NATURAL ENVIRONMENT RESEARCH COUNCIL

INSTITUTE OF GEOLOGICAL SCIENCES

CONTINENTAL SHELF DIVISION

MGU

Report No. 105

Cruise Report on Project 80/03
A Regional Geophysical Survey in
the northern North Sea

Edited by

C P Brett

M. I. A. S.
25 FEB 1981
(WORMLEY)

Institute of Geological Sciences
Marine Geophysics Unit
Murchison House
West Mains Road
Edinburgh EH9 3LA
031 667 1000

Institute of Geological Sciences
Continental Shelf Division
Marine Geophysics Unit

Report No. 105

Cruise Report on Project 80/03 A Regional Geophysical Survey in the northern North Sea

Edited by

C P Brett

Murchison House
West Mains Road
Edinburgh EH9 3LA

December 1980

CONTENTS

PREFACE

1980 Geophysical survey - overall cruise summary

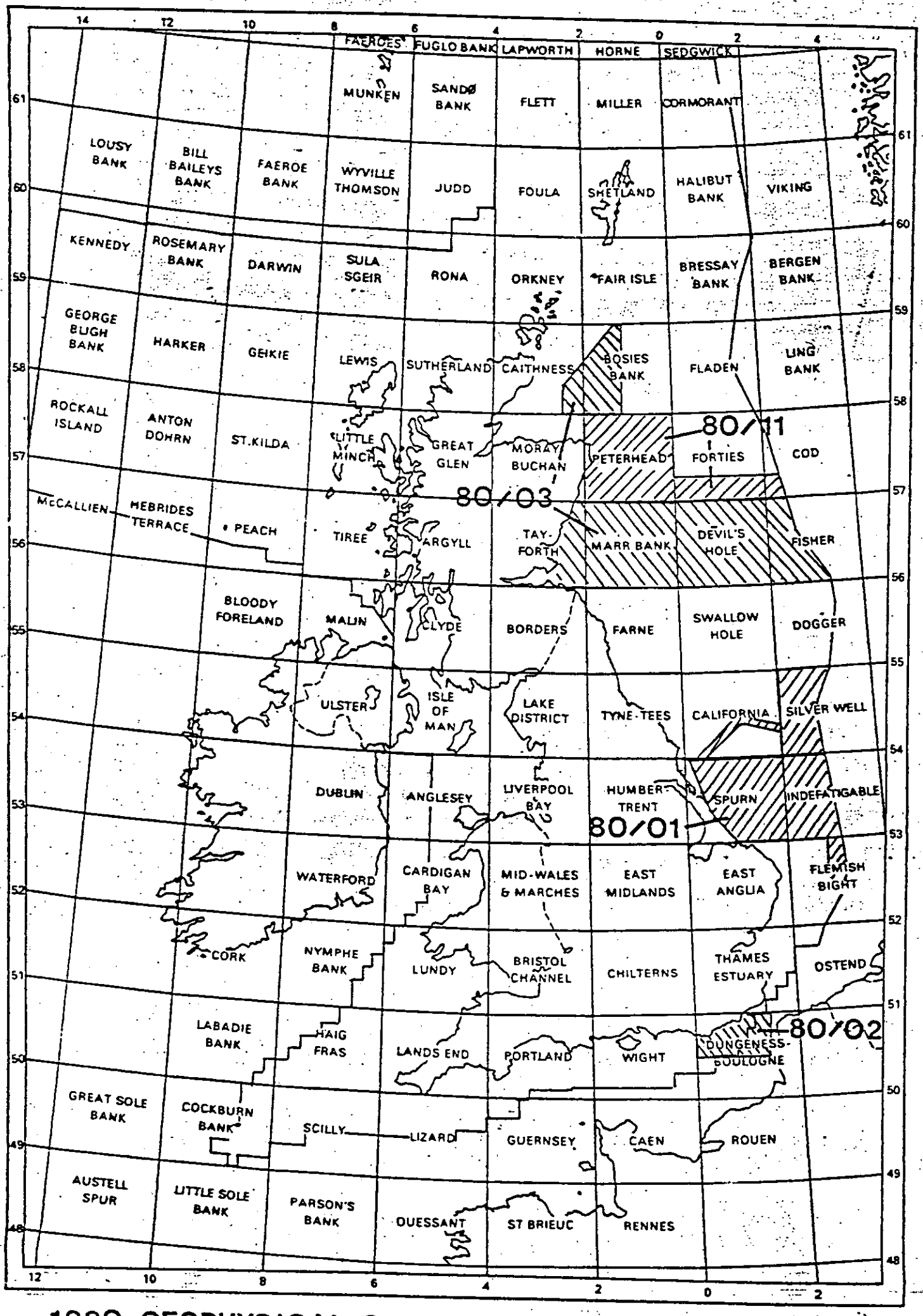
The 1980 geophysical survey programme was divided into eleven legs, comprising four projects, as follows:

