

INSTITUTE OF OCEANOGRAPHIC SCIENCES
WORMLEY, GODALMING, SURREY

D. E. VICKERS VOYAGER

AND

PISCES III

June - July, 1973

SUBMERSIBLE INVESTIGATIONS OF THE GEOLOGY
AND BENTHOS OF THE ROCKALL BANK

I. O. S. CRUISE REPORT No. 1

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DATES

Sailed	Hartlepool	19th June
Off	Stornoway	21st June
Anchored) Sailed)	Stornoway Harbour	1st July
Arrived	Aberdeen	4th June

SCIENTIFIC PERSONNEL

	<u>Affiliation</u>
D.G. Roberts (Principal Scientist)	IOS
R.A. Eden (Principal Scientist)	*IGS CSU II
E.P. Collins	IOS
M. Conquer	IOS
C. Hunter	IOS
D. Lawson	*IGS CSU II
C.D. Pelton	IOS
R. Sanderson	*IGS London
G. Strong	*IGS London
K. Tipping	IOS
J.B. Wilson	IOS
J. Aitken	¹ IMER
W. Miller	¹ RVB

IOS: Institute of Oceanographic Sciences (Wormley)

IGS CSU II: Institute of Geological Sciences, Continental Shelf Unit II, Edinburgh.

IGS London: Institute of Geological Sciences, Exhibition Road, London.

IMER: Institute of Marine Environmental Research, Edinburgh.

RVB: Research Vessel Base, Barry, Glamorgan.

* Left at Stornoway on 1st July.

¹ Joined at Stornoway on 1st July.

VICKERS OCEANICS LIMITED

R. Handley	Field Officer
D. d'Arcy	Senior Pilot
R. Mallinson	Pilot
M. Howarth	Pilot
R. Chapman	Pilot
G. Colquhoun	Pilot
D. Lockwood	Diver
K. Brumby	Diver
P. Ogilvie	Diver
Master D.E. Vickers Voyager	Captain R. Brown

SUMMARY OF CRUISE INTENTIONS

1. Solid Geology

The principle objective of this cruise was to study and intensively sample the Rockall Bank using the Pisces-III submersible fitted with a manipulator and Hyco drilling system. The submersible operation was oriented toward obtaining in situ solid geological data at localities not readily accessible to surface ship sampling techniques. The programme was aimed to both complement and contribute toward the geophysical interpretation of the area. The objectives were:-

- (a) To sample the acoustic basement and overlying sedimentary succession at exposures developed along the east margin,
- (b) To examine outcrops where other intrusive centres or metamorphic inliers might be exposed.
- (c) To obtain as much in situ material as possible for inter-comparison of E. Greenland, Rockall and Hebridean geology.
- (d) To examine the geology of Anton-Dohrn Seamount.

2. Benthic Geology

Benthos and carbonate sediments would be sampled and observed routinely during solid geology dives. Additional dives would examine iceberg plough marks and coral distribution.

3. On Board Evaluation of Dive Data

Evaluation of the rock samples would be made using portable thin section making equipment.

4. Back-up Geological/Geophysical Programmes

- (a) Passage work

Side-scan sonar, magnetics and the echo-sounder would be run on passage between the U.K. and Rockall.

- (b) Reconnaissance programme

The side-scan sonar and echo-sounder would be used to pre-survey potential dive sites.

- (c) Bad weather programme

Grabbing, seismic profiler, magnetometer and side-scan sonar

traverses would be made as necessary during these periods.

5. Navigation Data Logger

Trials of an analogue recorder and elapsed timing system designed to give a more complete chronological and navigational record of the dive.

6. IMER Undulator

The IMER undulator had been lost in the vicinity of the Nun Rock. A two-day extension of the charter had been funded by NERC to search for and salvage the undulator if found.

NARRATIVE

D.E. Vickers Voyager sailed from Hartlepool at 0553/June 19th following a delay due to problems associated with the Hyco drilling system. On sailing we headed north toward a site suitable for a drill acceptance trial by Vickers Oceanics. During our northward passage, the scientific party completed the installation of the grabbing davit and began to build an outboard support for the Transit Sonar since there were no supporting brackets welded onto the hull. At 1545/June 19th, Pisces dived on a Permo-Carboniferous dyke off Berwick for the drill evaluation trial. The trial was abortive due to breaks in the hydraulic lines leading to the drill and manipulator arms. During a second dive later that day, the drill barrel stuck in the hole and was severely bent. Hoping to complete repairs to the drill overnight we continued our northward passage towards an alternative drill site off Wick. During the day, an evaluation of the Transit Sonar mounting revealed that the existing support in the bilge keel was inadequate to rigidly hold the scaffold pole support. Although the 30 foot freeboard presented some difficulty, a suitable support pole and stays were constructed for divers to fix to the bilge keel. By 1100/June 20th, we had reached a suitable drill site though repairs to the drill had not been completed fully. We therefore steamed westward through the Pentland Firth towards a suitable site north of the Nun Rock and near the presumed location of the lost IMER undulator. During the afternoon, the LORAN-C was set up and construction of the Transit Sonar support completed. By evening, we reached the Nun Rock area and at 2151/20th June, Pisces dived and successfully completed a drill trial on a convenient boulder. During this dive, an attempt was made by the divers to fit the Transit Sonar mounting but this was unsuccessful due to the great length of the pipe necessary to give adequate support over the 30 foot freeboard. After completing the drill trial, we made an echo-sounder traverse (0155/21 - 0343/21 June) through the loss position of the IMER undulator before making for Stornoway to land Mr. H. Pass of Vickers and Mr. R. Macdonald of Hyco who had remained on board for the drill trials. We landed them at 0810/21st June and began our passage to Rockall pausing off the Butt of Lewis (1150 - 1233/21 June) to measure the dimensions of a pipe in the bilge keel that offered an alternative means of fitting the Transit Sonar. At 1514/21st June, the magnetometer was streamed and scientific

