INSTITUTE OF GEOLOGICAL SCIENCES
CONTINENTAL SHELF DIVISION
MARINE GEOPHYSICS UNIT

Report No. 092

Cruise Report on Project 78/04
SW Approaches Regional Survey
May-July 1978, MV Sperus

Edited by

E J Armstrong

Murchison House
West Mains Road
Edinburgh EH9 3LA.

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CONTENTS

INTRODUCTION

This report deals with the mobilisation and operation of the SW Approaches regional survey, project 78/04, and covers the period 22 May to 13 June.

The four legs comprising this project were designed to extend the regional survey of the SW Approaches to the south and west of the Scilly Isles out to the Continental Shelf edge. The survey was to be carried out using shallow seismic, gravity and magnetic techniques on a skewed 7km by 12½km grid. However, due to lack of time this programme was slightly modified (see report for leg 4).

The m.v. Sperus, chartered from Cosag Marine Services Ltd as used on project 78/02 was utilised for this project. Dimensions are 63m overall length, 11m beam, 4m draught and 921 tons net weight.

This report is based on the senior scientists', geophysical, geological, surveying and technical reports produced at the end of each leg, summary charts and log sheets held on open file in the Marine Geophysics Unit, Murchison House, West Mains Road, Edinburgh. The authors of the reports for the various legs are listed below.

Mobilisation and Leg 1

A S Mould	Senior Scientist
S E Deegan) P Western)	Geophysical
D Tappin	Geological
A S Mould	Surveying
P R Roberts	Technical

Leg 2

A Dobinson	Senior Scientist
M Glen) A Rochester) D K Smythe)	Geophysical
G K Scott	Geological
M Glen	Surveying
P R Roberts	Technical

Leg 3

R A Floyd	Senior Scientist
E J Armstrong) S D Spencer)	Geophysical
C D R Evans	Geological
R A Floyd	Surveying

Leg 4

A Dobinson	Senior Scientist
E J Armstrong) P Mulholland)	Geophysical
W Martindale	Geological
A S Mould	Surveying
A D Wilson	Technical

REGIONAL MOBILISATION

Millbay, Plymouth, 22-24 May 1978

The second stage mobilisation carried out at West Wharf, Millbay on the above dates involved adding basically only seismic equipment, particularly the compressor, air gun and water gun to equipment already on board. The compressor arrived 30 hours late at early pm on the 23 May and installation was complete the same afternoon. Meanwhile, prior to sailing on the evening of 24 May, the Brown platform, echo sounder and Hiab were checked by the respective manufacturers' engineers. The Hiab was unusable for any towing purpose as non return valves could not be fitted to lock the arms in the azimuth axis. The sat/nav tape decks were checked and test tapes obtained and forwarded to Edinburgh for checking. The LaCoste and Romberg gravity meter shaft encoder was inspected, the data logger fixed and the seismic control system was worked on.

LEG 1

Millbay to Millbay: 24 May-5 June 1978

A number of gravity lines were run over the Eddystone gravity range and in the western channel on sailing and the succeeding two days were spent testing sparkers, guns, hydrophones and seismic control system. During this time the compressor was overhauled and lines 6 and 7 were run near the Lizard. By 27 May all equipment was operating and during the leg 208km of gravity lines, 133km of sidescan and 1553km of regional survey were run. A speed of 150 revs on one engine, ie approximately 6¼ knots was found to be the best speed in calm conditions.

The new 1978 Geomecanique hydrophone array, towed approximately 50m astern, was found to be more sensitive than the old one which was intermittently faulty. Multi-electrode sparker arrays were not used due to lack of penetration; the 9-candle sparker was run on all lines at 1000J. All but one line gave excellent records, penetrating generally to 250msec two-way time with good resolution. Over the shelf break the records showed deterioration below 2secs two-way time even using 3000J. The eastern lines on the Lizard sheet were poor to average due to reflector characteristics and structure.

The pinger gave no better than average records on all lines run, due partly to the sandy nature of the seabed.

The sidescan was used on three lines and operated best without the depressor which tended to tilt the fish down to starboard. Lack of cable limited the depth of towfish flight but the resolution was excellent though over only about 60m maximum range.

The water gun was run on all lines but two and gave good results on the shelf though bubble pulse interference tended to obscure reflectors. The best records were obtained on the shelf slope with a two second sweep at four knots. Records were poor below two seconds on the four second sweep. The slow firing rate of 15 seconds (due to the size of the compressor) gave compressed records.

The air gun gave poorer data than the water gun in water less than 500m deep due to the large bubble pulse, though in very deep water the air gun had greater penetration. It was used on only two lines with poor results on the shelf and good to average results on the slope to below 2secs, before deterioration.

The air gun and the water gun were towed on a wire rope from the port outrigger on the A-frame. A small air cable bight was used for the air gun with a larger one with a tail droque for the water gun.

The seismic recording/control system worked well. Some mistakes were made with filter/amplification setting and tapes 12 and 13 have no reference frequency due to substitution of the tape decks without the proper facilities.

The magnetometer was towed approximately 140m astern using the spare bottle, as the one used on the previous leg failed. Data were recorded on the 990 scale and plotted minus 40,000γ without any corrections, giving $\pm$10-20γ misties. No major anomalies were observed.

The LaCoste gravity meter gave a mean mistie of 1.5mGal for 27 crossovers which were inclusive of data affected by navigational errors at the shelf edge and lines 10 and 11 will have to be re-reduced after processing of navigation data.

The LaCoste appeared to be more sensitive to pitching than last year. A discrepancy between spring tension and total correction and gravity was seen and a strong correlation between the total correction and gravity traces was noted. The cross coupling amplifier was down for two lines and the Texas Instruments gravity pen was subject to sticking giving a juddering trace.

The Askania GSS-3 gravity meter gave a mean mistie of 1.9mGal and although it gave no sign of going non-linear the misties were consistently worse than the LaCoste meter.

