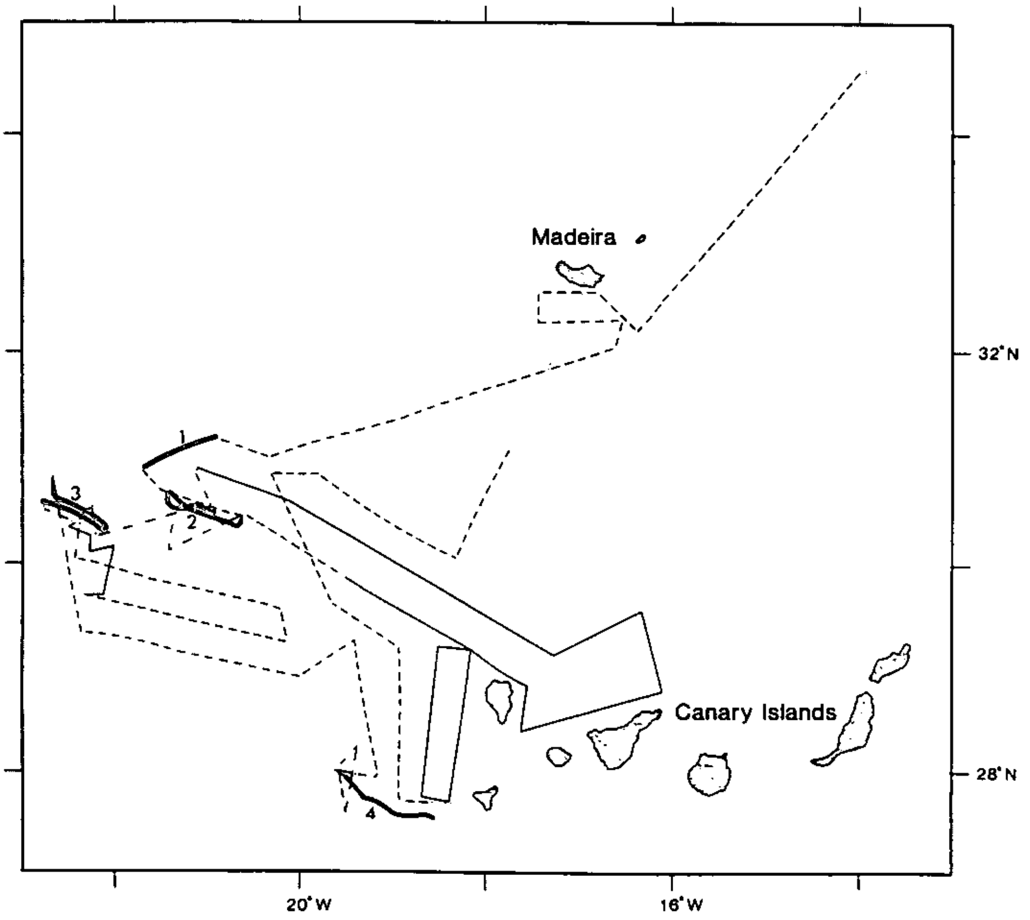
Institute of
Oceanographic Sciences
Deacon Laboratory

RRS Discovery Cruise 188

24 Jan - 24 Feb 1990

GLORIA and TOBI surveys of the continental slope and rise around the Canary Islands

Cruise Report No 212 1990



Natural Environment Research Council

INSTITUTE OF OCEANOGRAPHIC SCIENCES

DEACON LABORATORY

Wormley, Godalming,
Surrey, GU8 5UB, U.K.

Telephone: 0428 79 4141
Telex: 858833 OCEANS G
Telefax: 0428 79 3066

Director: Dr. C.P. Summerhayes

Natural Environment Research Council

INSTITUTE OF OCEANOGRAPHIC SCIENCES
DEACON LABORATORY
CRUISE REPORT NO. 212

R. R. S. DISCOVERY
Cruise 188
24 Jan - 24 Feb 1990

GLORIA and TOBI Surveys of the continental slope and rise around the Canary Islands

Principal Scientist
D.G. Masson

1990

DOCUMENT DATA SHEET

AUTHOR MASSON, D.G. *et al*	PUBLICATION DATE 1990

TITLE

RRS *Discovery* Cruise 188 24 Jan - 24 Feb 1990.
GLORIA and TOBI surveys of the continental slope and rise around the Canary Islands.

REFERENCE

Institute of Oceanographic Sciences Deacon Laboratory, Cruise Report, No. 212, 28pp.

ABSTRACT

The major objectives of the Discovery Cruise 188 were to investigate facies distributions and sedimentation patterns on the lower continental slope around the Canary Islands using surface towed long-range sidescan sonar (GLORIA), deep-towed medium range sidescan sonar, 7kHz profiler and magnetometer (TOBI), airgun and 3.5kHz seismic profilers, and various types of sediment core. The main area of interest was a large and complex sediment slide, the Saharan Slide, which extends from the upper continental slope off Spanish Sahara to the Madeira Abyssal Plain.

Discovery sailed from Barry on the 24th January, 1990 and docked in Madeira on the 24th February, 1990. During the cruise, some 168,000km^2 of seafloor were surveyed using GLORIA. Major features discovered include a large sediment slide on the southern slope of Madeira, a sediment wave field and possible slope failures around the western Canary Islands, and debris flows and turbidity current pathways on the lower continental slope and rise adjacent to the Madeira Abyssal Plain. The mapping of all of these features will greatly increase our understanding of the regional sedimentation patterns in this area of the Eastern Atlantic.

The highlight of the cruise, however, was the great success of the new TOBI deep-tow system. Spectacular sonographs of turbidity current channels and pathways, debris flows, and seamounts were obtained on four deployments of the system. Fine details of the features imaged, such as terraces on channel walls and fine grained 'flow patterns' on the floors of turbidity current paths, will allow new insights into the sedimentological processes operating in this geological environment.

ISSUING ORGANISATION	
Institute of Oceanographic Sciences Deacon Laboratory Wormley, Godalming Surrey GU8 5UB. UK.	TELEPHONE 0428 79 4141 TELEX 858833 OCEANS G TELEFAX 0428 79 3066

KEYWORDS		
ATLANTIC(NE)	*SAHARAN SEDIMENT SLIDE*	CONTRACT
DEBRIS FLOW	*SIDESCAN SONAR*	
GEOLOGY	*TOBI*	PROJECT
GLORIA	*TURBIDITY CURRENTS*	
N.W.AFRICA	*"DISCOVERY"/RRS - cruise(1990)(188)*	PRICE £7.00

Copies of this report are available from:
The Library, Institute of Oceanographic Sciences Deacon Laboratory.

CONTENTS

SCIENTIFIC PERSONNEL

MASSON, Douglas, G.(Principal Scientific)	IOSDL
HUGGETT, Quentin J.	IOSDL
EVANS, Jeremy, M.	IOSDL
MILLARD, Nick W.	IOSDL
FLEWELLEN, Chris. G.	IOSDL
ROUSE, Ian, P.	IOSDL
DARLINGTON, Eric	IOSDL
HARRIS, Andy, J.K.	IOSDL
PAULSON, Chris	RVS
BOOTH, David	RVS
DAY, Colin	RVS
PHIPPS, Richard	RVS
LAKE, Graham, A	IOSDL
JONES, Doriel	RVS
KIDD, Robert, B	University College of Wales, Cardiff
ROPER, Mark J.	University College of Wales, Cardiff
GARDNER, James V..	United States Geological Survey
FARRAN, Marcellino	Spanish Observer