watchkeeping of the LORAN-C, echo-sounder and magnetometer began. The magnetometer was initially unserviceable due to water in the inboard cable but by 1935/21 June, it was repaired and in service. Overnight, we steamed toward Rockall completing a magnetometer traverse across the Rockall Trough. During the morning, the weather deteriorated and there was a heavy swell. We completed the magnetometer run at 1330/22 June when we were five miles north of Rockall. At 1400, we hove to and divers attempted to fit the modified Transit Sonar mounting into the existing pipe. However, the heavy swell proved hazardous for the divers and the attempt was abandoned pending calmer conditions. We therefore surveyed, at a $\frac{1}{4}$ n. ml. line spacing, potential dive sites situated on the northern prolongation of Helen's Reef and selected a suitable site at the foot of the north face of this ridge. During pre-launch manoeuvring, Vickers Voyager drifted off station and the dive site had to be reoccupied. Pisces was launched at 1705/22 June on Dive site 1 and bottomed on a rock pavement with strongly rippled carbonate sand. Early in the dive, the manipulator jaws jammed while taking a sediment scoop. Nonetheless, a 4" core was drilled though they were unable to retract the drill successfully because of the jammed manipulator jaws. Photographs were subsequently taken until the flash failed and the dive was then terminated. Pisces surfaced at 1940 and was recovered by 2008/22 June with some difficulty owing to the heavy swell. Examination of the manipulator showed it was readily repairable and we therefore reoccupied the site of Dive 1 for a second dive. However, heavy swell prevented further diving and overnight we therefore surveyed in detail prospective sites to the west and south of Rockall to save time later in the cruise. By 0630/23 June the surveys were complete and we returned to Dive site 1 for our second dive. Pisces was launched at 0909/22 June and bottomed on a smooth rock pavement near massive, exfoliated outcrops. Two cores of micro syenite and a sample of porphyritic microgranite were taken during this Dive (No. 2). Pisces was recovered at 1229/22 June and we made for the site of Dive 3, located 3 miles west of Rockall. During our approach to the launch position, several buoys were sited to port; an investigation from the Gemini showed they were free and the dive continued after they were recovered. Pisces was launched on Dive 3 at 1547 and was recovered at 2058/23 June. During Dive 3 two cores

of granite similar to that forming Rockall Island were taken. Due to the length of this dive, a partial battery charge was necessary before Dive 4, which began at 0100/24th June and was intended to examine the transition from coarse carbonate sand through to finer sand. During this dive, the manipulator jammed again because of a small pebble caught in the jaws, and the submersible proceeded on a reciprocal course due to an incorrectly set gyro. Two sediment scoops were taken during this dive which ended at 0519/24th June. Experience with the navigation data logger on these dives revealed the desirability of marking on/off events on the video-tape recorder and Mr. Hunter designed a suitable modification. After all equipment was secured we made for the west side of Rockall Bank to pre-survey sites for the succeeding benthos dives. We reached the site of Dive 5 at around 1500 and Pisces was launched at 1611/24th June for a benthos/sediment sampling dive. During this five-hour dive, four sediment scoops were taken together with a large fragment of the coral, Lophelia porifera. Pisces was recovered at 2335/24th June and we streamed the magnetometer for an overnight traverse and survey of Bryony Bank where samples of Laxfordian granulites had been previously taken during Discovery Cruise 47. The pre-dive surveys revealed suitable sites at the foot and to the south west of this feature. Pisces was launched on Dive 6 at 0920/25th June. During the dive several large samples and one drill core of hornblende granulite were successfully taken. Pisces was recovered at 1250/25th June and a second dive (Dive 7 1600/25th June) was made on a deeper bank 1 ml to the south. At this site, hornblende granulites closely similar to those taken during Dive 6 were taken. During the recovery a French trawler (Directeur Chatte DZ 4239) hauling nets approached dangerously close to Vickers Voyager and ignored all international warnings. Pisces surfaced when the trawler was clear and was recovered at 1955/25th June. The final dive (Dive 8) of the day was made 2122/25th June on a low bank somewhat to the west of Sites 6 and 7 in the hope of sampling a different metamorphic lithology. At this site, the bottom consisted of carbonate sand encroaching upon flat lying outcrops. Samples of both rock and sand were taken. Pisces was recovered at 0002/26th June; and we streamed the magnetometer and headed north toward the next benthos dive sites on the west margin of the Bank to survey the line of proposed benthos traverses. The magnetometer was recovered at 0813 and Pisces was launched at 1030/26th June.

for Dive 9 to investigate coral ecology. A large patch reef was encountered during the dive and several coral samples were taken. Pisces was recovered at 1659/26th June and we made for the site of Dive 10 during the intervening maintenance period. Pisces was launched on Dive 10 at 1920/26th bottoming at 1000ft at 1959"26th June. This dive, intended to examine iceberg plough marks and corals, was hindered by the low, 6 ft visibility caused by a high concentration of plankton. The dive was ultimately curtailed because of this and Pisces was recovered at 2329/26th June. Overnight, we streamed the magnetometer and steamed southward toward outcrops north of the major E-W magnetic lineament mapped from the HMS Hecla survey. The dive sites were surveyed between 0616/27th June and 0920 when the magnetometer was brought inboard. The pre-dive survey showed a NNW-SSE trending cliff and Dive 11 was made at 1020/27th June on this position. At this site the bottom consisted of boulder fields, carbonate sand, with coral patches. A sample of gneissose rock was taken from an E-W lineated outcrop. Pisces was recovered at 1345/27th June and during the maintenance period we moved west to a nearby site mapped during the morning's survey. Pisces was launched on Dive 12 at 1527/27th June on a carbonate sand bottom with an abundant spatangoid fauna. The dive traverse was made along a 235° heading though progress was impeded by submergence of the surface buoy. During the latter part of the dive, a homogeneous granulite lithology was sampled from several boulder fields and a complete *Lophelia* growth was taken. Pisces was recovered at 1858/27th June. A third dive had originally been planned the evening of June 27th but this was cancelled to ensure a thorough overhaul of Pisces before the 2400 ft dive planned for June 28th on the east margin of Rockall Bank. A new on/off event marker for the video-tape recorder was completed and tested during the day. Overnight we streamed the magnetometer heading northeastward toward the dive site situated on the slump scar detected during M.V. Surveyor Cruise 1/71. We arrived on site at 0500/28th June and surveyed the upper slope to confirm the depth and dimensions of the scar. Throughout this period the swell increased and visibility decreased until at 0830/28th June, conditions were such that this deep dive was aborted. We therefore returned to the Rockall area to carry out further dives on the intrusive complex in shallower depths. Our first dive (Dive 13) was made at

