THE UNIVERSITY OF SOUTHAMPTON

STRENUIS ARDUA CEDUNT

DEPARTMENT OF OCEANOGRAPHY

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R.R.S. *Discovery*

Cruise 169

12 August - 31 August 1987

MIXING NEAR THE WEST SLOPE OF THE

PORCUPINE BANK AND PHOTOSLEDGE TRANSECTS

A joint cruise between

THE DEPARTMENT OF OCEANOGRAPHY

SOUTHAMPTON UNIVERSITY

and the

INSTITUTE OF OCEANOGRAPHIC SCIENCES DEACON LABORATORY

R.R.S.*DISCOVERY* CRUISE

12-31 August 1987

Mixing near the West Slope of the Porcupine Bank

and Photosledge Transects

Principal Scientist

S.A.Thorpe (SUDO)

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R.R.S. *Discovery*

Cruise 169

12 August - 31 August 1987

Falmouth to Falmouth

Participants.

Scientific Party	Ships Officers
S. Boxall SUDO	R.McCurry Captain
N.Hooker IOS DL	B.Richardson 1st Mate
G.Lake IOS DL	C.Leather 2nd Mate
R.Lloyd RVS	R.Ginger 3rd Mate
G.McEwen SUDO	B.Donaldson Radio Officer
J.Moorey IOS DL	P.Jago Chief Engineer
A.Rice IOS DL	B.McDonald 2nd Engineer
J.Smith RVS	B.Entwistle 3rd Engineer
J.Taylor IOS DL	P.Marsh 3rd Engineer
J.Taylor SUDO	D. Lutey Electrician
S.Thorpe SUDO (Princ.Sci)	F.Williams Bosun
I.Waddington IOS DL	M.Harrison Boson's Mate
D.White IOS DL	
M.White SUDO	

IOS DL Institute of Oceanographic Sciences Deacon Laboratory
SUDO Southampton University Department of Oceanography
RVS NERC Research Vessel Services, Barry

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Note: Computer operations by RVS staff have been reported separately and directly to Director, R.V.S. The ship board system appeared to work very well.

1. Cruise Objectives

1. To study the structure of the benthic boundary layer on the W.Slope of the Porcupine Bank near 51°N 15°W using CTD and transmissometer yo-yo's and BERTHA (Benthic Resistance Thermometer Array) with VACM's.

2. To deploy an array of moorings in 3000-4100m designed to examine the eddy field in deep water near the Continental Slope.

3. To obtain photographic transects using the epibenthic sledge as a photosledge.

2. Acknowledgements

The Scientific Party wishes to acknowledge the efficient and cheerful running of the ship and the provision of facilities by the Ship's Officers and Crew, without which the scientific work would be impossible. We acknowledge, and are grateful for, the support of the Natural Environment Research Council and, in particular, the R.V.S. The Principal Scientist wishes particularly to thank the party from the IOS DL and the RVS computer personnel for their splendid support on this cruise.

3. Summary of work completed.

54 CTD/transmissometer casts (including a cross-slope transect of 10 stations repeated 3 times) were made to within about 10m of the sea bed mostly to depth exceeding 3000m (see Fig.3 and Table 1).

2 25 hour CTD/transmissometer yo-yo series were completed (positions on Fig.3).

9 Moorings were deployed, and two recovered. (see Fig.4 and Table 3).

10 Successful photosledge transects were made and about 2380 useful photographs taken. (see Fig.5 and Table 4).

4. <u>Summary of Proceedings</u> (all dated in August 1987 and times GMT)

1240/12th	Sailed Falmouth
1217-2135/14th	Deployment of moorings 441, 442, 443.
2348/14th-0830/16th	First CTD transect of 10 stations (Stations 11640-11649)
1307/16th-1455/17th	First CTD yo-yo series (Stations 11650-11651)
1508-2314/17th	CTD survey of nephel layer near transect station 4 (Stations 11652-11654).
0042-0217/18th	Deployment of mooring 444.
1339/18th-1454/19th	Photosledge survey on Porcupine Bank (Stations 11656-11660).
1852/19th-2247/20th	Second CTD transect of 10 stations (Stations 11661-11670).
0211/21st-0321/22nd	Second CTD yo-yo series (Stations 11671-11672).
0419-0942/22nd	CTD survey of nephel layer along slope to NW (Stations 11673-11674).
1115-1634/22nd	Photosledge survey near foot of slope (Station 11675).
0105/23rd-0831/24th	Third CTD transect of 10 stations (Stations 11676-11685).
1029-1545/24th	Recovered moorings 444 and 443.
1830/24th-0415/25th	Photosledge survey in deep water (Station 11686).
0512/25th-2009/26th	CTD survey of nephel layer along slope to SE (Stations 11687-11696).
0042/26th-0633/27th	CTD survey of nephel layer along slope to NW (Stations 11697-11699).
0933-1821/27th	Deployment of moorings 445-447.
2217/27th-0846/28th	Photosledge survey in deep water (Station 11700).
1022-1607/28th	Deployment of moorings 448 and 449.
1805/28th-0733/29th	CTD survey of nephel layer on outer edge of plume and in canyons (Stations 11701-11704).
1455-1852/29th	Photosledge tow on Porcupine Bank (Station 11705).
1000/31st	Docked Falmouth.

5. Narrative

The course track, station and mooring positions, are shown in Figures 1-5.

Sailed Falmouth 1240 (all times GMT) 12 August. Sea trial of photosledge before leaving the Continental Shelf was abandoned because of faulty valve on trawl winch. Made trial lowering of CTD in Porcupine Seabight in good weather. Various faults were revealed in winch spooling, bottom pinger batteries and in CTD pressure calibration and conductivity values. Spooling was corrected the following morning by adjustment of traversing gear, batteries were replaced and CTD calibration adjusted. Lowering trials of releases for moorings 441 to 443 were carried out successfully. Moorings 441, 442 and 443 were deployed on 14th with no difficulty in good conditions, 442 somewhat to the SW of, and in deeper water than at the planned position, as the water depth found there was insufficient. (The prepared moorings were arranged to have several instruments at the same depths and this demanded that the correct water depth had to be found).

Proceeded to make CTD/transmissometer stations along the transect line 1 to 10 beginning at 2348, 14th (Stations 11640-11649). A fault in the CTD sea unit was detected during and corrected after, Station 11642, Transect completed at 0830 16th. The most notable feature of this CTD/transmissometer section was an intense 'nephel' layer of low transmittance extending from 2400m to 3000m with a multiple structure at the top and a gradual increase in transmissivity to background values near the foot. Bottom well-mixed layers were observed in deep water with near-adiabatic gradients.

A CTD/transmissometer yo-yo series (Stations 11650, 11651) was begun at 1301 on 16th and completed at 1455 on 17th. Stations 11652-11655 were made to examine the horizontal extent of the nephel layer, and a mooring (444) was deployed with a single Aanderaa current meter close to the level of the nephel layer.

At 0432/18th made passage on to the top of the Porcupine Bank to conduct a photosledge survey for Dr Rice. Five tows completed by 1454/19th. Some difficulties were encountered with the camera/flash operation but these were eventually overcome (see under 'Photosledge Transects', Section 9).

A second CTD/transmissometer transect begun at 1852/19th at Station 1. The nephel layer is still present at Stations 4 and 5, but less intense and deeper than on the first survey. Transect completed at 2247/20th. Proceeded past moorings 442, 443 and 441 to interrogate them, in passage to a second CTD/transmissometer yo-yo series at 50° 33.6′N, 14° 41.5′W. This was completed at 0321/22nd, with the CTD having to be brought on board only once whilst the ship recovered station. The nephel layer was again apparent with structure similar to that at transect station 4.

Following two further CTD casts to establish the extent of the layer to the NW, a photosledge tow was made from about 50° 29.1′N 14°44.5′W in a northerly direction at depths of some 3600m, and about 200 photographs were obtained. The sledge had to be temporary brought up off the bottom to avoid running into a gulley possibly leading from a canyon near 30° 33′N, 14° 34′W. The weather deteriorated suddenly just as the sledge was being recovered (1615/22nd), the wind reaching 35 knots, and thoughts of a further immediate deployment were abandoned. A wire test of 2 mooring releases was made (2102/22nd to 0016/23rd). A CTD series was begun at 0105/23rd from transect Station 10 to transect Station 1.

Met. forecasts on the morning of 24th were uncertain of the path of the remnant of Hurricane Arlene. It appeared possible that it might reach us on 25th. It was therefore decided to recover moorings 444 and 443 (BERTHA) and this was done by 1545, the only damage found being to a vane on the bottom current meter of 443. (This was especially regrettable since it would have provided valuable information of very-near-bottom currents). All current meter tapes had wound on correctly. A photosledge transect from about 4000m towards the slope was begun at 1830/24th and recovered at 0415/25th.

A study of the nephel layer to the S.E. and N.W. of the transect line was made between 0512/25th and 0633/27th with 12 CTD/transmissometer casts to about 10m off the sea bed. The nephel layer appears to be confined to within some 8-10 km of the 2500m contour and extends for some 70 km along the slope.

Moorings 445 to 447 were laid on 27th. The acoustic beacon on 445 appeared to be faulty but attempts to recover the mooring failed, and the remaining mooring arrangement was adjusted to provide two triangles, one near the slope and the other in deeper water, with the hope of still being able to resolve eddies and the variation in potential vorticity with distance from the slope even if this mooring cannot eventually be recovered.

Overnight 27-28th a photosledge tow was made on the Rise (Station 11700), again in deep water below the slope, before laying the final two moorings on 28th. Four further CTD stations were completed overnight 28-29th, the last being at the transect Station 4.

The ship proceeded to make a final photosledge tow in exceptionally calm conditions on the Porcupine Bank before sailing towards Falmouth to dock at 1000 31st August, one day early. The objectives of the cruise, to survey the benthic boundary layer, to lay moorings and to obtain photographs, have been exceeded in good measure.

6. CTD/Transmissometer (N.Hooker)

6.1 Operation

The IOS Neil Brown deep CTD system gave some early problems. At the trial Station (11639) the pressure calibration adopted was found to be incorrect, and conductivity was erratic. The former was amended after an exchange of telex messages, and the conductivity behaviour vanished after inspection but was eventually (after Station 11642) found to be due to a poor connection in the sea unit. A second similar fault was corrected after Station 11654.

For the majority of the casts however, the system worked correctly and well. Data was recorded on the Digidata mostly for down runs only recording continuing on the level C for the full dips. A small transmissometer drift was observed with the up-runs having consistently higher measured values of light transmittance than the down runs, but the main variations were clearly reproduced. A pressure-operated pinger was attached to the CTD to enable the system to be profiled to within 10m of the sea bed.

6.2 Use

In addition to 54 conventional CTD casts, two yo-yo series each lasting 25 hours were made (Stations 116509-51 and 11671-72) within 1.5 miles of a 'target' position. Each series was broken briefly once to allow the ship to recover position. The procedure adopted was to profile from surface to 10m off the sea bed, then to haul for 500m, back to 10m off, haul for 500m, back to 10m, and then up to 2000m (to sample the nephel cloud at 2400-3000m). The yo-yo's then continued with the down run from the surface replaced by that from 2000m. Contour plots were produced on board which revealed the presence of M_2 tidal frequencies (approximately) with apparent higher frequencies near bottom. Inversions of up to 40m were observed in potential temperature near the bottom.

The stations are listed in Table 1.

A cross-slope line of transect station (1-10, nominal positions are listed in Table 2) was repeated 3 times (Stations 11640-11649, 11661-11670, 11676-11685) with position 4 being repeatedly visited during the cruise (at Station 11643, 11664, 11682, 11687, 11697, 11704) as well as being the position of the first yo-yo series, to provide information about longer-term changes.

7. Calibration

7.1 Salinometer, Thermometers, and Rosette Multisampler (J.Moorey)

The rosette multisampler was used as a calibration check on every CTD dip. Six water bottles were used and were fired in pairs, the second bottle of each pair having a thermometer frame. After each pair there was a blank position on the multisampler, to ensure that thermometer frames could not touch each other when in the horizontal position. (In the past we have had 'hang-ups' on thermometer frames which were only two spaces apart. It is thought that the frames may swing violently even past the horizontal as the CTD is hauled, and if the frames are free to swing quickly back to the reversed position then the temperature recording is not lost. However, if the frames are close enough to jam each other beyond the horizontal position then one or both sets of thermometers drain and the temperature recordings are lost.)