There was no pattern to D.C. discrepancies between the meters which recorded up to $\pm$3mGal differences. Slow speeds on lines 14-16 inclusive gave poor GSS-3 records, possibly due to the ship yawing.

At the end of the leg a base check indicated that the Trinity Pier base value may have been 0.25mGal low while the previous value at West Wharf may have been 0.5mGal low. Subsequent base ties showed that the West Wharf value had been correct but time did not allow a reoccupation of the Trinity Pier base and the old value was used in the data reduction on board the ship. The data in table 3 are the base values as measured during the project with some necessary minor corrections applied using the old base value of 981115.0mGals for Trinity Pier.

Gross parity errors continued on both sat/nav tape decks, particularly deck 2 and recording was made on deck 1 only.

Further errors in write frequencies were later discovered. A programme halt was caused by recomputing an ERR-ITER satellite.

The doppler sonar worked well until off the edge of the Continental Shelf when the aft channel fault reoccurred, giving low doppler frequencies. Investigation rectified the problem though the port channel suffered from low gain. The water track logic was useless and the maximum depth of water track was not noticed. Manual speeds were used while the sonar fault was investigated and updates of up to 2½km occurred. There was insufficient accuracies in water track after repair to assess possible accuracies. Decca was not utilised.

In bottom track results were excellent after repair of the doppler sonar cable with a maximum on line update of 190m. Larger updates occurred after long satellite gaps. Little 150MHz noise was observed in the area and few ERR-iterations occurred.

LEG 2

Millbay-Millbay, 5-19 June 1978

Lines 22-45 inclusive were surveyed during this leg, a total distance of 1822km. The regional survey of the SW Approaches was extended and refraction experiments were conducted at two sites to compare sonobuoys and elucidate structure on an expected near surface high velocity layer. A third proposed

refraction site was cancelled due to lack of radio clearance for the operative buoys. The weather was generally good but deteriorated three days from the end of the leg necessitating working on seismic lines off the Lizard.

Forty cubic inch Bolt air guns were used as a seismic source in the refraction experiments, during which the anchored Bradley sonobuoys prove unusable. Ultra, disposable sonobuoys with free-floating hydrophones were used on all refraction lines and a high drift rate of up to 1km/hr was observed.

For site 1; 48° 45'N, 08° 54'W and site 3; 49° 35'N 07° 17'W a tentative interpretation was made on board the ship for a horizontally layered model using one unreversed line at each site. Estimates of the apparent P-wave velocity Vp and layer thicknesses z, are given below.

		Layer 1	Layer 2	Layer 3
Site 1 Vp	km/s	1.49	2.21	3.25
≠	m	168	760	-
Site 3 Vp	km/s	1.49	2.17	5.04
≠	m	125	390	-

The results are consistent with thin Tertiary over Cretaceous at site 1 and thin Tertiary over granite at site 3.

Two runs were made over the Eddystone gravity range on lines 22 and 45 and both meters generally agreed with the range values to within $\pm$1mGal.

In sea states of five and greater, the GSS-3 behaved poorly, reading higher than the LaCoste. On line 41 the GSS-3 was clamped for a short period after going non-linear, while on line 40 the S75 hit the 'stop' in moderate seas. On line 40 the meters disagreed by up to 2mGal although in calm seas the agreement between meters was generally about $\pm$1mGal. The mean crosstie for the LaCoste meter was 1.3mGal and 3.65 for the GSS-3, including line 40 data.

The LaCoste long axis gyro was changed after failure and the Texas Instruments recorder pens required constant attention.

The original magnetometer was used on lines 23-42 excluding lines 34, 35, 37 and 38 as the replacement was noisy. However, due to sparker interference the data were recorded on the 990 range for much of the time. Misties were $\pm$10-20γ generally and a general increase in total field values from SSW-NNE was seen with no major anomalies.

The parity problem on the sat/nav tape decks was resolved and both decks were used on this leg. Printout loss on the Silent 700 developed and worsened throughout the leg. Aeration caused occasional SNVAL-ERR as did reversal of engines on one refraction line. Water tracking occurred only between lines 25 and 26 when off the shelf, giving an update of over 1km, as no

manual speed was entered.

Some bunching of satellites continued and the average update of 50m worsened towards the end of the leg, when heavy seas affected the dead reckoning. Initially, almost all CC updates were positive, so the value of ABIA was changed from -0.4 to -0.2. Refraction lines 34, 35, 37 and 38 were run successfully in distance mode at 500m intervals.

An air gun was run with sparker and pinger for most lines as the water gun failed early and could not be repaired. The air gun records were good though obscured to some degree by the bubble pulse.

The sparker was generally good except in poor sea conditions at the end of the leg. Good resolution was obtained over the Haig Fras granite at depth and enabled steeply dipping Palaeozoic covered margins to be traced beneath a fairly thick Tertiary/Chalk cover. A second ?Palaeozoic anticlinal structure lying parallel to the SE of Haig Fras was also observed.

Traverses to the SW at refraction site no. 3 showed low dipping Tertiary cover at seabed and at 75-100msec below seabed a marked unconformity beneath which ?Eocene or Upper Cretaceous was gently folded with regular strong reflectors.

Geological interpretation on the Lizard sheet fits with the known geology with the exception of a small ?Tertiary down-

faulted basin noted on the previous leg.

LEG 3

Millbay-Millbay, 19-29 June

Due to very bad weather, survey work did not commence until Monday 26 June and only 623km of survey were completed on the seven lines, 46-52 inclusive.

The ship sailed at 1500GMT on 20 June but due to failure of the 700 teletype unit it was necessary to return on 21 June to pick up another teletype. The cruise was cut short by a further half day in order to return a ship's crew member for domestic reasons.

The sat/nav/doppler sonar performed well with the replacement silent 700 during the leg. Satellite bunching continued. Updates in good weather were of the order of AC, 60m and CC, 70m.