1315/28th June on the southerly extension of the reef surmounted by Rockall Island. The rocks sampled during this dive included granites, basalt and a basalt/dolerite contact. During recovery the buoy line broke, Pisces was finally inboard at 1800/28th June. We then surveyed a site some two miles distant located due south of Helen's Reef. Pisces was launched on Dive 14 at 2000/28th June in gradually deteriorating wind and sea conditions. During the dive, several sediment scoops were taken together with samples of a dyke and the adjoining granite country rock. The dive was curtailed at 2200/28th June because of high wind speeds (gusting to 40 knots) and Pisces was recovered at 2244/28th June. Overnight we surveyed other dive sites in the vicinity of Rockall Island occupying a series of closely spaced magnetic traverses along NE-SW lines hoping to return to the deep dive sites on the east margin and Anton-Dohrn seamount if the weather should moderate. However, at 0700/29th June there was still a 30 - 35 knot wind and a heavy swell so we decided to continue the geophysical survey pending a further evaluation of the weather at 1300/29th June. At 1330 we slowed and turned head to wind simulating launch conditions to better assess the feasibility of further dives. As the ship's motion was too severe for a safe launch and a further deterioration in weather conditions was forecast, further dives in the Rockall area were cancelled; at 1400/29th June we set course for St. Kilda making a new magnetometer traverse across the Rockall Trough and heading for alternative dive sites in the more sheltered Minches. At the beginning of our return passage, we closed and passed Rockall at 0.3 ml distance observing Hasselwood Rock and Helen's Reef. At about 2300/29th June the third engine failed and much of our eastward passage to St. Kilda was made at 8 knots. At 0830/30th June we passed within 0.5 ml of St. Kilda and Soay and observed the sills, dykes and faults beautifully exposed in the cliffs. We had hoped to continue the magnetometer traverse close to the coast of Lewis but as there was no prospect of an immediate engine repair we altered course for the Butt of Lewis hoping to arrive earlier at a suitable dive site in the Minch. We rounded the Butt of Lewis at 1700/30th June and steamed south toward a dive site just east of Lewis. During our southward passage down the Minch, the magnetometer failed at 1820/30th June. We reached the dive site around 2400/30th June where the southerly wind was gusting to 45 knots. The dive was therefore

cancelled and we turned northward to Stornoway. We anchored in the outer harbour at 0807/1st July and Messrs R.A. Eden, D. Lawson, R. Sanderson and G. Strong went ashore. Whilst we lay at anchor in the shelterd water, the modified Transit Sonar mount was fitted by divers and tested. During this period, HMS Kedleston - the minehunter assigned to the search operation, rendezvoused with Vickers Voyager and the opportunity was taken to discuss a search plan with her Commanding Officer (Lt.Cdr. W. Twist). A search plan and communications set up was agreed and at 1230/1st July, HMS Kedleston sailed to begin identification of likely targets in the loss area. J. Aitken (IMER) and W. Miller (RVB) joined Voyager bringing an underwater television system to assist in the search. Vickers Voyager weighed anchor at 1235/1st July and we made for the Nun Rock. During this passage, the Transit Sonar gave excellent records at speeds of 9 knots. We rendezvoused with HMS Kedleston on the position of the lost undulator at 1922/1st July and launched Pisces on a cluster of targets at 2306/1st July. Details of the search are given in the projects section of this report. Three dives were made (Dives 15, 16 and 17) and an area of about 45 million square feet was searched without success. Continuous video-records were taken during two dives (15 and 17) and sediment scoops were taken at the end of these dives. The search for the undulator was terminated at 1107/3rd July when Pisces was finally recovered. The Transit Sonar was housed and course set for Aberdeen where we docked at 0500/4th July.

This was a most successful cruise bearing in mind the swell and wind speed limitations on submersible operations. Dives were made typically in sea states 5 and at wind speeds of 25 - 40 knots. Only one day was lost owing to bad weather and about 75% of the scientific programme was completed successfully. The in situ rock samples and benthos could not have been taken in their proper geological perspective in any other way.

I would like to thank the scientists from IOS and IGS, the submersible team of Vickers Oceanics, Captain R. Brown, the officers and crew of Vickers Voyager for the teamwork and enthusiasm that considerably contributed to the success of this cruise. I would

particularly like to thank the IOS and IGS staff for their careful pre-cruise preparatory work that minimised difficulties on site.

PROJECT REPORTS

1. Solid Geological Programme

The solid geology dives were designed to investigate areas of key geological and geophysical interest revealed by the detailed survey made from HMS Hecla in 1969. Outcrops had previously been mapped using side-scan sonar and seismic reflection profiles (RRS Discovery Cruises 29, 39 and 47; MV Surveyor Cruise 1/71) so that the necessary pre-dive survey work was minimised to a great extent.

The solid geological dives were concentrated in three main areas of geological interest. The first series of dives (1 to 3) were designed to examine the spatial variations and differences within the Rockall intrusive complex. Samples of microsyenite, diorite (?) and riebeckite granite taken on these dives indicate a wide variety of intrusive rock types. Subsequent dives (13 and 14) yielded basic dykes intruding leucogranites indicating a third post-granite intrusive phase.