SHIPS PERSONNEL

HARDING, M.A.	Master
EVANS, P.A.	Chief Officer
OLDFIELD, P.T.	Second Officer
ATKINSON, R.M.	Third Officer
DONALDSON, B.	Radio Officer
MC GILL, I.G.	Chief Engineer
ANDERSON, J.E.	Second Engineer
MAC DONALD, B.J.	Third Engineer
DEAN, S.F.	Third Engineer
LUTEY, W.D.	Senior Electrician
POOK, G.A.	Chief Petty Officer (Deck)
DRAYTON, M.J.	Petty Officer (Deck)
CUETO, R.J.A.	Seaman
DOWIE, W.M.	Seaman
LEWIS, T.G.	Seaman
VRETTOS	Seaman
BENNETT, P.R.	Seaman
OLDS, A.E.	Seaman
GROUT, D.M.	Motorman
RAMSEY, D.M.	Motorman
SPROUL, B.S.	Motorman
PETERS, K.	Cook Steward
MC AULIFFE, A.G.	Ship's Cook
ACTON, P.C.H.	Second Steward
COLEMAN, J.T.	Steward
ELLIOTT, C.J.	Steward
ROBINSON, P.W.	Steward

ITINERARY

Sailed Barry	24th January, 1990
Arrived Madeira	24th February, 1990

CRUISE OBJECTIVES

The major objectives of the cruise were to investigate facies distributions, and sedimentation patterns and processes on the lower continental slope around the Canary Islands using surface towed long-range sidescan sonar (GLORIA), deep-towed medium range sidescan sonar, 7 kHz profiler and fluxgate magnetometer (TOBI), airgun and 3.5kHz seismic profilers, and various types of sediment core. The main area of interest was a large and complex sediment slide, the Saharan Slide, which extends from the upper continental slope off Spanish Sahara to the Madeira Abyssal Plain. It was planned that the major features of the sediment slide area would be mapped using GLORIA, and that the GLORIA mosaic would then be used to choose areas of interest for investigation using TOBI. All TOBI work was to be navigated using the Oceano bottom transponder system. Because the cruise was also the first trial of the re-built TOBI system, some time at the beginning of the cruise was also planned for TOBI test runs.

NARRATIVE

Discovery sailed from Barry at 1350/ 024 (all times GMT, Julian Day 024 = 24th January). Weather conditions steadily deteriorated as passage was made down the Bristol Channel, and by the early hours of the morning of day 025 winds were gusting to 90kts. Further progress on passage south was impossible, and, on entering the western English Channel, the ship was forced to run before the weather into the shelter of Falmouth Bay. After one of the worst storms of recent times, Discovery sailed again from Falmouth Bay at 0900/026. Logging of ship's track and gravity data began at 1300/027. Continuous bad weather during the next five days, however, resulted in slow progress southward.

Finally, at 1400/031 the main scientific programme began with a wire test of the TOBI electronics pressure tubes. This was successfully completed by 1900. The 3.5kHz fish and GLORIA were then deployed, at 34° 34'N, 14° 00'W, between 1900 and 2015, and the first survey line, bearing 220° towards Madeira, was begun at 2030. Initial teething troubles were experienced with both GLORIA and the 3.5kHz systems, but the 3.5kHz problem was soon cured and little data was lost. The GLORIA problem, however, plagued much of the cruise. It was first noted as a very low signal level as displayed on the real-time monitor, and was thought to a combination of noise generated by the EPC interface board and a cross-wiring of the main signal cables, which caused the port and starboard sonar arrays to be reversed both on transmission and receive. The latter problem was not recognised until 2020/032, but even after it had been rectified, the low signal levels persisted. A temporary solution was attempted by passing the recorded data through a gain-boosting programme prior to attempting to write it on to the laser negatives. A box survey of the slope south of Madeira was completed between 1600/032 and 1400/033, with spectacular GLORIA images of a large sediment slide, similar to those seen off Hawaii, being obtained. We then proceeded on a south southwest course toward the first TOBI study area. Further good GLORIA images of sediment 'flow-patterns' (turbidity current pathways), previously seen over a wide area of the lower rise west of the Canaries, were observed on this transit line southwest of Madeira. This transit line ended at 0800/034, at 31° 07'N, 20° 45'W, when GLORIA was recovered so that the first trial of the new TOBI vehicle could be undertaken. Up to this time we had not been able to produce any GLORIA prints, firstly because of the signal level problem described above, secondly because the anamorphic ratio and slant range correction programme could not be made to operate properly, and thirdly because difficulties were encountered in developing the laser films. The causes of these problems were gradually traced and eliminated, but further problems with the laser persisted and no GLORIA prints were produced during the cruise.

The TOBI trial began at 0930/034, when the vehicle was lifted down from the boatdeck using the after crane. Fortunately, the weather was near perfect, since the TOBI lift was very close to the crane's weight limit , and it is clear that it would not have coped on a moving ship. In addition, the long lifting wire required by the crane allows the vehicle to swing alarmingly, and weighing about 2000kg, it is not easily controlled. With TOBI and its depressor weight positioned on deck, the umbilical was attached, the whole system taking about an hour to prepare. After deployment of the acoustic navigation fish, so that a transponder could be operated on the wire to test for interference with TOBI, the vehicle was launched at 1100. About 30 minutes were required to deploy the umbilical cable - this was initially tried at a speed of 0.5kts, but trial and error indicated that 1kt was better. The depressor weight was then lowered and the system switched on to ensure that all was working. Immediately it was obvious that a partial short circuit was occurring, and the launch was therefore aborted. After ensuring that the problem was not associated with the winch, it was decided to recover the depressor weight and to break open the cable at one of its connectors, to test whether the problem lay inboard or outboard of this point in the system. At the first attempt, the plug connecting the main warp to the swivel on the depressor was found to have leaked, and this was dismantled for repair. The repair was completed by 1530, and the depressor weight was redeployed. Initially, this appeared to have cured the problem, but on lowering to only 40m, a short-circuit again became apparent. On this occasion, the outboard plug connecting the umbilical to the swivel on the depressor was found to have leaked. This too was repaired and the depressor redeployed at 1800.

The system now appeared to be operating, so an acoustic transponder was attached to the wire 30m above the depressor, and lowering began. Wire was paid out at 0.5m/s with the ship steaming at 1.5kts. By 2300/034, 8036m of wire had been paid out, and TOBI had reached a depth of 4490m, 446m above the seabed. For the next 14 hours, superb sidescan and profiler records were obtained from heights of between 200 and 450m above the seabed. Various combinations of tow speed, wire length, and height above seabed were tried as the flying characteristics of the vehicle were tested. Tow speed varied between 1.1 and 1.55kts, wire length between 7400 and 8500m, and height above seabed between 200 and 400m. It was very apparent that the flying characteristics could vary considerably without any obvious change in the speed of the ship, either through the water or over the ground. As an example of this, at one point 900m of wire had to be hauled in over a period of 2 hours to maintain the vehicle at a constant depth, although no change in the speed or behaviour of the ship was detected. This may have been related to subtle variations in the water column (tidal currents?).

Unfortunately, contact with the acoustic transponder was lost when some 7000m had been paid out. Acoustic noise from TOBI, interfering with the transponder, was suggested as a possible cause, and it was decided to mount the transponder further up the wire on subsequent deployments.

After 14 hours of operations near the seabed, with the satisfaction that the system had been well tested, it was decided to retrieve TOBI. This was begun at 1303/035. Wire was initially hauled at 0.2m/s, until the vehicle was well clear of the seabed. The speed of the ship was reduced to 1kt, and hauling proceeded at 0.5m/s, rising to 1.0m/s as the vehicle approached the surface. TOBI reached the surface at 1635. The depressor was recovered using the Schatt davit, and the umbilical disconnected. The umbilical was then retrieved using the hydrophone winch. This made light work of what had previously been a long and arduous task when undertaken by hand. Some disquiet was expressed regarding possible damage to the hydrophone, but none was apparent when the umbilical was removed from the winch. The TOBI vehicle was then lifted on board using the crane. As with launching, the use of the crane for retrieving TOBI is highly unsatisfactory, since both personnel and the equipment are at risk as the heavy vehicle swings on the long lifting rope. However, by 1710/035 all was recovered with only the loss of a small amount of paint from the vehicle.

Indeed, apart from the problems associated with the crane, the recovery went extremely smoothly.