The magnetometer was used on lines 48-52 and gave good quality data except for noisy connectors on line 50. Crossovers averaged $\pm$30γ and total field values on the outer part of the shelf show broad, low amplitude anomalies of about 300γ superimposed on the overall northsouth gradient.

The air gun and sparker were run on all lines excepting lines 46 and 47 and operated well. The air gun results were good

though the sparker results were not as meaningul due to geological conditions.

A succession of confused complex beds showing channeling and unconformities of about 60-80m thickness was seen to lie unconformably on well bedded, gently folded, mid Tertiary strata of at least 200m thickness. The upper unit, probably Pleistocene, thickens towards the shelf edge and is overlain by occasional sandbanks with well defined internal structures.

Both gravity meters were run on all lines. The LaCoste meter showed agreement to $\pm$3mGal with the Eddystone range on line 46 and $\pm$1mGal agreement on line 47 with a $\pm$1.67mGal average mistie in its data for the survey area.

The LaCoste meter behaved well after being fitted with a replacement spring tension shaft encoder at the start of the leg and the only problem was a minor fault on the shaft encoder interface, printed circuit board.

The GSS-3 read up to 5mGal at variance with the LaCoste meter on the gravity ranges and as on the previous legs exhibited a steplike trace in relatively calm seas, a DC shift with respect to the LaCoste and a tendency to go non-linear at $\pm$15,000mGal. The data collected with the GSS-3 gave a mean mistie of 3.95mGal and discrepancies of up to $\pm$5mGal between meters was observed.

On taking a manual base reading with the LaCoste meter at the end of the leg a change of approximately 1mGal in the gravity trace occurred when switching from the four minute to the two minute filter and a 1mGal discrepancy was noted between spring tension plus total correction and gravity in static conditions. The base tie was made with the 4 minute filter on.

LEG 4

Millbay-Millbay, 30 June-13 July 1978

This, the final leg of the regional survey, was extended by two days and as it was not possible to complete the planned grid, alternate line coverage in the NW-SE direction was obtained with full coverage in the NE-SW direction. During this leg 2097km were run at a speed of 5-7knots on lines 53-70 inclusive except in poor sea conditions.

The weather was generally good although one day was lost due to poor weather.

The printing problem occurred again on the reinstalled Silent 700 teletype and appeared to be caused by thermal conditions.

The doppler sonar thermister was damaged and a resistor was inserted giving a constant value of 1495.6m/sec for the velocity of sound in water. A power failure of momentary

duration caused the sat/nav programme to fail, necessitating reloading. ABIA was not affected by the removal and replacement of the transducer at the start of the leg while TADJ which had been 1.024 previously with the thermister in, gave 1.030 during the passage from Plymouth to the survey area, 1.036 in the western survey area and 1.032 in the northern survey area (thermister out) reflecting changes in temperature and salinity.

The water track logic worked only randomly in very deep water, although in water deeper than 300m the sonar tracked the water mass efficiently. Updates were generally less than 100m in bottom lock except when there was a satellite blank period. In water track, updates of over 1km were common. Decca Chain 1B red and green channels were recorded.

The seismic system worked well and the sparker and air gun were run on all lines. Penetration by the air gun was 200-300msec two-way time although the bubble pulse again tended to obscure reflectors.

The sparker penetrated to 100-200msec two-way time and showed evidence of faulting in marginal blocks at the shelf edge, although resolution was poor at depths greater than 1500m.

The magnetometer was run on lines 53-70 and due to noise, data from lines 58, 61 and 62 were unacceptable. Misties were generally small but were up to $\pm$80γ with data from the previous legs. Field characteristics were as before with a local

anomaly of 400ɣ at 48°40'N 9°20'W.

The GSS-3 was adversely affected by the prevalent long period swell and the nonlinearities appeared to correlate with large, horizontal accelerations as measured on the LaCoste platform monitor.

DC shifts between the meters of greater than 1mGal were observed on all but three lines.

The mean mistie for the GSS-3 was 3.79mGal, with a mistie of 3.90mGal for the overall survey.

The LaCoste meter performed well, although the discrepancy between spring tension plus total correction and gravity continued. After a power failure caused by the UPS system the meter was put back into operation quickly and a mean mistie of 1.42mGal from 133 crossovers was obtained. Overall, the mean mistie was $\pm$1.48mGal including data affected by navigational inaccuracies at the shelf edge.

Equipment performance summary

During the project the equipment listed in table 2 was carried. Delays were kept to a minimum and the main equipment faults are listed below for each piece of equipment.

LaCoste and Romberg gravity meter S75

The major problems were a faulty long axis gyro on leg 2 and the replacement of a spring tension shaft encoder which was removed at the end of leg 1. A slight discrepancy of approximately 1mGal between total correction plus spring tension and gravity continued for all of this project. During leg 1 the external functional test unit failed then, on leg 2 vibration gave slight problems and the platform 'stop' was resited after being caught by the oil damper in moderate seas. The 9400 data logging system, "time set-up" gave slight problems and on leg 3 a replacement shaft encoder, interface, printed circuit board was fitted, rectifying a 9400 logger print problem.

Askania GSS 3

Checks by a Brown engineer during mobilisation revealed bared wires but failed to fix problems observed previously during the season and on leg 2 it was observed that the trace seemed to step when the ship went into a nose down position. Gear drives were cleaned and further checks were made by an engineer but no improvement in performance of the system was obtained throughout this project.

Barringer magnetometer

On leg 1 a cable and screening unit were replaced due to ruptured bellows. Both bottles were operational on leg 2.

The electronics unit in use was noisy at times while the spare unit was excessively noisy. On leg 4 two faulty bottle cables were remade after breakdown of the insulation on one and pitting of the other by the sparker.

Power supplies

Generators

The generators were reliable although there was some surging which was associated with the offload condition of the UPS. The number 1 generator which was powering the compressor and sparker containers failed on leg 2 due to low levels of lube oil, after which there were no problems.