Sites further south on the Rockall Bank provided additional confirmation of the metamorphic basement and also yielded gneissose and mylonitic (?) rocks in the vicinity of the major east-west magnetic lineament.

The Hyco drill proved very useful in sampling the massive exfoliated outcrops near Rockall where little well jointed material could be found. Elsewhere many of the samples were taken from joint planes using the manipulator.

D.G.R.
R.A.E.

2. Benthos Investigations

The benthos and sediment dives were designed to provide detailed information on several sites on the top and margins of Rockall Bank suggested by previous surface investigations on Rockall Bank (M.V. Surveyor, 1970, 1971) and by data kindly supplied by the Fisheries Laboratories at Aberdeen and Lowestoft.

Samples of the coarse biogenic carbonate sand from the top of the bank were obtained during several dives in spite of a manipulator failure at a crucial stage during dive 4.

Detailed observations on the distribution and morphology of Lophelia prolifera were made on dives 5 and 9 and samples of living

coral were obtained. Additional observations on coral distribution were obtained on dives 11 and 12 and an important coral specimen was collected on dive 12.

Observations on the nature of the sediment infilling of iceberg plough marks were made on dives 9 and 10 and a core sample of this was taken.

Video tape records of parts of the dives were taken together with numerous photographs.

Data and samples collected on the solid dives provide valuable additional observations on the sediments and benthos of Rockall Bank.

J.B.W.

3. Submersible Navigation Data Logger

The purpose of this system was to provide greater accuracy of timing the observations made by the observer, and to record navigational data so that a more complete chronological picture of the dive could be built up after the event. The apparatus comprised a six channel pen recorder and inputs from the gyro compass, pressure transducer, e/m log, event marker and time marks. This equipment was fitted into Pisces at the start of the cruise and apart from a few minor teething troubles, has functioned very well.

For future work the system is capable of some improvements, mainly in layout and packaging. As part of a more complete navigation system it looks very promising. It is already clear that it has enhanced the value of the data. When the records are fully analysed it should provide a better post-plot than has hitherto been possible.

C.H.

4. Underwater Cameras

Because of the absence of a reliable underwater camera on the submersible, it was necessary, at fairly short notice, to find an alternative within the I.O.S.

Cameras developed at Wormley were designed for deep sea operation and in consequence are not normally equipped with shutter mechanisms. Two mono photographic units fitted with experimental capping shutters were however in existence and these were completely overhauled and synchronised to operate with a modified Mk 3 Flash. In addition a new UMEL camera system was obtained on a limited loan term basis from Barry as a back-up.

Following consultation with Vickers personnel both the UMEL and Wormley camera systems were fitted on the submersible, the former on a pan and tilt head and the latter rigidly attached to the upper badge bar on adjustable brackets designed for this purpose. The two cameras were remotely controlled by a press switch located on a wander lead in the crew's compartment.

Both photographic units were powered by dry disc cells and these were replaced at frequent intervals during the cruise. Two sets of rechargeable batteries were available for each flash unit and this simplified the problem of maintaining a satisfactory power supply during the fairly intensive programme.

Initially a high rate of unserviceability was experienced with the UMEL system, due mainly to the inadequate shutter contacts in the photographic unit which entailed major servicing between dives to keep the equipment operational. An opportunity occurred during the latter half of the programme to modify the electrical circuits in the flash system which to a large extent eliminated this problem.

Photographs obtained during the initial dives were grossly over exposed due to the unexpected high level of illumination on the submersible but in subsequent operations gave relatively good results. Due to long exposures given by the capping shutter on the upper camera some of the negatives showed signs of blurring but in general a high percentage of the 750 photographs obtained were of a satisfactory quality.

5. Surface Navigation Systems

The principal navaid used on Rockall Bank and during passage was a marine Loran-C set hired from Decca. The set gave little trouble and tracked satisfactorily throughout the cruise. The persistent illumination

- (c) Uncertain course made good prior to the loss,
- (d) Unknown hydrodynamic behaviour of the undulator after the tow had broken,
- (e) Decca position.

This was given to only 0.1 of a lane accuracy and it was not known whether this reflected the type of Decca set in use on Scotia or rounding error by the operator.

Mr. Aitken of IMER joined Voyager in Stornoway and was able to resolve some of these uncertainties. In particular:-

- (a) Fixes taken at hourly intervals over the preceding three hrs. indicated an average speed over the ground of 7.25 kts.
- (b) The time of loss was considered to be nearer three minutes to the time of fix than five minutes.
- (c) Shortly after 2400, FRS Scotia altered course to 265° and was on this heading at the time of loss though the precise time of course alteration was not known.
- (d) It was felt that the undulator would have most probably dived to the bottom close to the loss position.
- (e) Decca position - The available Decca data were read from the digital display of the Decca Mk 21 receiver on FRS Scotia. This type of display gives Decca values to only a 0.1 lane accuracy and also exhibits a lag behind the more accurate Decometer readings.

6.2 Plan of Operations

All the loss data were reanalysed on board to define a most probable area for search by the submersible and minehunter. This area lay to the east of the position taken by FRS Scotia after the loss (Fig. 1). Whilst we lay at anchor in Stornoway, we rendezvoused with the minehunter (HMS Kedleston) assigned to assist in the search operation. Lt. Cdr. W. Twist (C.O. HMS Kedleston) came on board Vickers Voyager to discuss the search operation with the NERC and Vickers personnel. Although scheduled to leave the area on the 1st July, Lt. Cdr. Twist generously agreed to remain on site until the 2nd July. The initial planning of the search was based on the presumed capabilities of the sonar on board the minehunter. The sonar was normally used to a depth of 180 ft. and could also discriminate between rock and metal though its capabilities in the deeper water around Nun Rock were unknown. It was agreed that the resolution and discrimination could

best be evaluated and calibrated on site. The following plan of operations was then agreed.