At this point it was decided that two or three days were required by the TOBI team to work on several minor faults which had become apparent during the initial deployment. These included an occasional failure to trigger the sidescan power amplifier, a lack of digital data from the compass, and incorrect data from the E/M log. A further GLORIA survey was therefore begun. GLORIA launching began at 1830/035 and the system was on line by 1908. A 80 in^3 airgun and the hydrophone were then rigged and made ready for deployment at 1000/036. Both guns, when initially deployed, refused to seal so seismic recording could not begin until 1150, when one of the guns had been rebuilt. The first GLORIA line was run from 30° 48'N, 21° 40'W, on a bearing of 120°, towards the north-west end of the Canary Island chain, ending at 1900/036. Between 1900/036 and 1900/037 two north-south lines were then run immediately west of the islands, to investigate the possible occurrence of large slope failures which might be the sources of sediment debris flows seen downslope. However, no obvious slope failure features were observed. A further box survey north of the western Canaries, run between 1900/037 and 0500/039 also failed to find any evidence for large-scale slope failure. At the end of this survey, we therefore decided to return to the lower slope area, and continue with the TOBI work. This transit line was completed at 0830/040 at 30° 53'N, 21° 07'W, and GLORIA and the seismic equipment were recovered by 0930.

The ship then steamed to the area chosen for the TOBI survey, arriving at 30° 28'N, 20° 55'W at 1200/040. The acoustic navigation fish was then deployed, followed by TOBI. Following discussions concerning the TOBI launch strategy, steadying lines were attached to the vehicle, and this launch proceeded much more smoothly than the previous attempt. The deployment was completed by 1330, and the system was tested and found to be operating satisfactorily. The acoustic transponder was attached 500m up the wire, in an attempt to isolate it from acoustic 'noise' produced by TOBI. However, contact was lost with the transponder when only 700m of wire had been paid out. Noise due to strumming of the wire was thought to be the most likely problem. As in the first deployment, wire was paid out at 0.5m/s, while the ship steamed at 1.5kts, so that TOBI reached its operating depth of around 4600m at 1730/040.

Between 1530/040 and 1000/042, a section of a meanderng channel was surveyed while we experimented further with the handling of the vehicle and our ability to follow a predetermined survey track. Superb sonographs were again collected. However, without the acoustic navigation, it soon became clear that determining the track followed by the vehicle was a complex problem. The best real-time solution to this problem was reached by plotting the TOBI track on a blow-up of the GLORIA image of the area being surveyed. In this way, the position of the ship could be verified by correlating features seen on the 3.5kHz profiler with their images on the GLORIA sonograph, while the position of TOBI could be determined by comparing the GLORIA and TOBI sidescan images. Making turns while towing TOBI required great care, particularly when turning into or through the wind, as the combination of a drop in ship's speed over the ground and the drop in effective tow speed caused by the turn was capable of causing the vehicle to sink at an alarming rate. Over 1500m of wire had to be hauled during one 90° turn in order to maintain the height of the vehicle above the seabed. As experience showed, it was usually required that hauling should begin before turning, as it was barely possible to haul fast enough after turning had begun.

By 1000/042, the weather conditions, which had been near perfect, had begun to deteriorate, and it was decided to begin recovery. TOBI reach the surface at 1300 and was secured on board by 1400. The ship then began a transit line to the next TOBI survey area, during which the opportunity was taken to run a 3.5kHz line across the area surveyed with GLORIA earlier in the cruise. At 1630/042, the ship was slowed to 1.0kts so that further tests of an acoustic navigation transponder could be undertaken on the conducting cable. However, at this point the generator supplying power to the main winch failed, and the test had to be abandoned. While attempts were made to repair the generator, a velocimeter dip was carried out, to generate a sound velocity profile for use with the acoustic navigation system. By 2300/042 it had become clear that repairing the generator might be a lengthy business, and it was decided to continue the transit to the next TOBI survey area, while running a 3.5kHz survey overnight. Attempts to repair the generator continued during the next day, but when no progress had been made by 1100/043, a decision was made to continue with GLORIA work. GLORIA was launched at 30° 28'N, 22° 21'W at 1200/043, and a survey of the lower part of the Saharan sediment slide was begun. The generator was finally restarted at 1600/043, and was tested under load during the following 24hrs. Meanwhile, the GLORIA survey was continued until 1900/044. GLORIA was then recovered and the acoustic transponder test restarted at 2000/044.

For this test, the transponder was suspended below the depressor weight, in an attempt to isolate it from any acoustic noise emanating from the wire. However, contact with the transponder was again lost when some 5000m of wire had been paid out. At this point it was noticed that the 10kHz record had also become very noisy, indicating that noise was being transmitted into the water as well as down the wire. This suggested that the loss of the acoustic navigation signal was due to the deterioration of the signal to noise ratio at the receiver fish, rather than to noise problems with the bottom transponder. Examination of all the 10kHz records collected during deployment or recovery of the conducting cable confirmed the presence of water column noise which increased with increasing amounts of cable paid out. A brief test showed that the noise completely disappeared when the propeller was stopped. The conclusion reached was that the wire was reacting in some unknown way to noise or turbulence generated by the propeller. To test this, a further wire deployment was carried out between 0900 and 1200/045, with the davit swung outboard to remove the wire as far as possible from the influence of the propeller. This showed some lessening in noise , but not to acceptable levels. Again, however, the noise completely disappeared when the propeller was stopped, apparently proving the relationship between the noise and the wire's reaction to the propeller turbulence. Acoustic navigation therefore had to abandoned for the cruise, and further 'unnavigated' TOBI surveys were planned.

Steaming to the preferred launch site at 30° 30'N, 22° 47'W, and a minor delay to correct a fault in the TOBI electronics meant that launching did not begin until 1800/045. However, the system was deployed and switched on by 1900, when a series of tests of the compass and magnetometer began. These were carried out with 300m of wire paid out, to minimise turning time, and involved towing TOBI for short periods along east, north, west and finally south-oriented tracks. The tests were completed by 0100/046, and by 0500, 8300m of wire had been paid out and surveying had begun. For the next 42 hours, superb sonographs were collected from a complex area of debris flows around 30° 30'N, 22° 30'E. However, this TOBI run had to be terminated abruptly at 2300/047, when it was discovered that a strand of the armouring in the conducting cable had broken, and that a considerable length of that strand had been stripped from the cable and jammed in the low-tension part of the winch gear. Thanks to the efforts of the technical staff, the wire was stopped off, the tension released, and the tangled strand of wire cut away from the winch in only two hours. At 0115/ 048, hauling of TOBI began, and the vehicle was recovered by 0500 without further incident.

Since further TOBI surveys were clearly impossible in the principal survey area in 5000m of water, a GLORIA line leading up to the Canary island slope was planned, while the possibility of using TOBI in shallower water, where a shorter tow cable would be required, was assessed. GLORIA was launched at 0900/048 at 30° 14'N, 22° 33' W and surveying began immediately. In the meantime, it was ascertained that TOBI surveys could be continued, provided that no more than 7000m of cable were paid out, and the Saharan Slide pathway immediately south of the island of Heirro was selected as the next target. GLORIA was recovered at 1630/049, and a short passage line run to the start of the TOBI station at 28°N, 19° 36'W.

TOBI was launched at 1900/049, but when switched on, it was found that the profiler was not triggering. After ascertaining that the fault did not lie in the on board electronics, the vehicle was recovered at 2200 so that the vehicle electronics could be checked. A 3.5kHz survey was then run overnight. After repairs to the profiler electronics, TOBI was re-launched at 0900/050, and all systems were tested and found to be operational. By 1400, 6000m of wire had been paid out and TOBI was within 500m of the seabed in a water depth of 4300m. Superb sonographs of the upper part of the Saharan Slide were obtained between 1400/050 and 0400/052, when data collection was abruptly terminated by an apparent short circuit in the deep-tow package, which caused all electrical contact with the vehicle to be lost. With the wind blowing at a steady 30kts, there was no possibility of recovering TOBI on the open sea, and it was decided to steam into the lee of the island of Heirro to gain some shelter from the weather. After a tedious 2kt steam, this was finally reached in mid-afternoon, and TOBI was recovered and secured on deck by 1830/052, despite a bowthruster failure in mid-recovery. No cause for the TOBI failure was immediately obvious, but later examination showed that the slip-rings on the depressor weight had failed due to water entering their oil-filled housing through an o-ring seal.