	Dates	Project No.	Area	Port
Mobilisation	9 Apr-20 Apr	-	-	South Shields
Leg 1 (80/01 PART I)	21 Apr-6 May	80/01	S. North Sea	Hull
Leg 2 (80/01 PART I)	7 May-20 May	80/01	S. North Sea	Gt Yarmouth
Leg 3 (80/01 PART I)	22 May-4 June	80/01	S. North Sea	Gt Yarmouth
Leg 4 80/02	6 June-17 June	80/02	English Channel	Gt Yarmouth
Leg 5 80/01 PART2	19 June-30 June	80/01	S. North Sea	Sunderland
Maintenance period	30 June-4 July	-	-	Sunderland
Leg 6 (80/03)	5 July-16 July	80/03	N. North Sea	Dundee
Leg 7 (80/03)	19 July-30 July	80/03	N. North Sea	Dundee
Leg 8 (80/03)	31 July-13 Aug	80/03	N. North Sea	Dundee
Leg 9 (80/03)	15 Aug-26 Aug	80/03	N. North Sea	Dundee
Leg 10 (80/03)	28 Aug-8 Sept	80/03	N. North Sea	Dundee
Leg 11 80/11	10 Sept-22 Sept	80/11	N. North Sea	South Shields

Projects 80/01, 80/02 and 80/03 were full regional surveys utilising multi-system seismics together with gravity and magnetics. Project 80/11 consisted only of gravity and magnetic surveying.

Project 80/03 described here is one of four geophysical survey projects conducted onboard RRS Shackleton in 1980. Similar reports for other projects are listed below:

Project 80/01	Report No. 103
Project 80/02	Report No. 104
Project 80/11	Report No. 106



1980 GEOPHYSICAL SURVEY AREAS

INTRODUCTION

This report covers the operation of Project 80/03, a regional geophysical survey in the northern North Sea.

The primary objective was to complete a 15km grid between latitudes 56° and 57°N from the Scottish coast to the median line, covering the Tay-Forth, Marr Bank, Devil's Hole and Fisher sheets of the IGS 1:250,000 map series. Secondary objectives were to survey along the track of a digital sparker line in the Fisher/Forties area which had been shot for IGS earlier in the year by Gardline Surveys Ltd and to clarify earlier geophysical work (Project 79/15, Report No. 101) in the Bosies Bank/Caithness area.

The vessel used was the NERC research ship RRS Shackleton which has an overall length of 61m, beam of 11m, draught of 4.4m and displacement of 1658 tons.

Geophysical methods employed were shallow seismic (sparker, airgun and water-gun), high resolution seismic (pinger and boomer), side-scan sonar, gravity and magnetics.

The senior scientist, geophysical, geological, navigation and technical reports produced for each leg of the survey, summary lists and log sheets on which this report is based are held on open file in the Marine Geophysics Unit, Institute of Geological Sciences, Murchison House, West Mains Road, Edinburgh. The authors of the reports for each leg are given in Table 1.

Excellent co-operation was received from the Master, Officers and Crew of Shackleton throughout the cruise and a total of 7381km were surveyed during the 65 days dedicated to this project.

NARRATIVE

Leg 6

5-16 July: Sunderland-Dundee

After a five-day mid-season refit period the vessel sailed from Sunderland on 5 July. Two days were spent testing equipment and calibrating the dead-reckoning input to the satellite navigation system whilst sailing north to the survey area. Thereafter lines 1-11 inclusive, totalling 1114km were completed with two breaks for poor weather, the second cutting short the leg with no useful data acquired after 14 July.

During the refit the deep tow boomer winch was moved to the foredeck, the boomer being towed from an A-frame on the starboard side. This permitted simultaneous towing of the Huntec boomer and side-scan sonar. Unfortunately, the towing sheave which had been fabricated for the boomer proved unsatisfactory and it was landed at Leith on 7 July to undergo modification. Whilst in the Firth of Forth the opportunity was taken to run lines over the Forth test range using a single $10in^3$ airgun and a combination of a $10in^3$ and $40in^3$ airgun. The single $10in^3$ gun produced a less dominant bubble pulse. Survey then commenced using a $10in^3$ airgun, 1kj multielectrode sparker, Edo Western pinger, UDI side-scan sonar, MS47 transit sonar, echo sounder, gravimeter and magnetometer. The first spell of poor weather forced the vessel back into the Forth on 9 July when the modified boomer sheave was collected and a further line over the Forth test range was carried out using the Sodera $80in^3$ watergun. Due to the absence of a bubble pulse from the watergun this was selected as the deeper penetration seismic source for the remainder of the leg. The modified boomer sheave proved successful but unfortunately, after a short time in use the boomer transducer plate cracked and the assembly was replaced with the spare. Thus the boomer was not used until line 9, thereafter giving records superior to the Edo pinger, the ringing having less effect in the deeper water. It proved impossible to trim the fish completely.

During the refit period the doppler sonar head was changed from the MX600 to the MX610 and the navigation equipment mounting plynth in the laboratory was replaced, causing the gyrocompass to be moved. This necessitated the recalibration of the system which was completed without incident over the first few days. Thereafter

satellite distribution was good and post processing navigational accuracy is estimated to be within 150m.

The gravity meter operated well, though the cross gyro was somewhat noisy, the results being good but with few cross-overs. Agreement with previous surveys was good apart from the latter part of line 11, where the results were approximately 4mGal lower.