1. HMS Kedleston to leave before Vickers Voyager and on reaching loss area to deploy a dhanbuoy at the Decca co-ordinates of loss before commencing search for targets in the most probable area of loss.
2. On arrival of Vickers Voyager in loss area, transfer R. Chapman of Vickers to HMS Kedleston to act as liaison officer using VHF channel 13.
3. Continue identification of targets in most probable area of loss discriminating between rock and metal where possible.
4. Pisces to dive and to be directed onto targets by HMS Kedleston; and Pisces to execute 360° sonar sweeps during target search, identification and calibration.
5. Between dives, Vickers Voyager to carry out side-scan sonar survey of the area.
6. On departure of HMS Kedleston, Pisces to continue search of loss area using 360° overlapping sonar sweeps each covering an area about 500 ft. in diameter.

6.3 Narrative

HMS Kedleston sailed from Stornoway at 1220/July 1st and was followed by Vickers Voyager at 1235/July 1st. Vickers Voyager arrived in the loss area at 1922/July 1st. HMS Kedleston had arrived earlier due to her faster speed and, after deploying a dhanbuoy on site to act as a reference point, had begun sonar sweeping the area. Our initial intention was to sweep the loss area using the side-scan sonar on Voyager to pick up targets. However, interference from the sonar on HMS Kedleston made this impossible. We therefore re-referenced the dhanbuoy using the Decca Mk 21 receiver on Vickers Voyager. It then became apparent that this buoy had been laid some 7000 ft. should west of the correct position and the minehunter was searching a somewhat less probable area of loss. Subsequent comparison of the decometer readings on the minehunter and Vickers Voyager revealed a further but smaller discrepancy, that possibly reflected the different sets in use. Throughout this period all targets identified by the minesweeper were plotted on a polar plot on which the most probable loss area had been marked previously. After the discovery of the discrepancy, the search was shifted into the most probable loss area and a further search for likely targets was begun. At this time,

several promising targets were detected including a 14' metallic object within the immediate area of loss. At 2304/1st July, Pisces was launched in calm conditions to dive on these targets. During this dive, Pisces was directed onto these targets by HMS Kedleston. At 2343/1st July the first target was found to be a rock. Subsequent targets were found to be sand waves, or sand and boulders. Throughout much of this dive, bottom current speeds were between $\frac{1}{2}$ and $\frac{7}{8}$ kt. at 0130, the dhanbuoy laid by HMS Kedleston broke adrift and we no longer had a fixed reference point. After examining several nearby targets, the dive was terminated and Pisces was recovered at 0238/2nd July. After recovery, Vickers Voyager reoccupied the Decca position taken by FRS Scotia and deployed Dhanbuoy I at 0342/July 2nd. We then manoeuvred around the buoy taking Decca readings at 15 minute intervals to ensure it was not drifting. At 0600/2ns July we began to resurvey the loss area using side-scan sonar and the echo-sounder. However, massive interference again rendered the sonar unuseable and a bathymetric survey was therefore made of the loss area. The first traverse revealed a bottom of rocky aspect on the Scotia Decca position and a smoother area in the loss area. After the first traverse, Dhanbuoy I broke adrift due to strong surface currents and we were again without a good reference point. HMS Kedleston had meanwhile returned to the area and recommenced her search using the position of Dhanbuoy I was a new datum. During this period, Dhanbuoy I was recovered and relaunched on the Scotia Decca position using 6 mm wire with a 15% scope, a Daanforth anchor and 3 x 120 lb. lengths of anchor chain. This buoy stabilised well but then partially submerged due to the strong currents. Despite this, we were able to use the buoy as a reference point. Several targets had been detected by the minehunter in the loss area and Pisces was launched at 1243 on the first of these (also detected on the side-scan sonar). The target was reached at 1414/2nd July and proved to be a rock measuring 10 ft. x 4 ft. At this time, HMS Kedleston returned to base having returned Mr. Chapman to Vickers Voyager. At 1419/2nd July Pisces began a systematic search of the loss area based on overlapping 360° sonar sweeps covering a circle some 500 ft. in diameter while moving along at 250° heading. In detail Pisces stopped and scanned 360° , moved for 500 ft. along a 250° heading before stopping and again scanning 500 ft. No targets were detected for much of the dive but at 1710/2nd July a strong target was identified that proved to be a coil of wire. Other targets proved ephemeral and were probably fish. No other targets were detected and at 2014/2nd July Pisces was recovered

because of low battery levels. During the overnight battery charge period, a detailed overlapping side-scan sonar survey of the whole area was made to search for alternative targets. During this survey, several promising targets were detected and noted for examination during the next dive. The search area for this next dive was therefore planned to examine the area due east and south-south-east of the Scotia Decca position to include these targets, the error bias in the Decca Purple Chain ($\frac{1}{2}$ cable in a 155° direction) and a small area just to the west of the Scotia Decca position. Pisces was launched at 0542/3rd July on the rocky bottom previously inferred near the Decca position. In this area, the bottom consisted of several small rocks on a sandy bottom but at 0638/3rd July a strong target was identified that proved to be a rock outcrop. The search was made on the same basis as before and to the east of the Decca position completing the survey of the most probable loss area. No metallic targets were identified in this period. The dive was terminated at 1039/3rd July. The dhanbuoy was left in position to act as a marker for any subsequent search operation and the relevant positional data were signalled to the Hydrographer. No further dives were possible because of the existing charter commitments of Vickers Voyager and at 1107/3rd July we began the return passage to Aberdeen.

Conclusions

An area measuring approximately 45 million square feet was searched to the east of the Scotia Decca position including the most probable loss position. Within this area, we were unable to find the undulator. It is conceivable that the sonar sweeps may have missed the undulator because of the small target size offered by the small air filled cylinders housed within the fibre glass fish. Further, the fish may be glided away after the tow broke in some unknown direction rather than sinking rapidly and directly to the bottom. Finally, the fish may have been lost beyond the area searched on the basis of the poor navigational data available to us. A pinger on the IMER undulator would have ensured that it would have been rapidly located and recovered.