The multisampler generally operated satisfactorily, but on the last few CTD's the deck unit occasionally had to be fired twice before it indicated that a bottle had fired. Another problem was the occasional snagging of thermometer frame lanyards. This problem was almost completely overcome by taping lanyards to minimise loops and to fit spare water bottles (without end caps) in the blank positions to avoid lanyards snagging on the rosette frame.

There were two sets of water bottles with thermometer frames, and these were used on alternate stations. This allowed more time for the incoming thermometers to equilibrate to laboratory temperature before reading. (The forward hydro lab is less well fitted for such work than it once was, presently housing the cooling system for the computer room). Each frame had a pair of protected thermometers and the 'deepest' two frames each had an unprotected thermometer. Some thermometers are readable to 0.002°C (-2 to 6° scale) and some to 0.005°C (-2 to 13 scale). Since each thermometer was read by two people, there were four readings for each 'frame' these were 'corrected' for the *in situ* values and the four readings averaged and quoted to 0.001°. Another advantage of two sets of thermometers was that a possible reading error could be checked if the thermometers were still in the hydro lab.

Two salinity samples were taken from each bottle and measured on the SUDO Guideline Salinometer. The salinometer functioned well. It was run at a bath temperature of 24°. It was used and standardised 11 times from 15th to 30th August. The standardised dial (Rs) setting ranged from a maximum of 688 to a minimum of 663, equivalent to a salinity change of 0.002 p.s.u. The salinometer's very good stability is indicated by the consistently good agreement of duplicates, the second of the pair always being measured on a separate day and hence separate standardisation. Also the salinities from adjacent water bottles showed good agreement indicating that there are no measurable leaks from the water bottles.

Also on board was the IOS Guideline serial No.42,508. This was not used for any of the rosette samples but a set of various salinities was made up by diluting with distilled water. The conductivities were such that the salinity range was from circa 6.0 to 36.6 p.s.u. In the oceanographic range (31 to 36.6 p.s.o.). The SUDO read higher than the IOS by only 0.001p.s.u. (at both 31 and 36.6). In the low salinity ranges (down to circa 6.0 p.s.u.) the SUDO read higher than the IOS by only 0.004. After 15 hours the two salinometers were compared by using water of 'about 35' p.s.u. The SUDO read lower than the IOS by 0.001 p.s.u. This shows that the two salinometers are consistent with each other over a wide range of conductivities although we do not know the absolute values of those conductivities.

7.2 CTD Calibrations for pressure, temperature and salinity.

(S.Boxall and J.Taylor, SUDO)

Pressure. Initial values of pressure as read by both the main shipboard computer and the BBC micro were low by a factor of 10, though correct on the CTD deck unit. This was due to necessary software corrections for both machines to take account of the deep pressure sensor fitted to the Neil Brown CTD. This problem was resolved after Station 11640.

Pressure data from the unprotected reversing thermometers gave no indications of any problems with the pressure transducer. However, a constant offset of approx. 8 db is present in the IOS CTD such that at 10m wire out, a reading of about 2 db was given. This offset drifted by about 3 db during the cruise.

Temperature: The temperature sensors on the CTD performed well, apart from an intermittent fault following Station 11654 which was remedied. This fault did not seem to effect the calibration of that Station.

The trend of the difference between CTD and thermometer values is linear, increasing with increasing temperature, with a spread of values about a line of 0.007°C. Most points lying outside of this limit can be counted as suspect due to samples being taken in a high gradient of temperature or to inconsistent readings on paired reversing thermometers. A liner correction (estimated by eye) of

$$T_{correct} = 1.0065T - 0.002°C$$

where T is the CTD uncorrected temperature
is recommended from this data set at the present time.

This was later compared to two other calibrations. The first, of unknown origin, is

$$T_{correct} = 1.0063T - 0.0015°C$$

which is in good agreement with the above, giving no resolvable difference in the deeper water (up to ~5°C), and the difference of .002 - .003 in the intermediate water masses at about 10°C.

The value used on the computer was

$$T_{correct} = 1.0074T - 0.0081°C$$

This does not fit the data set as well, giving errors of 0.005°C in deeper waters and shallower waters alike.

There were no noticeable trends with time.

Salinity (In all salinity calculations the temperature correction of 1.0065T - 0.002 was used).

Some problems were experienced with the conductivity measurements from the CTD. Readings over 1ppt high were initially given and there were significant jumps in values. The problem was traced to a faulty solder joint on the conductivity interface board on the under-water unit. This meant that any calibration of salinity was impossible prior to Station 11644.

Stations 11644-11655 demonstrated a better performance but also showed a slow calibration drift in time, from approximately 0.24 ppt low at Station 11644 up to 0.40 ppt low at Station 11654. The drift was neither linear nor consistent, and it is uncertain whether applying an individual correction for each station will produce reliable results. Though this may have to be done as a last resort, a better suggestion would be to correct to a standard water mass within each profile.

After Station 11655 the CTD was stripped down, checked and the conductivity cell thoroughly cleaned. Results from 11661 (the next CTD Station) were good. A plot of sample minus CTD salinity vs station number shows the above problems and the consistency of calibration with time for Station 11661 onward very clearly. A plot of Δs (Bottle salinity minus CTD salinity) vs salinity showed that with temperature there is a linear trend, though it is not quite so clearly defined as that of temperature. The recommended calibration for salinity, based on this data, is therefore

$$S_{correct} = 0.989S + 0.590$$

These are <u>no</u> salinity corrections implemented on the ship borne computer.

8. Moorings and Releases (see Table 3 and Fig.4)

8.1 Moorings (I. Waddington)

11 overside mooring operations were carried out, 9 deployments and two recoveries. The equipment used was, the IOS D.B.C., reeler, forward 'A' frame and Coles crane. All the operations were carried from the foredeck with the deployments being of the anchor first type.

The mooring ropes used on all 7 long-term deployments was of the polyester braided type of varying diameters. This rope was provided pre-measured and spliced ex factory. However it was apparent that the larger rope lengths were considerably overlength and not consistent in their error. This meant that the ropes had to be adjusted onboard and during the mooring operations. Each length was tensioned on to the winch in an effort to maintain some consistency of length and during the operation of deployment each length was carefully monitored on the measuring sheave.

The current meters used on the moorings were of the Aanderaa RCM 5 type modified to IOS standard, and the EG & G VACM. All instrumentation was tested onboard with no failures prior to deployment.

Three moorings (441 to 443) were laid, following release wire tests, on arrival at the study area. The rather complex mooring (443, including BERTHA) required the use of the Coles crane to lift over the anchor, release and VACM as one lift. With the anchor carefully controlled on steady lines the lift was successfully accomplished through the 'A' frame. The mooring was laid with little difficulty, and recovered later in the cruise having, so far as is known, operated successfully other than that the vane of the lowest VACM was found to be out of its pivot and jammed against a support bar when recovered on board.

An additional mooring, 444, with a single Aanderaa current meter was deployed in the 'nephel' layer to ascertain its motion and recovered with no difficulty after six days. On recovery of moorings 443 and 444, all recording instrumentation appeared to have worked although no tape reading could be done onbord to check.

Mooring 445 was deployed normally in good conditions, but on arrival on the sea bed sprurious 'pings' were received which suggested that the beacon had failed to time-out correctly. It was therefore decided to release the mooring and recover. Repeated attempts to release it however proved unsuccessful, and a fault in the release mechanism or pyros is suspected (see section 7.1.3.))

Moorings 446-449 were deployed normally, leaving an array of seven moorings carrying 7 VACMs and 12 Aanderaa's for recovery in April-May 1988 (see Fig.4b).

All operations went relatively smoothly with, so far as could be seen, no damage being caused to any components during deployment and recovery.

8.2. BERTHA (M.White)

BERTHA (Benthic Resistance Thermometer Array) is a chain of 6 high resolution (0.1m°C) platinum resistance thermometer sensors, set at a sampling rate of 20 secs. For this deployment the sensors were at heights of 1.5, 3.8, 7, 9.3, 13 and 20m above the bottom. In addition 5 VACM's were also used on the mooring. The position of the mooring was at 50° 29.61′N, 14° 38.51′W in a water depth of 3447m.

Before departing from Falmouth the polarity of the 1.5m sensor was found to be incorrect and was reversed, and on deck prior to deployment all sensors and reference checks were found to be correct. The mooring reached the bottom at 21.34:00 on 14/8 and the acoustic release was fired at 13.48 on 24/8. Total tape time is expected to be 237 hrs 59mins plus a small number of test records at the start of the tape.

On recovery all the sensors appeared to be functioning correctly, although the logger case had suffered a little from corrosion.

8.3 Releases (D.White)

8.3.1. Deployments

A total of nine moorings were deployed with two successful recoveries. All releases were wire-tested to working depth before deployment.

BERTHA (Mooring 443)

Two releases, CR2411 and 2417, firing a pyro and a retractor on one release. Deployed 14th and recovered 24th.

Mooring X (444)

One release, CR2302, firing a retractor and a pyro.

Mooring Array A-G

Mooring Letter	No.	CR Number	Release Frequency	Beacon Period
A	441	2402	360	0.98
B	448	2302	280	1.12
C	442	2400	340	0.94
D	445	2387	380	1.08
E	446	2401	440	0.96
F	449	2557	460	1.00
G	447	2107	300	1.08

Mooring D (445)

Failed on deployment. The beacon was switched on at the surface and monitored down to the sea bed. At the end of the beacon time-out period it continued to give small, irregularly spaced pings, rather than switching off completely, and it was decided to pop the mooring back up and redeploy using another release in case the beacon batteries became depleted. The release sequence operated with the relay operation indicating after five bursts of FM signal (as on the wire test). The mooring however failed to release from the bottom even after continued transmission bursts at the release frequency for almost 1 hr, 1018-1116/27th (day 239) and subsequently failed to operate the relay again and to fire the release. A further interrogation of the mooring at

2030/day 239 also failed to operate the relay, although the original fault (failure to switch off completely) then appeared absent and the unit behaved well in all other respects. The mooring was still in place with normal response from the beacon at 1230/28th (day 240).

8.3.2 Wire Tests

All units were satisfactorily wire tested before deployment.

CR2309 - leaked and was not used.

CR2557 - Required receiver adjustment and was re-tested.

CR2401 - Required a wiring modification removing after the wire test.

CR2387 - Only fired one side of its relay and had a 9 volt battery inserted which fired the relay correctly [2302, 2309 and 2400 already have this modification].

8.3.3. Photosledge

Monitors. J19 was used throughout and performed satisfactorily.

Cameras. P4A-14 and P4A-16 both developed faults before deployment. An I.C. was changed on P4A-14 and the on-off switch was modified on P4A-16 to prevent damage when loading film. Both cameras had their batteries changed. P4A-16 had an intermittent fault, so P4A-14 was used throughout. The Mk 4 camera was only used on two occasions.

9. Photosledge transects (A.Rice)

The planned cruise programme included two or three photosledge deployments in the neighbourhood of the CTD sections and moorings, preceded by a series of shallow water deployments on the Porcupine Bank. These shallow deployments were intended both to check the functioning of the gear and to supplement the existing IOS photographic coverage in this region.

The photosledge system employs an IOS camera mounted on the epibenthic sledge as described in IOS cruise report 175. The original intention on this cruise was to use only the Mark IV A half-frame version of the camera, but because of problems with the two available units a conventional Mark IV 35mm format camera was used on two occasions (see Table 4).

The first deployment (11656 #1), using camera P4-16, was aborted shortly after bottom contact because the Mufax record gave no evidence of photographs being taken. Accordingly, the other half-frame unit (P4-14) was used on the second deployment (11656 #2) in the "continuous" mode, that is not under the control of the pinger, and produced about 250 usable bottom photographs. This technique can, of course, only be used in relatively shallow water for otherwise the film would be severely depleted before the bottom was even reached. Since however this camera appeared to be functioning normally a third deployment was made at the same station with the camera under the control of the pinger. The camera was switched on successfully on bottom contact, but stopped working after only 14 minutes due, it transpired, to flat batteries.

