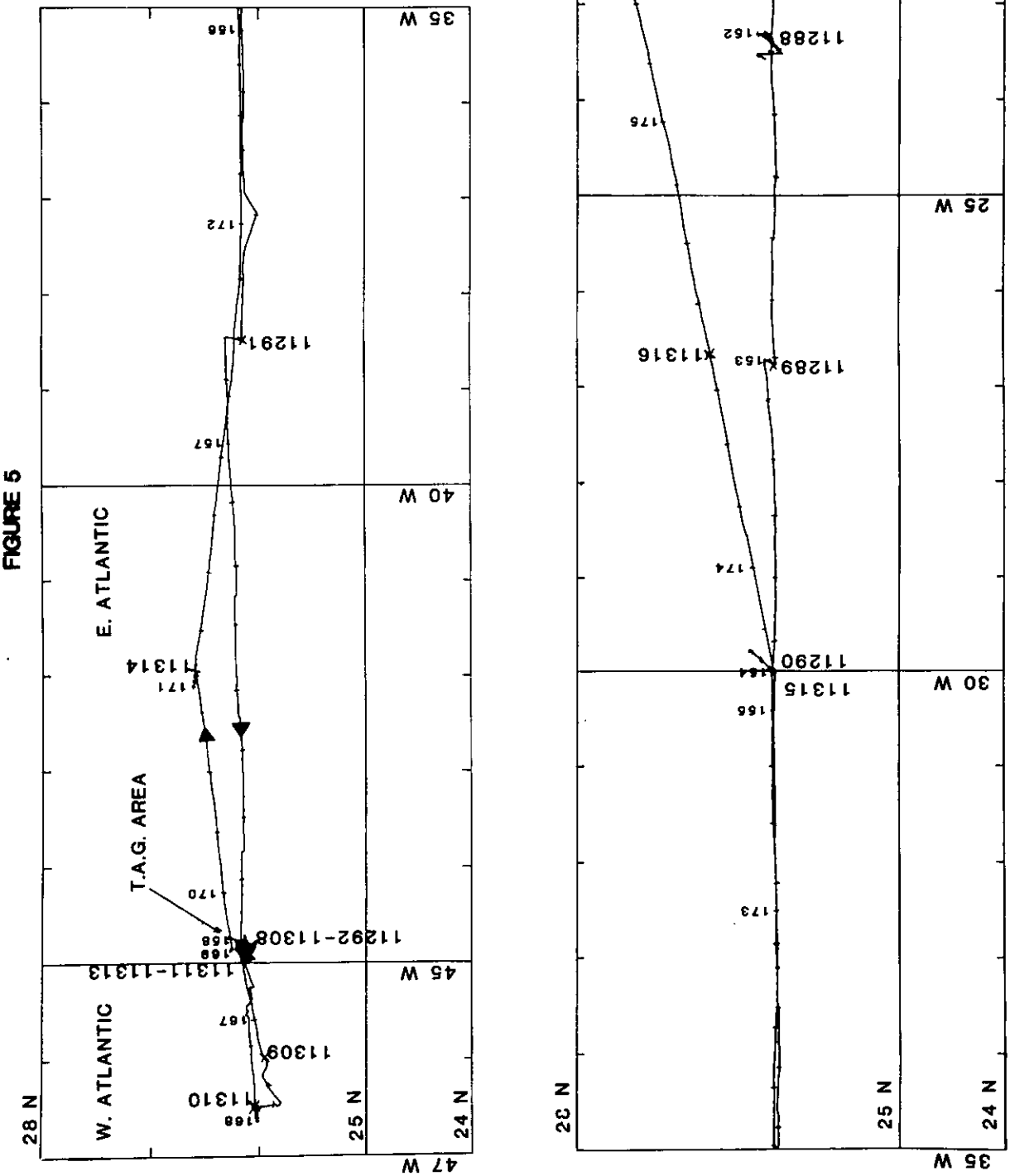


FIGURE 5