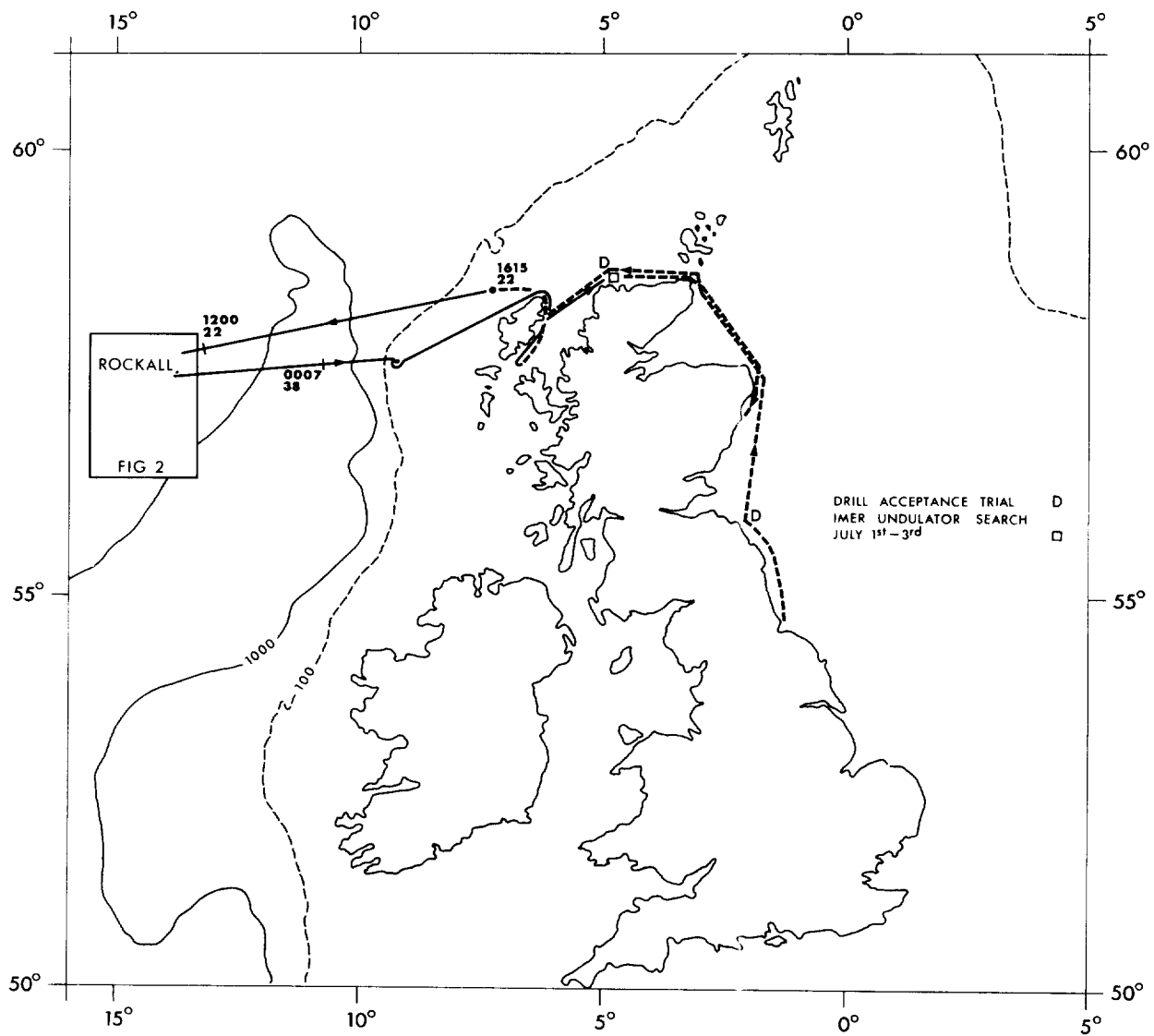
D.G.R.

DIVE NO.	DATE	TIME ON BOTTOM	TIME OF ASCENT	FROM Lat.	FROM Long.	TO Lat.	TO Long.	APPROX DEPTH (M)	SAMPLE DATA	DESCRIPTION	NIO	UMEL	OPTICAL DATA	VRTT's	other	OBSERVER
1	22.6.73	1719	1937	57°39.4'N	13°38.8'W	57°39.3'N	13°39.3'W	116	NIL-Manipulator failure	-	16	14	1 colour	2	1AT	R.A.Eden
2	23.6.73	0920	1200	57°39.55'N	13°39.1'W	57°39.42'N	13°39.38'W	108	2R1-D 2R2-D 2R3-M 2R4-M	Microsyenite Microsyenite Porphyritic microgranite Augite diorite (or monzonite?) Carbonate sand	16	14	1 colour	2	1AT	D.G.Roberts
3	23.6.73	1559	2004	57°37.8'N	13°43.2'W	57°37.7'N	13°44.2'W	96	3R1 D 3R2 D	Riebeckite-aegirine microgranite Fine grained riebeckite aegirine granite Carbonate sand Carbonate sand			1 colour	2	2AT	R.A.Eden
4	24.6.73	0110	0442	57°37.3'N	13°45.2'W	57°37.5'N	13°44.8'W	183	3S1 S 3S2 S 4S1 S 4S2 S	Carbonate sand Carbonate sand Carbonate sand Carbonate sand	25	32		1 1/2	HHC 1AT	J.B.Wilson
5	24.6.73	1632	2255	57°54.9'N	13°52.3'W	-	-	158	5R1 M 5R2 M 5/S1 S 5/S2 S 5/S3 M 5/S4 S 5/S5 S	Erratic pebbles and epifauna Carbonate sand Carbonate sand Hydrocoral Carbonate gravel Carbonate gravel	38	49		1 1/2	HHC 1AT	J.B.Wilson
6	25.6.73	0937	1231	57°3.75'N	14°39'W	57°04.2'N	14°31.5'W	152	6R1 M	Biotite-cordierite granulite " Hornblende-biotite granulite " Coarse granulite Carbonate sand	37	37		3	1AT	D.G.Roberts
7	25.6.73	1625	1808	56°58.5'N	14°35.6'W	56°58.55'N	14°35.5'W	155	6R4/ 6R5 M 6R6 D 6S1 S 7R1 M 7R2 M	Granulite Carbonate sand Carbonate sand Granulite Fine grained granulite Carbonate sand Carbonate sand	13	20	1 colour	3	1AT	R.A.Eden
8	25.6.73	2146	2332	56°58.1'N	14°43.4'W	56°58.1'N	14°43.1'W	158	7S1 M 7S2 M 8R1 M 8R2 M 8S1 S 8S2? S	Granulite Carbonate sand Carbonate sand Erratic (?) + epifauna Carbonate sediment	15	17		2	1AT	D.G.Roberts
9	26.6.73	1120	1614	57°36.6'N	14°29.1'W	57°35.7'N	14°29.2'W	256	9S1 S 9S2 M 9R1 M 9R2 M	Carbonate sand Coral Erratics + epifauna "	72	142		2 1/2	HHC 2AT	J.B.Wilson