The limited data acquired on this leg established a pattern of easterly younging rocks with a thick, complex Quaternary sequence in the east.

Leg 7

19-30 July: Dundee-Dundee

The vessel sailed from Dundee on 19 July after a twelve hour delay caused by the failure of both sparker generators during in port checks. Lines 12-22 inclusive, totalling 1744km were surveyed with one interruption of 24 hours (20-21 July) for poor weather.

The equipment configuration was largely the same as during leg 6, the only exception being the use of a $10in^3$ airgun instead of the Sodera watergun on most lines. Over the first few days the Huntec boomer fish was finely trimmed during traverses between lines. As this was carried out it was found that the pitch and roll meters had been indicating with reversed polarity. Thereafter the boomer records were very good and operation of the Edo Western pinger was suspended after line 17. Seismic record quality was good throughout the leg and reflectors down to 500msec were resolved with the sparker and to 1sec with the airgun.

Satellite coverage was generally good throughout, it being very rare to have a gap of more than two hours between updated fixes. Post-processing navigational accuracy is again estimated to be within 150m.

Gravity results were again good and over the first two legs of this survey a mean crosstie of 0.5mGal is obtained based on 40 crossovers.

Seismic reflectors and textures identified as Dalradian, Devonian, Carboniferous, Permian, Triassic, Lower and Upper Cretaceous, Tertiary and Quaternary were mapped, generally younging to the east. In most cases clear boundaries, unconformities and faults could be resolved, but top Tertiary was difficult to identify with any degree of certainty and the nature of the Permian/Triassic boundary was unclear.

Leg 8

31 July-13 August: Dundee-Dundee

The vessel sailed from Dundee on 31 July and, after spending two days conducting Huntec boomer trials continued with the regional survey between latitudes 56° and 57°N. Gravity transit lines 23-25 inclusive, totalling 447km were completed en route to and from the boomer trials area. Lines 26-36 inclusive, totalling 1729km of regional survey were completed in the main survey area. During the latter part of the leg the weather generally deteriorated and forced a 22 hour break in survey on 8/9 August. Data quality was generally good though the sparker records suffered somewhat from sea conditions during the latter part of the leg. The ship's auto pilot suffered several breakdowns during the leg, one of which precipitated the decision to abandon survey in deteriorating weather conditions.

An ornithologist from the Nature Conservancy Council's Seabirds at Sea Group accompanied the vessel on this leg.

A Huntec representative joined the ship in Dundee to replace the plate in the boomer transducer which had failed during leg 6 and to assess the performance of the present system. In-port checks showed that the boomer transducer used during the previous two legs was giving an output pulse of less than half its original amplitude. The repaired transducer was fitted and successful tests carried out in an area previously surveyed with a Huntec boomer in 1976. The records were comparable in terms of penetration and resolution, but excessive ringing was still apparent with the new style plate. The Huntec engineer also fitted a modification to enable simultaneous use of depth and heave compensation, but unfortunately, the heave accelerometer failed before this mode of operation could be tested. The Huntec representative was landed at Montrose on 2 August.

The watergun was used in preference to the airgun due to absence of a bubble pulse. On one occasion during routine maintenance of the watergun the solenoid valve block was ejected at ballistic speed, shearing two retaining bolts. Further detail of this potentially lethal incident is given in the equipment performance summary.

Satellite coverage continued to be good throughout the leg and post-processing navigational accuracy is again estimated to be within 150m.

The gravity results were good throughout, the accuracy enhanced by the high quality navigation resulting in good definition of the Eotvos curves. Consistency of results was good both internally (mean crossover 0.59mGal) and with data from 1973 but were approximately 4mGal lower than 1972 data north of 57^{o}N.

During this leg the CAMAC minilogger underwent its first sea trials. Gravity, magnetic and depth data were logged successfully, but only for a few hours at a time.

Seismic record quality was generally good and the results amplified the geological patterns of easterly younging rocks established during earlier legs. The Devonian/Permian contact in the Tay to Montrose area was not clear and the nature of the Permian/Triassic contact was not established on most lines. The Cretaceous contacts in most cases were clear and in most instances the base Tertiary could be identified. No clear evidence exists, however, to indicate the Tertiary/Quaternary contact. The Quaternary sequence to the east is particularly complex.

Leg 9

15-26 August: Dundee-Dundee

The vessel sailed from Dundee on 15 August after a twelve hour delay to complete repairs and in-port checks on the Huntec boomer system. With one twelve hour break for poor weather overnight 17-18 August, lines 37-42 inclusive, totalling 634km, were completed in the main survey area before poor weather forced a shutdown on 19 August. This completed the survey in the Marr Bank area but there followed an extended period of very poor weather which lasted throughout

the remainder of the leg preventing any further work in the main survey area. No work was possible until 23 August and from then on survey was confined to the Tay/Forth coastal area, lines 43-50 inclusive, totalling 433km being surveyed.

The watergun firing line connector failed after completing line 40 and whilst repairing this the gun was stripped for maintenance. This revealed a major crack in the main shuttle which rendered the watergun unserviceable for the remainder of the season.