FIGURE 6

TAG – Hydrothermal Vent Area

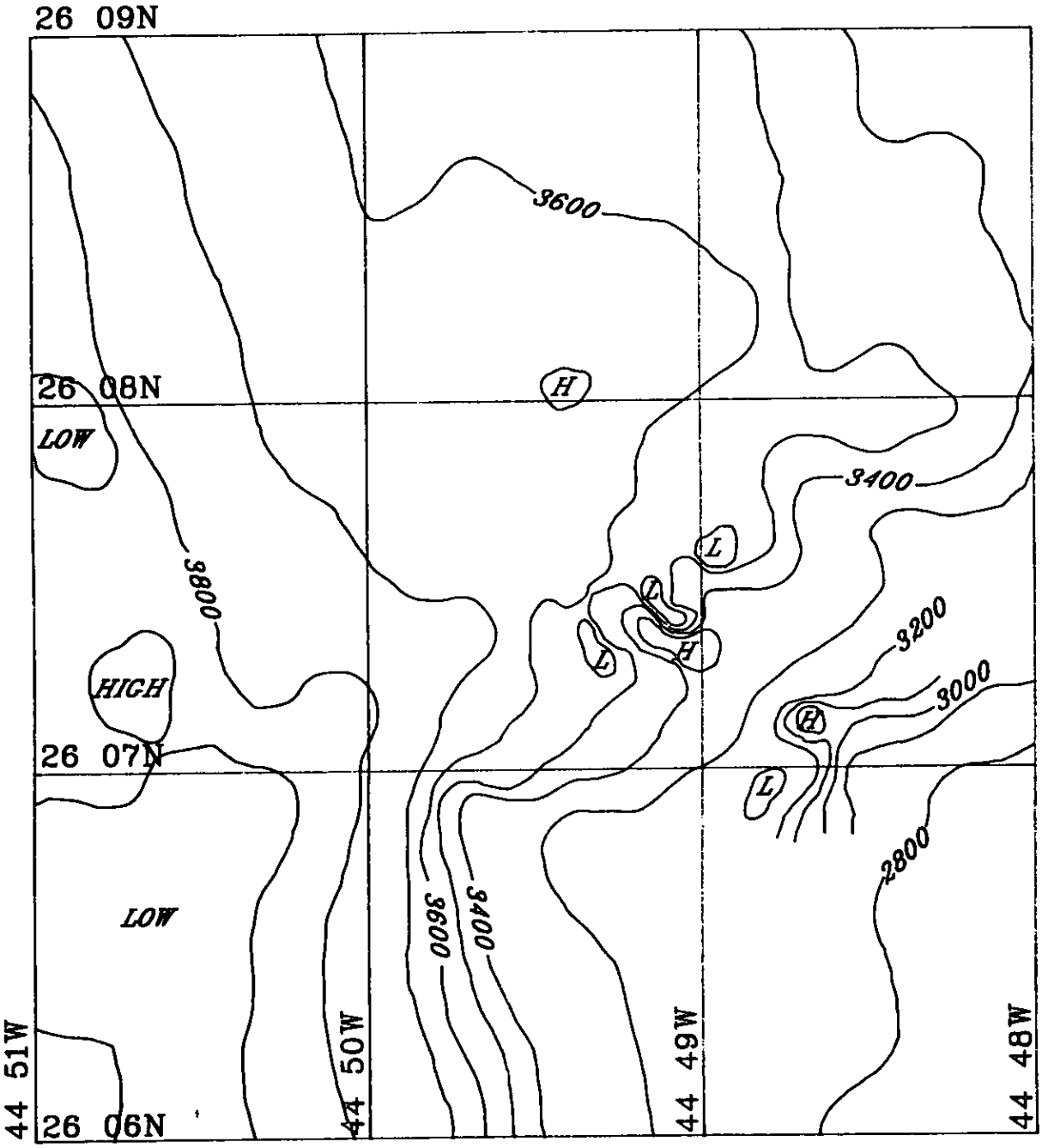
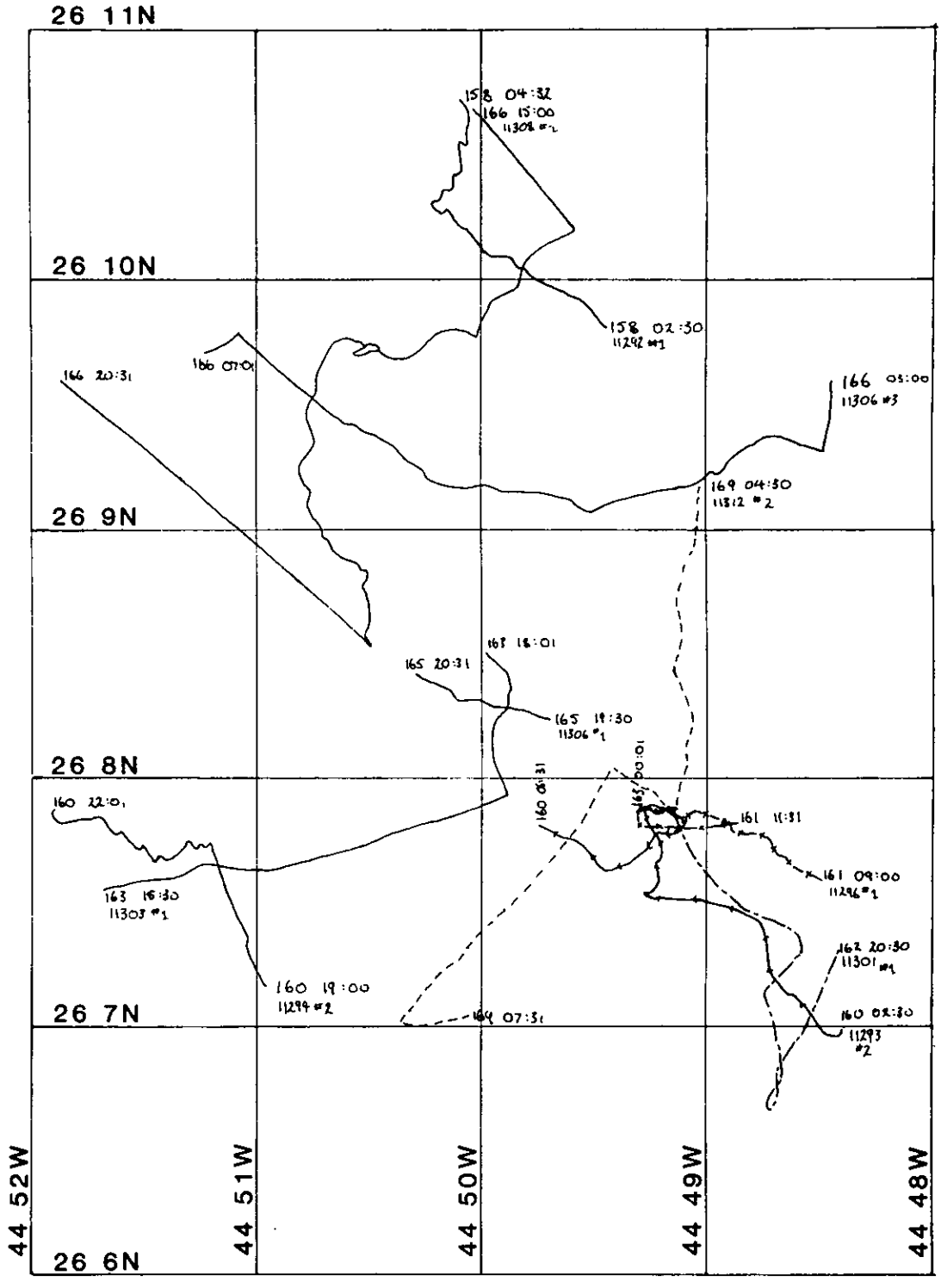