Uninterruptable power supply

On leg 1 the UPS caused the GSS-3 platform to shut down after a short circuit on the data logger. It was operated in the invertor mode only during leg 2 while the batteries were serviced. It tripped out towards the end of leg 4 for some unknown reason and affected the LaCoste meter, the sat/nav and corrupted the data logger printout.

Decca data logger

This unit failed on leg 1 when the power supply unit in the logic drawer short circuited. A malfunction of the automatic deck changeover which occurred at this time extended throughout the project. Some corruption of data was caused by failure of the parity board connected with the printer output

and the red lane counting did not change in the correct sequence.

During leg 2 minor problems occurred with the tape transports while on leg 4 a couple of minor problems were rectified and no RAW output was obtained from deck two.

Satnav/doppler sonar

On leg 1, parity errors on the tape decks were investigated and traced to incorrect speed settings.

When the doppler sonar tracked water it was noticed that the water track flag to the computer was not raised and this fault continued throughout the project. Poor aft channel signal returns were traced to the misrouting of a +13.5V connector which fed the preamplifiers in the transducer and were rectified, after which the port channel was found to be noisy. At the end of leg 3 the doppler sonar was retracted to enable a new preamplifier to be fitted. During this the thermister was damaged beyond repair and a new resistor giving an appropriate constant speed of sound in water was inserted.

A number of problems occurred with the Silent 700 teletype. On leg 2, the plug at the rear was broken, causing intermittent misprinting of data and at the beginning of leg 3 the teletype failed and was replaced. However, the intermittent misprinting

of characters observed on leg 2 occurred again on leg 4 and appeared to be a thermal problem.

Seismic systems

Hydrophones

The new Geomecanique array gave occasional intermittent problems which indicated a cable fault, though investigations of array connections proved negative. The old array was useable but had a tendency to saturate. Both hydrophones performed well on the last legs until late in leg 4 when the new 1978 hydrophone gave low outputs. This was overcome by replacing the batteries but the problem reoccurred two days later.

Sparkers

These systems operated well on all legs with only minor adjustments and component changes.

Water guns

These operated well on tests during leg 1 and on leg 2 until a failure occurred. The gun could not be dismantled due to incorrect spares in manufacturer's kit and was not used after that time.

Air gun

This operated well except for approximately two days downtime during leg 2, due to misassembly of both heads. On recovery at the end of leg 4, the towing wire was badly frayed although

servicing two days previously had not revealed any cable faults.

Compressor

Performed well after initial rewiring of the electrical motor. A cooling system failure occurred on leg 2 when the electrical trip operated, but was found before mechanical failure occurred.

Seismic recording and control system

Performed well though debugging continued during legs 1 and 2. Failure of a mains input transformer necessitated removal of a Racal store 4 recorder on leg 1 and some difficulties with dual operation occurred during leg 2 when further modification to pulse and trigger control units was necessary. After this, using channels one and three in the forward mode, operations were satisfactory.

Sidescan

The sidescan operated well on leg 1 although the results were unsatisfactory due to the depth of water and lack of sufficient faired cable.

Atlas Deso 10 and Edig 10

Some components were changed after Edig failure on leg 1 and the equipment was reset. Both operated well in shallow water though the Edig dropped out at approximately 250m depth on leg 4.

Pinger

The pinger failed on the final day of leg 1 when excessive noise was observed. All the insulating standoffs on the booster power unit had sheared though when this unit was removed the fault persisted until an in port check when the fault disappeared. The pinger was not run on leg 3 and despite mechanical repairs to the booster at the start of leg 4, the original noise was still seen with the tail end of the transmission apparently swamping the incoming returns.

EPC recorders

Apart from 5v supply problems with the spare recorder and minor problems on leg 4, these units worked well.

Sonobuoys

The Bradley buoy system failed and no useable results were obtained with them. The Ultra buoys worked well.

CONCLUSIONS

A successful project during which, despite the periods of bad weather, a total of 6436km of survey data were obtained, consisting of 31km of refraction data only, 133km of sidescan and gravity data, 300km of gravity data only and 5972km of regional, gravity, shallow seismic and magnetic data. Various pieces of new equipment were tested and a modified survey grid

was completed leaving a number of lines to be infilled in succeeding years while providing sufficient data for a geological interpretation of the area.

TABLE 1

PERSONNEL ON PROJECT 78/04

Leg 1
22 May-5 June. Stage 2 Mobilisation - Regional Survey
Millbay-Millbay, Plymouth

A S Mould	Senior Scientist	IGS MGU
J Donato		
S Deegan		
P Western		
P R Roberts		
A D Wilson		
K Dimitropoulos	Observer Edinburgh Univ./NERC studentship at MGU.	
D Tappin	Geologist	CSSU
P Armitage		IOS MSES Barry
J Strangeward		

Leg 2
5 June-19 June. Millbay-Millbay

A Dobinson	Senior Scientist	IGS MGU
D K Smythe		
M Glen		
A K Rochester		
P R Roberts		
A Oliver		
G K Scott		IGS CSSU
M Wilson	Glasgow Univ/NERC studentship at MGU	
R Cumberland	Glasgow Univ. research assistant	
J Strangeward		IOS MSES Barry
C Paulson		

Leg 3
19 June-29 June. Millbay-Millbay, regional

R A Floyd	Senior Scientist	IGS MGU
M C Tully		
E J Armstrong		
J Bulat		
S D Spencer		
A J Davies		
A Oliver		
M Davis		
C Evans		CSSU Leeds
K Robertson		IOS MSES Barry
P Walters		

Leg 4
29 June-13 July. Millbay-Millbay, regional

A Dobinson	Senior Scientist	IGS MGU
A S Mould		
D Ham		
E J Armstrong		
P Mulholland		
A D Wilson		
W Martindale		CSSU Leeds
K Smith		IOS MSES Barry
A Cummings		