Navigation was generally good and post-processing accuracy is again estimated to be within 150m with the exception of the latter part of line 37. Here an intermittent fault occurred and navigation should be treated with caution.

Despite poor weather gravity results continued to be good. Completion of survey work in the Tay/Forth and Marr Bank areas resulted in RMS crossties of 1.0mGal (based on 57 values) and 0.8mGal (based on 74 values) respectively.

The CAMAC system underwent further trials and a link to the satellite navigation system was successfully established with navigation data being written to magnetic tape. The trials over these last two legs have shown it possible to replace the function of the Decca data logger, excluding the logging of Decca Main Chain data, and to log navigation data.

Completion of the grid on the Marr Bank sheet allowed the solid geology of the area to be mapped. The boundaries of the Lower Cretaceous were drawn on the assumption that it has a lower well-bedded unit, a central massive unit and an upper well-bedded unit above which occurs the more weakly-bedded Upper Cretaceous. The Quaternary geology was examined in some detail but the stratigraphy was not established.

Leg 10

28 August-8 September: Dundee-Dundee

The vessel sailed from Dundee on 28 August with the objective of completing the work in the main survey area, to run a transit line along the track of a digital

sparker survey completed earlier in the year for IGS by Gardline Surveys Ltd and then to survey lines in the Bosies Bank/Caithness area to clarify earlier geophysical work (Project 79/15, Report No. 101).

The first objective was completed in six days (lines 51-56 inclusive) with one 24 hour break for poor weather on 30-31 August. The transit line (no. 57) was then run giving excellent correlation with the digital sparker records. Due to the limited time remaining the proposed programme could not be carried out in the Bosies Bank area but ten lines (nos. 58-67 inclusive) were run, concentrating towards the end of the leg on one particular geological boundary. A total of 1280km of regional survey was carried out.

There was no significant equipment downtime, the only notable failure being one Huntec boomer transducer which was replaced by the spare. Seismic records were good, particularly the sparker, though the side-scan sonar records over a known pockmark area (line 57) were rather disappointing. Experiments were made with a basic 3/4 sec firing cycle causing the boomer and sparker graphic records to always print on the same stylus. This resulted in a more even display, reducing stylus jitter, the improvement in record quality being more significant for the boomer.

Navigation continued to be very good and, again, the post-processing accuracy is estimated to be within 150m.

Gravity results were again good and for the Devil's Hole sheet an overall mean mistie of 0.7mGal was obtained based on 68 crossovers.

In the main survey area the seismic data confirmed the complexity of the thick Quaternary sequence in the eastern part of the area. The Aberdeen ground beds have not been positively identified but may be present along some lines. The channelling of the upper part of the section was most striking and a number of major channels were identified with shoulder to trough relief of up to 300m. One channel group has been traced for over 85km trending in a NW-SE direction. In the Bosies Bank/Caithness area the feather edge of the folded Palaeocene was successfully mapped.

EQUIPMENT PERFORMANCE SUMMARY

The gravity meter, magnetometer, echo sounder, MS47 transit sonar, airgun system and Edo Western pinger all operated throughout the survey period without significant problems.

Data logging systems

The power supply to the Decca data logger failed during leg 6 and was replaced. An intermittent fault on the 9400 logger causing the tape to wind forward became serious during leg 7. It was cured by adjustment of the beginning and end of tape optical detector assembly.

Satellite navigation system

During leg 6, large, along course, updates were traced to a faulty pitch axis inclinometer which was repaired. With the inclinometers off the dead reckoning accuracy remained good. This suggested that the contribution made by the inclinometers is small, whilst the errors caused by their incorrect operation are potentially quite large. Two faults occurred during leg 9, the first being the failure of an integrated circuit in the MX200 interface unit resulting in radically erroneous thermistor readings. The second was a poor connection in the MX200/CPU interface cable which resulted in incorrect timing. Both faults were quickly rectified but the second affected navigation on the latter part of line 37. The premature rewind of deck 2 experienced earlier in season continued intermittently throughout the survey.

Sparker system

Throughout the survey period the sparker operated reliably, the only significant problem being the failure of both sparker generators delaying the start of leg 7 by twelve hours. This was caused by dirty fuel, a considerable amount of sediment entering the fuel injection systems. This was cleared by frequent filter changes and repeated flushing of the fuel lines.

Sodera watergun

In the early part of the survey the watergun operated reliably and was considered preferable to the airgun because of the absence of a bubble pulse.

Corrigendum

Page 12 - final paragraph

"Both transducers also suffered from a partial loss of air from the pressure compensation chamber which had to be reinflated."