With both half-frame cameras now out of action a full-frame unit (P4-08) was employed successfully under pinger control for the next two stations (11657 and 11658). Unfortunately, however, the camera was mounted incorrectly and therefore took photographs in the portrait rather than landscape format.

Having had its batteries replaced, P4-14 was now working correctly and, after a successful deployment at a depth of about 400m (11659), this unit was used for all of the remaining photo transects.

Up to this point the aperture used was the recommended setting of between f8 and f5.6, but the resulting negatives were rather thin. Accordingly, a setting of f5.6 was used for the last shallow deployment (11660) before the deep hauls. The resulting negatives were good and this setting was therefore used for the remaining deployments.

With the gear now working satisfactorily and producing good photographs, three deep hauls were undertaken. The first of these (11675) attempted to cross the mouth of the canyon near the head of the mooring transect and the gear was launched at a point about 4n.m. west of the BERTHA position and hauled on a roughly northerly course. During the haul the vessel crossed a steep-sided gulley about 50m deep and some 500m across, apparently an extension of the canyon. About 90 good photographs were obtained to the south of this depression over which the sledge was 'flown' in mid-water. The sledge was then successfully towed for a further 17 minutes, obtaining about 70 photographs, on the northern side.

Although the camera still contained a great deal of unexposed film, the sledge had to be recovered at this point to avoid the 400m high foothills of the escarpment over which the ship had by this time sailed.

The second deep deployment (11686) was much less adventurous, being simply an attempt to photograph along the lower section of the CTD transect to the east of proposed mooring positions E and G. To increase the potential duration of this and future hauls the inter-frame interval was increased from 15 to 30 seconds and more than 500 good frames were obtained on this occasion over a distance of about 7 n.m.

The final deep deployment (11700) attempted to continue the coverage of 11686 towards the escarpment. However, although the sledge was placed on the bottom very close to the end of the previous transect, after 70 minutes of bottom contact the Mufax record indicated that one side of the sledge was raised, though photographs continued to be taken. All attempts to correct this fault over the succeeding four hours failed and it subsequently transpired that only the first 140 or so frames were good, the remaining 600 exposures obtained during this haul being either obscured by mud or disorientated to varying degrees.

A final photosledge (11705) extended the series of shallow deployments to cover the depth range 570m to 630m and obtained 350 good photographs.

10. <u>General Deck Equipment, Winches etc.</u> (G. Lake)

Winches generally functioned well. A broken weld in the aft leg of the CTD A frame was fortunately noticed before leaving Falmouth, rewelded, and the frame recertified to 6 ton. Adjustment to the position of traversing gear was necessary to achieve smooth and regular winding on the cable to the CTD drum. The cable appears rusty but is no better or worse in the outer sections than in those with 4000m of wire out.

A sticking valve in the traction winch prevented deployment of the photosledge in passage to the site, but was eventually identified and cured. A leak around the shaft of the reeler motor of the double barelled winch on the foredeck was repaired, but another leak of hydraulic fluid from the aft ram and seal of the forward 'A" frame whilst in the inboard position, due to chrome damage on the shaft, could only be avoided (by not leaving the frame fully in board). The ES fish worked without fault.

11. Ornithology and Cetaceans (J.J.Taylor, IOS)

The commonest bird throughout the cruise was the Manx Shearwater (*Puffinus puffinus*), at least 100 being observed on the 18th and usually 5-10 visible at any time. Within these flock were also some Great Shearwaters (*P.gravis*), distinguishable by their larger size and dark 'capped' appearance. Up to 5 Sooty Shearwaters (*P.griseus*) also appeared on the 12th, 18th and 25th. The latter were species now returning from their breeding quarters far south on the South Atlantic and sub Atlantic islands.

About 30 Kittiwakes (*Rissa tridactyla*) accompanied the ship for the first two days, thereafter up to 10 occurred on the 18th, 25th , 27th and 30th. Only one adult bird appeared due to the fact that most breeding birds are still at their nesting cliffs. Similarly most of the Gannets (*Sula bassana*) seen were first or second year birds - up to 9 being seen throughout the cruise.

A second winter Lesser Blacked-backed Gull (*Larus fuscus*) was seen on the 25th and on the 27th, when it was joined by an adult. Another 8 immature birds followed the ship on the 30th.

Fulmars (*Fulmarus glacialis*) were constantly seen from the ship in numbers up to 8. Petrels were also often seen, though positive identification was not always possible; on the 18th 10-15 British Storm Petrels (*Hydrobates pelagicus*) came close enough to be identified by virtue of the pale patch on the underwing.

Small numbers of Skuas were observed: an Arctic Skua (*Stercorarius parasiticus*) on the 12th, a Pomarine Skua (*S. pomarinus*) in pale phase plumage on the 17th and a Great Skua (*S.skua*) on the 27th and 29th.

Several migrants were observed, mostly waders returning from breeding sites of Iceland, Scandinavia and the northern tundra to overwinter in Britain and northern Europe. A Ringed Plover (*Charadrius* *hiaticula*) in summer plumage was sighted on the 17th. 3 Turnstones (*Arenaria interpres*) arrived on the 20th, followed by 5 more on the 23rd - all were in winter plumage. A tired looking Sanderling (*Calidris alba*) also in winter plumage turned up on the 25th. An interesting observation was that of a juvenile Pied Wagtail (*Motacilla alba*) on the 23rd. Although this is a year round resident in Britain, it breeds as far north as the Arctic Circle, after which it overwinters as far south as the Southern Mediterranean.

Incidental observations of dolphins and whales were recorded. Common Dolphins (*Delphinus delphis*) were numerous throughout the cruise. 3 Bottlenose Dolphins (*Tursiops truncatus*) were spotted on the 17th amongst 10-15 whales, presumed to be Longfin Pilot Whales (*Globicephala melaena*), some of which were young calves. 2 more adults were spotted on the 20th. An alternative identification of False Killer Whales (*Pseudocra crassidens*) has been offered for these.

On the 25th, distant views were obtained fo a Balaenopterid whale, thought to be either a Fin Whale (*Balaenoptera physalus*) or a Sei Whale (*B.borealis*).

Reference: WATSON, Lyall, 1981. Whales of the World. Hutchinson 302pp.

Discovery Cruise 169

FIGURE CAPTION

1. The Cruise Track (a) Falmouth-Falmouth
   (b) The Survey Area

2. (a) to (h) 2-day cruise tracks and proceedings.

   (a) 0000 day 226 (14th) to 2400 day 227 (15th)
   (b) 0000 day 228 (16th) to 2400 day 229 (17th)
   (c) 0000 day 230 (18th) to 2400 day 231 (19th)
   (d) 0000 dya 232 (20th) to 2400 day 233 (21st)
   (e) 0000 day 234 (22nd) to 2400 day 235 (23rd)
   (f) 0000 day 236 (24th) to 2400 day 237 (25th)
   (g) 0000 day 238 (26th) to 2400 day 239 (27th)
   (h) 0000 day 240 (28th) to 2000 day 241 (29th)

3. CTD Stations (except 11639). Add 11600 to the numbers shown to obtain the full Station number. The dashed line shows the approximate position of S.Westerly edge of the nephel plume. Depths in metres (from chart by P.M.Hunter, IOS).

4. The moorings

   (a) Positions

   (b) Vertical section of the array to be recovered April-May 1988. Depths of bottom and of the instruments shown in metres. A = Aanderaa, V = VACM, 0 = top float. Depth in metres.

5. Photosledge transects with station numbers. Depths in metres.

TABLE 1 CTD STATIONS

Discovery Cruise 169

St.No.	Day 1987	Time Start down	end	Position Lat deg.N	Long deg.W	Water Depth (m) at start of descent	End.Dist. off bottom (m)	Sounding at closest approach (m)	Comment (Transect St.N^{O})
11639✓	225	1914	2049	50° 14.5′	12° 23.1′	2340	680	241	Trial Station conductivity erratic
11640✓	226	2348	0056/227	50° 35.7′	14° 22.6′	1526	10	1514	T.S.1
11641✓	227	0202	0324	50° 32.7′	14° 27.2′	1871	7	1851	T.S.2
11642✓	227	0416	0609	50° 29.9′	14° 31.3′	2553	6	2522	T.S.3 Conductivity sensor failed
11643✓	227	0830	1053	50° 27.3′	14° 34.2′	3471	15	3311	T.S.4
11644✓	227	1247	1459	50° 24.8′	14° 38.4′	3555	11	3521	T.S.5
11645✓	227	1617	1834	50° 20.9′	14° 42.8′	3744	5	3748	T.S.6
11646✓	227	1917	2215	50° 18.3′	14° 47.1′	3938	12	3943	T.S.7
11647✓	227	2328	0147/228	50° 15.5′	14° 52.0′	4008	15	4016	T.S.8
11648✓	228	0241	0513	50° 12.4′	14° 55.6′	4078	10	4102	T.S.9
11649✓	228	0600	0830	50° 09.6′	14° 59.1′	4155	13	4157	T.S.10
11650	228	1301	2009	within 1.0nm of 50° 26.8′	14° 35.3′	Repeated profiles to 10m off bottom (see text)			yo-yo series 1 T.S.4 12 profiles
11651	228	2037	1455/229	"	"	"	"		yo-yo continued 36 profiles
11652	229	1507	1656	50° 28.0′	14° 33.7′	3190	18	3236	Nephel Survey
11653	229	1806	2012	50° 23.8′	14° 39.4′	3600	10	3595	T.S.5
11654✓	229	2106	2314	50° 26.4′	14° 37.8′	3500	12	3594	Nephel Survey
11655✓	230	0238	0432	50° 25.6′	14° 30.8′	3515	10	3507	Nephel Survey
11661✓	231	1852	1958	50° 35.6′	14° 23.5′	1572	14	1572	T.S.1
11662	231	2051	2211	50° 33.0′	14° 27.6′	1879	10	1879	T.S.2
11663✓	231	2301	0046/232	50° 30.2′	14° 31.5′	2530	11	2571	T.S.3
11664✓	232	0139	0338	50° 27.7′	14° 35.5′	3439	10	3452	T.S.4
11665✓	232	0432	0645	50° 23.9′	14° 39.6′	3571	10	3592	T.S.5
11666	232	0732	0952	50° 20.8′	14° 43.9′	3764	10	3744	T.S.6
11667	232	1040	1302	50° 17.9′	14° 47.5′	3954	10	3959	T.S.7
11668	232	1343	1617	50° 15.6′	14° 52.1′	4021	11	4025	T.S.8
11669	232	1704	1935	50° 11.8′	14° 55.8′	4104	8	4114	T.S.9
11670	232	2015	2247	50° 08.3′	14° 55.8′	4154	12	4166	T.S.10
11671	233	0211	0850	within 1.5n.m of 50° 34.0′	14° 41.0′	Repeated profiles to 10m off bottom (see text)			yo-yo series 2 12 profiles
11672	233	0926	0321/234	"	"	" "	"	" "	yo-yo continued 39 profiles
11673	234	0419	0622	50°39.0′	14° 47.7′	3104	12	3096	Nephel Survey
11674	234	0724	0942	50° 32.4′	14° 50.7′	3698	10	3690	Nephel Survey
11676	235	0106	0334	50° 09.4′	14° 59.7′	4154	10	4165	T.S.10
11677	235	0437	0657	50° 12.8	14° 54.7′	4094	10	4106	T.S.9
11678	235	0802	1044	50° 15.6′	14° 50.0′	4003	10	4015	T.S.8
11679	235	1141	1407	50° 17.9′	14° 46.8′	3952	13	3950	T.S.7
11680	235	1623	1836	50° 21.2′	14° 43.4′	3738	10	3762	T.S.6
11681✓	235	2036	2238	50° 24.4′	14° 39.8′	3572	8	3686	T.S.5
11682	235	2337	0207/236	50° 27.2′	14° 35.3′	3449	11	3388	T.S.4
11683	236	0249	0433	50° 30.3′	14° 30.5′	2444	10	2328	T.S.3
11684	236	0511	0640	50° 33.3′	14° 27.3′	1844	12	1832	T.S.2
11685	236	0721	0831	50° 35.2′	14° 23.1′	1530	10	1545	T.S.1
11687	237	0512	0734	50° 27.5′	14° 36.6′	3460	10	3438	T.S.4
11688	237	0907	1130	50° 25.4′	14° 25.4′	3287	10	3257	Nephel Survey
11689	237	1249	1507	50° 22.3′	14° 15.7′	3234	10	3218	" "
11690	237	1621	1830	50° 22.1′	14° 06.9′	3232	10	3260	" "
11691	237	2004	2210	50° 17.7′	13° 53.3′	3146	12	3148	" "
11692✓	237	2355	0221/238	50° 16.8′	14° 07.6′	3598	15	3580	" "
11693	238	0349	0622	50° 14.2′	14° 19.5′	3731	10	3690	" "
11694	238	0803	1040	50° 16.3′	14° 33.7′	3877	13	3864	" "
11695	238	1225	1511	50° 18.6′	14° 48.0′	3930	11	3932	T.S.7
11696	238	1739	2009	50° 21.4′	14° 29.0′	3679	8	3636	Nephel Survey
11697	238	2116	2338	50° 26.8′	14° 35.4′	3499	10	3469	T.S.4
11698	239	0042	0304	50° 27.9′	14° 45.1′	3702	10	3721	Nephel Survey
11699	239	0424	0633	50° 37.0′	14° 56.3′	3575	10	3540	" "
11701	240	1805	2042	50° 09.8′	14° 25.7′	4104	7	3949	" "
11702	240	2236	0044/241	50° 22.0′	14° 08.3′	3019	10	3069	" "
11703	241	0416	0619	50° 33.6′	14° 35.9′	3272	7	3280	" "
11704	241	0733	0933	50° 26.8′	14° 35.6′	3484	12	3469	T.S.4