LINE SUMMARY

TABLE 2

Line No.	Fix Nos.	START		END		Line Length Km.	Main Nav. Aid	EQUIPMENT USED									
		Day	Time	Day	Time			Echo Sounder	Magnet-ometer	Data Logger	L R S75 / 9400	Askania GSS3	Pinger	Sparker	Airgun	Water-gun	Side-scan
001	1 – 12	144	22:20	145	23:15	18	SATNAV/ DOPPLER SONAR	ATLAS		IGS/DECCA	✓ / ✓	✓					
002	1 – 18	145	00:40	145	03:30	65	"	✓		✓	✓ / ✓	✓					
003	1 – 19	145	03:50	145	06:50	54	"	✓		✓	✓ / ✓	✓					
004	1 – 11	145	08:50	145	10:30	31	"	✓		✓	✓ / ✓	✓	✓				
005	1 – 13	145	11:20	145	13:20	40	"	✓		✓	✓ / ✓	✓	✓				
006	1 – 35	146	03:35	146	09:15	62	"	✓		✓	✓ / ✓	✓	✓	1KJ ✓ 9-CANDLE	BOLT ✓		
007	1 – 31	146	23:50	147	04:50	61	"	✓		✓	✓ / ✓	✓	✓	✓		SQUEEGE ✓	
008	1 – 44	147	05:45	147	12:55	78	"	✓		✓	✓ / ✓	✓	✓	✓		✓	
009	1 – 155	147	16:20	148	18:00	295	"	✓	✓	✓	✓ / ✓	✓	✓	✓		✓	
010	1 – 73	149	04:40	149	16:40	121	"	✓	✓	✓	✓ / ✓	✓	✓	✓		✓	
011	1 – 61	149	21:00	150	07:00	111	"	✓	✓	✓	✓ / ✓	✓	✓	✓	✓		
012	1 – 158	150	12:30	151	14:40	305	"	✓	✓	✓	✓ / ✓	✓	✓	3KJ/1KJ 9-CANDLE		✓	
013	1 – 111	151	17:15	152	11:35	192	"	✓	✓	✓	✓ / ✓	✓	✓	1KJ ✓	✓		
014	1 – 47	152	17:30	153	01:10	58	"	✓		✓	✓ / ✓	✓	✓				✓
015	1 – 37	153	03:20	153	09:20	55	"	✓		✓	✓ / ✓	✓	✓				✓
016	1 – 17	153	10:25	153	13:05	20	"	✓		✓	✓ / ✓	✓	✓				✓
017	1 – 51	153	16:00	154	00:20	88	"	✓	✓	✓	✓ / ✓	✓	✓	1KJ 9-CANDLE		✓	
018	1 – 27	154	01:00	154	05:20	49	"	✓	✓	✓	✓ / ✓	✓	✓	✓		✓	
019	1 – 14	154	08:25	154	10:35	28	"	✓	✓	✓	✓ / ✓	✓	✓	✓		✓	
020	1 – 46	155	00:40	155	08:10	88	"	✓	✓	✓	✓ / ✓	✓	✓	✓		✓	
021	1 – 60	155	09:30	155	19:20	75	"	✓	✓	✓	✓ / ✓	✓	✓	✓		✓	
022	1 – 24	157	18:35	157	20:30	23	"	✓		✓	✓ / ✓	✓	✓		"		
023	1 – 30	158	03:10	158	08:00	51	"	✓	✓	✓	✓ / ✓	✓	✓	✓		✓	
024	1 – 123	158	12:00	159	08:20	207	"	✓	✓	✓	✓ / ✓	✓	✓	✓		✓	
025	1 – 101	159	21:20	160	14:00	205	"	✓	✓	✓	✓ / ✓	✓	✓	✓	✓	•	

LINE SUMMARY

TABLE 2

Line No.	Fix Nos.	START		END		Line Length Km	Main Nav Aid	EQUIPMENT USED									
		Day	Time	Day	Time			Echo Sounder	Magnet-ometer	Data Logger	L R S75 / 9400	Askania GSS3	Pinger	Sparker	Airgun	Water-gun	Sidé-scan
026	1-108	160	17:10	161	11:00	190	SATNAV/ DOP. SONAR	✓	✓	✓	✓ ✓	✓	✓	1KJ EQUIP PART			
027	1-57	161	17:00	162	02:30	91	"	✓	✓	✓	✓ ✓	✓	✓	✓			
028	1-39	162	04:10	162	10:30	72	"	✓	✓	✓	✓ ✓	✓	✓	✓			
029	1-39	162	14:00	162	20:20	73	"	✓	✓	✓	✓ ✓	✓	✓	✓			
030	1-29	162	21:00	163	01:40	44	"	✓	✓	✓	✓ ✓	✓	✓	✓			
031	1-49	163	04:10	163	12:10	86	"	✓	✓	✓	✓ ✓	✓	✓	✓	PART ✓		
032	1-49	163	14:10	163	22:10	82	"	✓	✓	✓	✓ ✓	✓	✓	✓	✓		
033	1-55	164	00:00	164	09:00	79	"	✓	✓	✓	✓ ✓	✓	✓	✓	✓		
034	1-20	164	14:38	164	15:26	9	"	✓		REFRACTION ULTRA BOUYS					✓		
035	1-18	164	15:55	164	16:54	9	"	✓		SONO BOUYS					✓		
036	1-57	164	23:20	165	08:40	92	"	✓	✓	D/L ✓	✓ ✓	✓	✓	✓	✓		
037	1-15	165	19:25	165	20:21	7	"	✓		SONO BOUY					✓		
038	1-13	165	22:01	165	22:38	6	"	✓		SONO BOUY					✓		
039	1-68	166	00:30	166	11:40	74	"	✓	✓	D/L ✓	✓ ✓	✓	✓	1KJ ✓ / 3KJ	✓		
040	1-74	166	14:00	167	02:10	134	"	✓	✓	✓	✓ ✓	✓	✓	✓ 3KJ	✓		
041	1-79	167	05:10	167	18:10	92	"	✓	✓	✓	✓ ✓	PART	PART	✓ 3KJ	PART		
042	1-34	168	11:30	168	17:00	60	"	✓		✓	✓ ✓	✓		✓ 1KJ			
043	1-25	168	19:10	168	23:10	42	"	✓		✓	✓ ✓	✓		✓			
044	1-50	169	02:20	169	10:30	73	"	✓		✓	✓ ✓	✓		✓			
045	1-15	169	13:10	169	14:20	21	"	✓		✓	✓ ✓	✓					
046	1-15	171	16:15	171	17:25	22	"	✓		✓	✓ ✓	✓					
047	1-17	172	13:40	172	15:00	26	"	✓		✓	✓ ✓						
048	1-81	177	00:50	177	14:10	139	"	✓	✓	✓	✓ ✓	✓		1KJ EQUIP / 1KJ MESS	✓		
049	1-61	177	16:40	178	02:40	120	"	✓	✓	✓	✓ ✓	✓		1KJ MESS	✓		
050	1-69	178	04:40	178	16:00	105	"	✓	✓	✓	✓ ✓	✓		✓	✓	•	