DIVE NO.	DATE	TIME ON BOTTOM	TIME OF ASCENT	FROM		TO		APPROX DEPTH (M)	SAMPLE DATA	DESCRIPTION	NIO	UMEL	OPTICAL DATA		OBSERVER
				Lat.	Long.	Lat.	Long.						Hassel	VTRT's	
10	26.6.73	1957	2219	57°29.3'N	14°43.5'W	57°29.7'N	14°43.7'W	340	10S1 S 10R1 M	Carbonate sand Erratics + epifauna	39	41	1 2	HHC IAT	J.B.Wilson
11	27.6.73	1041	1311	56°35.30'N	14°52.30'W	56°35.3'N	14°53.3'W	183	10R2 M 11R1 M	Pyroxene-hornblende- biotite granulite Crushed and sericitised coarse granulite + dark carbonate sand Coral	19	20	2	1AT	R.A.Eden
12	27.6.73	1545	1820	56°34.0'N	14°58.9'W	56°33.50'N	14°59.60'W	200	11S2 12R1 M	Pyroxene-hornblende granulite	22	9	2	1AT 1CC	D.C.Roberts
13	28.6.73	1323	1718	57°34.1'N	13°42.0'W	57°34.86'N	13°42.7'W	118	12R2 M 12R3 M 12S1 S 12S2 S 12S3 M 13R1 M 13R2 M	Carbonate sand Coral Dolerite probably altered Dolerite/ dolerite breccia junction Weathered coarse granite Porphyritic basalt Weathered coarse granite Dolerite with zeolite filled amygdales Carbonate sand	13	14	1 colour 3	2AT	R.A.Eden
14	28.6.73	2021	2221	57°33.85'N	13°39.4'W	57°33.79'N	13°39.3'W	125	13S1 S 14R1 M 14R2 M 14/S1 S 14/S2 S 14/S3 S 14/S4 S 15/S1 S	Porphyritic dol. granite jet. Leucogranite Carbonate sand " " Carbonate sand	39	53	2	HHC IAT	J.B.Wilson
*15	1-7-73 - 2-7-73	2304	0238	Dives around				104	15/S1 S	Carbonate sand			1		R.Mallinson M.Howarth
*16	2-7-73	1243	2027					94	16/S1 S	Carbonate sand			none		D.d'Arcy
*17	3-7-73	0545	1058	58°49.65'N	05°04.95'W			83	17/S1 S	Carbonate sand			2		C.Colquhoun M.Howarth R.Mallinson

*Dives dedicated to search for lost IMER undulator

NB Depths of dives recorded from PISCES pressure gauge



D.E. VICKERS VOYAGER FIG (1)