A transit line towards the beginning of the next GLORIA survey was started at 1900/052, and GLORIA was launched at 2300 at 27° 42'N, 18° 34'W. Surveying then continued until 2030/054, when, at 31° 19'N, 17° 37'W, all equipment was recovered and made secure for the passage to Madeira. Discovery docked in Madeira at 0830/055 and the scientific party disembarked at 1100.

TOBI OPERATIONS

During the cruise, TOBI had four deployments totalling 201 hours in the water and covering some 450km of track. The scientific payload comprised a dual sidescan sonar system operating at approximately 30kHz, a sub-bottom profiler operating at 7.5 kHz, and a triaxial magnetometer with a resolution of 10 nT (limited by the digitisation, not the instrument). The received acoustic signals are sent up the wire in analogue form and are then digitised, prior to being logged on optical disc and displayed on a high resolution monitor and on line-scan recorders. In addition, the vehicle carries a suite of housekeeping sensors, namely a two component electromagnetic (EM) log, compass, pitch and roll sensors, and a pressure transducer. All of these instruments are sampled at 10Hz and signals are sent up the wire in digital form to be logged and displayed to provide real time information on the vehicle behaviour.

The vehicle was ballasted to be neutrally buoyant assuming a density of 1.03. When flying in an equilibrium state it had a nose down attitude of about 3°, implying that it was slightly buoyant at depth. At the surface, the roll sensor indicated rolls of 2 to 3°, but at depth the vehicle appeared very stable with only occasional 0.1° movements. Yaw was not apparent from either the compass or from any evidence on the sidescan records. The logging of the data onto optical disc and the outputting of the data to the displays worked almost faultlessly, which combined with good quality data from the vehicle, gave very satisfactory results.

The first deployment, to the relief of all, showed that all the major systems were working, with signals being received from both sidescan arrays out to the full range of 3km and the profiler receiving a bottom echo with the vehicle close to the surface in 4900 metres of water. This signal was to improve as the vehicle approached the bottom and gave useful penetration from altitudes in excess of 300 metres. There was, however, no data from the compass, and the EM log data appeared suspect, although the other digital data looked good. There were also occasional failures to trigger the sidescan power amplifiers. All of these problems were solved for the next deployment, except for those associated with the EM log, which continued to be troublesome. This problem was eventually attributed to a cracked head. A final problem, one of bad corrosion on the two main electronics tubes, was discovered on recovery. This was tackled by the addition of zinc anodes to the tubes, a solution that was to prove successful.

During the first two deployments, the vehicle had to be flown at about 200 metres or less above the seabed, rather than the 300-400m which had been expected, in order to make best use of the main lobe of the sidescan arrays. This indicated that the sidescan transducers were not angled down enough. Wedges were made up and installed before the third deployment to increase the downward angle of the sidescan transducers from 8 degrees to 20 degrees. It also became apparent on the first two deployments that the time-varied gain (TVG) law being applied to the sidescan data in the vehicle was giving too much gain in the far range. The TVG law initially installed in the vehicle was 40(log r+0.067r), but it was decided that this should be changed to the more conventional law of 40(log r+5*2r), where 5 is the attenuation caused by absorption at 30kHz modified for depth as indicated in the most recent addition of Urick. This law could be tested by modifying the PS/2 software to multiply the signals by an appropriate factor before displaying them, and it resulted in a great improvement. However, to avoid making two changes at once (the sidescan tilt angle and the TVG), the modified TVG eprom was not installed until the fourth deployment.

Operational problems during the cruise were minimal. The first deployment was delayed by two separate incidents of plug failure. Both plugs were on the swivel and suffered tracking between the two pins. Only the depressor weight had to be recovered to rectify these problems. The start of the third deployment was held up by a problem with the digital data. However, a solution was achieved with a small modification to the deck unit and recovery of the vehicle was avoided. It did, however, highlight a design problem which has to be addressed. The third deployment also had to be terminated prematurely after 58 hours because of the failure of a wire strand in the tow cable. The start of the fourth and final run had to be postponed because of failure of the profiler, necessitating the recovery of the vehicle. A broken connection to the transducer array inside the electronics tube was found to be the cause. Finally, 72 hours after the eventual start of run four, a total failure of the system occurred. After recovery, this was traced to ingression of water into the slip ring assembly in the swivel. Overall, however, the operational problems associated with TOBI were of minor importance, and all concerned with both the technical and scientific operation of the system were delighted with its performance.

NWM,DGM

GLORIA OPERATIONS

Some 168,000 km^2 of seafloor were insonified with GLORIA during five deployments totalling some 11 days of operation. Although very little data was actually irretrievably lost, a number of difficulties were experienced during the cruise which combined to harass the GLORIA operators, and eventually prevented the replay of any data at sea. It is certainly possible that at least some of these difficulties could have been avoided if time for testing the system at sea had been allowed for, following its rather hurried fitting on Discovery in Barry. However, it is also true that the system has suffered badly from lack of investment over the last few years, both in terms of capital (spares and replacement of worn-out parts) and maintenance time.

The difficulties which beset GLORIA operations began with the first deployment. Earthing problems in the GLORIA portakabin, cross-wiring of the port and starboard sonar arrays, and intermittent noise caused by oscillations in the line-scan recorder/logger interface circuit all conspired to degrade the record. The latter problem, in particular, was hard to diagnose, since it was largely hidden by the other problems. In addition, once these problems had been resolved, an extremely featureless area of seafloor led to the gain on the Rx filter being set at too low a level, which later compounded major problems associated with the exposure times for the photographic processing of the replayed data. A further problem which developed during the cruise was the failure of the battery charger control circuit (due to corrosion of the thyristor drive transformer). This was temporarily cured by inserting the spare card, but it did not allow the charge and voltage level to be set correctly, and a more permanent repair could only be effected by stealing the transformer from the spare card and inserting it into the original board. Two Pulse Power Amplifier (PPA) failures occurred during the 11 days of operation. The first to fail, port PPA 3, went when the system was switched on for the first time. Although subsequently repaired, it could not be persuaded to produce the same power as the others, and was unusable for the remainder of the trip. A second PPA, starboard 3, failed late in the cruise and had also to be replaced with a spare. Overall, the battery charger and the PPAs were judged to be in a poor state, and are in urgent need of replacement.

Only one minor problem occurred in the GLORIA vehicle when the pressure transducer stopped producing an output (it was noted that no spare was on board). This unit came back to life after the vehicle nose was removed for inspection, and it then continued to work for the rest of the trip. The modified Cetrek compass worked continuously, but the beam steering results are still disappointing. The Cosmac data logger performed well for most of the time, although on occasion it failed to write tape headers, and it once refused to acknowledge the existence of the Tandberg recorder. As far as we were aware, none of these hiccups resulted in significant data loss, although problems with the data replay system, discussed below, meant that the quality of the recorded data was never actually checked. However, the low incidence of write errors, and the good quality of the real-time monitor EPC record suggested that good quality data was being recorded.

Problems with the data replay system started at an early stage, when the production of anamorphically and depth corrected files proved to be impossible, probably due to corruption of the computer software. This problem was solved by loading a copy of the equivalent software used on the 'Farnella'. However the first films produced were extremely anaemic, partly because of the error in Rx setting mentioned above, and partly because an increased density optical path filter had been fitted in the laser system. Unfortunately, no spare filters were available, but, as things transpired, this proved irrelevant, for as soon as a good balance of contrast been obtained in the development side of the photographic process, the laser camera data writing function lost synchronisation, resulting in a very marked striping of the film. Despite an exhaustive hunt for the cause of this intermittent synchronisation fault, nothing was found in the hardware, and it was concluded, after trying many permutations of the software, that the IBM or its interface was at the root of the problem. This view was reinforced towards the end of the cruise when the IBM would neither accept raw data from the Tandberg cartridges nor communicate with the 9-track Digidata tape-drive used for archiving the raw data.