LINE SUMMARY

TABLE 2

Line No.	Fix Nos.	START		END		Line Length Km	Main Nav Aid	EQUIPMENT USED									
		Day	Time	Day	Time			Echo Sounder	Magnet-ometer	Data Logger	LR S75 / 9400	Askania GSS3	Pinger	Sparker	Airgun	Water-gun	Sidé-scan
051	1-53	178	18:00	179	02:40	103	SATNAV/ DOPBONDA	✓	✓	✓	✓ ✓	✓		✓	✓		
052	1-59	179	04:40	179	14:20	108	"	✓	✓	✓	✓ ✓	✓		✓	✓		
053	1-188	182	10:20	183	17:30	315	"	✓	✓	✓	✓ ✓	✓		✓	✓		
054	1-69	183	20:50	184	08:10	106	"	✓	✓	✓	✓ ✓	✓		✓	✓		
055	1-30	184	10:50	184	15:40	54	"	✓	✓	✓	✓ ✓	✓		✓	✓		
056	1-69	184	20:50	185	07:40	107	"	✓	✓	✓	✓ ✓	✓		✓	✓		
057	1-41	186	11:30	186	18:10	71	"	✓	✓	✓	✓ ✓	✓		✓	✓		
058	1-53	186	19:50	187	04:30	94	"	✓	U/S ✓	✓	✓ ✓	✓		✓	✓		
059	1-86	187	06:30	187	20:40	161	"	✓	✓	✓	✓ ✓	✓		✓	✓		
060	1-94	187	22:40	188	14:10	154	"	✓	noisy ✓	✓	✓ ✓	✓		✓	✓		
061	1-79	188	16:30	189	05:30	148	"	✓	U/S ✓	✓	✓ ✓	✓		✓	✓		
062	1-34	189	10:10	189	15:40	62	"	✓	U/S ✓	✓	✓ ✓	✓		✓	✓		
063	1-73	189	19:00	190	07:00	139	"	✓	✓	✓	✓ ✓	✓		✓	✓		
064	1-65	190	10:30	190	21:10	136	"	✓	✓	✓	✓ ✓	✓		✓	✓		
065	1-28	190	22:30	191	03:00	56	"	✓	✓	✓	✓ ✓	✓		✓	✓		
066	1-29	191	04:10	191	08:50	64	"	✓	✓	✓	✓ ✓	✓		✓	✓		
067	1-39	191	11:50	191	18:10	75	"	✓	✓	✓	✓ ✓	✓		✓	✓		
068	1-70	191	23:40	192	11:10	126	"	✓	✓	✓	✓ ✓	✓		✓	✓		
069	1-75	192	14:50	193	03:10	140	"	✓	✓	✓	✓ ✓	✓		✓	✓		
070	1-49	193	05:30	193	13:30	89	"	✓	✓	✓	✓ ✓	✓		✓	✓		

GRAVITY BASE TIES

TABLE 3

Day	Base	g at Harbour Base +	mGal diff to dock	F.A. corrn to M.S.L. +	g_{corr} +	Meter reading corrected for tidal effects		$\Delta M_c \times C.F$ +		Δg_{corr} +	Drift +	
						S 75	GSS3	S 75	GSS3		S75	GSS3
144 24/5/78	SOUTH WEST WHARF MILLBAY	981115·0	−0·16	+1·5	981116·3	11903·8	3331·4	0·0	+1·1	DAY 144 − 142 0·0	0·0	+1·1
156 5/6/78	TRINITY PIER MILLBAY	981115·0	—	+1·4	981116·4	11904·6	3329·6	+0·8	−1·7	156 − 144 +0·1	+0·7	−1·8
157 6/6/78	TRINITY PIER	981115·0	—	+1·3	981116·3	11905·3	3330·2	+0·7	+0·6	157 − 156 −0·1	+0·8	+0·7
170 19/6/78	NORTH WEST WHARF	981115·0	+0·2	+1·3	981116·5	11906·5	3328·5	+0·2	−1·6	170 − 157 +0·2	0·0	−1·8
171 20/6/78	NORTH WEST WHARF	981115·0	+0·2	+1·3	981116·5	11906·4	3330·4	+0·9	+1·8	171 − 170 0	+0·9	+1·8
171 20/6/78	NORTH WEST WHARF	981115·0	+0·2	+1·2	981116·4	11906·4	3330·0	0·0	−0·4	171 − 171 −0·1	+0·1	−0·3
172 21/6/78	NORTH WEST WHARF	981115·0	+0·2	+1·3	981116·5	11907·2	3329·1	+0·8	−0·9	172 − 171 +0·1	+0·7	−1·0
180 29/6/78	NORTH WEST WHARF	981115·0	+0·2	+1·2	981116·4	11907·6	3329·9	+0·4	+0·8	180 − 172 −0·1	+0·5	+0·9
181 30/6/78	NORTH WEST WHARF	981115·0	+0·2	+1·2	981116·4	11907·6	3329·9	0·0	0·0	181 − 180 0·0	0·0	0·0
194 13/7/78	SOUTH WEST WHARF	981115·0	−0·1	+1·3	981116·2	11908·1	3330·4	+0·5	+0·5	194 − 181 −0·2	+0·7	+0·7

+ All readings in mGal.
C.F = calibration factor

M_c = change in corrd meter rdgs.
g_{corr} = " " " base " .