TABLE 2

TRANSECT LINE STATIONS (NOMINAL POSITIONS)

Station No.	Approx. Water Depth (m)	Position	
1	1500	50° 35.7'N	14° 23.0'W
2	1900	50° 32.7'N	14° 27.1'W
3	2500	50° 29.9'N	14° 31.1°W
4	3500	50° 26.8'N	14° 35.3'W
5	3730	50° 24.1'N	14° 39.2'W
6	3850	50° 21.1'N	14° 43.3'W
7	3940	50° 18.3'N	14° 47.2'W
8	4030	50° 15.3'N	14° 51.4'W
9	4110	50° 12.4'N	14° 55.6'W
10	4170	50° 09.6'N	14° 59.3'W

TABLE 3

Discovery Cruise 169

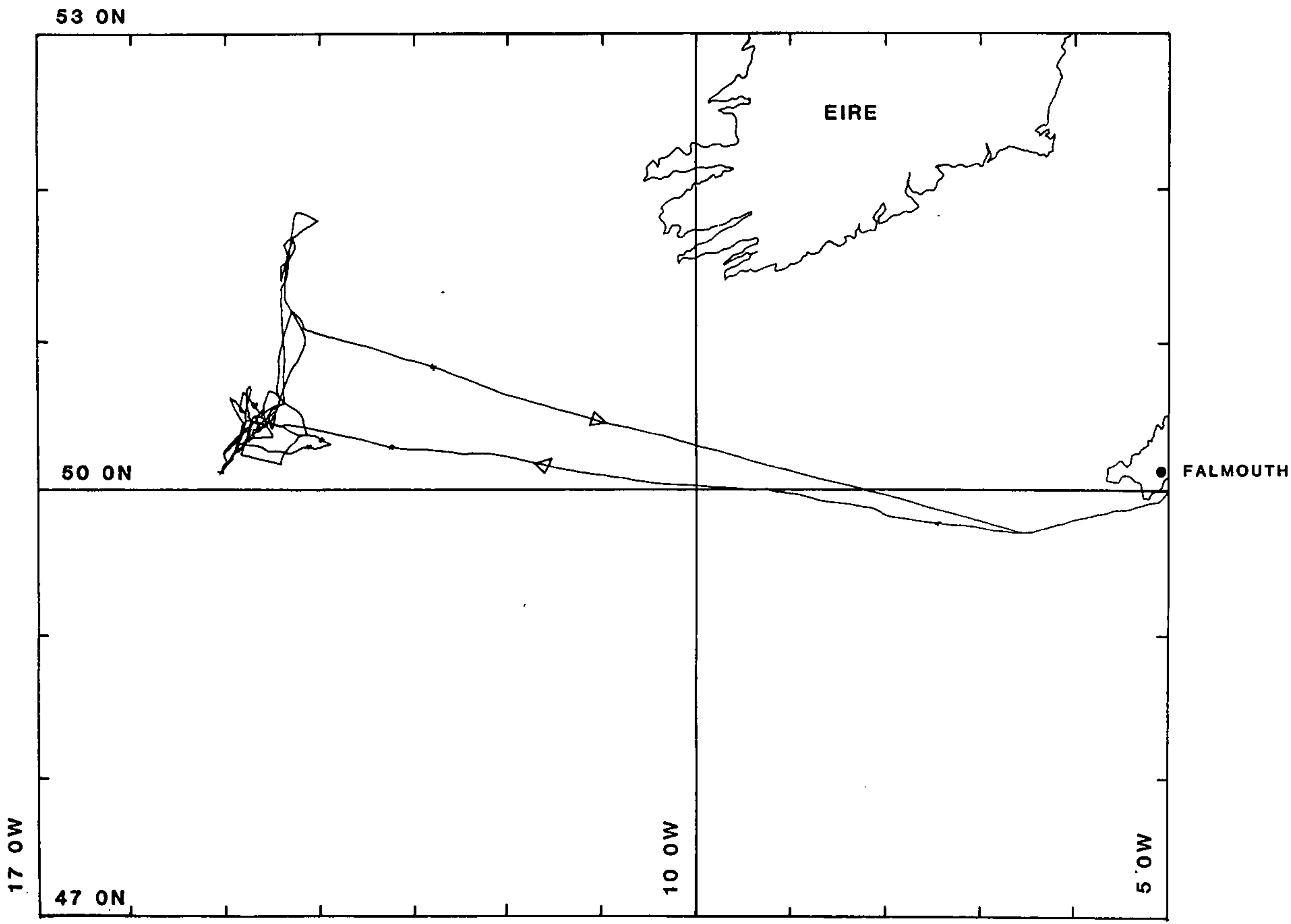
MOORINGS V = Vector Averaging Current Meter A = Aanderaa Current Meters

Mooring No	Date (Day No.)	Time arrived on sea bed	Position Lat.deg.N	Long.Deg.W	Water Depth (m)	Instrument and number	Sampling Interval min	Ht of bottom (m)
441	14/8 (226)	1329	50° 30.78′	14° 38.26′	3347	V 0666	30	21
"A"						A 4738	30	370
442	14/8(226)	1636	50° 25.25′	14° 44.72′	3697	A 2109	30	22
"C"						V 0130	30	374
						A 2107	30	727
443	14/8(226)	2134	50° 29.61′	14° 38.51′	3447	V 0629	7.5	4.5
						V 0430	7.5	10.0
"BERTHA"						V 0673	7.5	25.5
						V 0668	7.5	70.0
						V 0627	7.5	170.5
						BERTHA	20 sec	1.5, 3.8
						SENSORS		7.0, 9.3
	MOORING RELESED FROM SEA BED AT 1348 DAY 236 AND RECOVERED							13,20
444	18/8(230)	0213	50° 25.44′	14° 29.22′	3487	A 6225	5	1009
"X"	MOORING RELEASED FROM SEA BED AT 1029 DAY 236 AND RECOVERED							
445	27/8(239)	0959	50° 27.92′	14° 41.89′	3565	V 0668	30	240
"D"						A 8009	30	594
446	27/8(239)	1451	50° 20.15′	14° 53.10′	3964	A 7948	30	287
"E"						V 0627	30	636
						A 7946	30	992
447	27/8(239)	1821	50° 14.42′	15° 00.71′	4127	A 5207	30	22
"G"						A 3630	30	446
						V 0673	30	793
						A 5206	30	1153
448	28/8(240)	1147	50° 25.48′	14° 35.60′	3552	V 0629	30	227
"B"						A 8010	30	582
449	28/8(240)	1606	50° 13.35′	14° 50.23′	4026	A 5205	30	347
"F"						V 0430	30	700
						A 5204	30	1054