However, during leg 8 a potentially lethal incident occurred during routine maintenance of the gun when the solenoid valve block cover was ejected at ballistic speed shearing two of its retaining bolts. The gun had been in continuous, problem-free operation, excepting routine inspection between lines, for approximately five days. It was recovered in the normal manner, all pressure being released before landing on deck where it remained, de-pressurised, for an hour before work on it commenced. On stripping the gun the solenoid valve block was noticed to be tight in its mounting and on tapping with a soft hammer the cover came off with explosive force. This was presumably due to a build up of high pressure air in the solenoid housing caused by leakage past O-ring no. 141. There was absolutely no indication of the build up of pressure in the solenoid block which should have remained at atmospheric pressure. That such a build up could occur at all is a potentially lethal design fault and the manufacturers have been informed. A modification has been made to prevent the recurrence of such an incident. A groove has been cut in connector no. 119 and the leads lengthened so that any pressure in the housing can be bled off before attempting to strip the gun.

During leg 9 the firing lead connector failed and on recovering the gun to rectify this the opportunity was taken to strip the gun for routine maintenance. This revealed cracks in the main shuttle and the gun was withdrawn from service. Since this is an integral, custom built part of the gun it could not be replaced at short notice, thus the watergun was unserviceable for the remainder of the survey.

Huntec boomer

As on Project 80/01 (report no. 103) the new style boomer transducer proved to be unreliable and generally disappointing in overall performance.

Two transducer assemblies were available and both suffered from cracked plates, the first during leg 6 and was replaced before the start of leg 8, and the second during leg 10. Both transducers also suffered from a partial loss of air from the pressure compensation chamber which had to be installed. There was also a marked reduction in output power from both transducers after only a few days in operation.

The ringing observed earlier in the season persisted in both transducers, however, it was less significant in deeper water and despite the technical problems a considerable amount of good quality data were acquired.

Side-scan sonar

The winch was modified to reduce its response time during the refit period at the start of the project and thereafter operated satisfactorily throughout. Only minor technical problems were encountered with the side-scan system. However, the records whilst useful are generally of only moderate quality. The alternate firing in the dual channel mode reduces the horizontal resolution, this being further reduced by having to gate out the sparker which produces serious acoustic interference. A modification was made to the transceiver unit to display the start points of the two TVG ramps as an aid to the setting up procedure. Throughout the survey the fish appeared to tow with the starboard side inclined slightly too high resulting in surface returns on the starboard channel when towed shallow. This also made it extremely difficult to produce an even display across the full record width in the dual channel mode.

TABLE 1

Personnel on Project 80/03

Leg 6
5-16 July: Sunderland-Dundee

		Leg Report
G A Day)		Senior Scientist
A S Mould)	IGS MGU	Navigation
J R Walker)		Geophysical
J F Derrick)		
K Hitchen	IGS HCU	
J Price)		Technical
A Cumming)	RVS Barry	
K Smith)		
D Leachman	Emoos Ltd	
M Smith	IGS MGLU	Geological
P R Roberts	IGS MGU (5-7 July)	

Leg 7
19-30 July: Dundee-Dundee

M C Tully)		Senior Scientist/Geophysical
C P Brett)		
J R Walker)	IGS MGU	Navigation
R Hemingway)		
A Cumming)		Technical
M Gallon)	RVS Barry	
I Strangward)		
M Garratt	Emoos Ltd	
R Owens	IGS MGLU	Geological
R Price	Comap Ltd	

Leg 8
31 July-13 August: Dundee-Dundee

		Leg Report
A S Mould)		Senior Scientist/Navigation
A Dobinson)		Geophysical (seismic)
M Glen)	IGS MGU	
E J Armstrong)		Geophysical (gravity)
J F Derrick)		
J Bulat	IGS HCU	
C Paulson)	RVS Barry	
R Robinson)		
M Garratt	Emoos Ltd	Technical
N G T Fannin	IGS MGLU	Geological
A O'Neill	Nature Conservancy Council	
S Theodolou	Huntec Ltd (31 July-2 August)	

Leg 9
15-26 August: Dundee-Dundee

M C Tully)		Senior Scientist/Geophysical
A S Mould)		Navigation
M Glen)	IGS MGU	
P R Roberts)		Technical
I Williamson)		
J Donato	IGS HCU	
K Robertson)		
R Robinson)	RVS Barry	
K Smith)		
D Leachman	Emoos Ltd	
D Evans)	IGS MGLU	Geological
M McMillan)		

Leg 10

28 August-8 September: Dundee-Dundee

		Leg Report
A Dobinson)		Senior Scientist/Navigation
C P Brett)		Geophysical (seismic)
J R Walker)	IGS MGU	Geophysical (gravity)
P R Roberts)		
I Williamson)		
J F Derrick)		
R Owen	IGS HCU	
A Cumming)		Technical
I Innes)	RVS Barry	
G White)		
D Leachman	Emoos Ltd	
N G T Fannin	IGS MGLU	Geological