The only problem with the vehicle and launching gantry occurred when the bolts securing the plates which hold the cantilever arm pivot pin bearing in place sheared off, allowing the bearings and the arm to escape. This was presumably the result of the bad weather during the early part of the cruise. There was a heart-stopping delay before the arm and bearing were persuaded to return to their proper alignment, but all was made secure while the vehicle was in the water.

In view of all the difficulties reported above, it is with some relief that we are able to report that almost all the data was ultimately saved, although some was recorded at a lower than optimum signal level. For this we are grateful to the GLORIA engineering staff, whose efforts ensured that the system continued to operate even under the most adverse conditions.

ED,DGM

OCEANO ACOUSTIC NAVIGATION SYSTEM

While alongside at Barry, prior to sailing, several tests were carried out to investigate any interference problems between TOBI transmissions and the Oceano Acoustic Navigation System. TOBI was deployed from the aft crane at an approximate depth of 5m, the navigation Acoustic Module (Fish) lowered over the side forward, and the relay transponder lowered into the water at the other side of the docks (giving a range of about 260m). Various tests were carried out, from which it was concluded that any interference from TOBI would not affect the overall range and functioning of the Acoustic Navigation System when it was used to monitor the position of the TOBI vehicle. (Some fixes may be lost, but at the slow tow speed (1.5 kts) accuracy of the position will still be maintained).

On reaching the work area, a trial TOBI deployment was carried out, during which it was also decided to check out the Acoustic Navigation System. The fish was deployed and the relay transponder clamped onto the conducting cable 30m above the depressor weight. TOBI was then lowered to its operating depth some 200-300m above the seabed in a water depth of 4900m (about 8000m of wire out). The descent of the transponder was watched on the rangemeter and could also be seen as interference on the PES (Mk4) Echo Sounder. From about 4500m of wire out, false ranges were received, and the PES interference showed that the transponder was self triggering occasionally. At a wire out of 7000m, the rangemeter stopped receiving replies from the transponder, although the self triggered replies could still be seen on both the PES and the TOBI profiler records. This continued to the full depth of the deployment, with no further range data being received by the rangemeter. Since the signal coming from the acoustic module (fish) looked noisier than usual, both the PES and TOBI profiler transmissions were turned off. Although this resulted in less clipping of the receive AGC amplifiers, the transponder could still not be heard by the rangemeter. During recovery, ranges began to be received again when wire out was about 6000m. However these ranges were never very consistent. Following recovery, several tests were carried out to check the functioning of both the acoustic module/rangemeter and the transponder. However, apart from a slight drop in the transponder batteries, which were replaced, all equipment appeared to be fully operational. Throughout the deployment, the return signal receive from the acoustic module seemed very noisy. Normally the AGC holds the noise level at 1.0 volt peak-peak, and only the signal returns causes peaks of 4 v. However, on this occasion, the noise was causing a large amount of 4v spikes.

It was then decided to do a TOBI run without acoustic navigation, with a transponder was clamped to the wire at 500m above the vehicle and the fish again deployed to carry out further tests. On deployment, however, the transponder almost immediately started to self trigger and ranges on the rangemeter were lost. The signal from the fish again showed a large amount of noise. The fish was lowered to 50m of cable out but this did not improve the situation. The fish was recovered and the acoustic module removed from the fish to allow further testing, but this revealed no obvious problems. However, on testing the cable, slight electrical leakage was found between the ground and the receive signal conductors. This was traced to the tow bracket which was reterminated and a new connector fitted.

On recovering the TOBI vehicle, it was discovered that the bracket holding the transponder had been vibrating to such a degree that some of the previously locked screws had come loose. This appeared to pinpoint strumming of the conducting cable as the cause of the acoustic navigation problems. In a final attempt to overcome these problems, it was decided to redeploy the depressor weight with the transponder hanging from it.

The transponder was rigged using the normal transponder strop hung from a dual bridle fastened to two eye bolts at the front of the depressor weight. The release ring was also fitted and a rope fastened leading to the tail of the depressor. This held the transponder at an angle of about 60 degrees to the horizontal. All metal to metal contact was avoided by using plastic hosing and insulation tape. When deployed on its own the fish responded to the interference from the 3.5kHz echo sounder triggering on several channels every transmit and receive pulse. The 3.5kHz was therefore turned off. The depressor weight was deployed with a 10kHz pinger clamped 50m up the the wire as an independent acoustic transmission test. However, at around 4000m wire out, the rangemeter again lost the returns from the transponder, which was responding correctly to the pulses from the rangemeter. This could be seen on the PES record. At this point, the direct return from the pinger could still just be seen above the background noise on the PES, but the pinger seabed return could not be seen. It was decided to continue to the normal TOBI operating conditions, i.e.. around 8000m of wire out. Again the rangemeter showed a lot of noise being generated in the water. Examination of the PES record showed that it too was showing a large amount of background generated noise. After discussions with the Captain and Chief Engineer it appeared that the most likely source was the propeller, and it was agreed that when the wire out was less that the sea depth then we could stop the propeller. The ship's speed was increased to over 3 knots and then the propeller stopped. Immediately the noise level dropped and good ranges from the transponder were received. The signal noise showed very little spiking. The equipment was then recovered. The conclusion was that resonant strumming of the wire in the propeller wash was swamping the acoustic navigation system with background noise.

To confirm these results the depressor weight was again deployed on its own the following day. With the weight just it the water and the propeller stopped, the noise on the PES (at 1.4 mS pulse width) was visually noted. The weight was then lowered until about 3500m wire was out. The noise level had increased by about 12dB. Stopping the propeller reduced the noise by a similar amount. Changing the towing position only caused a minor change to the noise level. The conclusion given above was therefore confirmed, with the wire vibration being responsible for both the perceived problems. These were the self triggering of the relay transponder when clamped on the wire and a large amount of 'mechanical' noise in the water which swamped the receive system of the acoustic module.

Investigations will be carried out in conjunction with Oceano (UK) Ltd. to check the sensitivity and signal/noise range of the Acoustic Module AGC and amplifiers on the return of the equipment to RVS.

DB,DGM

PRECISION ECHO-SOUNDER MK IV

The IOS precision echo-sounder (PES) MKIV 10kHz system was used successfully throughout the cruise. Users found the video waterfall display and cursor depth measurement system a considerable improvement over the PES MKIII wet paper system. The Waverley 3700 thermal line-scan recorder provided excellent high-definition hard copy of the 10kHz data, although there is a delay of some 2 minutes before the trace can be seen. In summary, an excellent system throughout, which should now entirely replace the antiquated MKIII system.

AJKH,DGM

NAVIGATION AND DATA LOGGING

With the exception of a three to four hour gap between the hours of 0100 and 0500 each day, all navigation was undertaken using the Global Positionong System (GPS). The gap, due to a lack of satellite coverage, was filled using transit satellite data . Gravity, bathymetry and position data were logged on a Sun workstation using standard RVS geophysical logging techniques.

PRINCIPAL RESULTS AND CONCLUSIONS

This was a highly successful cruise, despite the weather problems in its early part and the GLORIA problems throughout. Although no GLORIA data could be replayed onboard, the real-time monitor records showed a variety of features which relate to the sedimentological processes operating on the continental margin. These include a large sediment slide on the southern slope of Madeira, a sediment wave field and possible slope failures around the western Canary Islands, and debris flows and turbidity current pathways on the lower continental slope and rise adjacent to the Madeira Abyssal Plain. The mapping of all of these features will greatly increase our understanding of the regional sedimentation patterns in this area of the Eastern Atlantic.

The highlight of the cruise, however, was the great success of the new TOBI deep-tow system. That the system worked almost perfectly from the start of its first deployment is a great credit to the engineers who built it. Spectacular sonographs of turbidity current channels and pathways, debris flows, and seamounts were obtained on four deployments of the system. Fine details of the features imaged, such as terraces on channel walls and fine grained 'flow patterns' on the floors of turbidity current paths, will allow new insights into the sedimentological processes operating in this geological environment.