TABLE 4 STATION DATA FOR PHOTOSLEDGE DEPLOYMENTS

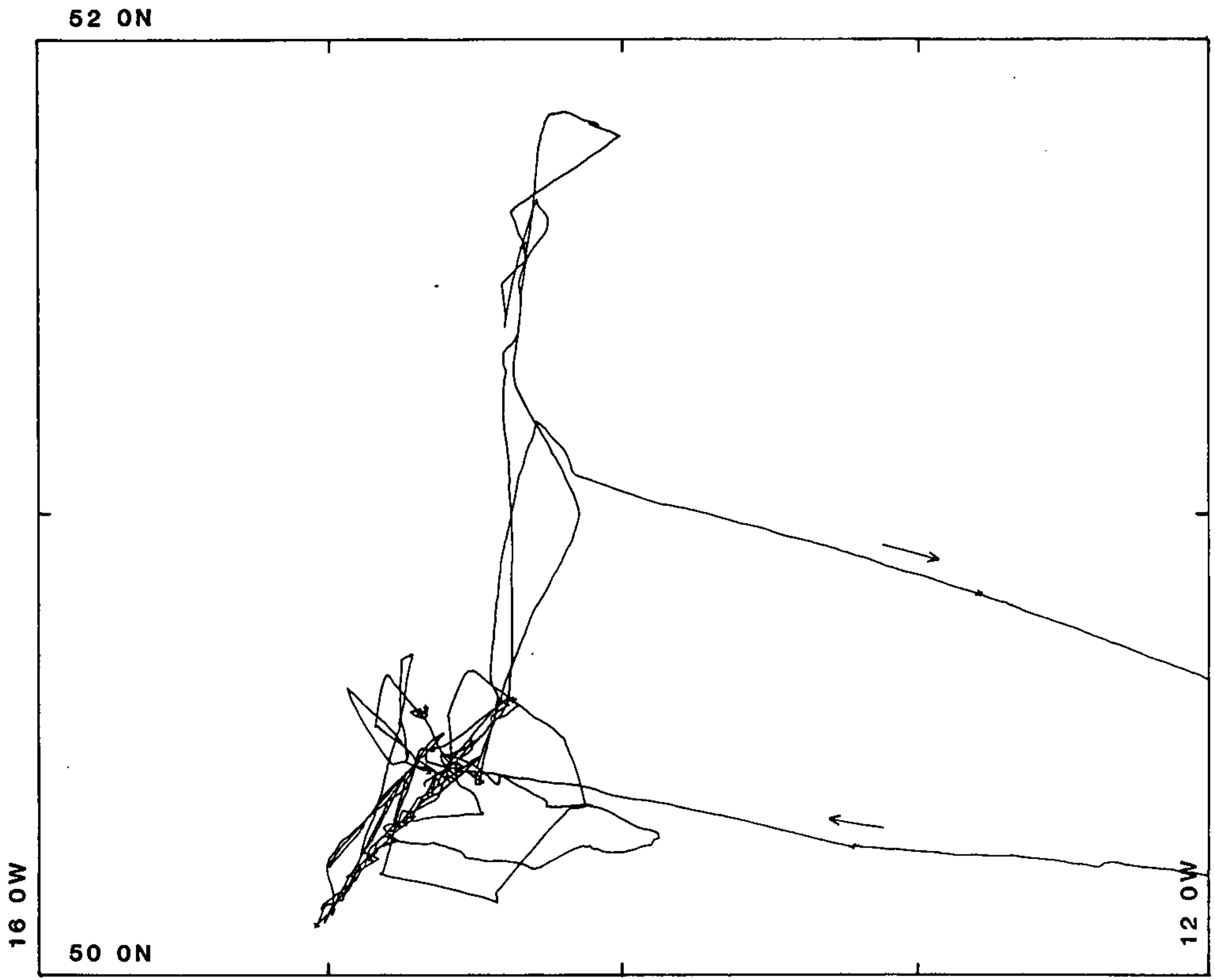
Discovery Cruise 169

Station No.	Date Started	Time on Bottom (GMT)	Start Position	End Position	Depth (Corrected M)	Usable Photographs	Remarks
11656 # 1	18.8.87	1359-1427	51° 50.6′N:14° 11.9′W	51° 50.5′N:14° 11.2′W	355	0	Aborted; camera malfunction
11656 # 2	18.8.87	1530-1631	51° 49.8′N:14° 08.8′W	51° 49.3′N:14° 06.3′W	365-368	c250	Camera running continuously; 15 second intervals
11656 # 3	18.8.87	1746-1837	51° 48.8′N:14° 05.7′W	51° 48.2′N:14° 02.8′W	370-373	c60	Camera stopped at 1805; low batteries. 15 sec.interval
11657	18.8.87	2314-0014	51° 35.8′N:14° 21.4′W	51° 33.9′N:14° 20.2′W	411-421	c170	Mk IV camera; portrait format 15 sec. interval.
11658	19.8.87	0224-0351	51° 27.9′N:14° 24.3′W	51° 25.3′N:14° 24.1′W	461-469	c230	Mk IV camera; portrait format 15 sec. interval.
11659	19.8.87	0717-0820	51° 39.2′N:14° 17.3′W	51° 38.2′N:14° 15.4′W	391-401	c180	Mk IV A; 15 Secs.
11660	19.8.87	1250-1418	51° 18.6′N:14° 24.1′W	51° 15.6′N:14° 15.2′W	523-551	c300	Mk IV A; 14 secs.
11675	22.8.87	1325-1430	50° 32.7′N:14° 45.3′W	50° 34.5′N:14° 45.7′W	3567-3511	163	95 frames before canyon, 68 frames after canyon.
11686	24.8.87	2118-0152	50° 14.7′N:14° 52.7′W	50° 20.2′N:14° 46.3′W	4043-3858	540	Mk IV A; 30 secs.
11700	28.8.87	0037-0650	50° 19.3′N:14° 46.4′W	50° 29.5′N:14° 36.3′W	3910-3578	140	Mk IV A; 30 secs.
11705	29.8.87	1531-1828	51° 10.9′N:14° 16.6′W	51° 06.3′N:14° 10.7′W	570-630	350	Mk IV A; 30 secs.



SCALE 1 TO 4000000

FIG. 1a CRUISE TRACK



SCALE 1 TO 1500000

FIG. 1b THE SURVEY AREA

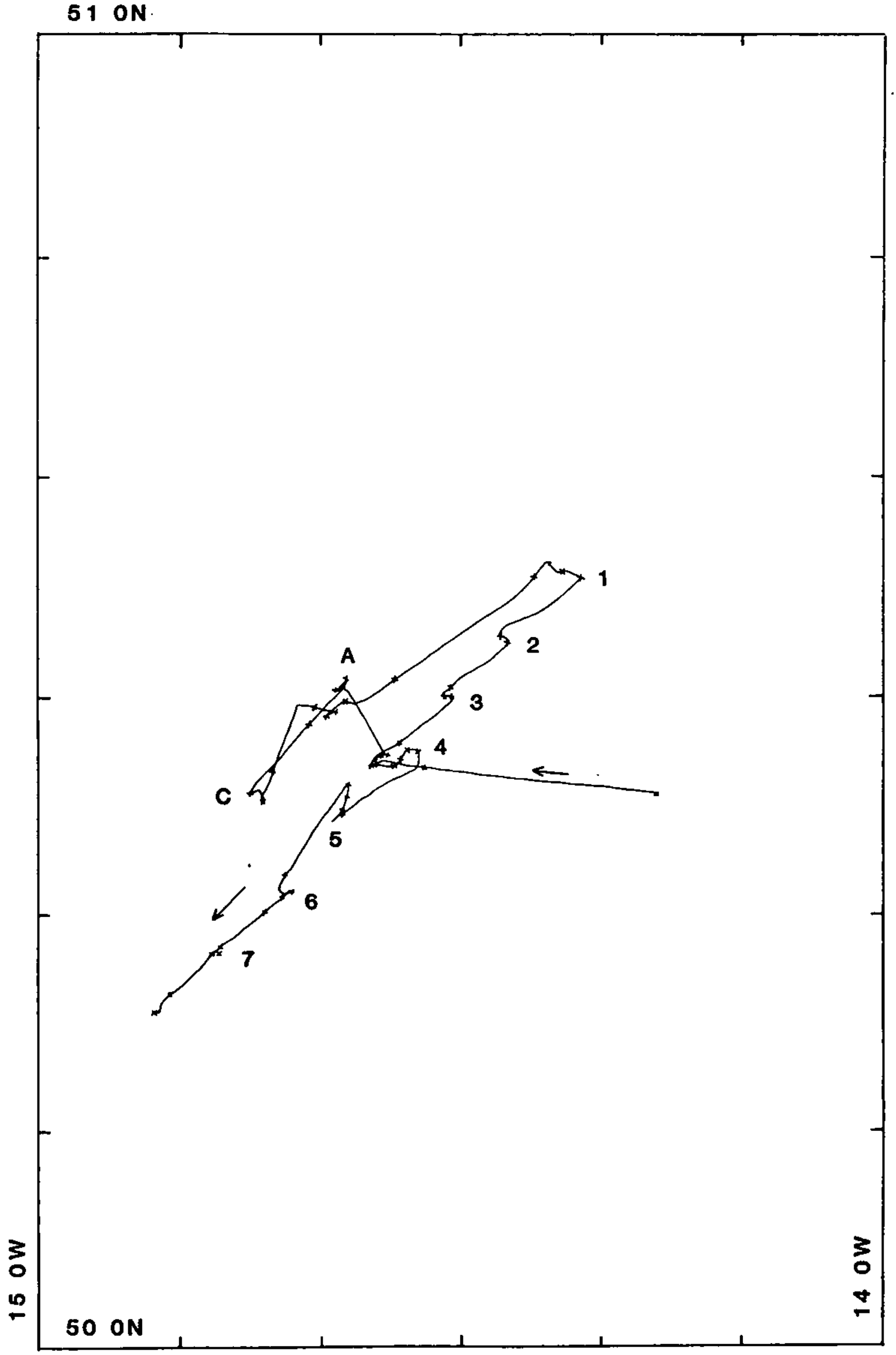


FIG. 2(a)

SCALE 1 TO 500000

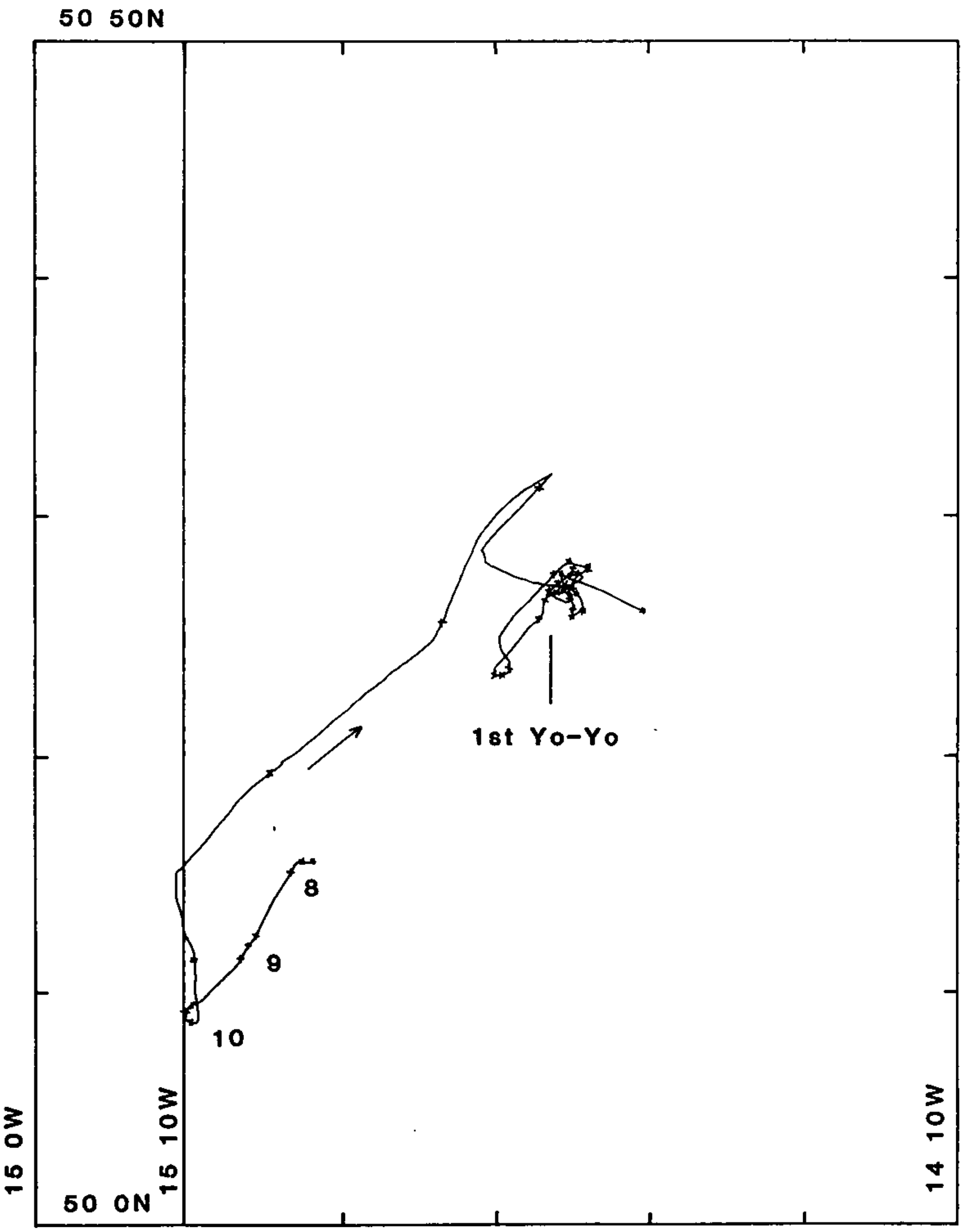


FIG. 2(b)

SCALE 1 TO 500000

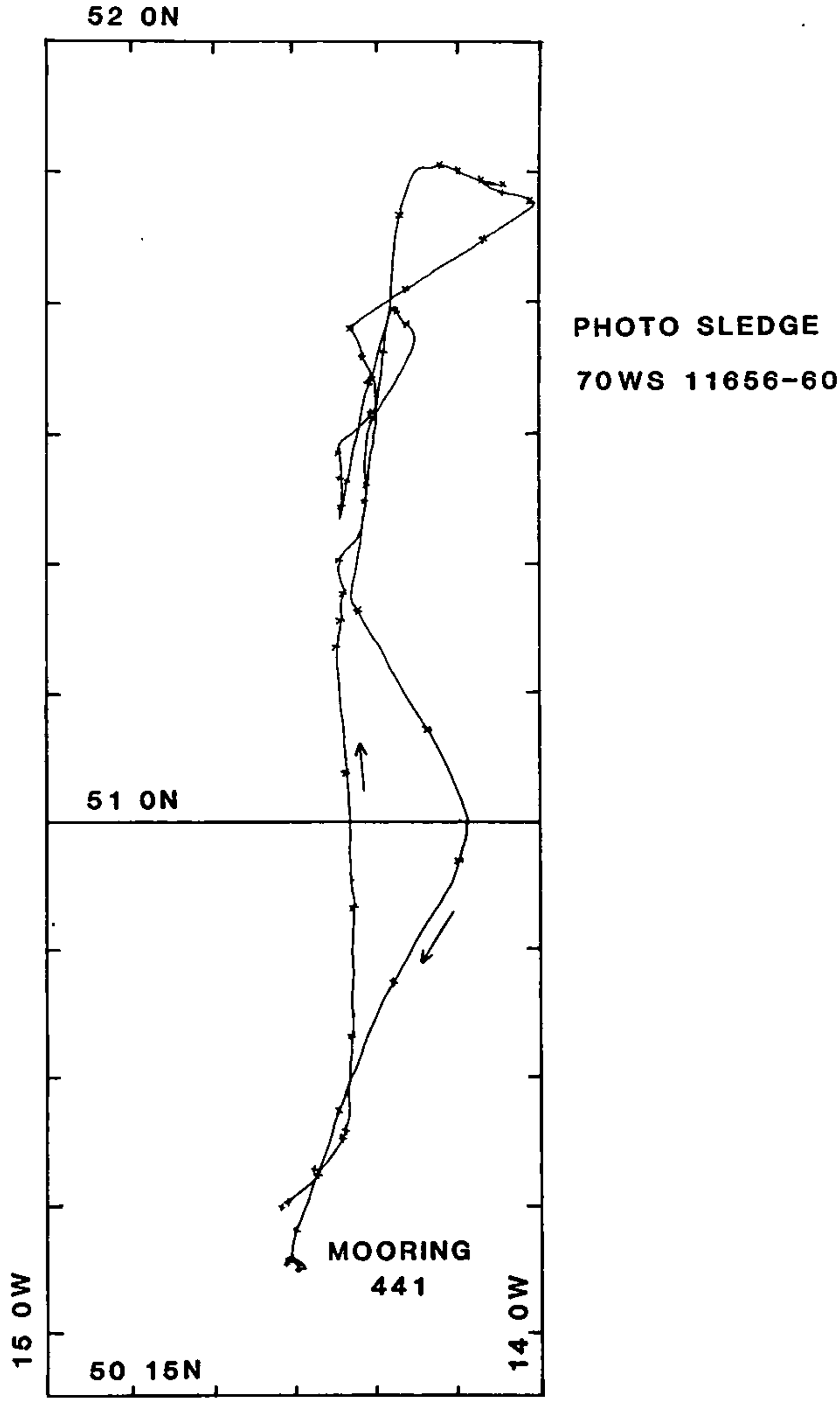


FIG. 2(c)