LINE NO.	LAST FIX	START Day Time	END Day Time	LINE LENGTH KM	NAVIGATION		BATHYMETRY ATLAS DESO 10 EDIG 10	GRAVITY LACOSTE & ROMBERG S75	MAGNETICS BARRINGER	DATA LOGGING		SONAR			SEISMIC				
					SATNAV-DOPPLER SONAR	OTHER				DECCA-IGS	MONITOR LABS 9400	KELVIN HUGHES MS47	DUAL CHN. SIDE SCAN	UDI AS350	PINGER EDO WESTERN	BOOMER HUNTEC DEEP-TOW	SPARKER EG&G	AIRGUN BOLT 600B	WATERGUN SODERA MICA-T
01	12	189 0540	189 0730	18	✓		✓	✓		✓	✓		✓				✓ 1KJ	✓ $10IN^3$	
02	41	189 1120	189 1800	66	✓		✓	✓		✓	✓	✓	✓		✓		✓ "	✓ "	
03	56	189 1940	190 0150	87	✓		✓	✓	✓ FIX 18 →	✓	✓	✓	✓		✓		✓ "	✓ "	
04	68	190 0700	190 1810	121	✓		✓	✓	✓	✓	✓	✓	✓		✓		✓ "	✓ "	
05	17	191 2230	192 0110	24	✓					✓	✓								✓
06	21	193 0000	193 0320	36	✓		✓	✓	✓	✓	✓	✓	✓		✓		✓ "		✓
07	33	193 0530	193 1050	47	✓		✓	✓	✓	✓	✓	✓	✓		✓		✓ "		✓
08	21	193 1200	193 1520	32	✓		✓	✓	✓	✓	✓	✓	✓		✓		✓ "		✓
09	203	193 1600	195 0140	369	✓		✓	✓	✓	✓	✓	✓	✓		✓		✓ "		✓
10	20	195 0330	195 0640	32	✓		✓	✓	✓	✓	✓	✓	✓		✓	✓	✓ "		✓
11	197	195 0910	196 1830	282	✓		✓	✓	✓	✓	✓	✓	✓		✓	✓	✓ "		✓
12	92	201 1530	202 0640	119	✓		✓	✓	✓	✓	✓	✓	✓		✓	✓	✓ "		✓
13	40	203 0950	203 1620	74	✓		✓	✓	✓	✓	✓	✓	✓		✓	✓	✓ "	✓ $10IN^3$	
14	170	203 1800	204 2210	296	✓		✓	✓	✓	✓	✓	✓	✓		✓	✓	✓ "	✓ "	
15	163	205 0140	206 0440	274	✓		✓	✓	✓	✓	✓ PART	✓	✓		✓	✓	✓ "	✓ "	
16	36	206 0544	206 1134	66	✓		✓	✓	✓	✓	✓ PART	✓	✓		✓	✓	✓ "	✓ "	
17	230	206 1610	208 0620	351	✓		✓	✓	✓	✓	✓	✓	✓		✓	✓	✓ "	✓ "	
18	81	208 1220	209 0140	120	✓		✓	✓	✓	✓	✓	✓	✓		✓	✓	✓ "		✓
19	84	209 0540	209 1930	120	✓		✓	✓	✓	✓	✓	✓	✓		✓	✓	✓ 500J		✓
20	75	209 2320	210 1140	120	✓		✓	✓	✓	✓	✓	✓	✓		✓	✓	✓ 500J/ 1KJ	✓ $10IN^3$ PART	✓ PART
																✓	✓ 1KJ/ 500J	✓ $10IN^3$	

LINE SUMMARY

TABLE 2

LINE NO.	LAST FIX	START Day Time	END Day Time	LINE LENGTH KM	NAVIGATION		BATHYMETRY ATLAS DESO 10 EDIG 10	GRAVITY LACOSTE & ROMBERG S75	MAGNETICS BARRINGER	DATA LOGGING		SONAR		SEISMIC				
					SATNAV-DOPPLER SONAR	OTHER				DECCA-IGS	MONITOR LABS 9400	KELVIN HUGHES MS 47	UDI AS350 DUAL CHN. SIDE SCAN	PINGER EDO WESTERN	BOOMER HUNTEC DEEP-TOW	SPARKER EG&G	AIRGUN BOLT 600B	WATERGUN SODERA MICA-T
21	74	210 1500	211 0310	120	✓		✓	✓	✓	✓	✓	✓	✓		✓	✓500J	✓10IN³	
22	52	211 0520	211 1350	84	✓		✓	✓	✓	✓	✓	✓	✓		✓	✓ "	✓ "	
23	79	213 2200	214 1100	226	✓		✓	✓		✓	✓							
24	17	215 0020	215 0300	45	✓		✓	✓		✓	✓							
25	63	215 0450	215 1510	176	✓		✓	✓		✓	✓							
26	79	216 0210	216 1510	120	✓		✓	✓	✓	✓	✓	✓			✓	✓500J	✓5IN³	
27	72	216 1900	217 0650	124	✓		✓	✓	✓	✓	✓	✓			✓	✓ "	✓ "	
28	76	217 1030	217 2300	123	✓		✓	✓	✓	✓	✓	✓			✓	✓ "		✓
29	97	218 0110	218 1710	157	✓		✓	✓	✓	✓	✓	✓	✓	✓		✓ "		✓
30	225	218 2130	220 1050	371	✓		✓	✓	✓	✓	✓	✓	✓		✓	✓ "		✓
31	39	220 1450	220 2110	52	✓		✓	✓	✓	✓	✓	✓	✓		✓	✓500J/1KJ		✓
32	76	220 2300	221 1130	117	✓		✓	✓	✓	✓	✓	✓	✓		✓	✓1KJ		✓
33	27	222 0940	222 1400	44	✓		✓	✓	✓	✓	✓	✓	✓		✓	✓500J		✓
34	135	222 1720	223 1540	214	✓		✓	✓	✓	✓	✓	✓	✓		✓	✓ "		✓
35	143	223 1756	224 1736	213	✓		✓	✓	✓	✓	✓	✓	✓		✓	✓ "		✓
36	119	224 2040	225 1620	194	✓		✓	✓	✓	✓	✓	✓	✓		✓	✓ "		✓
37	82	228 1630	229 0610	122	✓		✓	✓	✓	✓	✓	✓	✓	✓ PART	✓	✓ "		✓ PART
38	73	229 1030	229 2230	123	✓		✓	✓	✓	✓	✓	✓	✓		✓	✓ "		✓
39	74	230 0240	230 1450	122	✓		✓	✓	✓	✓	✓	✓	✓		✓	✓500J/1KJ		✓
40	74	231 0930	231 2140	122	✓		✓	✓	✓	✓	✓	✓	✓		✓	✓1KJ		✓