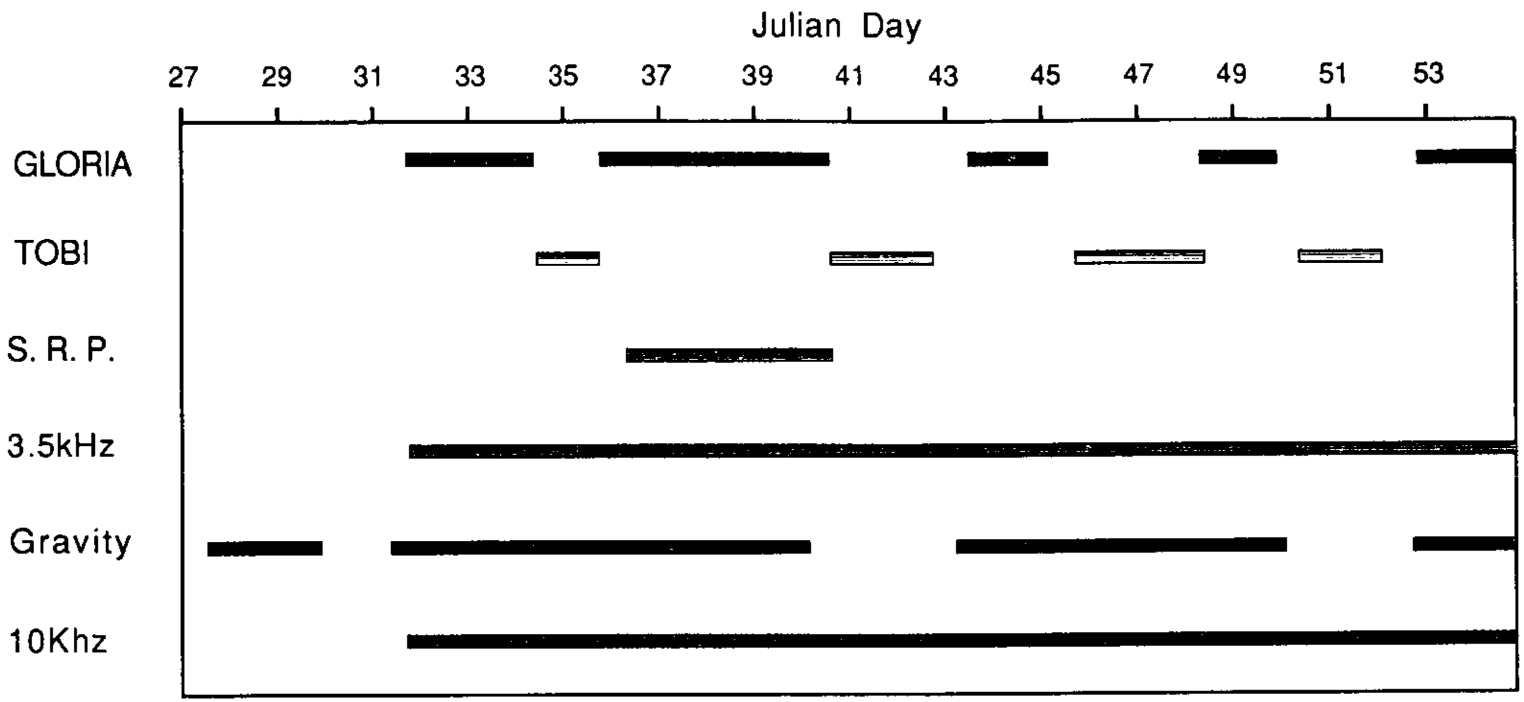


Table 1 : Data collected against time during Discovery Cruise 188

System	Line km	Area Insonified (km^2)
GLORIA	4200	168000
TOBI	450	2650
SEISMIC REFLECTION	1300	---
GRAVITY	6100	---
3.5kHz	5500	---
10kHz	5500	---

Table 2 : Data collected during Discovery Cruise 188

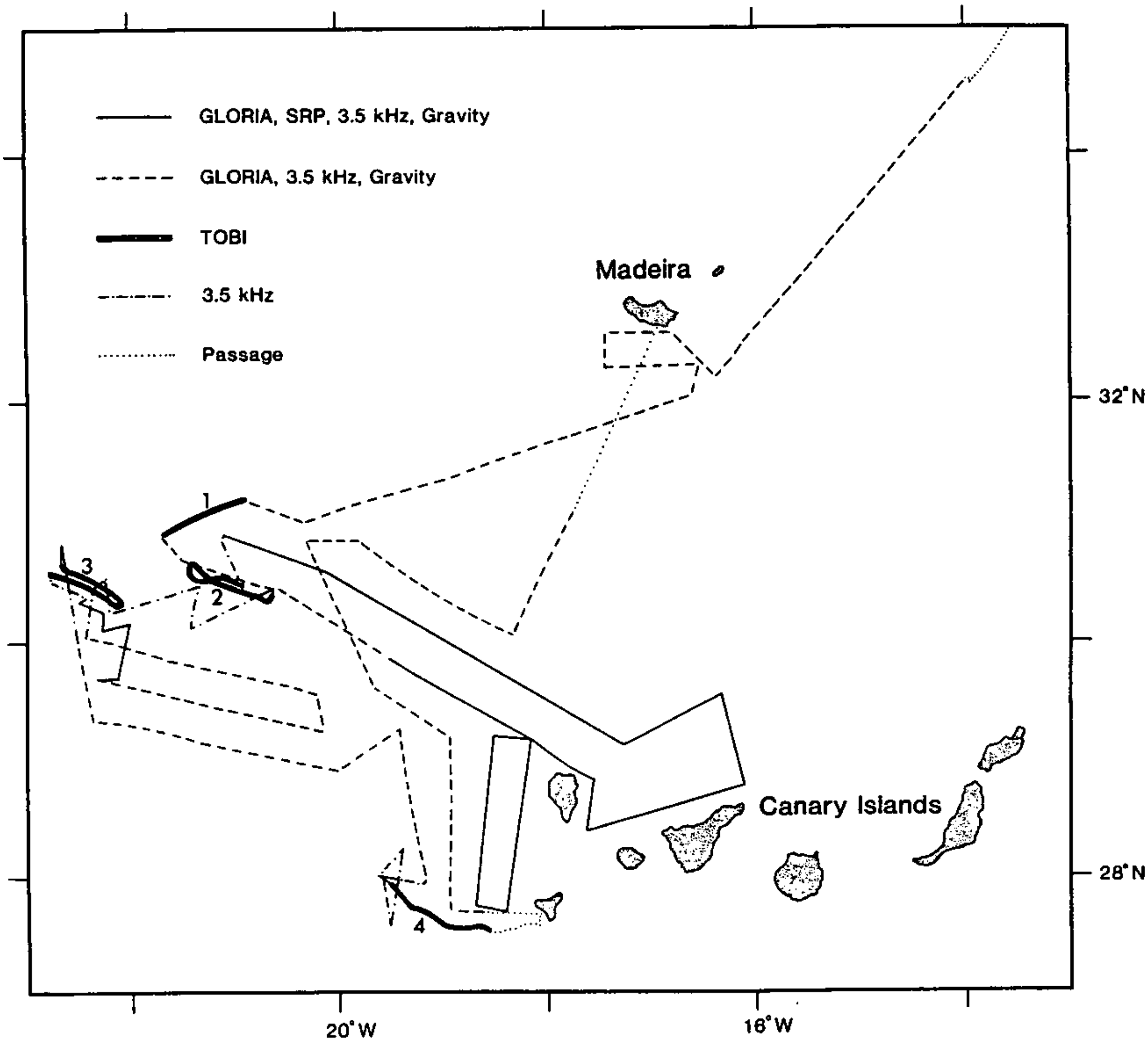


Figure 1 Track chart for Discovery Cruise 188, 24th January - 24th February, 1990, showing the various data types collected along track. Numbers 1 to 4 refer to TOBI deployments discussed in text and shown in detail in figures 2 to 5.