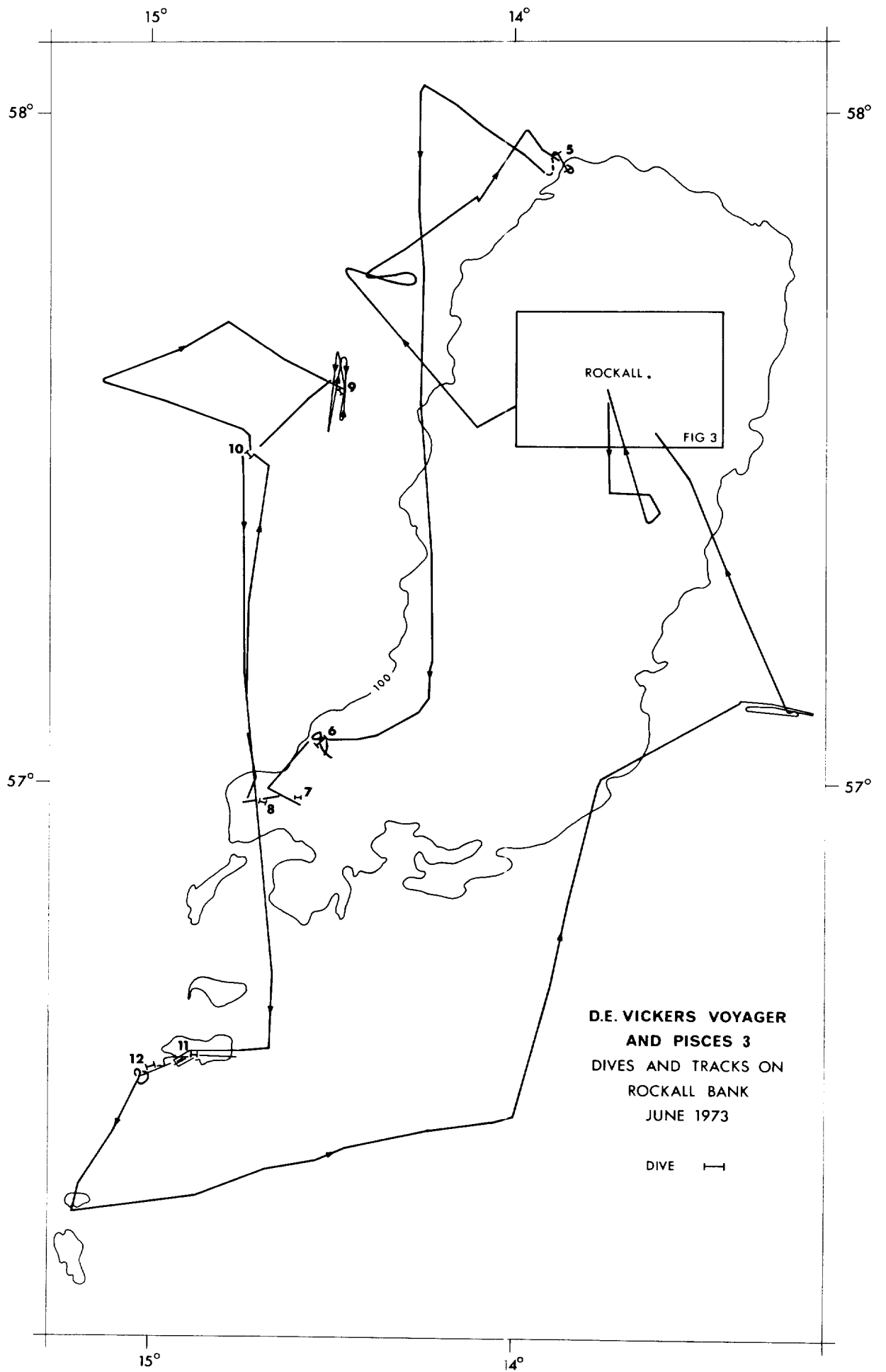
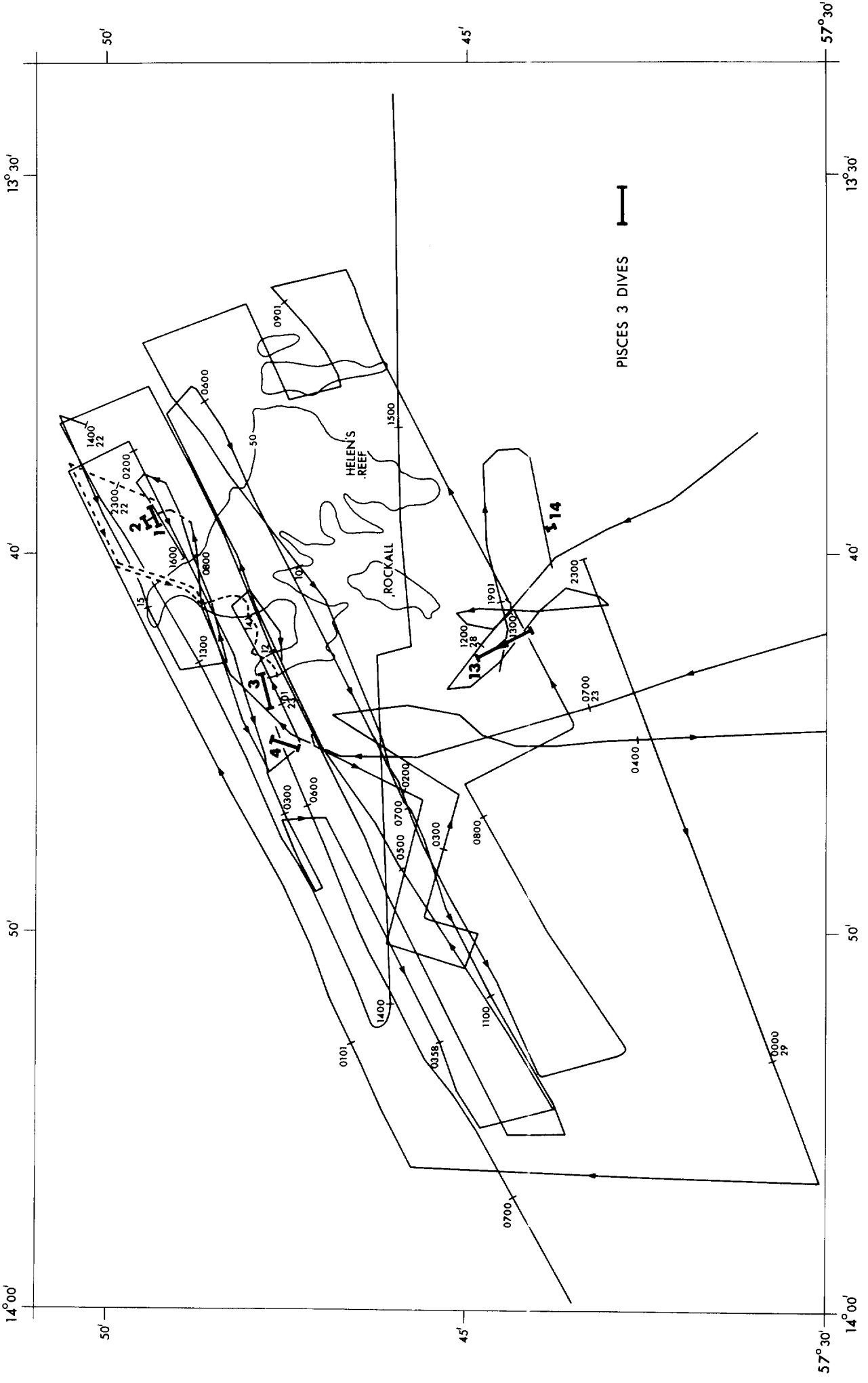


FIG (2)



DIVES AND DETAILED SURVEYS AROUND ROCKALL ISLAND FIG (3)