LINE SUMMARY

TABLE 2

LINE NO.	LAST FIX	START Day Time	END Day Time	LINE LENGTH KM	NAVIGATION			BATHYMETRY ATLAS DESO 10 EDIG 10	GRAVITY LACOSTE & ROMBERG S75	MAGNETICS BARRINGER	DATA LOGGING		SONAR			SEISMIC				
					DOPPLER SONAR	SATNAV-OTHER					DECCA-IGS	MONITOR LABS 9400	KELVIN HUGHES MS 47	DUAL CHN. SIDE SCAN	UDI AS350	PINGER EDO WESTERN	BOOMER HUNTEC DEEP-TOW	SPARKER EG&G	AIRGUN BOLT 600B	WATERGUN SODERA MICA-T
41	74	232 0220	232 1430	123	✓		✓	✓	✓	✓	✓	✓	✓	✓			✓	✓ 1KJ	✓ $10IN^3$	
42	18	232 1820	232 2110	22	✓		✓	✓	✓	✓	✓	✓	✓	✓			✓	✓ "	✓ "	
43	22	237 0042	237 0412	28	✓		✓	✓	✓	✓	✓	✓	✓	✓			✓	✓ "	✓ $5IN^3$	
44	28	237 0516	237 0946	37	✓		✓	✓	✓	✓	✓	✓	✓	✓			✓	✓ "	✓ "	
45	34	237 1240	237 1810	57	✓		✓	✓	✓	✓	✓	✓	✓	✓			✓	✓ "	✓ "	
46	36	237 1940	238 0130	53	✓		✓	✓	✓	✓	✓	✓	✓	✓			✓	✓ "	✓ "	
47	37	238 0320	238 0920	60	✓		✓	✓	✓	✓	✓	✓	✓	✓			✓	✓ "	✓ "	
48	50	238 1530	238 2340	89	✓		✓	✓	✓	✓	✓	✓	✓	✓			✓	✓ "		
49	57	239 0040	239 1000	100	✓		✓	✓	✓	✓	✓	✓	✓	✓			✓	✓ "		
50	7	239 1144	239 1244	9	✓		✓	✓			✓	✓								
51	153	242 1010	243 1130	220	✓		✓	✓	✓	✓	✓	✓		✓			✓	✓ 500J	✓ $5IN^3$	
52	78	244 2020	245 0910	100	✓		✓	✓	✓	✓	✓	✓		✓			✓	✓ 1KJ/ 500J	✓ $1IN^3$	
53	30	245 1246	245 1736	55	✓		✓	✓	✓	✓	✓	✓		✓			✓	✓ 500J		
54	70	245 2000	246 0730	93	✓		✓	✓	✓	✓	✓	✓		✓			✓	✓ "	✓ $1IN^3$	
55	95	246 1200	247 0340	122	✓		✓	✓	✓	✓	✓	✓		✓			✓	✓ "	✓ "	
56	79	247 0730	247 2030	121	✓		✓	✓	✓	✓	✓	✓		✓			✓	✓ "	✓ "	
57	80	248 0130	248 1440	132	✓		✓	✓	✓	✓	✓	✓		✓			✓	✓ "		
58	37	249 0110	249 0710	53	✓		✓	✓	✓	✓	✓	✓		✓			✓	✓ "	✓ $1IN^3$	
59	49	249 1050	249 1850	73	✓		✓	✓	✓	✓	✓	✓		✓			✓	✓ 1KJ	✓ "	
60	48	249 2310	250 0700	76	✓		✓	✓	✓	✓	✓	✓		✓			✓	✓ "	✓ "	