SCALE 1 TO 1000000

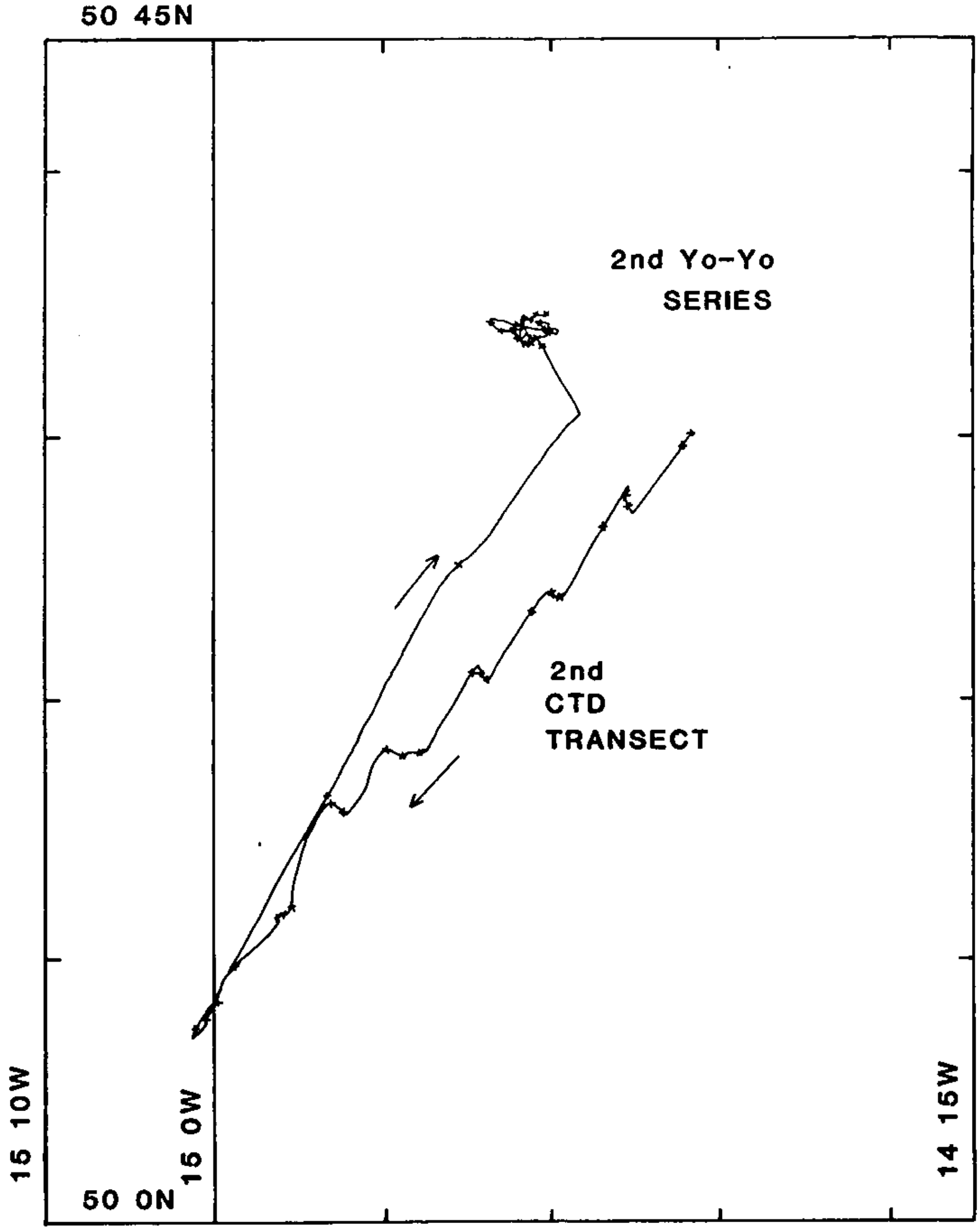


FIG. 2(d)

SCALE 1 TO 500000

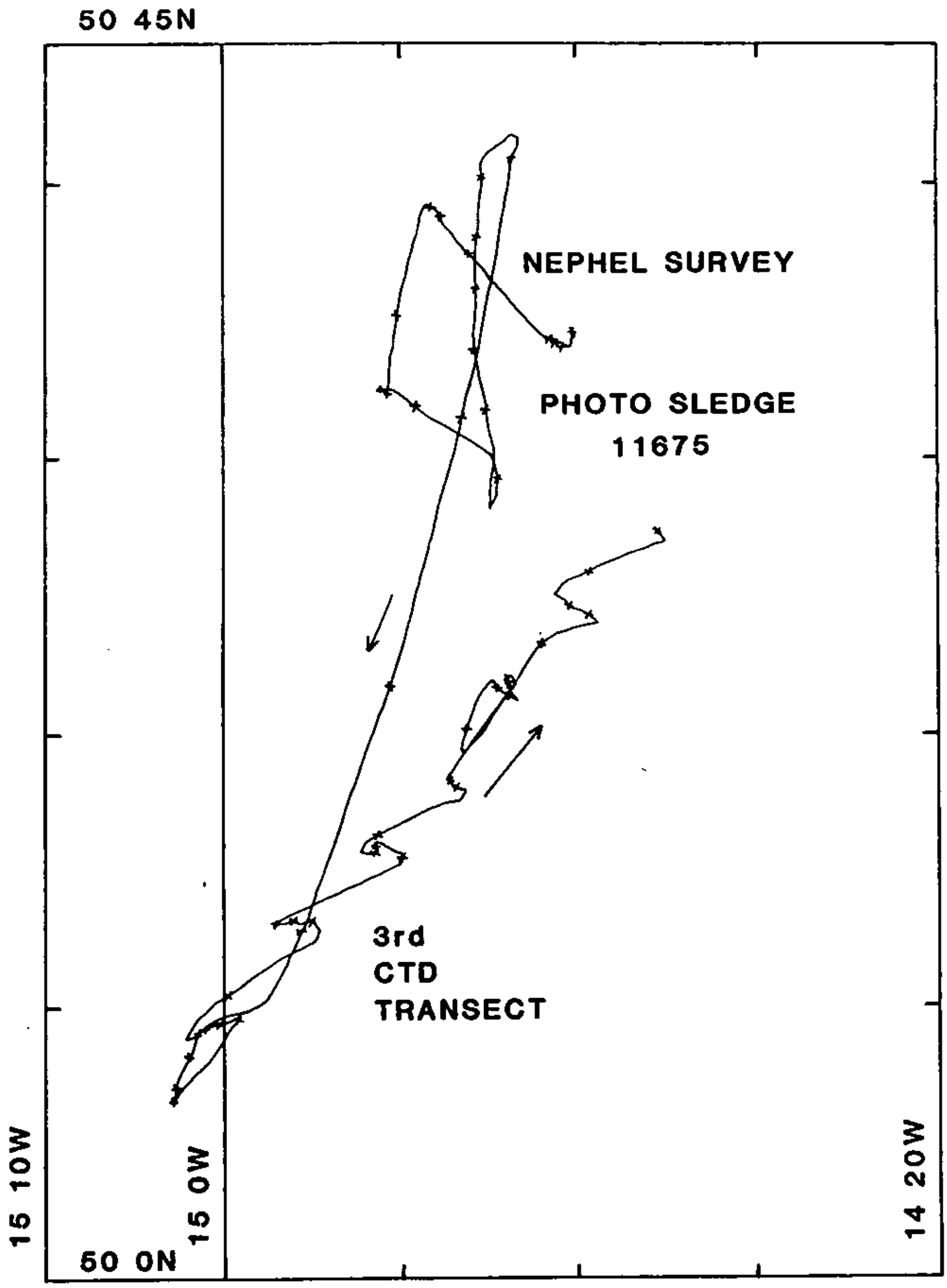


FIG. 2(e)

SCALE 1 TO 500000

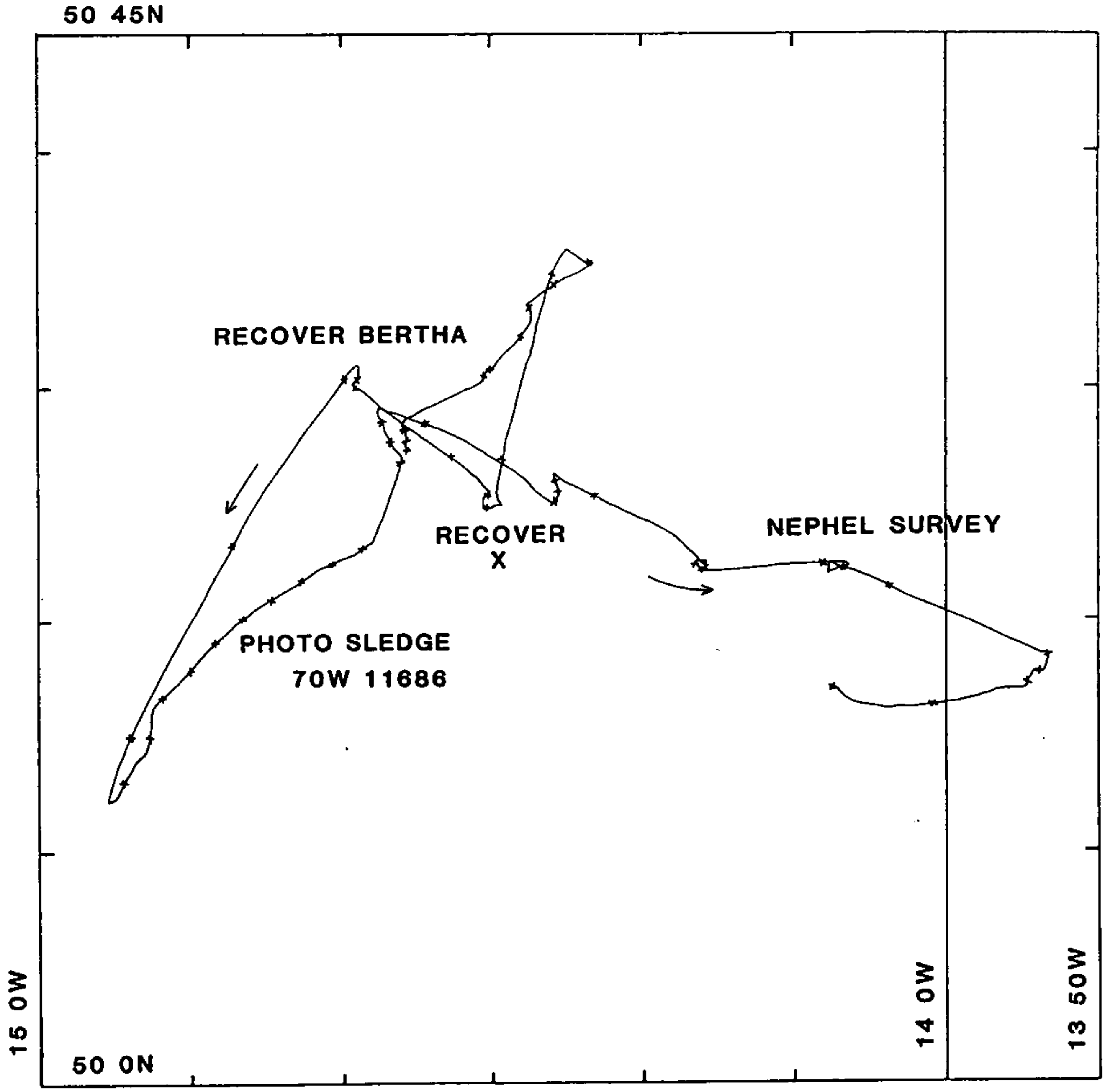


FIG. 2(f)