TABLE 4

EQUIPMENT CARRIED

1.1 LaCoste and Romberg air-sea gravity meter S75.

1.2 LaCoste and Romberg 9400 data acquisition system.

2. Askania GSS-3 gravity meter.

3. Two Barringer magnetometers.

4. Edo Western pinger with hull mounted transducers.

5. Klein sidescan sonar and associated winch.

6. Atlas Deso 10 echo sounder with hull mounted transducer and digital readout unit (EDIG 10).

7. Seismic system:

(i) Bolt 40cu.in. air gun (200B).

(ii) Multi-element sparker array (IGS).

(iii) EG & G 9 element sparker array.

(iv) Sodera water gun 80 cu.in.

(v) 2 x 30m Geomecanique hydrophones.

(vi) Reavell SAT6H compressor.

(vii) EG & G trigger, power and capacitor units.

(viii) EPC graphic recorders (4100 and 4600).

(ix) Analogue tape and control system.

(x) Ultra sonobuoys.

(xi) Bradley sonobuoys.

8. Magnavox satellite navigation system integrated with MX610 doppler sonar.

9. Decca MK21 main chain receiver.

10. Decca data logger.

11. Three 60KVA generators.

12. Stabilised no break power supply system (UPS).

INSTITUTE OF GEOLOGICAL SCIENCES

MARINE GEOPHYSICS UNIT

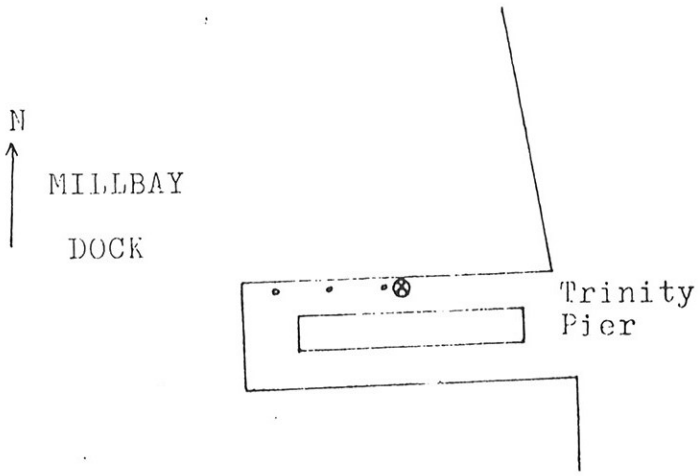
GRAVITY BASE STATION

STATION NAME: DEVONPORT, Trinity Pier, Devon. NO.(if any):

SITE DESCRIPTION:

Half way along northern side of Trinity Pier beside third small bollard from western end of pier.

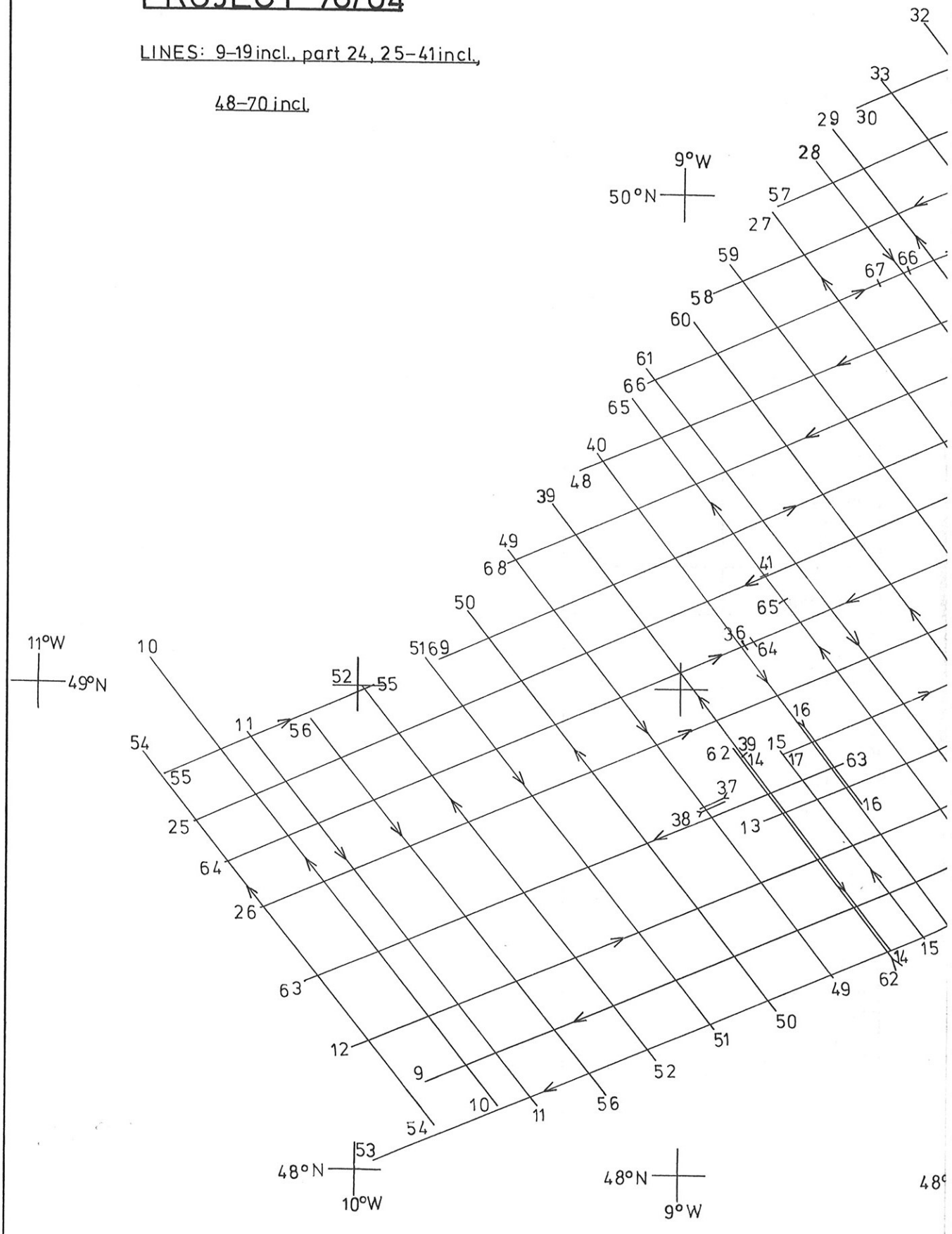
STATION REFERENCE NO.	
LATITUDE	50°21'50"N
LONGITUDE	04°09'07"W
HEIGHT	
$g_{obs.} - g_{P.H.}$	
GEOLOGY	
BOUGUER ANOMALY $\rho =$	
BOUGUER ANOMALY $\rho =$	
FREE AIR ANOMALY	
TERRAIN CORRECTION	
METER NO.	G427 W470
OBSERVER	Hydrog. D. HoD
DATE	1974
FIELD SHEET NO.	
E (IGSN'71 / NGRH'73)	981,115.0