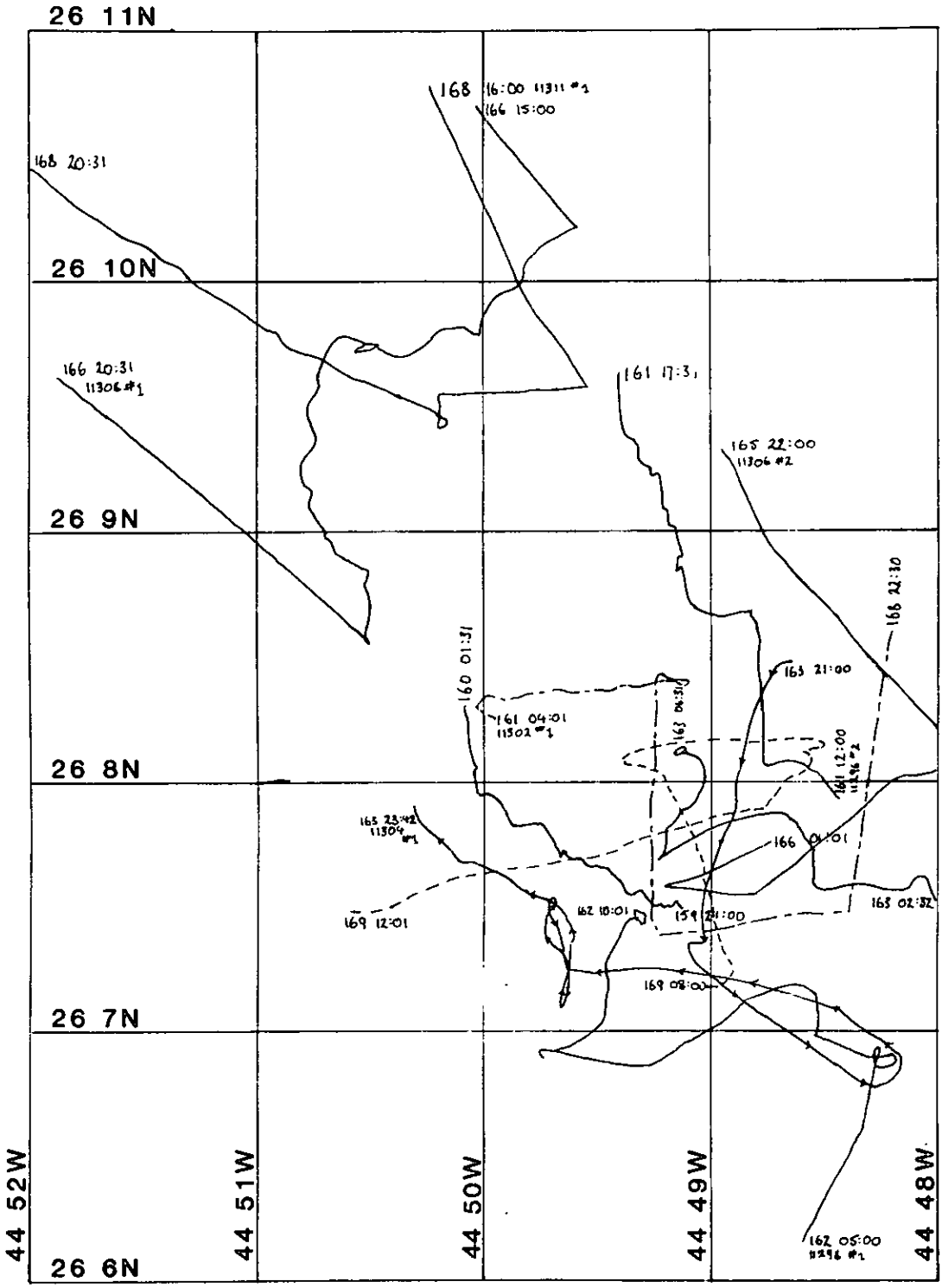