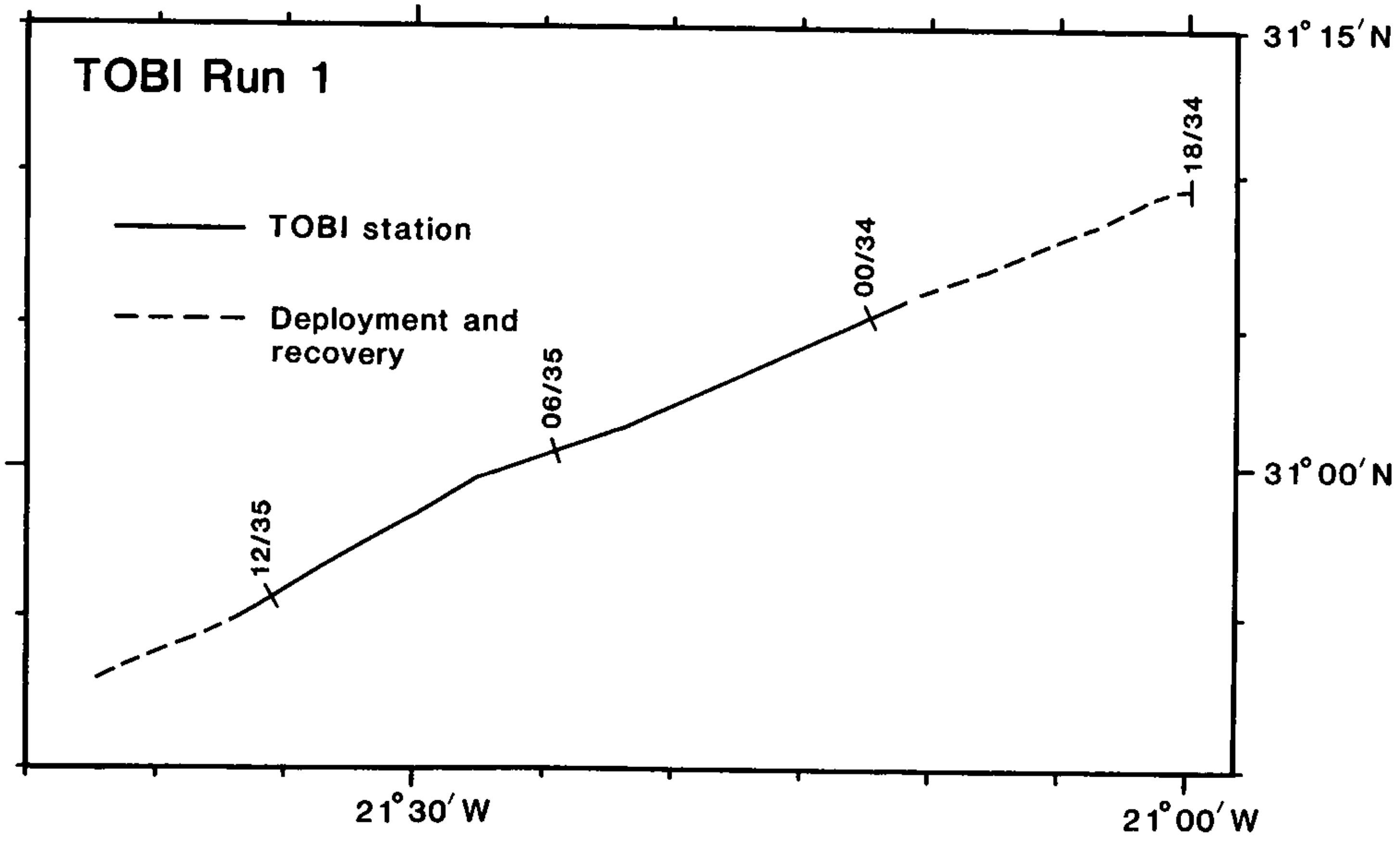


Figure 2 Track chart for TOBI run 1. See figure 1 for location.

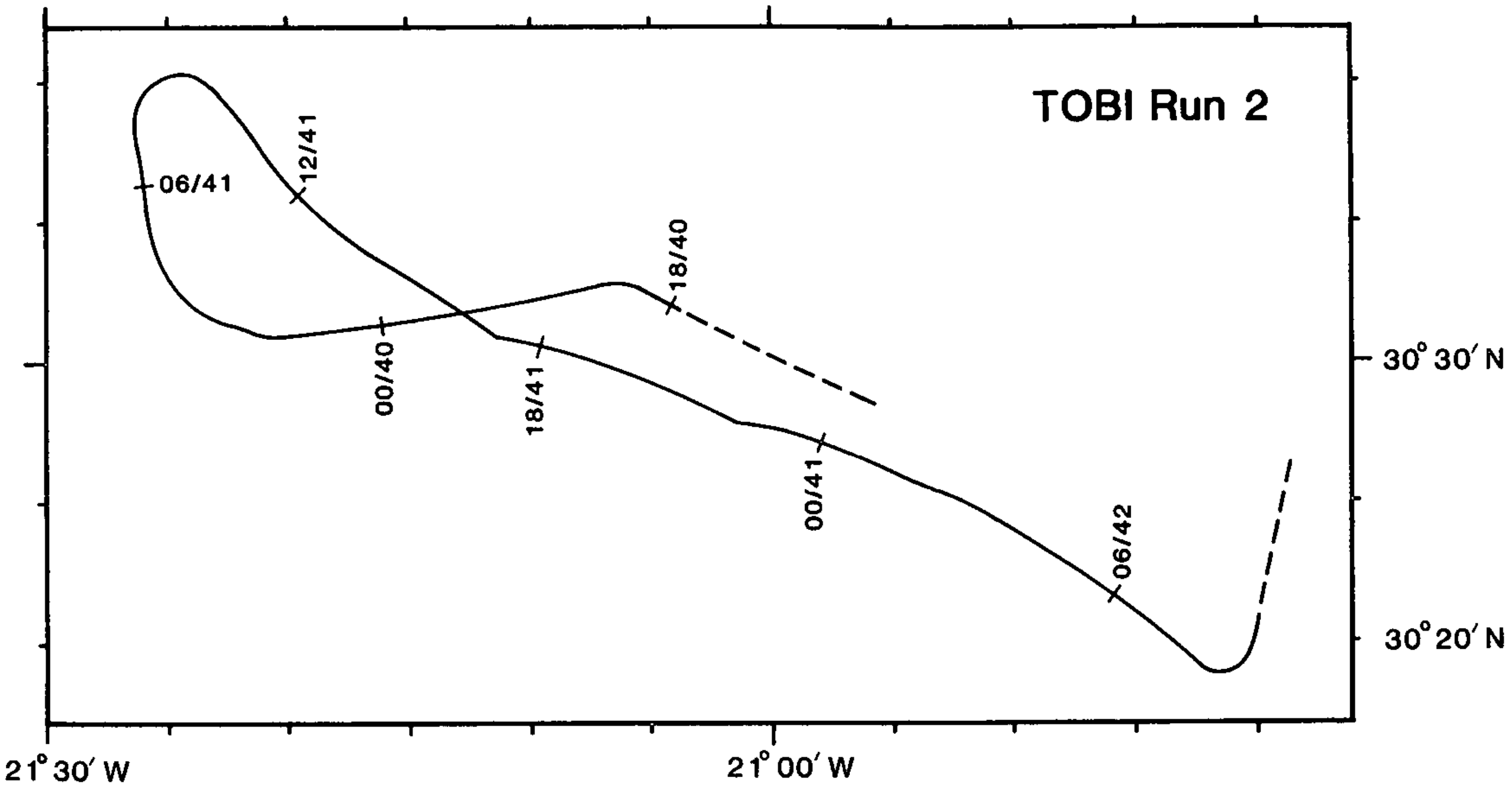


Figure 3 Track chart for TOBI run 2. See figure 1 for location.