PROJECT 78/04

LINES: 9–19 incl., part 24, 25–41 incl.,

48–70 incl.



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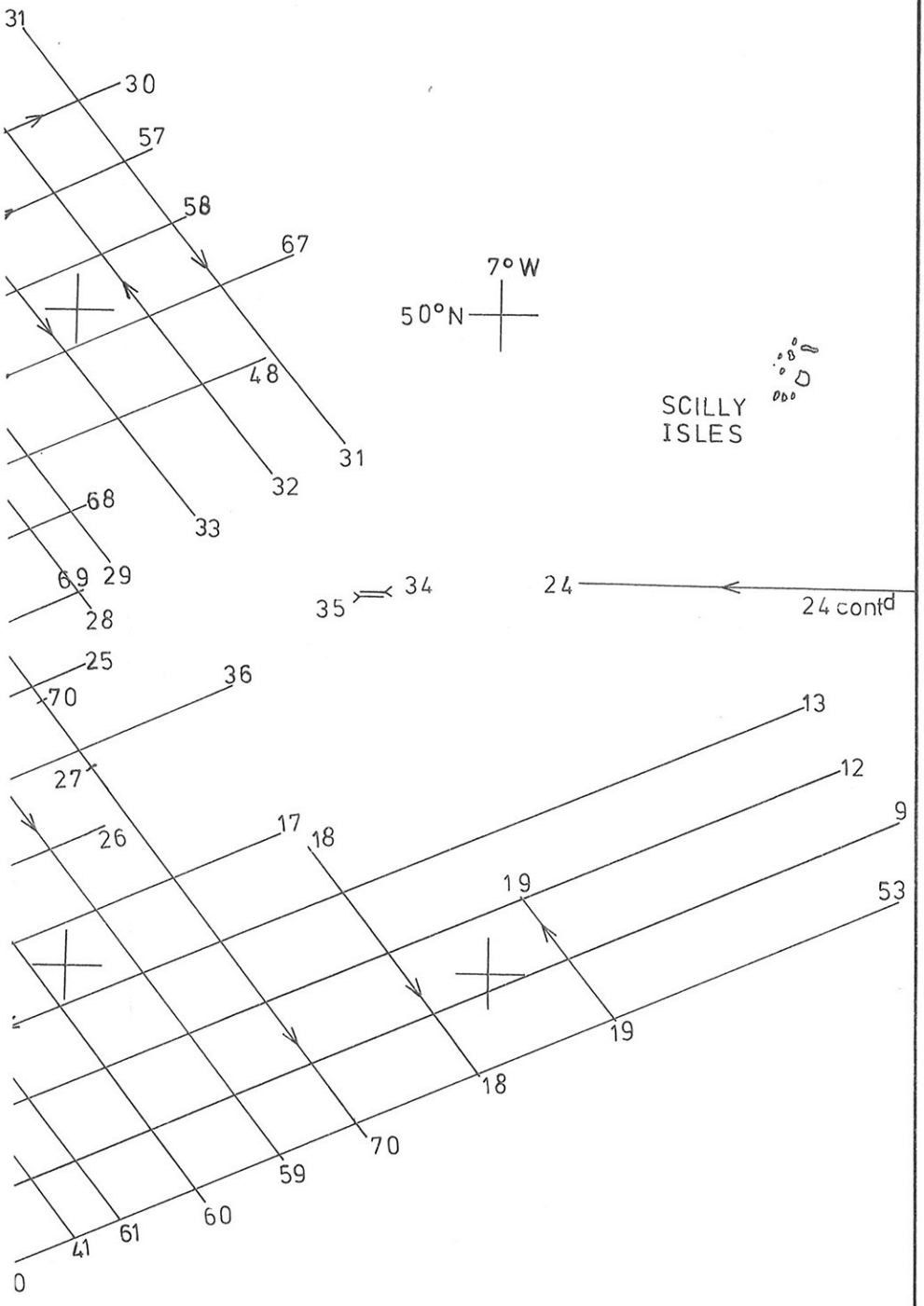
Line Diagram, Figure 1(a)



10 0 10 20 KILOMETRES

10 0 10 20 STATUTE MILES

10 0 10 20 NAUT. MILES

8°W

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Line Diagram, Figure 1(b)