FIGURE 7



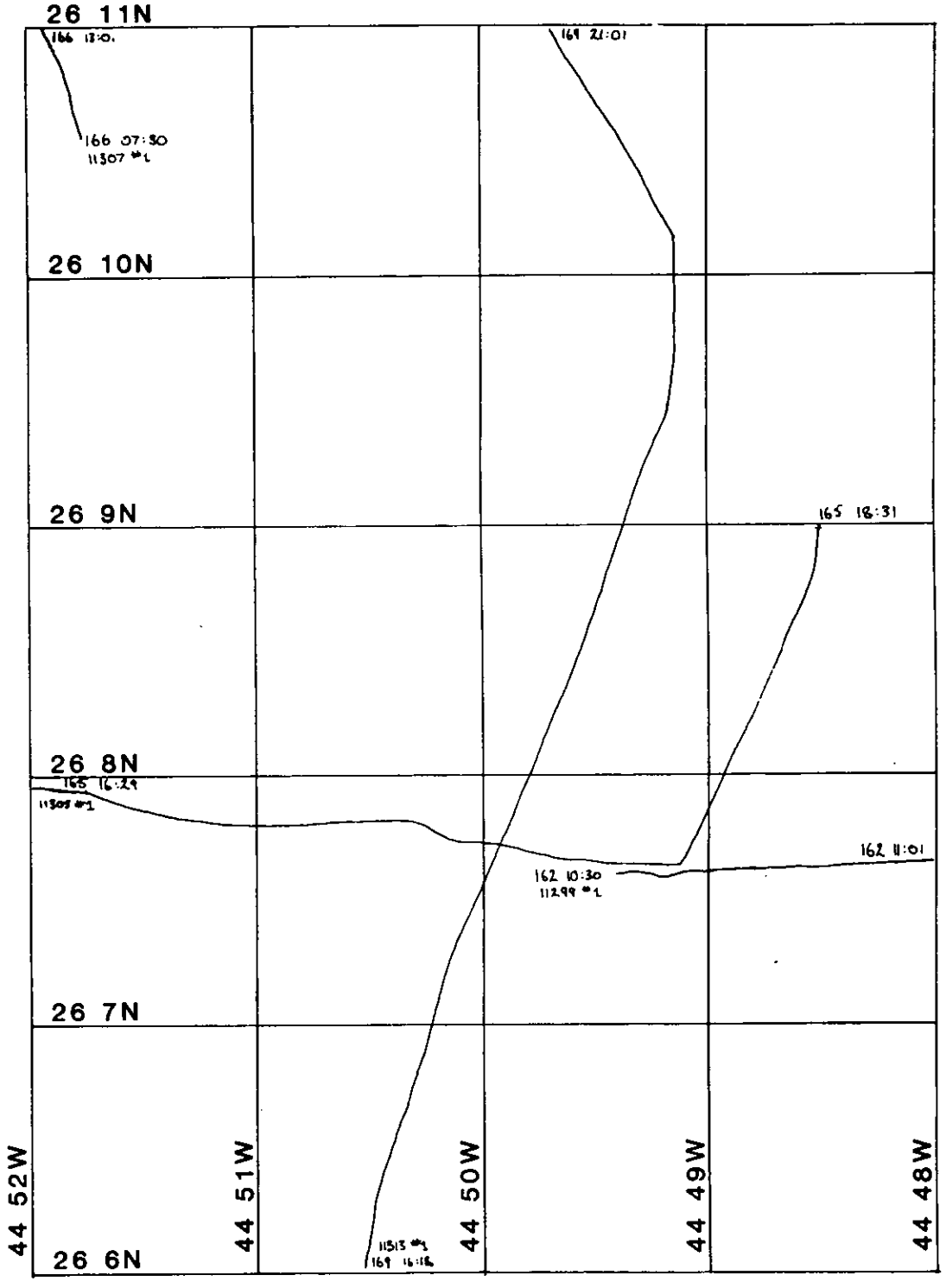
C.T.D. TRACKS AROUND T.A.G. AREA

FIGURE 8



PUMP TRACKS AROUND T.A.G. AREA

FIGURE 9



NET TRACKS AROUND T.A.G. AREA