SCALE 1 TO 500000

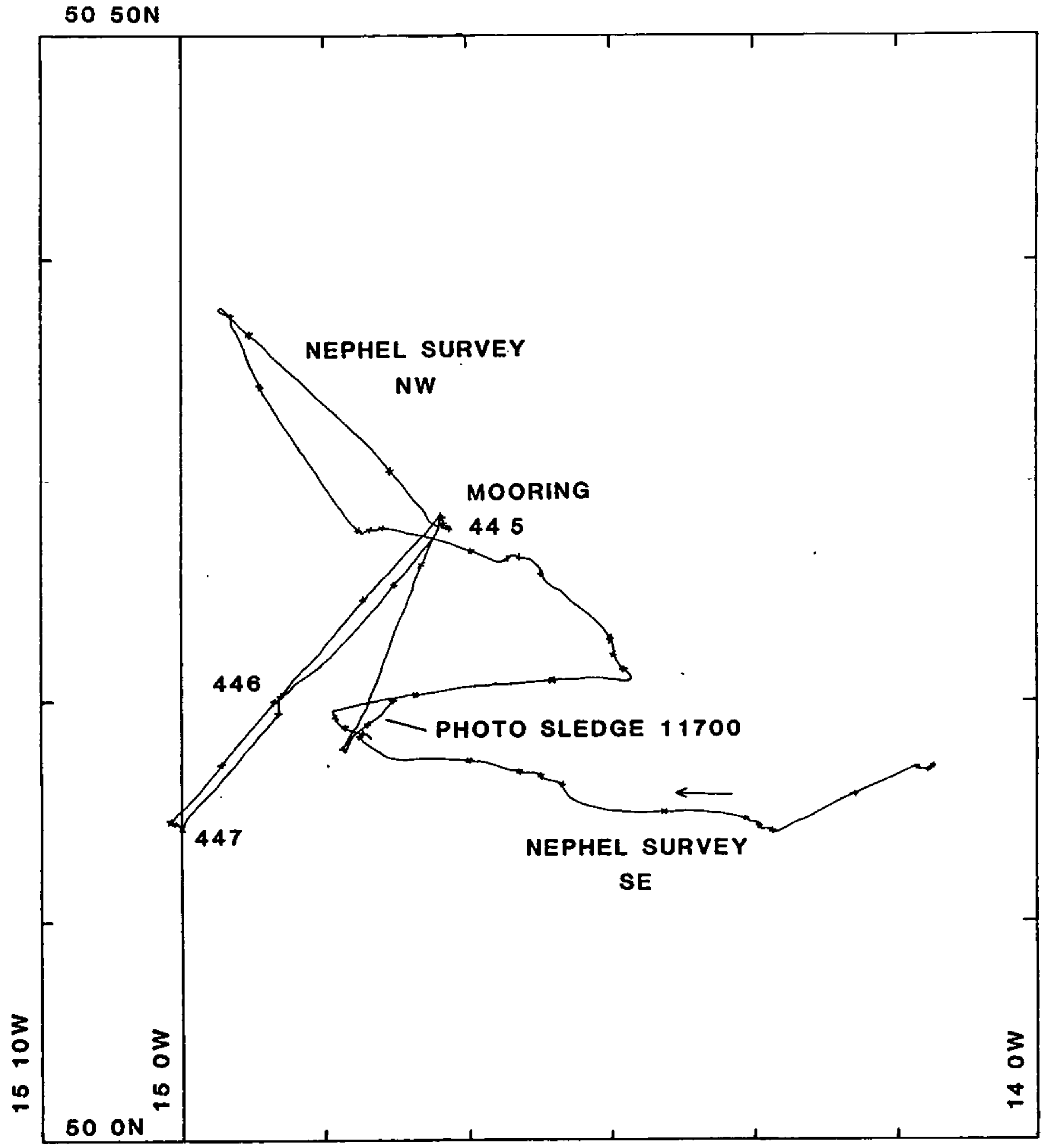


FIG. 2(g)

SCALE 1 TO 500000

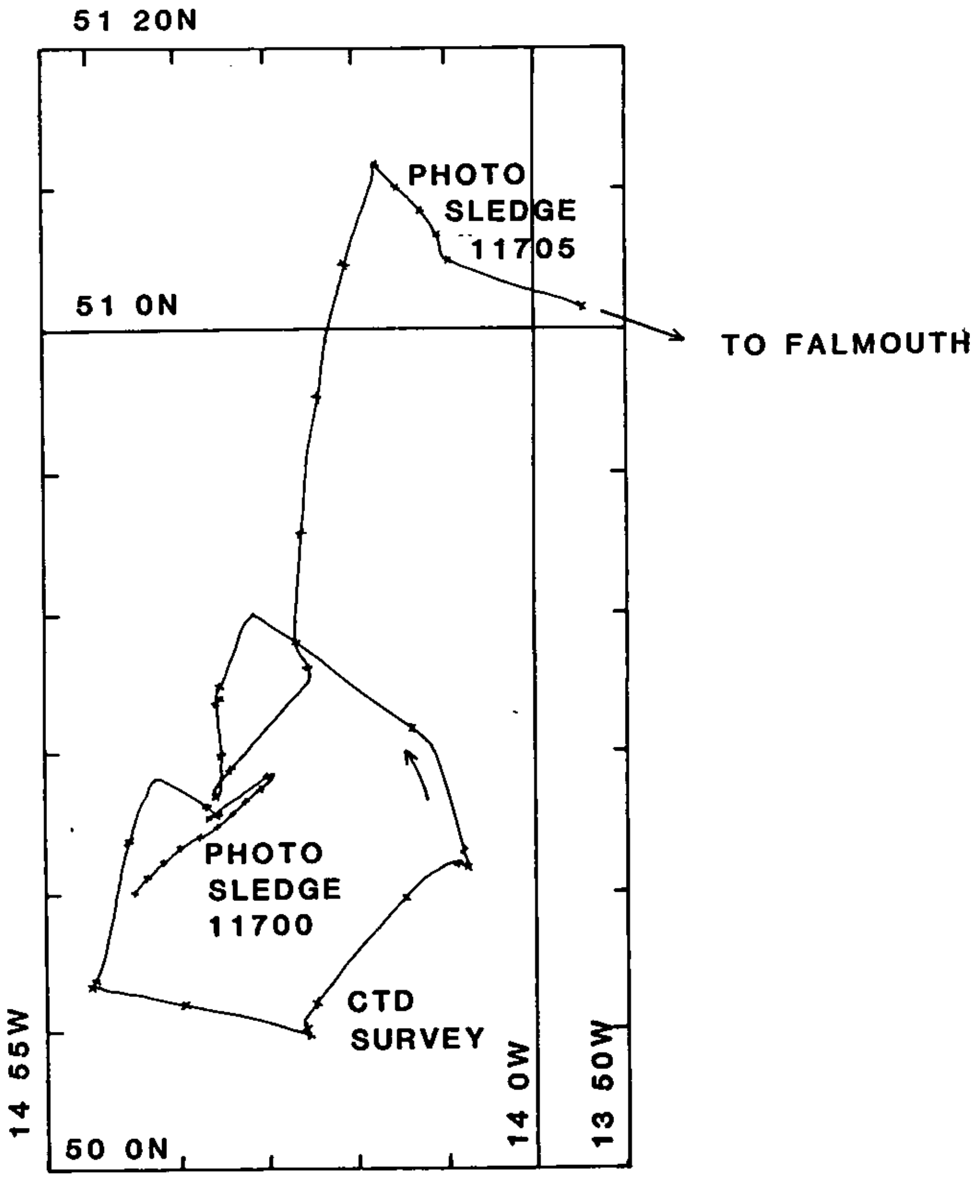


FIG. 2(h)

SCALE 1 TO 1000000

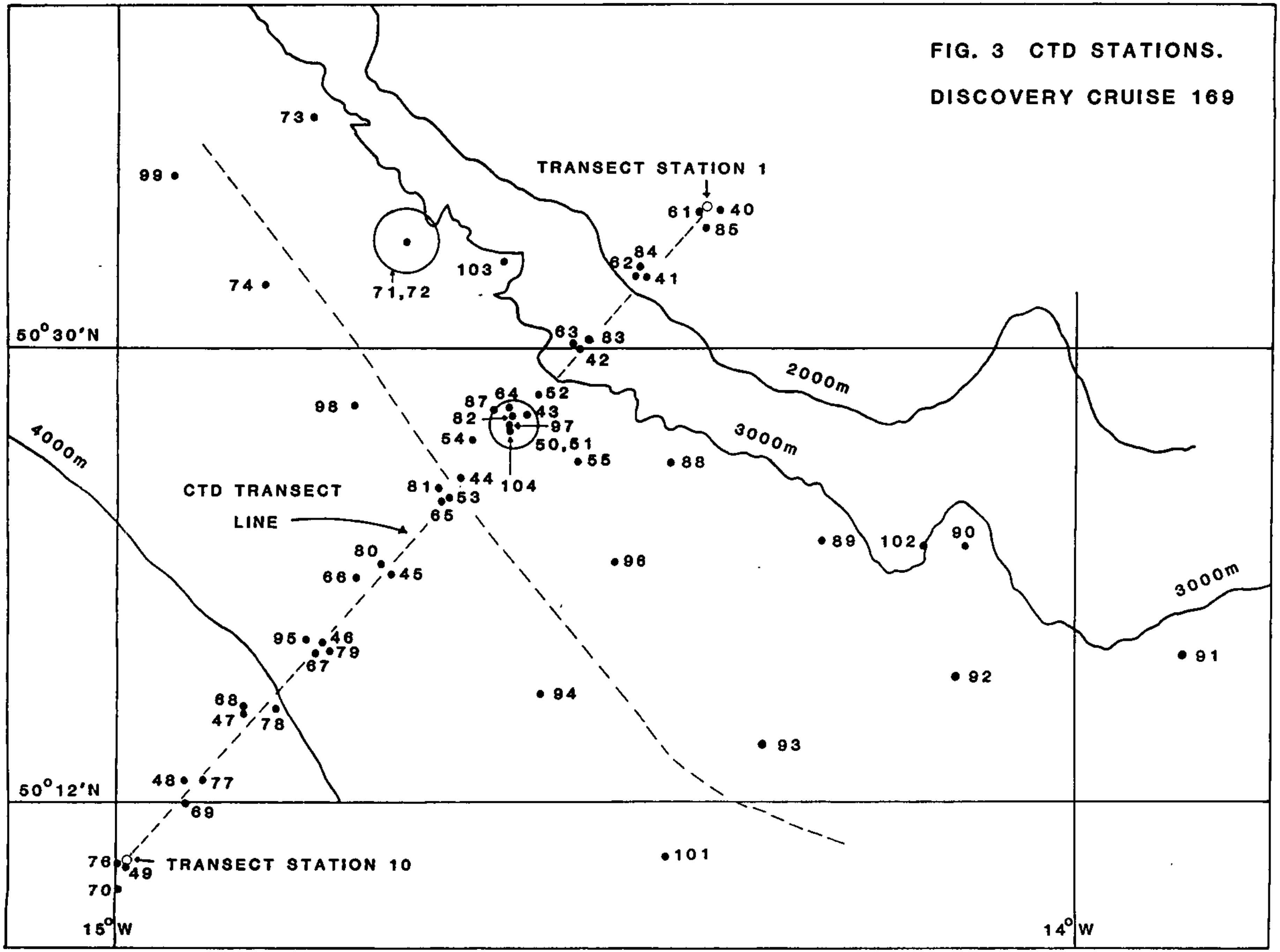


FIG. 3 CTD STATIONS.
DISCOVERY CRUISE 169
TRANSECT STATION 1
CTD TRANSECT LINE
TRANSECT STATION 10
50°30'N
50°12'N
15°W
14°W
2000m
3000m
3000m
4000m
73
99
74
71,72
103
61
40
85
84
62
41
63
83
42
98
87
64
52
82
43
97
54
50,51
55
88
104
81
44
53
65
80
66
45
96
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69
101
76
49
70