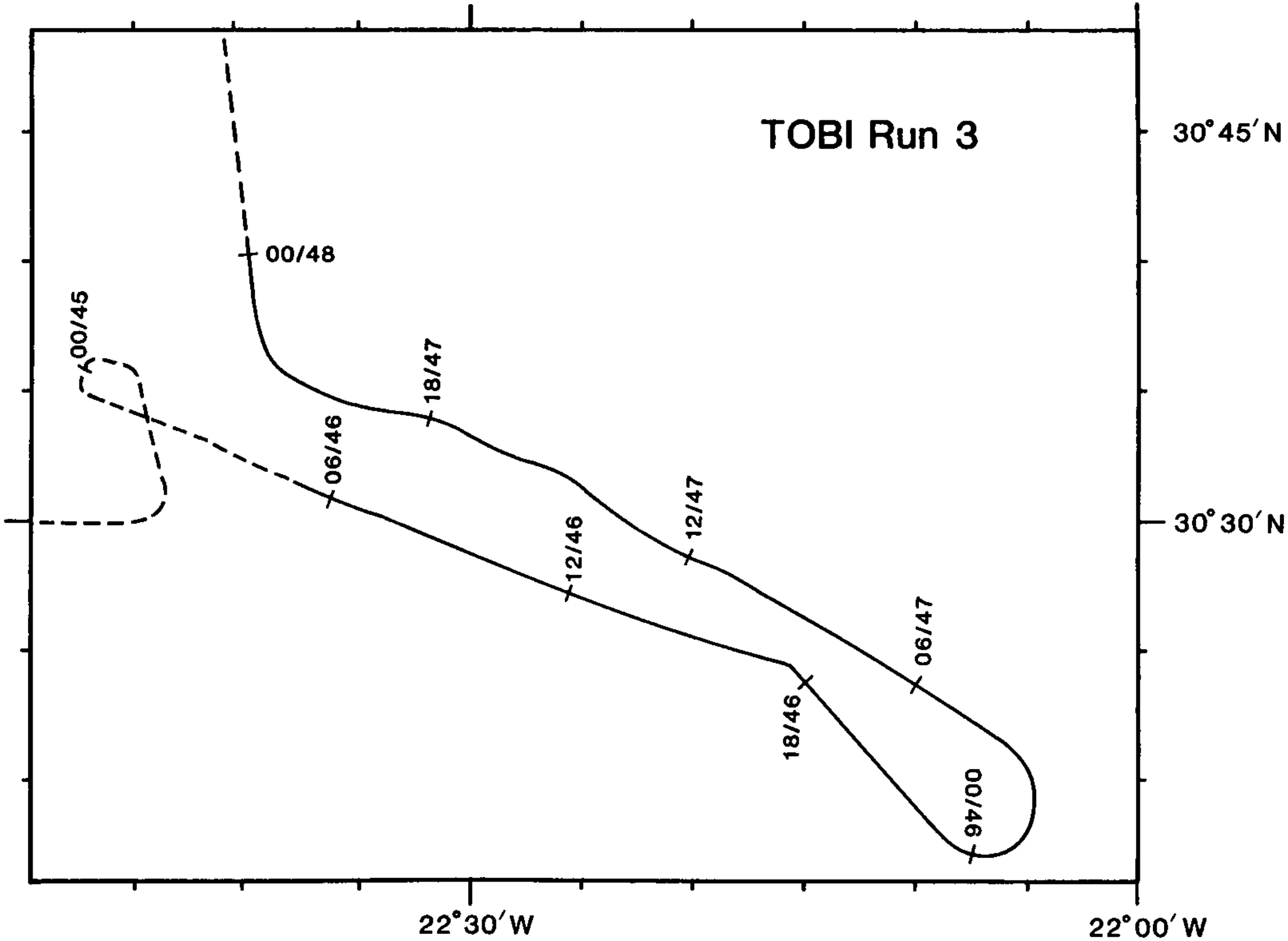


Figure 4 Track chart for TOBI run 3. See figure 1 for location.

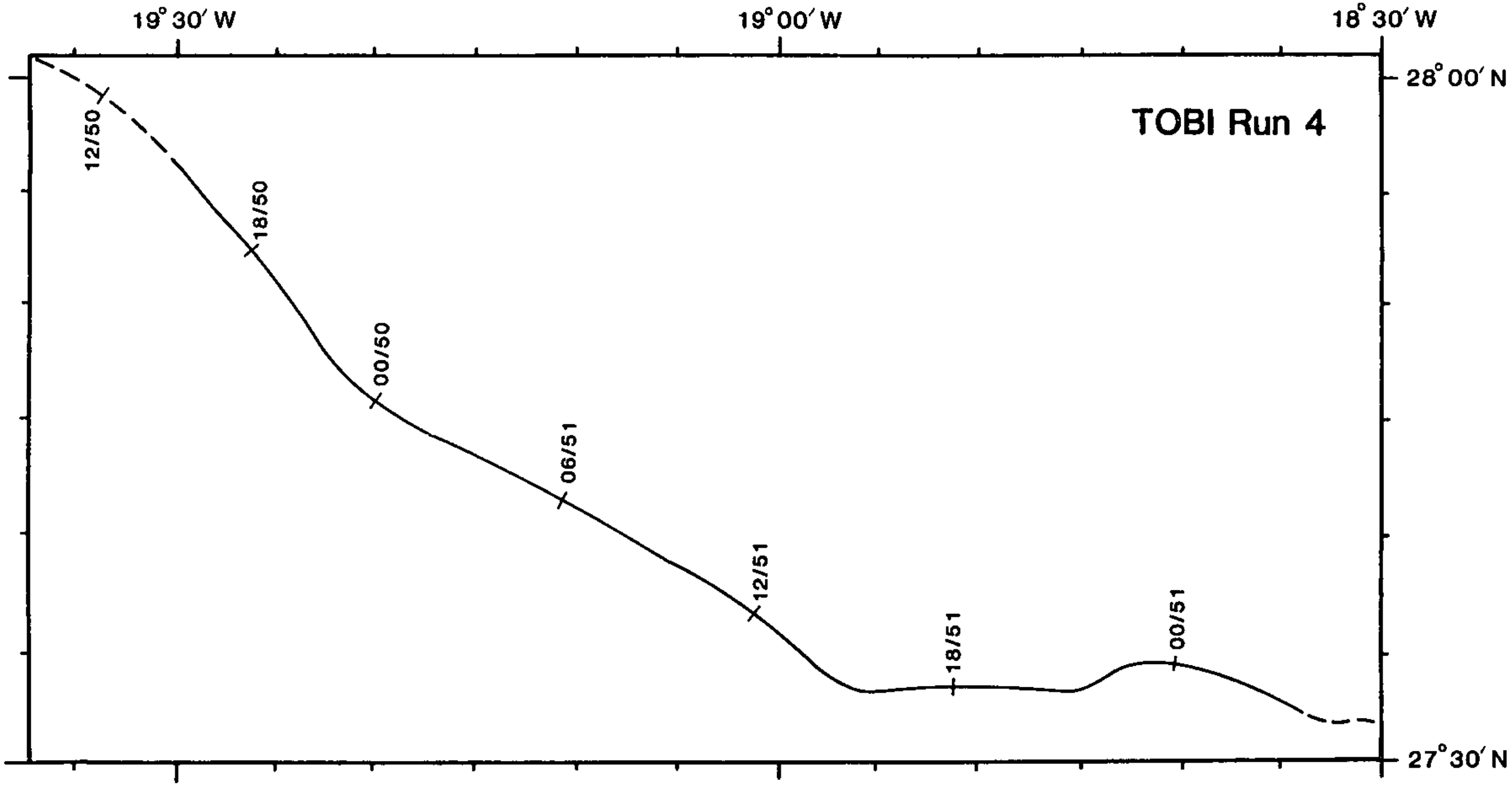


Figure 5 Track chart for TOBI run 4. See figure 1 for location.