LINE SUMMARY

TABLE 2

LINE NO.	LAST FIX	START Day Time	END Day Time	LINE LENGTH KM	NAVIGATION		BATHYMETRY ATLAS DESO 10 EDIG 10	GRAVITY LACOSTE & ROMBERG S75	MAGNETICS BARRINGER	DATA LOGGING		SONAR		SEISMIC						
					SATNAV-DOPPLER SONAR	OTHER				DECCA-IGS	MONITOR LABS 9400	KELVIN HUGHES MS 47	UDI AS250 DUAL CHN. SIDE SCAN	WESTERN EDO PINGER	HUNTEC DEEP-TOW BOOMER	EG&G SPARKER	BOLT 600B AIRGUN	MICA-T SODERA WATERGUN
61	98	250 1030	251 0240	117	✓		✓	✓	✓	✓	✓		✓		✓ PART	✓ 1 KJ	✓ PART 1 IN³		
62	10	251 0330	251 0500	16	✓		✓	✓	✓	✓	✓		✓			✓ "			
63	15	251 0610	251 0830	22	✓		✓	✓	✓	✓	✓		✓			✓ "			
64	9	251 0930	251 1050	12	✓		✓	✓	✓	✓	✓		✓			✓ "	✓ 1 IN³		
65	13	251 1130	251 1330	20	✓		✓	✓	✓	✓	✓		✓			✓ "	✓ "		
66	16	251 1410	251 1640	22	✓		✓	✓	✓	✓	✓		✓			✓ "	✓ "		
67	15	251 1720	251 1940	26	✓		✓	✓	✓	✓	✓		✓			✓ "	✓ "		

LINE SUMMARY

TABLE 2

TABLE 3

Corrected Gravity Base Ties

Date Day Time GMT	Place & Berth	g at main base mGal	g at berth corrected for tidal effects mGal	Meter reading corrected for tidal effects Meter divs	Drift mGal
4.7.80 186 2000	Sunderland Shear's Quay	981506.98	981500.8	12297.8	
16.7.80 198 1840	Dundee Camperdown Dock	981630.7	981632.5	12430.9	+0.2
18.7.80 200 1755	Dundee Camperdown Dock	981630.7	981632.5	12431.1	+0.2
31.7.80 213 0950	Dundee Camperdown Dock	981630.7	981632.0	12431.8	+1.2
13.8.80 226 0950	Dundee Camperdown Dock	981630.7	981632.0	12433.0	+1.2
26.8.80 239 1650	Dundee Camperdown Dock	981630.7	981632.0	12433.3	+0.3
28.8.80 241 1400	Dundee Camperdown Dock	981630.7	981632.0	12433.0	-0.3
8.9.80 252 1500	Dundee Camperdown Dock	981630.7	981632.0	12434.0	+1.0

APPENDIX 1

Equipment Carried

Navigation

1. Magnavox satellite navigation system integrated with MX610/MX600 doppler sonar and Arma Brown Mk I Mod 5 gyro compass.

2. Decca Mk 21 main chain receiver - optional integration with above.

Gravity

LaCoste and Romberg S75 air-sea gravity meter. World Wide land gravity meter for base ties.

Magnetics

Barringer proton magnetometer - two tow cable/sensor assemblies.

Bathymetry

Atlas Deso 10 echo sounder with hull mounted transducers (33 and 210KHz) and Edig 10 digitiser unit.

Data logging

1. Decca/IGS data logger.

2. Monitor Labs 9400 data logger.

Sonar

1. Kelvin Hughes MS47 transit sonar - hull mounted, port scanning.

2. UDI AS350 dual channel side scan system with catamaran tow fish, 2500' tow cable and remote controlled winch. Recording on an EPC 3200 graphic recorder.

Seismic

1. Edo Western 248 pinger, 3.5KHz, 10KW transducer in tow fish assembly. Used with TSS Model 302 swell filter, recording on EPC 4600 graphic recorder.

2. Huntec deep tow boomer system with remote controlled winch, two Krohn-hite bandpass filters, recording on an EPC 4100 graphic recorder.

3. EG & G sparker system - up to 5KJ capability, one three element and one nine element spark array, Krohn-hite band-pass filter, TSS Model 307 TVG amplifier, recording on an EPC 4600 graphic recorder.

4. Air gun system:- Bolt 600B, two guns with standard (1-40in^3) range of chamber sizes, Krohn-hite bandpass filter, TSS Model 307 TVG amplifier and recording on an EPC 4600 graphic recorder.

5. Sodera Mica-T 80in^3 water gun recording as for air gun system.

6. Analogue tape and seismic control system (IGS) incorporating a Racal Store 4 tape deck.

7. Hydrophones

   (a) Huntec ST2.

   (b) EG & G 265.

   (c) EG & G 263C, 2 off - used with sparker.

(d) Teledyne 7 channel (10m) - used with sparker latter half of season.

(e) Geomecanique 30m used with air gun.

(f) Geomecanique 50m 3 section - used with air gun/water-gun.

8. Seismic amplifiers - Bell and Howell, 10 off.

9. Additional EPC 3200 recorder - normally used for additional display of air gun or simultaneous display of air gun and sparker.

10. Spare EPC 4600 recorder.

11. Spare Racal Store 4 tape deck.

Miscellaneous

1. Two UDI closed circuit television systems for monitoring remote winches.

2. Hewlett Packard 9810 desk top calculator with 9862A graph plotter.

PROJECT 80/03

0 10 50 100 KM.

58

57°N

2°W

0

2°E

FIGURE 1