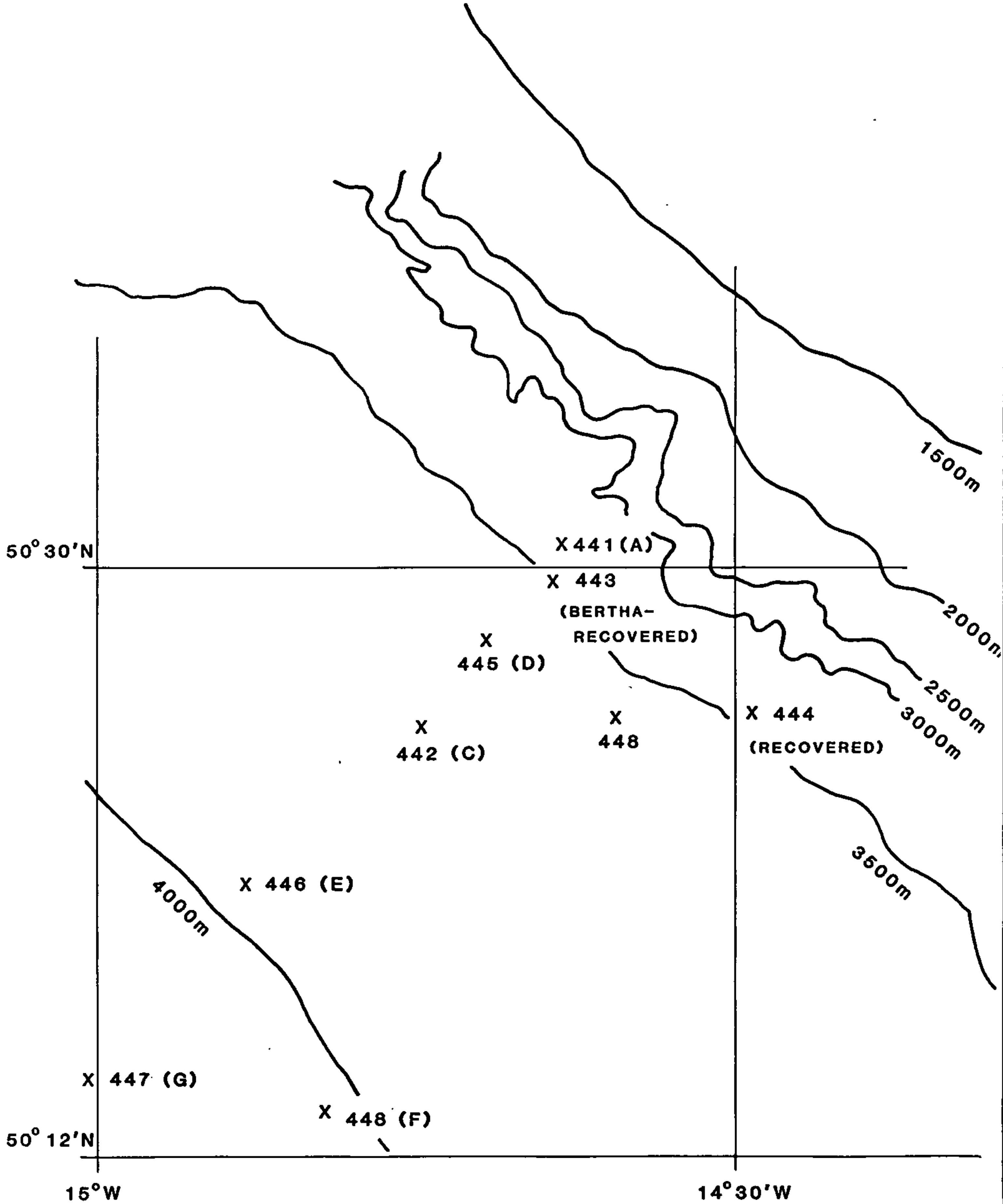

FIG. 4a MOORINGS. DISCOVERY CRUISE 169

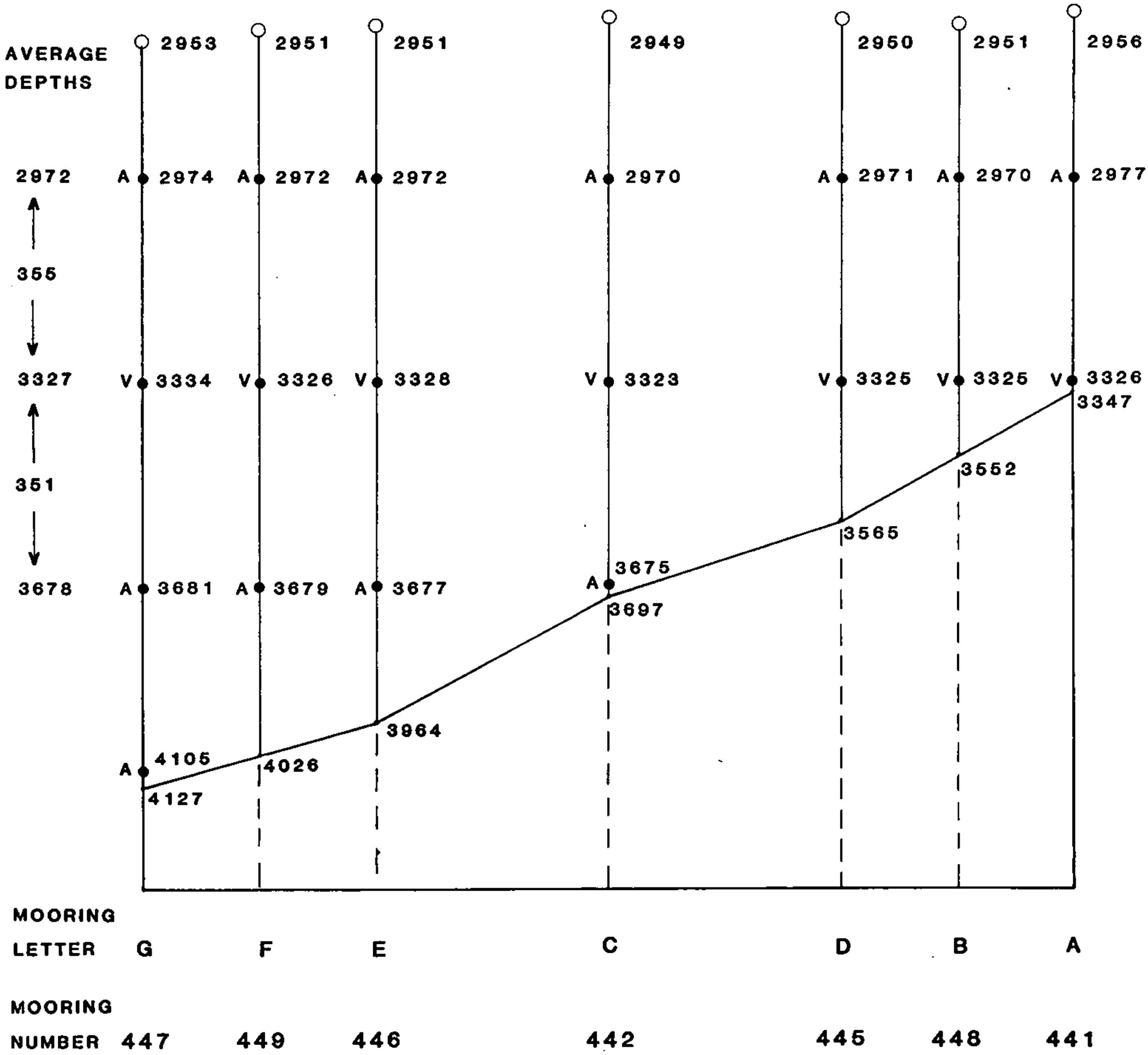

FIG. 4b THE MOORING ARRAY. DISCOVERY CRUISE 169

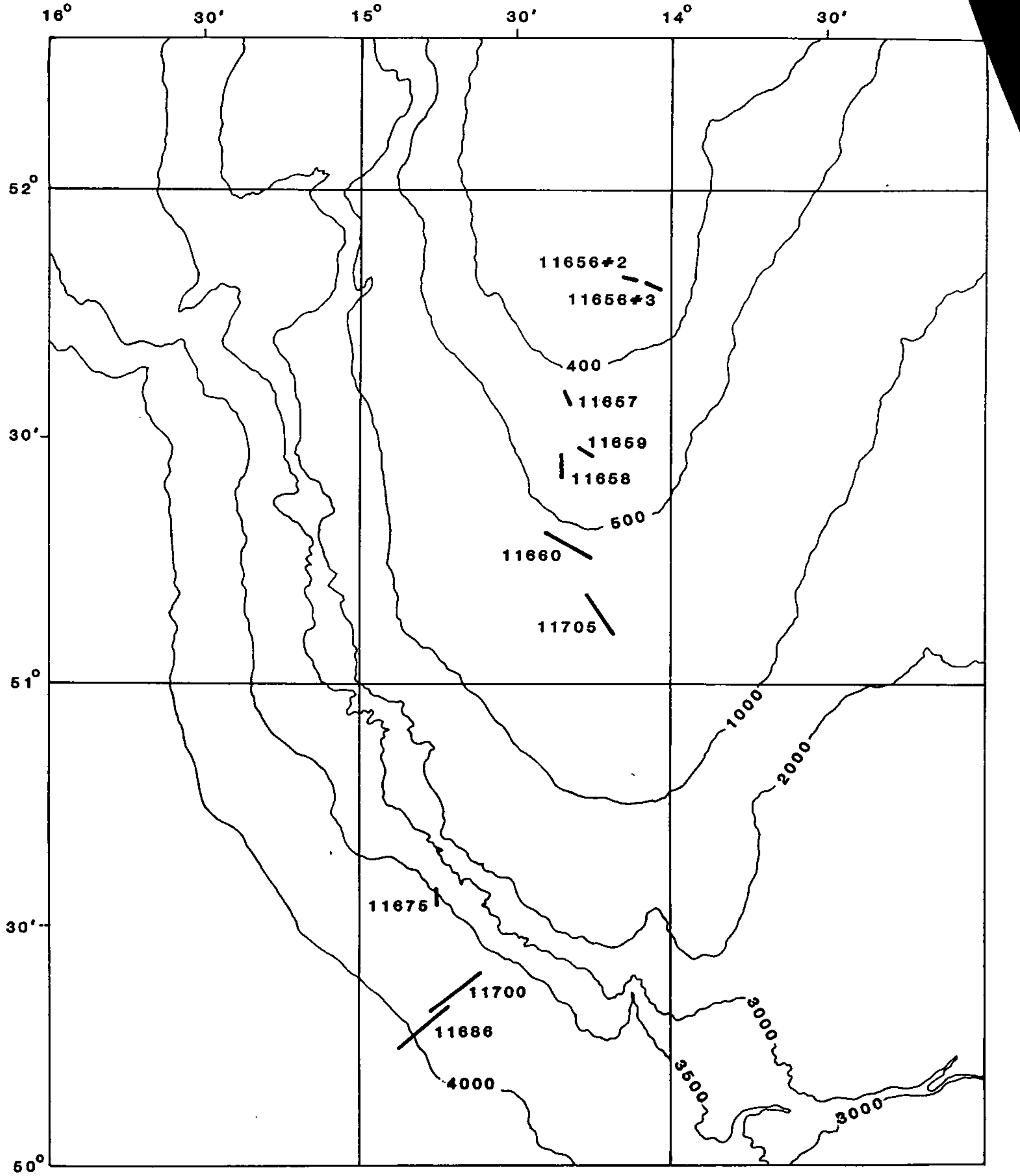

FIG. 5 PHOTOTRANSECT HAULS. DISCOVERY CRUISE 169